

ICAR Syllabus of PG

Minimum Credit Requirement:			
SN	Subject	Master's programme	Doctoral programme
1.	Major	20	15
2.	Minor	9	8
3.	Supporting	5	5
4.	Seminar	1	2
5.	Research	20	45
6.	Total Credits	55	75
7.	Compulsory Non Credit Courses	See relevant section	

Common Supporting Course:			
CODE	COURSE TITLE	CREDITS	
STM-501	STATISTICAL METHODS	2+1	
STM-502	RESEARCH METHODOLOGY	1+1	
STM-601	ADVANCED STATISTICAL METHODS	2+1	1st year I-Semester
STM-602	SOFTWARE FOR FISHERIES DATA ANALYSIS AND MANAGEMENT	0+2	1st year II-Semester

Define Major, Minor Course	
Major subject:	The subject (department) in which the students takes admission
Minor subject:	The subject closely related to students major subject (e.g., if the major subject is Entomology, the appropriate minor subjects should be Plant Pathology & Nematology).
Supporting subject:	The subject not related to the major subject. It could be any subject considered relevant for student's research work.
Non-Credit Compulsory Courses:	Please see the relevant section for details. Six courses (PGS 501-PGS 506) are of general nature and are compulsory for Master's programme. Ph. D. students may be exempted from these courses if

COMPULSORY NON-CREDIT COURSES**(Compulsory for Master's programme in all disciplines; Optional for Ph.D. scholars)**

CODE	COURSE TITLE	CREDITS
PGS 501	LIBRARY AND INFORMATION SERVICES	0+1
PGS 502	TECHNICAL WRITING AND COMMUNICATIONS SKILLS	0+1
PGS 503 (e- Course)	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	1+0
PGS 504	BASIC CONCEPTS IN LABORATORY TECHNIQUES	0+1
PGS 505 (e- Course)	AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES	1+0
PGS 506 (e- Course)	DISASTER MANAGEMENT	1+0

Compulsory Non-Credit Courses

PGS 501 LIBRARY AND INFORMATION SERVICES 0+1 Objective	
To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines etc.) of information search.	
Practical	Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.

PGS 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS 0+1 Objective	
To equip the students/scholars with skills to write dissertations, research papers, etc. To equip the students/scholars with skills to communicate and articulate in English (verbal as well as writing).	
Practical	Technical Writing -Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article. Communication Skills -Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.

PGS 503 INTELLECTUAL PROPERTY AND ITS 1+0 (e-Course) MANAGEMENT IN AGRICULTURE Objective	
The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.	
Theory	Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and bio-diversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

PGS 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES 0+1 Objective

To acquaint the students on the basics of commonly used techniques in laboratory.

Practical

Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccumets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy

PGS 505 AGRICULTURALRESEARCH,RESEARCH ETHICS 1+0 (e-Course) AND RURAL DEVELOPMENT PROGRAMMES Objective

To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Theory

UNIT I History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

PGS 506 DISASTER MANAGEMENT 1+0 (e-Course) Objectives	
To introduce learners to the key concepts and practices of natural disaster management; to equip them to conduct thorough assessment of hazards, and risks vulnerability and capacity building	
Theory	UNIT I Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches, Volcanic eruptions, Heat and cold Waves, Climatic Change: Global warming, Sea Level rise, Ozone Depletion
	UNIT II Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents.
	UNIT III Disaster Management- Efforts to mitigate natural disasters at national and global levels. International Strategy for Disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media. Central, State, District and local Administration; Armed forces in Disaster response; Disaster response: Police and other organizations.

