RANI RASHMONI GREEN UNIVERSITY

M.Sc. in Fishery Science

Program outcome (P.O):

The purpose of the postgraduate program in **Fishery Science** at ***Rani Rashmoni Green University*** is to develop strong-minded graduates with high-quality skills as professional in the field of Fisheries Science. The curriculum designed to prepare the students in understanding the vital concept of fishery resources, fish taxonomy, identification of fish using molecular tools, modern craft and gears in capture fishery, diversity, biology, genetics, breeding, freshwater, coastal and marine aquaculture, and fishery conservation and management. At the end of the program, the student will gain profound knowledge of professional skills in fishery biology and aquaculture as well as well-known with national and international fishery science/technology and equipped with comprehensive knowledge structure. This will help the students to play an active role in research, government or non-government organization, private and corporate sectors.

On successful completion of the Master of Fishery Science programme, the students may acquire the following:

a) The students will be capable to connect in notable, self-governing, and original research in the field of fishery biology and aquaculture.

b) The students are competent enough to setup aquaculture, fish processing and fish by product business.

c) Students are able to support fish production, improving the welfare of fishermen, promoting export earnings and providing food security to the country.

d) Student would acquire significant knowledge to clear the competitive examinations in the field of fishery science.

e) Students will get expertise and knowledge for the following job types: Aquaculture Entrepreneur; Fisheries Extension Officer; Consultant and Fish Breeders; R&D Professional; Fish Exporters and Export Manager; Hatchery/ Farm Operator; Feed Mill Manager; Fish Export Inspector; Hatchery Manager and Fish Traders; Processing and Production Manager etc.

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M.Sc. in Fishery Science

Semester	Course Code	Course Title		Full Marks
Sem - I	EVS	Environmental Science		40+10
	FSC-CC-101	Unit - I	Integrated Taxonomy of Finfish & Shellfishes	40+10
		Unit - II	Functional Anatomy of Finfish & Shellfishes	
	FSC-CC-102	Unit - I	Fisheries Resources & Aquaculture Systems	40+10
		Unit - II	Aquatic Ecology & Limnology	
	FSC-CC-103	Unit - I	Aquatic Pollution and Ecotoxicology	40+10
		Unit - II	Aquatic Microbiology	
	FSC-CC-194	Practical	Based on 101 (Unit 1 & 2) + 102 (Unit – 1)	40+10
	FSC-CC-195	Practical	Based on 102 (Unit - 2) + 103 (Unit - 1 & 2)	40+10
	Total			**300**
Sem - II	FSC-CC-201	CBCS – I (Fundamentals of Fisheries & Aquaculture) / Self-Learning Course (SLC) – MOOCs		40+10
	FSC-CC-202	Unit - I	Fish breeding and Seed production technology	40+10
		Unit - II	Construction and Management of Hatcheries	
	FSC-CC-203	Unit - I	Integrated Fish Farming	40+10
		Unit - II	Aquariculture & Live Food Production	
	FSC-CC-204	Unit - I	Fish Nutrition & Bioenergetics	40+10
		Unit - II	Feed Technology	
	FSC-CC-295	Practical	Based on 202 (Unit 1 & 2) + 203 (Unit – 1)	40+10
	FSC-CC-296	Practical	Based on 203 (Unit - 2) + 204 (Unit - 1 & 2)	40+10
	Total			**300**

Sem - III	FSC-CC-301	CBCS – II (Aquatic pollution and Waste Water Management) / Self-Learning Course (SLC) – MOOCs		40+10
	FSC-CC-302	Unit - I	Finfish diseases and Health Management	40+10
		Unit - II	Shellfish diseases and Health Management	
	FSC-CC-303	Unit - I	Fish Immunology	40+10
		Unit - II	Coastal Aquaculture and Mariculture	
	FSC-CC-304	Unit - I	Post Harvest technologies & Quality Assurance	40+10
		Unit - II	Fisheries Extension, Economics & Entrepreneurship	
	FSC-CC-395	Practical	Based on 302 (Unit 1 & 2) + 303 (Unit – 1)	40+10
	FSC-CC-396	Practical	Based on 303 (Unit - 2) + 304 (Unit - 1 & 2)	40+10
	Total			**300**
Sem - IV	FSC-CC-401	Unit - I	Fish Genetics & Conservation	40+10
		Unit - II	Fish Biotechnology& Molecular Biology	
	FSC-CC-492	Practical	Based on 401 (Unit 1 & 2)	20+05
	FSC-CC-403	-	Research methodology in Fishery Science	20+05
	FSC-EC- 404* (Any one)	DSE-1	Systemic Fish Physiology	40+10
		DSE-2	Aquatic Animal Pathology & Disease Diagnosis	
	FSC-EC-405* (Any one)	DSE-1	Freshwater Aquaculture & Diversification	40+10
		DSE-2	Marine & Brackishwater Fisheries	
	FSC-EC-496	Practical	Based on 404 (any one) & 405 (any one)	40+10
	FSC-CC-497	Practical	Project / Review Work / Internship	40+10
	Total			**300**

*Discipline Specific Elective / Special Paper

SEMESTER – I

Course Code: FSC-CC-101	Semester - I	Marks: 40 + 10 Credits: 4
Unit - I Marks: 20 + 05	Course Title (Theory) : Integrated Taxonomy of Finfish and Shellfishes	Hours/Week: 1.5

Objective

- To understand the basic principles of taxonomy, classifications, and the characteristics of different finfish and shellfishes
- To understand the applications of molecular tools for fish identification

	Principles of Taxonomy: Classification, Taxonomy and Systematics - definitions and differences, Theories of taxonomy, Type concepts in fish taxonomy – description of species based on type specimen. Binomial nomenclature - Dichotomous keys. Synonyms and antonyms. Criteria for generic and specific identification. Preservation, cataloguing, submission in museums (National Digital Repository for Museums of India) and maintenance of specimens.
	Crustacean: Taxonomic classification of commercially important crustacean up to genus level - Morphomertic and meristic characteristics of Crustacean. Key characters for identification - commercially important species.
	Mollusca: Taxonomic classification of commercially important mollusks up to genus level, Morphological characteristics of mollusca. Key characters for identification - commercially important species.
	Finfish Classification: Taxonomic significance - Major taxa of commercially important inland and marine finfishes - Morphometric and meristic characteristic features of finfishes. Key characters for identification - commercially important species.
	Molecular Taxonomy: Karyo-taxonomy, Cytotaxonomy of fishes - protein analysis and DNA polymorphism. Mitochondrial DNA - allozyme analysis, RFLP, RAPD, AFLP, microsatellite typing, mini satellites, single nucleotide polymorphism (SNP), and expressed sequence tag (EST) markers, DNA barcoding, NCBI - BLAST- MEGA - Phylogenetic tree.

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Lagler, K.E. et al. (1977). Ichthyology. John Wiley and Sons. Rd Eds.

Mayer, E. (1977). Principle of Systematic Zoology. Tata McGraw Hill.

Joseph Nelson, S., Terry Grande Mark, C., Wilson, V. H. (2016). Fishes of the World. 5th Eds. Wiley
Norman, J.R., Greenwood, P.H. (1975). A History of Fishes, 3rd Ed. Ernest Benn Ltd.
Ponniah, A.G., George, J. (1998). Fish Chromosome Atlas. National Bureau of Fish Genetic Resources (NBFGR), Lucknow.
Whitmore, D.H. (1990). Electrophoretic and Isoelectric Focusing Techniques in Fisheries Management. CRC Press.

Outcomes

- By the end of the course, students acquire comprehensive knowledge and also exhibit depth and breadth of fishery taxonomy
- Students can be able to identify the commercially important fishes using molecular tools

Unit - II **Marks: 20 + 05**	**Course Title (Theory) :** **Functional Anatomy of Finfish & Shellfishes**	**Hours/Week: 1.5**

Objective

- To understand the fundamentals of anatomy and biology of finfishes
- To study the anatomy and different biological systems of shellfishes

	Finfish: Gross external anatomy of fishes, Skin and its derivatives, scales and their significance; Food and feeding habits - age & growth, anatomy and histology of digestive system and physiology of digestion; Respiratory organs in fishes – Modification of gills and Tracheae in relation to habit and habitat – Structural adaptations of air breathing fishes; Nervous system, Sense Organs and Endocrine organs in fishes
	Crustaceans: Commercially important prawn, shrimps, crab and lobsters; life cycle – larval stages; ; food, feeding habits and adaptations of cultured crustaceans; Integument and exoskeleton of crustaceans, their structure and functions; Respiratory organs, Excretion and Endocrine organs in crustaceans; Reproductive patterns in crustaceans, reproductive organs, gonad maturity, spawning and fertilization
	Molluscs: Clam, oyster, green and brown mussel - present national and international status - life cycle; Commercially important freshwater snails and Abalone - life cycle; squid, octopus, cuttlefish, commercially important species - life cycle; Food, feeding habits and adaptations of cultured Molluscs; Respiratory organs and Excretion in Molluscs, Reproductive patterns in Molluscs, reproductive organs, gonad maturity, spawning and fertilization

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Shanmugam, K. (1990). Fishery Biology and Aquaculture. Leo Pathippagam, Madras.
Thomas, P. C. (2003). Breeding and Seed Production of Fin Fish and Shell Fish. Daya Publ. House.

Outcomes

- The student can be able to critically discuss the biology of finfishes and shellfish
- The student understands the physiology of commercially important Fishes

Course Code: FSC-CC-102	**Semester - I**	**Marks: 40 + 10 Credits: 4**
Unit - I Marks: 20 + 05	**Course Title (Theory) : Fisheries Resources & Aquaculture Systems**	**Hours/Week: 1.5**

Objective

- To learn the Fisheries Resources & Aquaculture Systems for sustainable production
- To familiarize with different aquaculture production and farming systems

	Riverine and reservoir fisheries: Major river systems of India and their fisheries. Current status, trend and problems of riverine fisheries. Effect of human intervention in rivers. Classification of lakes and reservoirs, present productivity levels and fishery potentials. Problems and prospects of reservoir fisheries in India. Measures to increase their production and economic management of reservoirs.
	Coldwater fisheries: Coldwater resources of India. Important cold-water fish species. Status of cold-water fisheries in India - Mahseer, Trout and sports fisheries in India.
	Brackish water and Marine fisheries: Brackish water fishery resources of India. Estuaries of India and their fisheries. Coastal fisheries resources, Problems and management practices; present trend of marine capture fisheries of India; Management of marine fisheries in Indian context. Important finfish and shellfish resources in demersal and pelagic systems. Important groups of finfishes and shellfishes having commercial importance.
	Fundamental Aquaculture systems: Extensive, semi-intensive and intensive culture of fish, Pen and cage culture in lentic and lotic water bodies, polyculture, composite fish culture - species selection, culture practices, harvesting. Integrated farming systems (concept only).

	Different culture Systems practiced in India: Kerala-monoculture, integrated farming-case studies of paddy cum fish culture, fish culture in pokkali fields, Re-circulating systems, RAS, aquaponics, flow-through systems, raceways, Biofloc culture, Waste water aquaculture – sewage treatment, removal of nitrogen and phosphorus from waste water, role of aquatic macrophytes in treatment of wastewater - ASTP; Integrated Multi-Trophic Aquaculture (IMTA)

References

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Pandey, D. K., De, H.K. (2014). Fisheries Governance and Legistation In India. Narendra Publ. House.
Pingsun Leung, Carole Engle (2007). Shrimp Culture Economics, Market, and Trade. WileyBlackwell.
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Sarma, D., Shahi, N. (2020). Coldwater Fisheries and Aquaculture. Narendra Publ. House.

Outcomes

- Students gain knowledge on fisheries resources and aquaculture systems
- Students acquire skill on management of fish farming systems

Unit - II **Marks: 20 + 05**	**Course Title (Theory) :** **Aquatic Ecology & Limnology**	**Hours/Week: 1.5**

Objective

- To acquaint the students with the theoretical and practical aspects of the aquatic environment
- To teach the importance of physic-chemical parameters of water, and planktons

	Concepts in aquatic environment: Aquatic environment/ecosystem – components - structure and functions; Ecological concepts – succession, homeostasis, natality and mortality, r and k selection; Concepts of habitat and ecological niche; carrying capacity.
	Aquatic ecology: Origin and classification of water bodies – Rivers, lakes and ponds; Ecology of ponds, rivers and lakes – Structure and dynamics - energy flow; Freshwater, estuarine and marine - Biotic features of a freshwater, estuarine and marine ecosystem; biological features of Coral Reefs, Seaweeds, Seagrasses and Mangroves.

	Biological Ecosystem: Environmental factors influencing life in the oceans: Salinity, temperature, light, currents, waves, tides, oxygen, and carbon dioxide. Phytoplankton and Zooplankton, interrelationship, vertical migration of zooplankton, geographical and seasonal variation in plankton production, plankton and fisheries; Methods of Plankton collection, preservation and identification.
	Bio-geochemical cycle: Definition, general concept of complete and incomplete biogeochemical cycles, sedimentary cycles in tropics. Overexploitation of resources; Environmental stresses; Pollution control and management - Global warming; Ocean acidification, Carbon credit, Ozone Depletion.
	Limnology: Physical characteristics of water - Temperature, thermal stratification and thermal exchange, light; Chemical characteristics of water: Chlorides, dissolved oxygen, alkalinity and acidity, total hardness, pH, productivity of water bodies – Primary, secondary, tertiary - Factors affecting primary production.

References

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Welch, P.S. Limnology. McGrawHill, NY, 1952.

Wetzel, R.G. Limnology. W.B. Saunders Co., 1975.

Outcomes

- The student proficiently discuss about the aquatic ecosystem and its importance to the fishes
- Student can discuss and analysis the limnology and productivity of an aquatic body.

Course Code: FSC-CC-103	Semester - I	Marks: 40 + 10 Credits: 4
Unit - I Marks: 20 + 05	Course Title (Theory) : Aquatic Pollution and Ecotoxicology	Hours/Week: 1.5

Objective

- To teach fundamental and basic knowledge on different aspects of aquatic pollution
- To educate aquatic pollution management

	Aquatic pollution: Current national and international status of aquatic pollution. Pollution sources, types and their impacts; Pollution problems of groundwater resources – sources of contamination, management issues - Methods of aquatic pollution surveys. EIA and its impact on aquaculture. Impact of pollution on fish health.
	Pollutants: Sewage, pesticides, oils, metals, radioactive wastes, nanoparticles, microplastics, biomedical wastes, etc. Common transport processes of pollutants in the aquatic environment; dispersal of pollutants; eutrophication and their management
	Ecotoxicological principles: Dose–response relationships, acute *vs*. chronic toxicity, teratogenic, mutagenic, carcinogenic effects; Bioaccumulation, biomagnification, bioconcentration in organisms - Minamita, *itai itai*, etc. and their toxic effect.
	Mechanistic insights: Toxicokinetics and toxicodynamics; cellular, biochemical, physiological responses; biomarkers; bioindicators; Pollutant mixtures, synergistic/additive/antagonistic effects.
	Monitoring Strategy: Pollution control and management – Ocean acidifications – current status of global warming**;** Use of indicator species in aquatic biomonitoring (invertebrates, algae, fish) and community assessments; Criteria for selection of indicator organism: Red tides phenomena: Monitoring strategies of marine pollution: Mitigation – Global warming and Climate change. Role of international and national organizations and role of NGO.

References

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Outcomes

- The student can able to critically discuss aquatic pollution

• The student will able to analyse and implement aquatic pollution management

Unit - II Marks: 20 + 05	Course Title (Theory) : Aquatic Microbiology	Hours/Week: 1.5
Objective • To teach aquatic microorganisms and their function in aquatic ecosystems • To become skilled in aquatic microbiology and management		
	Diversity of Aquatic Microorganisms and their function: Bacteria, archaea, protists, viruses, and their ecological significance; Roles in nutrient cycling and energy flow	
	Microbial Roles in Aquatic Ecosystems: Carbon, nitrogen, phosphorus, iron, manganese—mediated by microbes. Contributions of photosynthetic and heterotrophic microbes. Phytoplankton–Microbe Interactions, Contrasts in microbial communities and functions in Freshwater *vs* Marine *vs* Extreme Environments**.**	
	Environmental Applications: Effects on microbial populations and ecosystem health, Microbial roles in biodegradation, water purification, and ecosystem restoration; Formation of Biofilms, pathogen reservoirs, and management in fish farming	
	Microbiological techniques: Techniques in sterilization; Preparation of media. Safety in microbiology laboratory, bio-safety levels. Stains, staining and its chemistry. Isolation and culture of different types of bacteria; Techniques for identification: biochemical, serological and molecular techniques. Microscopy: bright field, fluorescence, phase contrast, dark field and electron microscope.	
References Willey, J., Sherwood, L., Christopher J. Woolverton (2016). Presscott's Microbiology. 10th Eds. McGraw Hill Inc, NewYork. APHA, AWWA, WPCF. 1998. Standard Methods for the Examination of Water and Wastewater, 20thEd. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, Washington, D. C		
Outcomes • After completion of this course, students can be able to critically discuss importance of various aquatic microorganisms • Students become skilled in microbial techniques and its application		

Course Code: FSC-CC-194	Semester - I	Marks: 40 + 10
Credits: 4	Course Title (Practical) : Taxonomy, Biology & Fishery resources [Based on 101 (Unit 1 & 2) + 102 (Unit – 1)]	Hours/Week: 3
Objective • To identify and familiarize with commercially important shellfish and finfish • To make acquainted with the biology of commercially important shellfish and finfish • To gain practical knowledge on Inland, coastal and marine fishery resources		
	Taxonomy: Identification of commercially important freshwater, coastal and marine finfish, crustacean, Mollusca - morphometric and meristic characters – DNA barcoding and phylogenetic analysis.	
	Biology of finfish and shellfish: Estimation of oxygen consumption and rate of respiration in a fish – marine and freshwater fish gut analysis – display various organs of shellfish and finfish.	
	Fishery resources: Visit to nearest freshwater body. Catching methods – catch data analysis on major freshwater resource – Reservoirs – lakes - Biodiversity indices – Gear selectivity. Visit to nearest coastal and marine landing center – length frequency analysis – catching method – catch data analysis on marine fishery resources of India – closed season studies – gear selectivity.	
Outcomes • Students will be able to identify the commercially important phytoplankton, zooplankton, fishes and other aquatic plants and animals • Students will have an idea about different organ systems in fish – important for captive rearing • Students will have field exposure to different aquatic resources		