Supporting Course

STM 501 STATISTICAL METHODS 2+1 Objective	
To acquaint the students with various statistical methods and techniques To provide hands on training in data analysis through statistical software.	
Theory	UNIT I Sampling distribution for mean and proportion, standard error, confidence interval for mean and proportion; Test of hypothesis: type I and type II errors, level of significance, tests based on Z, t, X ² and F distribution.
	UNIT II Properties of estimators: unbiasedness, efficiency, sufficiency and consistency.
	UNIT III Simple correlation and regression, Spearman's rank correlation.
	UNIT IV Basic concepts of sampling techniques: simple random, stratified, systematic, cluster and two stage sampling and their applications in fisheries.
	UNIT V Analysis of variance: one way and two way classification; Non-parametric test, advantages and disadvantages over parametric tests; Run test and Sign test.
Practical	Tests of hypothesis based on Z, t, X ² and F; Simple correlation and regression, Rank correlation; Analysis of variance: one way and two way; Simple random, stratified, systematic, cluster and two stage sampling; Sign test, Run test; Hands on experience in using the statistical software packages MS Excel, Systat and SPSS in data analysis and interpretation.

STM 502 RESEARCH METHODOLOGY 1+1 Objective

To acquaint the students with basic concepts of research methods and processes. To develop research skills for planning, designing, conduct and reporting of research.

Theory	UNIT I Elements of scientific method; Research - purpose, relevance and scope; Generalization and transferability of research data; Objectivity and value-neutrality in scientific research; ethical dilemmas in research.
	UNIT II Types of research - basic, applied, strategic, anticipatory and adaptive research; historical, descriptive and experimental research; Qualitative and quantitative research methods; Experimental and ex-post facto approaches, survey research, action research, participatory research, case study method, content analysis.
	UNIT III Steps involved in research process; Identifying and defining researchable problems; Formulation of research objectives; Hypothesis - meaning, types, development of hypothesis and its testing; Constructs; Nature and type of variables; Types and levels of measurement; Types of reliability and validity and their measurement.
	UNIT IV Methods of observation and data collection for biological and social sciences research; Selection of appropriate tools for analysis of biological and social sciences research data;
	UNIT V Formats of research report - writing thesis/dissertation, research articles - abstracts, literature review, materials and methods, results and discussion, summary and references.
Practical	Exercises on identification of a problem and formulation of research questions and hypothesis; use of data base systems and online resources; Preparing a mock synopsis / outline of research work; Exercises on case study research / developing case studies; Exercises on reliability and validity; Review and evaluation of research articles, books, theses and their presentation; Conduct of a mock research including designing a research programme, conducting experiment / field research, data collection, analysis, report writing and presentation; Writing a research article; Writing a winning research proposal.

AQUACULTURE Course Structure -at a Glance		
CODE	COURSE TITLE	CREDITS
AQC 501*	SUSTAINABLE AQUACULTURE	2+1
AQC 502*	SOIL AND WATER QUALITY MANAGEMENT IN AQUACULTURE	2+1
AQC 503*	NUTRITION AND FEED TECHNOLOGY	2+1
AQC 504*	AQUATIC ANIMAL HEALTH MANAGEMENT	2+1
AQC 505	SEED PRODUCTION AND HATCHERY MANAGEMENT OF FINFISHES	2+1
AQC 506	SEED PRODUCTION AND HATCHERY MANAGEMENT OF SHELLFISHES	1+1
AQC 507	APPLIED GENETICS IN AQUACULTURE	2+1
AQC 508	NON-FOOD AQUACULTURE	1+1
AQC 509	COASTAL AQUACULTURE	2+1
AQC 510	FRESHWATER AQUACULTURE	2+1
AQC 511	LARVAL NUTRITION AND CULTURE OF FOOD ORGANISMS	1+1
AQC 512	AQUACULTURE ENGINEERING	2+1
AQC 591	MASTER'S SEMINAR	1+0
AQC 599	MASTER'S RESEARCH	20