Course Code: FSC-CC-195	Semester - I	Marks: 40 + 10
Credits: 4	Course Title (Practical) : Aquatic ecology, Pollution & Microbiology [Based on 102 (Unit - 2) + 103 (Unit - 1 & 2)]	Hours/Week: 3
Objective • To learn different limnological methods to analyze water quality parameters • To get acquainted with the pollution and toxicity assessment methods • To gain practical knowledge on microbiological techniques		
	Aquatic ecology & Limnology: Estimation of salinity, DO, pH, ammonia, nitrite, nitrate, inorganic phosphate, alkalinity, hardness, BOD, COD and primary productivity (Dark & Light bottle method). Identification of mangroves, seaweeds, seagrass and important aquatic animals. Phytoplankton and zooplankton – collection and identification of major groups up to genus level, Estimation of phytoplankton and zooplankton, Predaceous freshwater insects, Identification of common freshwater benthic organisms, Estimation of benthic organisms – Micro, meo and macro	

	benthos; Macrophytes in freshwater
	Pollution and Ecotoxicology: Determination of LC_{50}, LD_{50} and probit analysis, Study of toxicity bioassay techniques. Experimental pesticide toxicity exposure to any fish and subsequent behavioural and biochemical (acetylcholinesterase, catalase, SOD) assays; Identification of different aquatic pollution indicator species.
	Microbiology: Practical on microscopic techniques; Sterilization Methods, Isolation and culture of aquatic bacteria in agar plate (Total plate count) and broth, Gram staining, Antibiotic sensitivity testing; Identification of microorganisms - aerobic and anaerobic bacteria, mycological and virological techniques.
Outcomes • Students can be able to analyze water quality parameters independently • Students will be able to detect pollution through toxicity bioassay • Students will be able to isolate and characterize aquatic microorganisms	

SEMESTER – II

Course Code: FSC-CC-202	**Semester - II**	**Marks: 40 + 10 Credits: 4**
Unit - I Marks: 20 + 05	**Course Title (Theory) : Fish breeding and Seed production technology**	**Hours/Week: 1.5**
Objective • To learn and provide overall knowledge about breeding and seed production of commercially important cultivable fishes, crustaceans and mollusks		
	Introduction: Historical development of fish breeding and domestication, constraints and current-status of natural seed resources and collection methods, Bundh breeding of carps.	
	Reproductive biology of finfishes: Physiology and morphology; Reproductive cycles, sex determination, age of maturity, fecundity and spawning, Courtship and mating, Molecular and physiological basis of reproduction, Overview of current developments in reproductive biology. Gonad maturation and developmental stages, Spermatogenesis and oogenesis	
	Hormonal pathways and mode of control: Environmental and endocrine control of reproduction, Seasonality (Photoperiod, change in water quality and quantity, temperature, lunar cycle, etc.), Environmental and exogenous hormonal stimuli.	
	Induced spawning: Criteria for selection of brood fish, Methods of natural and artificial fertilization, Hypophysation technique, Use of GnRH and different synthetic hormones/analogues for induced spawning, Synchronization of spawning, multiple breeding, evaluation of milt and egg, cryopreservation of gametes and embryos, Egg staging, Stripping and fertilization, Seed quality and fish seed certification, Biosecurity	

	Reproductive biology of shellfishes: Gonad anatomy, endocrinology and reproductive mechanisms in prawns, shrimps, crabs, lobsters, mussels, oysters, scallops and clams. Broodstock availability of crustaceans and molluscs. Nutritional requirements; transport; captive rearing and maturation; induced spawning; physical and chemical inducing agents; physiology and techniques of eyestalk ablation, Importance of selective breeding in aquaculture

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Thomas PC, Rath SC & Mohapatra KD. 2003. Breeding and Seed Production of Finfish and Shellfish. Daya Publication.

Wootton, R.J. and C.Smith (2015) Reproductive biology of teleost fishes. John Wiley & Sons 451p

Outcomes

- Students acquire in depth knowledge on seed production of finfish and shellfish
- Students will develop expertise in breeding and seed production of fishes, crustaceans and mollusks for promotion of aquaculture production and export

Unit - II **Marks: 20 + 05**	**Course Title (Theory) :** **Construction and Management of Hatcheries**	**Hours/Week: 1.5**

Objective

- To study the various cultivable aquaculture species seed production
- To learn hatchery skills to cater manpower requirement for finfish and shellfish seed production

	Introduction: History, constraints and current international and national status of finfish, shrimp, crab and molluscan hatchery – Biology and life cycle of cultivable finfish and Shellfishes.
	Hatchery Engineering: Types of hatchery, Site selection, design, construction, equipments – water filtering systems, layout and design of hatchery sections, quarantine - brood stock – spawning and larval rearing, post larval - nursery for different species, Hatchery standards and bio-security, Better management practices (BMPs), Seed packaging and

	transportation methods.
	Hatchery technology for different cultivable fin fish species: Seed production and hatchery management of fin fishes: Indian major and minor carps, Exotic carps, Catfishes, Murrells, Tilapia, Masheer, Trout. Marine fish seed production: Seabass, milkfish, mullets, sea breams, Pompano, Silver pomfret, grouper, and Cobia. Larval rearing – water, feed and health management, Nursery management for different finfish species
	Crustacean seed production and hatchery management: Prawn, Shrimp, Crab and lobster - brood stock collection, quarantine and broodstock management, stocking, selective breeding, induce breeding, water quality – feed - health management. Shrimp captive brood stock development - SPF seed production - HACCP. Nursery technology.
	Molluscan seed production and hatchery management: Green and brown mussel, oyster – edible and pearl oyster abalone, scallop, brood stocks collection – induce breeding, water – feed – health management.

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Outcomes

- Students acquire in depth knowledge on hatchery management of finfish and shellfish.
- Students will achieve competency and expertise to manage commercial fin and shell fish hatcheries

Course Code: FSC-CC-203	**Semester - II**	**Marks: 40 + 10 Credits: 4**
Unit - I Marks: 20 + 05	**Course Title (Theory) : Integrated Fish Farming**	**Hours/Week: 1.5**

Objective

- To impart theoretical Integrated Fish Farming Systems and knowledge on application of new technique in fisheries science

	Types of Culture Systems: Operational details of monoculture, composite fish culture, polyculture in freshwater and coastal aquaculture, running water systems – Integrated farming.

	Agriculture: Introduction, history, national and international status, different type of crops - farming systems, Suitable agriculture crops for integrated farming, suitable horticulture crop for integrated fish farming, Mushroom cultivation - Suitable species for integrated production system.
	Animal husbandry: Introduction, history - national and international status, different type of animals for integrated fish farming systems – cattle, goat, piggery, duck and poultry - farming system, problems and economics.
	Integrated fish farming: Introduction, history - national and international status, different types of integrated farming systems –Paddy cum fish culture, Fish cum livestock, Pig cum fish farming, Duck cum fish farming, Poultry cum fish farming, cost analysis.
	Aquaponics: National and international status, types of aquaponics – layout and design of different aquaponics systems, production of fish and plants, water, feed and health management, nutrient dynamics and cost analysis.

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Outcomes

- Students can critically discuss the different agriculture and animal husbandry productions
- Students can acquire thorough knowledge on integrated fish farming

Unit - II **Marks: 20 + 05**	**Course Title (Theory) :** **Aquariculture & Live Food Production**	**Hours/Week: 1.5**

Objective

- To impart knowledge on ornamental aquaculture and aquarium keeping
- To teach biology, taxonomy, and life cycles of live food and their culture
- To explore the nutritional value, enrichment methods, and quality control of live feeds

	Introduction to Ornamental fish: History – international and national status. Capture and cultivable ornamental fishery recourses. Aquarium plants. Different freshwater fishes – indigenous and exotic species, and marine species. Biology and life cycle of different finfish and shellfish species.
	Infrastructure facilities: Site selection, layout, design and construction of

	Aquarium, freshwater and marine aquarium design, aquarium accessories. Equipments required for freshwater and marine ornamental hatchery and farm production.
	Ornamental fish production: Farming management – Types of marine and freshwater and marine ornamental fish, water quality, feed and health management. Arowana – flower horn - koi carp - gold fish - angel – discuss – breeding and faming. Marine Clown Fish, Damsel Fish, Marine Angels, Butterfly Fish etc. - hatchery and farm management. Coldwater ornamental fish production. Cross breeding and selective breeding. Good Management Practices.
	Classification and Biology of Live Food: Candidate species of phytoplankton and zoo-plankton. Classification and taxonomic identification of live feed organisms. Biological features, habitat and reproduction of important live food organisms; Green algae, blue-green algae, spirulina, diatoms, infusoria, rotifers, cladocerons, tubifex, brine shrimp, chironomids, earthworms etc. Nutritive value of commonly used live food. Use of live feed in aqua hatchery and ornamental fishery.
	Culture and Management of Live Food Organisms: Culture of live food organisms - phytoplankton, zooplankton and periphyton: Green algae, blue-green algae, spirulina, diatoms, infusoria, rotifers, cladocerons, tubifex, and brine shrimp. Stock, batch, mass and mixed culture methods, and Nutrient requirements of live feed culture medium. Chironomids and earthworms - vermiculture. Bio-enrichment of live food organisms with different nutrients. Bioencapsulation of live food. Biofilm and its uses. Marine live feed culture systems. Processing and preservation of live feed.

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Outcomes

- Students will gain in depth knowledge on freshwater and marine ornamental fish production

- Students can design aquarium and understand the market potential of ornamental fishes.
- Students will be able to adopt live food culture and production technology

Course Code: FSC-CC-204	**Semester - II**	**Marks: 40 + 10 Credits: 4**
Unit - I Marks: 20 + 05	**Course Title (Theory) : Fish Nutrition & Bioenergetics**	**Hours/Week: 1.5**

Objective

- To provide a comprehensive understanding of nutrient requirements and bioenergetics in different fish species
- To acquire knowledge on recent advances in nutraceuticals, feed additives, and functional feeds in aquaculture

	Principle of Nutrition: Fundamentals of fish nutrition and growth in fish. Appetite and satiation. Source, structure, classification and metabolism of proteins, lipids, carbohydrates, nucleic acids, vitamins and minerals
	Nutritional Requirements. Nutritional requirements of cultivable fish and shellfish. Methods of studying nutritional requirement, Factors affecting nutritional requirement. Nutritional diseases in fish and shellfish.
	Nutrient Digestion and Growth: Digestive organs and their roles in fish and shellfish. Digestion, absorption and transportation of nutrients. Hormonal regulation and factors affecting digestion. Response indices for nutrient requirement studies: Weight gain, Specific growth rate, Feed conversion ratio, Condition factor, Protein efficiency ratio and Net protein utilization. Digestibility determination.
	Advances in Fish Nutrition: Role of nutraceuticals, Mode of action of nutraceuticals, Introduction of nutrigenetics, nutrigenomics, transcriptomics, proteomics and metabolomics. Nutritionally important genes.
	Nutritional bioenergetics: Energy requirement of cultivable Finfish and Shellfish - protein to energy ratio, digestible energy, protein sparing effect, high energy feeds. Definition and forms of energy partitioning, Factors affecting energy requirements, Energy budgeting. Role of energy budgeting in growth, maturation and reproduction of fish.

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Outcomes

- After completion of this course, students can critically discuss the fish nutrition and

bioenergetics

- Students will be able to analyze and interpret nutrient requirements across species and developmental stages
- students can design and evaluate balanced feed formulations using conventional and non-conventional ingredients

Unit - II **Marks: 20 + 05**	**Course Title (Theory) :** **Feed Technology**	**Hours/Week: 1.5**
Objective • To study the fish feed formulation, processing techniques, and feed types • To familiarize students with nutritional evaluation methods, feed quality control, and feeding strategies		
	Feed ingredients: Conventional and non-conventional feed ingredients, novel ingredients and anti-nutritional factors. International coding of feed ingredients. Quality evaluation of feed ingredients.	
	Types of feeds: Wet feeds, moist feeds, dry feeds, mashes, pelleted, floating and sinking pellets. Micro-encapsulated, micro-bound and micro-coated diets. Reference diets, purifird and semi-purified diets, Starter, grower, finisher and broodstock feeds, High energy diets, Farm made feeds, High energy diets, Eco-friendly and medicated feed.	
	Feed additives and supplements: Classification; binders, antioxidants, enzymes, pigments, growth promoters, attractants, feed stimulants, probiotics, prebiotics, synbiotics, postbiotics and acidifiers.	
	Feed formulation and manufacturing: Principles of Feed formulation, Different methods of feed formulation and manufacturing. Use of feed formulation softwares. Receiving raw material, grinding, mixing, conditioning, pelleting/extrusion, drying/cooling, coating, packaging and labeling. Effect of processing on the nutritional value of feeds, Design of pelleted and extruded feed mill. Layout, Feed mill design and safety of operation, maintenance and record keeping.	
	Feed storage and quality control: Quality assurance, Factors responsible for spoilage and deterioration. Use of preservatives and antioxidants. Feeding strategies.	

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Publishing house, New Delhi.
Outcomes • Students can acquire knowledge on fish feed formulation and processing including grinding, mixing, pelleting, and extrusion • Students will be able to assess feed quality and explore the use of feed additives, probiotics, and functional ingredients for improved fish health and productivity

Course Code: FSC-CC-295	**Semester - II**	**Marks: 40 + 10**
Credits: 4	**Course Title (Practical) : Fish breeding, Hatchery Management & Integrated Farming** [Based on 101 (Unit 1 & 2) + 102 (Unit – 1)]	**Hours/Week: 3**
Objective • To impart practical knowledge of fish reproductive biology and breeding techniques • To provide hands-on experience in hatchery operations, including induced breeding and larval rearing • To introduce the principles and practices of integrated fish farming systems (e.g., fish-livestock, fish-agriculture) • To develop skills in the design, operation, and management of small- to medium-scale hatcheries and integrated farms		
	Fish Breeding: Tagging methods, Construction of growth curves, Morphometric analysis, Identification and Selection of Broodstock (carps, catfishes and prawns), Sex Differentiation: External morphological differences. Histological study of developmental stages of gonads. Induced Breeding Techniques: Use of hormones (e.g., pituitary extract, Ovaprim/other hormone analogues); handling, injecting, and monitoring of brooders; Stripping in catfishes. Synchronization of spawning: Natural vs. artificial spawning, use of hapa and circular hatchery systems.	
	Finfish fish and shellfish hatchery: Hatchery Design & Setup: Types: Chinese, circular, jar hatcheries. Water quality parameters (DO, pH, ammonia, nitrite; Equipment: test kits, probes, sensors), Aeration and filtration systems, Maintaining oxygen and temperature levels. Egg Collection and Incubation: Eggs, larval and post-larval stages of shrimp, prawn, crab, and fin-fish. Handling fertilized eggs. Larval Rearing: Feeding protocols: infusoria, Artemia, egg yolk; Grading and weaning techniques. Biosecurity and Disease Management: Quarantine, sterilization, prophylaxis, Identification of common diseases. Counting methods of eggs and larvae, Seed packing.	
	Integrated Farming: Pond Preparation & Management: Liming, fertilization, stocking density; Types of ponds: monoculture, polyculture. Field visit to study different integration models. Waste Utilization Techniques: Poultry/dung waste for plankton production, Aquaponics basics. Monitoring Growth & Health: Sampling techniques, Calculating FCR (Feed Conversion Ratio), SGR (Specific Growth Rate).	

Outcomes

- Students will acquire skill to perform induced breeding using hormonal techniques and operate hatchery units
- Students will be able to plan and implement integrated farming models, and apply best management practices in hatchery hygiene

Course Code: FSC-CC-296	**Semester - II**	**Marks: 40 + 10**
Credits: 4	**Course Title (Practical) : Fish Nutrition, Feed Technology, Aquariculture & Live Food Production** [Based on 102 (Unit - 2) + 103 (Unit - 1 & 2)]	**Hours/Week: 3**

Objective

- To become familiarize with feed formulation techniques, ingredient selection, and nutrient balancing
- To gain hands-on experience in the preparation and processing of artificial fish feeds and live food organisms
- To provide practical knowledge on aquarium setup and quality assurance of fish

	Fish Nutrition: Fish growth tables and Nutritional charts, Identification of feed ingredients, Proximate Composition Analysis: Moisture content (oven drying), Crude protein (Kjeldahl method), Crude fat (Soxhlet extraction), Crude fiber, Ash content (muffle furnace), Nitrogen-Free Extract (by difference). Estimation of gross energy of feed ingredients and feed (Bomb-calorimetry). Estimation of digestibility of nutrients and feed.
	Feed Technology: Use of Pearson's square method and feed formulation software, Inclusion of additives (Enzymes, probiotics, binders, pigments). Feed Processing and Pellet Preparation: Ingredient weighing and mixing, Pellet preparation (Manual pelletizer or mechanical extruder), Drying and storage of feed, Water stability test.
	Aquariculture & live food production: Identification of common ornamental fishes and plants. Fabrication of all-glass aquarium. Setting up and maintenance of Aquarium accessories and equipment. Conditioning and packing of ornamental fishes. Identification and mounting (permanent slide) of phytoplankton and zooplankton, analysis of periphyton, culture of important live food organisms (algae, diatoms, infusoria, cladocerans, copepods, rotifers, tubifex, brine shrimp, Chironomids and earthworms).