*** Compulsory for Master's programme;**

AQC 501 SUSTAINABLE AQUACULTURE 2+1 Objective	
To gain in depth knowledge and field exposure on sustainable aquaculture practices.	
Theory	UNIT I Present scenario and problems: Trends in global and Indian aquaculture; different farming systems; intensive systems and constraints -environmental degradation and disease outbreaks.
	UNIT II Sustainability and development: Systems approach and its application in aquaculture with special reference to resource-poor systems; Role of aquatic resources in food and nutrition; Aquatic resource and livelihood systems.
	UNIT III Environmental issues: Exotic species introduction; escapement; contamination of indigenous gene pool; salinization of soil and water; environmental impact; over exploitation of wild stocks; mangrove deforestation.
	UNIT IV Socio-economic issues: Conflicts over water and land use; conflicts of interest between aqua farmers and fishermen; resistance from local public; anti-dumping duties.
	UNIT V Strategies for sustainability: Sustainability concept; food security; biosecurity; organic farming; integrated farming; responsible aquaculture; rotational aquaculture; bioremediation; role of biotechnology, traceability. Application of renewable energy in aquaculture - solar energy, wind, and tidal energy, Seed certification, Sustainable use of antibiotics.
	UNIT VI Economic viability: export vs. domestic marketing, value addition.
	UNIT VII Guiding principles to sustainable aquaculture development: Coastal Aquaculture Guidelines Source Book, FAO Code of Conduct for Responsible Fisheries; Holmenskollen Guidelines for Sustainable Aquaculture.
Practical	Visit to conventional aquafarm to see the management of used water; Survey on environmental impact nearby aquaculture farms; Setting model for sustainable aquaculture (organic farm, integrated farm); Applications of remote sensing and GIS (geographical information system); Economic evaluation of aquaculture practices.

AQC 502 SOIL AND WATER QUALITY MANAGEMENT IN 2+1 AQUACULTURE Objective	
To learn effective soil and water quality management practices.	
Theory	UNIT I Soil and water interaction: Physical and chemical properties of soil and water, Productivity vs nutrient quality and quantity of soil and water; aquatic microorganisms and their role in carbon, nitrogen, phosphorus and sulphur cycles and impact on aquatic habitats and species.
	UNIT II Soil and water quality monitoring: soil and water quality standards; soil and water quality monitoring and management.
	UNIT III Fertilizers and manures: Different kinds of fertilizers and manures, fertilizer grade, source, rate and frequency of application, Biofertilizers, Use of treated sewage for pond fertilization, Ecological changes taking place after fertilizing, Primary production, degradation of molecules in aquatic environment, Utilization of bioactive compounds by microorganisms.
	UNIT IV Soil and water quality management: Cat clay/pyrite soil, seepage, water treatment, water filtration devices, aeration, chlorination, ozonation and UV radiation, Algal bloom control, eutrophication, Aquatic weed management, Waste water treatment practices, Water quality management in hatcheries, Waste discharge standards, Role of microorganisms in fish production, fish health and fish safety; Microbial load and algal blooms.

Practical	Equipment used in soil and water analysis; Soil sampling, determination of soil moisture and bulk density; pond filling, analyses of mud acidity and soil texture; Measurements of temperature, pH, conductivity, salinity, transparency, turbidity and solids; Analyses of dissolved oxygen, alkalinity and hardness, phosphorus, nitrogen; Estimation of primary productivity and chlorophyll; Application of fertilizers and pond liming; Analysis of toxic elements; Microbial techniques; Visit to effluent treatment plant; Design and operation of biological filters.
------------------	---