Outcomes

- Students will be able to identify and categorize fish feed ingredients based on their nutritional value
- Students will develop expertise to formulate and prepare fish feeds, analyze feed samples and culture live food organisms
- Students will acquire practical skill on construction and decoration of aquarium, and culture of common ornamental fishes

SEMESTER – III

Course Code: FSC-CC-302	Semester - III	Marks: 40 + 10 Credits: 4
Unit - I Marks: 20 + 05	Course Title (Theory) : Finfish diseases and Health Management	Hours/Week: 1.5
Objective • To provide advanced knowledge on the etiology, diagnosis, and control of finfish diseases. • To train students in disease surveillance, biosecurity, and health management practices.		
	Introduction: Diseases: Definition, Disease problems in aquaculture, Infectious and non-infectious diseases.	
	Bacterial diseases of fish: Etiology, general characteristics, diagnosis, mode of transmission, prevention and treatment of some common bacterial diseases – (a) Bacterial heamorrhagic septicemia, (b) Bacterial cell diseases and (c) Columnaris diseases. **Fungal diseases of fish:** Clinical features, symptoms and pathology and prophylaxis of fish – (a) Branchiomycosis, (b) Saprolegniasis, (c) EUS.	
	Viral diseases of fish: Clinical features, pathology, symptoms and prophylaxis of some common viral diseases – (a) Papillomatosis, (b) Lymphocystis and (c) Infectious pancreatic necrosis. **Protozoan diseases of fish:** Clinical features, pathology, symptoms and prophylaxis of some common diseases – (a) Nodular coccidiosis, (b) Entero coccidiosis, (c) Whirling disease, and (d) Ichtythyophthirius	
	Metazoan parasites of fish: Clinical features, pathology, symptoms and prophylaxis of some common diseases – (a) Monogenetic trematode parasites (*Dactylogyrus*, *Gyrodactylus*, *Diplozoan*), (b) Digenetic trematodes (trematode larval and Neodiplostomum), (c) Cestode parasites (*Ligula* and *Dibothriocephalus latus*), (d) Nematodes and fish leeches. **Crustacean parasites of fish:** Clinical features, pathology, symptoms and prophylaxis of some common diseases – (a) *Argulus*, *Ergasilus* and *Lernea*	
	Non-infectious Diseases: Nutritional diseases in hatcheries and grow out systems. Identification, diagnosis, prevention and control - Avitaminosis, Mineral deficiency, Starvation, Gas bubble disease.	
	Diagnostic Techniques & Disease Management: OIE-listed finfish diseases, Clinical signs and gross pathology, Microscopic examination, histopathology, Molecular and serological diagnostics (PCR, ELISA, LAMP). Biosecurity planning and implementation, Chemotherapy: approved drugs and responsible use, Antimicrobial resistance (AMR) and One Health approach.	

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Outcomes

- After completion of this course, students can be able to critically discuss various fish diseases
- Students will become skilled in aquatic animal disease management, farm consultancy, or regulatory roles in aquatic animal health

Unit - II **Marks: 20 + 05**	**Course Title (Theory) :** **Shellfish diseases and Health Management**	**Hours/Week: 1.5**
Objective • To provide in-depth knowledge of diseases affecting commercially important shellfish • To explore advanced diagnostic, epidemiological, and management techniques		
	Bacterial diseases of shrimp: Etiology, general characteristics, diagnosis, mode of transmission, prevention and treatment of some common bacterial diseases – (a) Vibriosis, (b) Shell diseases, (c) Black spot disease, (d) Red diseases. **Fungal diseases of shrimp:** Clinical features, symptoms and pathology and prophylaxis of fish – (a) Lagenidium, , (b) Fusarium, (c) Larval mycosis	
	Viral diseases of shrimp: Clinical features, pathology symptoms and prophylaxis of some common viral diseases – (a) *Monodon baculo* virus (MBV), (b) HPV, (c) YHV (Yellow head virus), (d) JHHNV, (e) White spot syndrome, (f) Taura syndrome virus (TSV)	
	Protozoan diseases of shrimp: Clinical features, pathology, symptoms and prophylaxis of some common protozoan diseases – Microsporidiosis, Zoothamniosis, Gregarine disease. **Metazoan parasites of shrimp:** Clinical features, pathology, symptoms and prophylaxis of some common diseases caused by *Orthione griffenis*, *Rhabdochona* and *Indocucullanus*, Annelids, Flatworms, Acanthocephalans	
	Non-infectious Diseases and Environmental Disorders: Nutritional disorders, Toxin-related syndromes (e.g., PSP, DSP, HABs), Shell deformities and growth anomalies, Stress-related syndromes (temperature, salinity, pollutants).	
	Diagnostic Techniques, Epidemiology & Disease Management: Field observation and clinical diagnosis, Microscopy, histopathology, and cytology, Molecular diagnostics: PCR, qPCR, LAMP, ELISA. Preventive measures and biosecurity in hatcheries and grow-out systems, Selective breeding for disease resistance, Therapeutic approaches and regulatory	

	constraints, Probiotics, immunostimulants, and functional feeds

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Outcomes

- After completion of this course, students can be able to identify different shellfish diseases
- Students will be equipped for roles in shellfish aquaculture, health monitoring, research, or policy

Course Code: FSC-CC-303	**Semester - III**	**Marks: 40 + 10 Credits: 4**
Unit - I Marks: 20 + 05	**Course Title (Theory) : Fish Immunology**	**Hours/Week: 1.5**

Objective

- To introduce the fundamental concepts of the fish immune system, including innate and adaptive components.
- To provide insights into immunopathology, immunodiagnostics, and immunoprophylaxis (e.g., vaccines, adjuvants).

	Introduction: Background and History of Immunology, Host-pathogen-environment relationship, Environmental stress, Immune system in fish and shellfish, Lymphoid system: Lymphoid organs and tissues. Phagocytic systems. Crustacean immune system.
	Factors of Immune Response: Cellular components of the Immune System, Antigen – Haptens : Carriers – adjuvants - Complement – other serum factors, Antibody : Immunoglobulin classes, Structure and function of IgM – its properties and diversity. Antigen processing and major histocompatibility complex. Antigen – Antibody interactions
	Immune Response: Types of Immune Response in various Representative fish groups, Non – Specific and Specific Defense Mechanisms, Cell mediated immunity and Humoral immunity, Immunotoxicology in Fish – Immuno-suppression & Immuno-modulation in response to various toxicants.

	Immunization and Immuno-diagnostic techniques: Immunization Procedures and Types of Vaccines and Vaccination programmes for various fish diseases, Disease diagnosis using Immuno-diffusion, Agglutination, Blotting techniques and ELISA. Hybridoma Technology: Monocloral Antibodies and their application in fisheries. Advanced tools: RNAi, gene editing.
	Quarantine: Fish health and quarantine systems, national and international status. Design of quarantine and equipments for fish and shellfish brood stock maintenance - Seed certification, SPF and SPR stocks development and management - cost analysis.
References Douglas P Anderson: Text Book of Fish Immunology Nandini Shetty. Immunology. Introductory Textbook. Karunasagar, I. Aquaculture and Biotechnology. Oxford-IBH Publishers, New Delhi, Goldsby, R.A., J.K. Thomas and B.A. Barbara. Kuby Immunology. 4th Edition	
Outcomes • By the end of this course, students will be able to describe the structure and function of fish immune organs (e.g., thymus, spleen, head kidney, etc.) • Students will be able to interpret laboratory-based immunological assays such as ELISA, agglutination, flow cytometry, and immunoblotting • Students will be able to apply immunological principles in solving practical fish health problems in aquaculture systems	

Unit - II **Marks: 20 + 05**	**Course Title (Theory) :** **Coastal Aquaculture and Mariculture**	**Hours/Week: 1.5**
Objective • To teach coastal aquaculture and mariculture skills • To provide recent knowledge on farming systems for sustainable production		
	Coastal aquaculture: History, global and Indian status of coastal aquaculture – Principles to sustainable aquaculture development - Types of culture - farm design – infrastructure facilities for shellfish and finfish species.	
	Mariculture: History, present global and Indian status of Mariculture – cultivable speciesCage, Pen and raft – different types of cages – raw materials – constructions. Mariculture international and national regulation.	
	Crustacean Farming: Shrimp-crab-lobster. Pond preparation, soil culture – water culture – acclimatization – stocking - water quality – feed - health management - Biosecurity – HACCP and Biofloc technology in shrimp farming. Seaweed culture, Recirculation aquaculture system, Integrated multi-trophic aquaculture (IMTA).	
	Molluscan Farming: Mussels – oyster – abalone – scallop - pearl oyster culture - types of culture - stocking - water quality, feed and health management. Major problems in farming in India.	
	Finfish farming: Cultivable species – types of culture - site selection – pond	

	preparation – soil culture - water culture - stocking – feed management – water quality parameters and management –health management – Recirculating aquaculture system - Biofloc technology - Biosecurity procedure for fish farming.

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Outcomes

- After completion this course, student acquires skill in seed production of major cultivable finfish and shellfishes
- Students will be talented in the farming system and proficient in recent faming technology

Course Code: FSC-CC-304	**Semester - III**	**Marks: 40 + 10 Credits: 4**
Unit - I Marks: 20 + 05	**Course Title (Theory) : Post Harvest technologies & Quality Assurance**	**Hours/Week: 1.5**

Objective

- To learn the techniques for bulk fish preservation, processing, production and purification in technology concern

	General introduction: History and status of processing technology - Biochemistry of fish - Biochemical changes after fish death. Types of fish spoilage, causative factors – autolytic spoilage, microbial spoilage, oxidative changes. Post-harvest management for finfish and shellfishes: Grading of fish, fish quality evaluation - Packing, different storage procedure and transportation up to process plants- Quality assurance in Postharvest.
	Processing methods: Principles and different methods of chilling, Freezing: Air Blast Freezers, Plate freezers- Horizontal, vertical, IQF – Brine freezer, other freezers. Irradiation methods of preservation and Pasteurization for different fishery products. Salt curing - conventional and modern methods of

	drying (Solar driers) - pickling and smoking. Biochemical changes during processing.
	Canning: Introduction, history, status, products, types of canning – processing - seaming – types of canned products – finfish and crustaceans. Problems related to canning.
	Fishery By-products: Fish silage – Definitions - methods – production and uses – Fish hydrolysate, Fish meal, bone meal, fish oil, surgical sutures from intestine, chitin, chitosan and etc. Additives and preservatives. Value added products – type of products - processing methods.
	Quality Control, Packaging and Marketing: Quality control and quality assurance – HAACP, USFDA, EU, BIS, BRC, Good Management Practices etc. for different fish products and processing techniques. Packing: materials sources – types – packing - quality assurance during packing. Trading: role of EIA and MPEDA. Inland and export trade. Fast Moving Goods (FMG) – Products – retail marketing - chilled and frozen product market. Logistic management and quality assurance of fishery products.

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Outcomes

- The student will be able to discuss various fish processing methods
- The student acquire knowledge on quality assurance in seafood processing and critically discuss the HACCP.

Unit - II **Marks: 20 + 05**	**Course Title (Theory) :** **Fisheries Extension, Economics & Entrepreneurship**	**Hours/Week: 1.5**

Objective

- To impart theoretical knowledge on Fishery Economics and Marketing with application of new technique in fisheries science
- To study the concept, objectives and principles of fisheries extension for entrepreneurship development

	Scope of Economics: Bio-economic analysis of fisheries. Growth, development and natural resource interrelationships. Pricing and optimal resource use over time under different market situations - role of market structure, interest rate and property rights in fisheries exploitation.

	Concept of Economy: Positive and negative externalities. Physical, legal and economic incentives to internalize the externalities. Fishery resource management policies markets, taxes, subsidies, permits, direct controls, distributional effects of fisheries development. Fisheries marketing and Organizations.
	Economics: Principles; Factor-Product, cost principles, Factor-factor, Product-product and law of comparative advantage, law of equimarginal returns, returns to scale and farm size, Homogeneous production functions; Cobb-Douglas and quadratic production functions. Fisheries and Socio-economic Analysis, meaning and measurement of socio-economic variables. Factors determining development. Role of sociology in the process of fisheries development. PRA and RRA for studying socio-economic problems, stake holder analysis.
	Fisheries extension and education: Fishery as a tool for rural development and employment potentiality. Different fisheries development plan/schemes in India. Role of Government, NGOs, fisheries co-operatives and other agencies in fisheries sector. Different fishery related laws in India. Planning and design of different projects related to aquaculture and their economic analysis.
	Entrepreneurship development: Business Development: Business idea generation and validation, Preparing business plans for fisheries enterprises, Cost-benefit analysis and break-even point. Financial and Legal Aspects: Sources of finance (loans, grants, subsidies), Budgeting and accounting for small fisheries enterprises, Licensing, registration, and regulations (local and export), Insurance and risk management in aquaculture. Innovation and Sustainable Practices: Use of technology in fisheries (IoT, mobile apps, automation), Eco-friendly and climate-resilient aquaculture, Waste utilization and circular economy, Certification and traceability (e.g., organic aquaculture, eco-labels)

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Outcomes

- The student will acquire knowledge on fishery economics and proficient to critically discuss the subject on fishery economics for entrepreneurship development
- The student will be able to understand fishery extension and talented to implement extension activity

<table>
<tr><td>Course Code:
FSC-CC-395</td><td>Semester - III</td><td>Marks: 40 + 10</td></tr>
<tr><td>Credits: 4</td><td>Course Title (Practical) :
Finfish and Shellfish diseases & Immunology
[Based on 302 (Unit 1 & 2) + 303 (Unit – 1)]</td><td>Hours/Week: 3</td></tr>
<tr><td colspan="3">Objective
To recognize the signs and symptoms of infectious and non-infectious diseases in finfish and shellfish through direct examination.
To apply laboratory techniques such as histopathology, microbiology, and molecular diagnostics for pathogen detection</td></tr>
<tr><td></td><td colspan="2">Finfish diseases: General procedures for disease diagnosis; Taxonomy and identification of fish parasites; Collection, Slide preparation - fixing - staining and mounting of parasites; Sampling, preparation of media and culture of pathogenic bacteria; Techniques for bacterial classification; Histological techniques for disease diagnosis; Histopathology of organs of diseased fish (Sectioning – Staining and Mounting). Molecular techniques – Gel electrophoresis, PCR.</td></tr>
<tr><td></td><td colspan="2">Shellfish diseases: Visual inspection for signs of disease: shell deformities, color changes, lesions; Tissue abnormality identification: nodules, swellings, or necrosis in gills or digestive glands. Histopathology: Tissue fixation, Paraffin embedding, sectioning, and H&E staining, Microscopic examination for parasites, bacteria, or tissue degradation. Cytology: Hemolymph or tissue smears. Molecular Diagnostics: PCR-based methods for detection of specific pathogens (e.g., Perkinsus marinus, Bonamia spp., Haplosporidium spp., WSSV), DNA extraction from shellfish tissues, Gel electrophoresis to confirm amplification. Microbiological Techniques: Culture-based identification of bacterial pathogens (e.g., Vibrio, Aeromonas), Antibiotic susceptibility testing, Colony morphology, Gram staining, and biochemical tests</td></tr>
<tr><td></td><td colspan="2">Immunology: Immunization - Routes of Immunization, Preparation of Inoculum. Blood film preparation (Giemsa Staining), Differential Count of WBC, Cell Viability Test, Quantification of Antibody - Agglutination, Precipitationand Immuno – Diffusion. Immunological techniques – ELISA, Agglutination test.</td></tr>
<tr><td colspan="3">Outcomes
Students will develop hands-on skills in sample collection, disease diagnosis, and health management
Students will be able to interpret diagnostic results to recommend appropriate disease control and biosecurity measures</td></tr>
</table>

Course Code: FSC-CC-396	Semester - III	Marks: 40 + 10
Credits: 4	Course Title (Practical) : Coastal Aquaculture, Post Harvest technologies & Fisheries Extension [Based on 303 (Unit - 2) + 304 (Unit - 1 & 2)]	Hours/Week: 3

Objective

- To understand and demonstrate key coastal aquaculture practices, including pond preparation, stocking, feeding, and water quality management
- To apply post-harvest handling, preservation, chilling, and processing techniques to maintain fish quality
- To gain exposure to fisheries extension methods, tools, and communication strategies for technology transfer

	Coastal Aquaculture: Analysis of water: Turbidity, pH, Dissolved oxygen, Alkalinity etc., Primary productivity, Estimation by Light and Dark Bottle method; Identification of Cultivable species of finfish and shellfish based on the theory; Visit to aquaculture farms, finfish and shellfish hatcheries.
	Fish Processing Technology: Studies on physical, chemical and sensory changes. Filleting of fish, treatments, glazing, packaging, freezing, Processing of Prawns, Lobster, Squid, Cuttle Fish, Crab etc. in different styles, Packaging and Freezing, Freezing curve, determination of freezing point.
	Fisheries Extension: Visiting Fishery institutes and Fish Farms. Collecting data of the Fishermen in the nearby fishing villages. Collecting the particulars of Farming practices and its economics, and submission of report.

Outcomes

- Students will gain expertise to operate and manage culture systems for commercially important finfish, shellfish, and seaweeds in coastal regions
- Students will be able to demonstrate skills in value-added fish product preparation and packaging
- Students will develop practical skills in organizing training programs, demonstrations, and data collection

SEMESTER – IV

Course Code: FSC-CC-401	Semester - IV	Marks: 40 + 10 Credits: 4
Unit - I Marks: 20 + 05	Course Title (Theory) : Fish Genetics & Conservation	Hours/Week: 1.5

Objective

- To study the fish genetic resources
- To study the fish conservation

	Introduction: Definitions, the scope of genetics, Physical basis of heredity; genetic correlation, domestication and local adaptation. Mendelian principles

	and contribution, linkage, polygenic inheritance, multiple alleles, sex determination, sex differentiation and sex reversal in fishes, sex control and its role in aquaculture.
	Principles of genetics: Interactions and environmental influences - Molecular genetics: Concept of gene - Gene structure and function – Gene complementation, cistron, mutan, recon, molecular recombination, gene expression, gene regulation.
	Cytogenetics: Techniques and methods of karyotyping fish, Importance of karyotyping.
	Conservation genetics: Conservation strategies, fish genetic recourses, collection and preservation of fish germplasm, endangered species. Cryopreservation of fish gametes. Importance of fish gene banking.
	Diversity: Genetic diversity and Habitat Diversity - importance, estimation and influencing factors; Determination of sample size. Introduction to population genetics, Hardy - Weinberg law and its significance. Factors influencing gene frequency, genetic drift and genetic equilibrium, consequences of random genetic drift. Marker assisted selection - biochemical and molecular markers. Molecular tools for stock differentiation for selection.

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Terence A. Brown (1990). Genetics: A molecular approach. Chapman and Hall.

Outcomes

- Student can critically discuss the fish genetics and genetic resources
- Student can acquire through knowledge on fish conservations and gene banking

Unit - II Marks: 20 + 05	Course Title (Theory) : Fish Biotechnology & Molecular Biology	Hours/Week: 1.5

Objective

- To understand basis of genome manipulation strategies
- To study techniques for genetic engineering applications used in aquaculture

	Introduction: Principles of cell and molecular biology – Cell structure, Structure of DNA & RNA – Composition and properties. DNA replication. Transcription in prokaryotes and eukaryotes. DNA mutation and recombination. Genetic regulation of development and differentiation. DNA barcoding.
	Principles of genetic engineering: Isolation of DNA & RNA and characterization of DNA, recombinant DNA technology, cloning, plasmids, cosmids, bacteriophages, Transformation, Transduction, in vivo packaging, construction of genomic library. Applications of Recombinant DNA technology. Molecular hybridization. Labelling of nucleic acids, molecular markers. Amplification of DNA, blotting technique – Southern, Northern and Western blotting, DNA Sequencing.
	Application of genetic engineering in fisheries: Genomic manipulation, Hybridization of fishes, Heterosis, hybrid vigour, introgression. Recent trends and techniques in hybridization, selective breeding, cross breeding, development of disease resistance and high quality of new strains. Inbreeding depression and consequences, measures to reduce inbreeding in hatcheries.
	Chromosome manipulation: Ploidy induction methods and its role in aquaculture - triplody and tetraploidy, advantages and disadvantages of polyploids, androgenesis and gynogenesis. Sex reversal - production of monosex population and super males, hormonal manipulation in advancing maturity and reproduction, role of steroid in sex reversal.
	Transgenic fish production: Selection of fish species, gene transfer technology – Microinjection technique, electroporation, detection of transgenesis by PCR applications in transgenic fishes and biotechnology.

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Outcomes

- Students will gain knowledge on the application of genetic engineering in fisheries
- The students will be able to analyze the impact of different genome manipulation strategies

Course Code: FSC-CC-492	Semester - IV	Marks: 20 + 5
Credits: 2	Course Title (Practical) : **Fish Genetics, Biotechnology& Molecular Biology** [Based on 401 (Unit 1 & 2)]	Hours/Week: 1.5
Objective • To understand the basic principles of fish genetics, including inheritance patterns, population genetics, and selective breeding • To gain knowledge of molecular biology techniques used in fisheries science		
	DNA Extraction from Fish Tissues: Hands-on extraction from fin, muscle, or blood samples. Use of commercial kits or manual protocols. **Gel Electrophoresis:** Running agarose gels to separate DNA fragments. Understanding the principles of DNA migration.	
	Molecular Markers: Study of RAPD, SSR, RFLP, AFLP markers in fish genetics. Application in population studies or breeding programs. **PCR (Polymerase Chain Reaction):** Amplification of specific gene markers. Primer design and optimization. **Bioinformatics Tools for Genetic Analysis:** Use of NCBI, BLAST, and phylogenetic tools. Analysis of gene or protein sequences.	
	Fish Karyotyping: Chromosome preparation and observation from fish cells. Identification of chromosomal aberrations.	
	Estimation of gene and genotype frequencies: Exercises on Hardy-Weinberg equation; Estimation of inbreeding coefficient. Cryopreservation of milt.	
Outcomes • Students will be able to analyze genetic variation in fish populations using molecular markers • Students will be able to apply molecular tools (e.g., PCR, gel electrophoresis) in laboratory settings		

Course Code: FSC-CC-403	Semester - IV	Marks: 20 + 5 Credits: 2
	Course Title (Theory) : **Research methodology in Fishery Science**	Hours/Week: 1.5
Objective • To recognize the essential components of research and its methodology in fisheries • To identify an appropriate fishery research problem and to solve them		
	Literature survey: Collection of research literature, design a research projects, analysis, compilation and presentation of research data, preparation of transparencies, research papers, dissertations, oral and visual delivering of results. H-index , I-10 index – citation index – calculation - research gate –	

	Scopus index - Google scholar citation etc.
	Laboratory practices and spectral analysis: Good laboratory practices. Normality and Molarity calculation. Working principle and applications of pH meter, UV-visible, Spectrophotometer, Fourier Transform – Infrared spectrophotometer, flame photometer, Atomic Absorption Spectrophotometers, Nuclear Magnetic Resonance, and Mass spectrophotometer.
	Chromatography and Molecular techniques: Principles and use of Centrifuges, Chromatography (Paper, thin-layer, and column chromatography), Electrophoresis, ELISA, PCR, RT-PCR, Blotting Techniques, Microarray techniques.
	Microscopy and Histology: Principles and application of Light Microscopy: Bright field, Dark field, Phase contrast, Differential Interface Contrast Microscopy, Fluorescence Microscopy, Confocal Microscopy. Electron microscopy: Scanning and Transmission. Principles and application of Histology and Histochemistry.
	Biostatistics: Sampling or census methods - random and non-random technique – Data collection. Description statistics of central tendency and dispersion – mean, median, mode, standard deviation, standard error. Probability distribution, data - binominal, Poisson and normal distribution. Relational statistics of correlation and regression – Student's' test, ANOVA – one way and two-way analysis. **Manuscript Preparations:** literature collection - preparation of dissertation/thesis - preparation of scientific paper for publication in a peer reviewed journal.

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Outcomes

- Students can able to perform literature reviews using print and online databases and identify, explain, compare, and prepare the key elements of a research proposal/report.
- Gain knowledge on major research instruments.

Course Code: FSC-EC-404	Semester - IV	Marks: 40 + 10 Credits: 4
DSE-1	Course Title (Theory) : Systemic Fish Physiology	Hours/Week: 1.5

Objective

- To understand the various systems of fishes and shrimps with specific reference to their normal well being

	Introduction: Integration of organ systems, Homeostasis, Environmental adaptation. **Integumentary system:** Cuticular, epidermal, dermal and hypodermal changes, hyperplasia and ulceration. Scale, poison gland. **Nervous system:** Brain, spinal cord, peripheral nerves, sense organs (Eye and photoreception, olfactory organ, and chemoreception, acoustico-lateralis system in fish).
	Respiratory system: Structure and physiology of gills, Lamellar oedema, lamellar hyperplasia and lamellar fusion. **Blood vascular system:** Heart, vessels, blood composition, cellular components of blood and haemopoietic tissue.
	Digestive system: Digestive tract and its pathology; hepatic necrosis, lipid infiltration, hepatic granuloma, cirrhosis, pancreatic atrophy, neoplasia; epithelial sloughing of intestine. **Excretory system:** Kidney and its pathology, renal tubules and collecting ducts, osmoregulatory system.
	Reproductive system: Structure and functions of reproductive organs, gametogenesis, types and modes of reproduction, sexuality (intersex, bisexuality, hermaphroditism); breeding and parental care.
	Endocrine system: Hypothalamo-hypophyseal system, Pituitary gland (Origin, location, anatomy and functional morphology, hormones),Other endocrine glands (structure and functions): Thyroid, Adrenal, Corpuscles of Stannius, Ultimobranchials, Caudal neurosecretory system and Pineal (Endocrine function of the gonads). **Systemic physiology in shrimp:** Respiratory, digestive and nervous systems and its pathology.

References

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Outcomes

- Students will have concepts regarding structural organization and life processes in fish, which would be useful for rearing of diverse fish species

Course Code: FSC-EC-404	Semester - IV	Marks: 40 + 10 Credits: 4
DSE-2	Course Title (Theory) : Aquatic Animal Pathology & Disease Diagnosis	Hours/Week: 1.5

Objective

- To learn the principles and protocols of diagnostic tests used in the diagnosis of fish diseases.
- To teach methods in clinical pathology of aquatic organisms.

	Causes, pathogenesis, pathology, diagnosis and differential diagnosis of various diseases due to nutritional imbalance and avitaminosis, anorexia, mineral deficiency and toxicity. Detection of metabolic diseases in finfish and shellfish. Normal and abnormal constituents of blood with reference to pathogenic condition.
	Stress induced conditions in fishes and their pathology. Physiological effects of stressors on fish, tolerance level (pH, ammonia, oxygen, temperature, handing stress, crowding, transportation, chemicals and bacterial toxins). Cellular response to stress, response to some specific disease.
	Common bacterial pathogens of fishes. Handling of diseased fish for bacteriological examination, Withdrawal of blood and materials from internal organs for bacteriological examination. Diagnosis and infection experiments, Cultural and biochemical identification procedures. Mycological techniques.
	Culture media for isolation of pathogens, non-selective, enriched, enrichment and selective media. Inoculation and purification techniques. Staining methods.
	Serology of microbial disease – agglutination precipitation and ELISA methods in disease diagnosis. Processing tissue samples for virological examination. Techniques for isolation of viruses. Serological tests for identification of viruses.

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Outcomes

- Students will gain knowledge on disease diagnosis in finfish and shrimps
- Students will acquire skill on diagnostic tools and techniques

Course Code: FSC-EC-405	Semester - IV	Marks: 40 + 10 Credits: 4
DSE-1	Course Title (Theory) : Freshwater Aquaculture & Diversification	Hours/Week: 1.5

Objective

- To learn the basic concept of freshwater aquaculture for sustainable production
- To familiarize with freshwater aquaculture cultivable species, hatchery technology and farming

	Introduction: Present status, problems and scope of fish and prawn farming in global and Indian perspective. Major cultivable freshwater species. Aquaculture systems: Extensive, semi-intensive and intensive culture of fish, Pen and cage culture in lentic and lotic water bodies, raceway culture.
	Culture of Indian major carps & exotic carps: Major species of carps used for culture, culture systems, spawning and fry production, larval rearing, nursery and grow out pond culture, harvesting and marketing. Breeding and culture of exotic carps (grass carp, silver carp, common carp). Polyculture system – Definition and various patterns – Mixed fish farming in India – Composite culture of Indigenous and Exotic fishes.
	Diversification of aquaculture: Culture of air breathing fishes (*Heteropneustus, Clarius, Channa, Anabas*) – Ecology of swamps and their use for culture of air breathing fishes. Tilapia culture: Genetically Improved Farmed Tilapia production, monosex Tilapia, all male production. Culture of Amur carp, murrels, mullets, mud crab. Wastewater-fed aquaculture: Water treatment methods, species selection, culture practices, harvesting and depuration process.
	Freshwater prawn culture: With special reference to *Macrobrachium rosenbergii* – Seed procurement from natural resources, breeding and larval rearing of freshwater prawn hatchery and management, management of culture ponds.
	Farming: Farm design and equipments - Small, Medium and large scale farming for freshwater finfish and prawn. Present global and Indian status of freshwater finfish and prawn farming – Monoculture – polyculture - composite culture. Finfish and prawn farm management – pond preparation - water culture – stocking – feed, water and health management. Sampling procedure – harvesting. Recent management techniques – Biosecurity – Biofloc - HACCP. Freshwater pearl culture.

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Outcomes

- Students will gain knowledge on seed production of Indian fresh water prawn major carps, Exotic carps, Minor carps, Murrells
- Students will acquire skill on sustainable freshwater finfish and prawn farming

Course Code: FSC-EC-405	**Semester - IV**	**Marks: 40 + 10 Credits: 4**
DSE-2	**Course Title (Theory) : Marine & Brackish water Fisheries**	**Hours/Week: 1.5**

Objective

- To familiarize the students with the basic concepts and principles of coastal and marine fishery resources
- To discuss estuaries, mangrove ecosystems, lagoons and marine fisheries of India

	Introduction to coastal and marine fisheries: History, national and international status of fisheries - lagoons, mangroves, estuaries, backwaters and brackish water impoundments in India and their fishery resources.
	Fishery resources: Important finfish and shellfish resources in demersal, pelagic, brackish water systems; conservation strategies. Principles, objectives and management of fisheries resources. Brackish water fish species for culture, management, traditional culture of brackish water fish. Culture of finfish – Sea-bass, milk fish and mullet culture.
	Mangrove fishery: Introduction, national and international status - Fishery resources – status - environmental sustainability and livelihood security - productivity, conditions, capture scenario, prospects of culture-based systems. Degradation - impact of climate change.
	Fisheries and fishing methods: Introduction to Crafts and Gears, Inshore fisheries (up to 50 m depth), Offshore fisheries (50-200 m depth), High sea fisheries (beyond 200m) up to outer limit of EEZ and in International waters. Application of remote sensing and GIS in fisheries (Environmental satellites, Elements of GIS, Generation of PFZ, Challenges of fisheries information systems and future perspectives). Sustainability of fisheries: Principles, social, economic, ecological, biological and legal issues - Fisheries co-management. Illegal Unreported and Unregulated (IUU) fishing - national and international status.
	Mariculture: Indian status of Mariculture – cultivable species. Mussels – oyster – abalone – scallop - pearl oyster culture, types of culture, stocking, water quality, feed and health management. Cage, Pen and raft – different types of cages, raw materials – constructions. Seaweed culture, Recirculation aquaculture system, Integrated multi-trophic aquaculture.

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Outcomes

- After completion of this course, student can gain significant knowledge on coastal and marine fisheries
- The student can analyze coastal and marine fishery resources and able to conserve the fishery biodiversity

Course Code: FSC-EC-496	**Semester - IV**	**Marks: 40 + 10**
Credits: 4	**Course Title (Practical) : Fish Physiology / Pathology & Disease Disgnosis / Freshwater Aquaculture / Marine & Brackish water Fisheries** [Based on 404 (any one) + 405 (any one)]*	**Hours/Week: 3**

Objective

- To understand the basic principles involved in life processes of fish, or its pathology (based on elective paper chosen)
- To gain knowledge on culture and farming practices in freshwater, marine or brackish water fisheries

FSC-EC-404 / DSE-1	Study of different organ systems (Digestive systems in herbivore/omnivore and carnivore fish species, detection of food and feeding habits through analyses of bucco-pharynx, gill and digestive tract; Urino-genital systems in male and female catfish; Affarent and efferent branchial systems; Swim bladder and weberian ossicles in carps; Accessory respiratory organs in *Clarias*, *Heteropneustes* and *Anabas*), Identification and mounting of scales, Necropsy techniques.
OR	
FSC-EC-404 / DSE-2	Study of cellular components of blood: T.E.C., D.L.C., T.L.C., haemoglobin, total protein, glucose and other parameters, cholesterol, lipid profile, creatinine, urea and enzymes in blood during disease conditions. Study of gross and histopathological changes due to various metabolic diseases and nutritional disorders.

	Methods for examination and analyzing fish for health certification/diagnosis of disease condition, techniques for sample collection and processing for bacteriological, mycological and virological agents, methods for isolation of various bacterial, fungal and viral pathogens by conventional methods, rapid nucleic acid based methods and serological procedures.
FSC-EC-405 / DSE-1	Analysis of freshwater resource: Turbidity, pH, Dissolved oxygen, Alkalinity, Hardness etc.; Primary productivity, Estimation by Light and Dark Bottle method. Identification of commercially important cultivable fish and prawn species; Assessment of seed quality- stress test; Calculating carrying capacity of pond and stocking density; Check tray assessment and feed ration calculation; Sampling procedure and growth assessment; Lime and fertilizer requirement.
OR	
FSC-EC-405 / DSE-2	Analysis of brackish water/marine resource: Turbidity, pH, Dissolved oxygen, Alkalinity, Hardness etc.; Primary productivity, Estimation by Light and Dark Bottle method. Identification of commercially important brackish water, coastal and marine finfish, crustacean, Mollusca, morphometric and meristic characters, DNA bar coding and phylogenetic analysis.
Outcomes • Students will acquire practical skills in Fish Physiology / Pathology & Disease Disgnosis / Freshwater Aquaculture / Marine & Brackish water Fisheries (any two, based on his/her choice)	

Students need to opt for any two from the above modules based on the Electives chosen for the papers *FSC-EC-404 and FSC-EC-405.

Course Code: FSC-CC-497	**Semester - IV**	**Marks: 40 + 10**
Credits: 4	**Course Title (Practical) : Project / Review Work / Internship**	**Hours/Week: 3**
Objective • To provide hands-on experience and critical evaluation skills to the students • To enable the students to manage a project from start to finish, demonstrating self-reliance and the ability to achieve a set objective independently		
	Students can choose either Review work, or Dissertation work or Industrial training as internship. Dissertation Work and Internship are preferred. The duration of the Dissertation Work or Internship shall be a minimum of two months in the fourth semester. Students shall have to prepare the report in a standard format and to submit the same in triplicate for examination.	
	The Review paper / dissertation work / Internship report will be evaluated on the basis of the submission of the hard copy, seminar delivered by the student and Viva-voce. The distribution of marks will be as follows: • Submission: 20 • Presentation : 10 • Viva-voce: 10	

Outcomes

- Students will develop technical expertise, research skills, problem-solving abilities, and an understanding of real-world practices
- Students will have deepened understanding of a specific area within fisheries science