AQC 503 NUTRITION AND FEED TECHNOLOGY 2+1 Objective	
To create basic understanding on the nutritional requirements of fish/shellfish and feed manufacture.	
Theory	UNIT I Fish nutrition: Principles of fish nutrition and terminologies, nutritional requirements of cultivable finfish and shellfish: larvae, juveniles and adults.
	UNIT II Nutritional biochemistry: Classification, nutrient quality and evaluation of proteins, lipids and carbohydrates.
	UNIT III Role of nutrients: amino acids, fatty acids, proteins, lipids, carbohydrates, vitamins and minerals.
	UNIT IV Nutritional bioenergetics: Fish as an open thermodynamic system, Energy requirement of fishes, protein to energy ratio, digestible energy, nitrogen balance index, protein sparing effect, high energy feeds, isocaloric diets, Optimal foraging theory, Mathematical modeling of ingestion, Metabolic rate, Energy budgets, Energetic efficiency of fish production.
	UNIT V Nutritional physiology: Digestion, accretions and nutrient flow, Factors affecting digestibility.
	UNIT VI Nutritional pathology: Antinutritional factors and antimetabolites, microbial toxins, methods of elimination, nutrient deficiency and symptoms.
	UNIT VII Feed Resources: Nutritional value of feed ingredients and live feed, Contribution from natural food to nutrient requirements of fish, Feed additives (attractants, growth stimulants and probiotics and binders), and Feed resources assessment.
	UNIT VIII Feed Manufacture: Feed formulation and processing, On-farm feed manufacture, Commercial feed manufacture, Feed storage.
	UNIT IX Feeding Practices: Supplementary feed–theory and practice, Complete diet theory and practice, Feeding methods and scheduling, ration size, feed performance and economics.
Practical	Formulation and preparation of a balanced fish feed; Feeding trials; Proximate analysis- moisture, crude protein, crude lipid ,ash , acid insoluble ash content of feed; Estimation of crude fibre, nitrogen free extract, calcium and phosphorus content of feed; Estimation of protein and lipid quality; Determination of gross energy content of feed and feed ingredients; Determination of the digestibility of feed using markers; Estimation of FCR from feeding trials and preparation of feeding table; Estimation of growth parameters from feeding trials; Analysis of mycotoxins from feed ingredients/feed; Gut content analysis to study artificial and natural food intake. Visit to feed manufacturing units.

AQC 504 AQUATIC ANIMAL HEALTH MANAGEMENT 2+1 Objective	
To provide holistic knowledge on fish and shellfish pathogens and their control measures.	
Theory	UNIT I Basics of fish and shellfish health management: Host-pathogen-environment relationship, Management of culture systems, Environmental stress.
	UNIT II Defence system in fish and shellfish: Defence systems in fish, innate and acquired immunity, inflammation response to diseases. Antibody and cell mediated immunity in fish and shellfish.
	UNIT III Parasitic and mycotic diseases: General characteristics, Epizootiology, Diagnosis, Life cycle, Prevention and treatment.
	UNIT IV Infectious bacterial and viral diseases: General characteristics, Epizootiology, Diagnosis, Prevention and treatment.
	UNIT V Non-infectious Diseases: Nutritional diseases, water, soil, environmental parameters and their effects on fish health. Disease in hatcheries and grow-out systems.
	UNIT VI Techniques in health management: Microbiological, haematological, histopathological, immunological and molecular techniques. Disease surveillance and reporting.
	UNIT VII Disease control and management: Environment management, chemotherapeutic agents, host management, prophylaxis-vaccines, adjuvants, immunostimulants and probiotics. Use and abuse of antibiotics and chemicals in health management. Fish health and quarantine systems. Seed certification, SPF and SPR stocks - development and applications.
Practical	General procedures for disease diagnosis; Taxonomy and identification of fish parasites; Sampling, preparation of media and culture of pathogenic bacteria; Techniques for bacterial classification; Histological techniques for disease diagnosis; Molecular and immunological techniques; Biochemical tests; PCR; ELISA; Agglutination test; Challenge tests; Purification of virus; Stress related study of fish and shellfish; Disease treatments.

AQC 505 SEED PRODUCTION AND HATCHERY OF FINFISHES 2+1 Objective	
To learn seed production and hatchery management of commercially important cultivable fishes.	
Theory	UNIT I Introduction: History, constraints and current status of natural seed collection and hatchery seed production.
	UNIT II Reproductive biology: Physiology and morphology; Molecular and physiological basis of reproduction, Overview of current developments in reproductive biology.
	UNIT III Gamete maturation and development: Spermatogenesis and oogenesis, Hormonal pathways and mode of control.
	UNIT IV Environmental and endocrine control of reproduction: Reproductive cycles, Seasonality (Photoperiod, change in water quality and quantity, temperature, lunar cycle, etc.), Environmental and exogenous hormonal stimuli.
	UNIT V Induced spawning: Methods of natural and artificial fertilization, GnRH and Linpe models, evaluation of milt and egg, cryopreservation technique, use of different synthetic hormones and analogues for induced spawning, Egg staging, Stripping and fertilization.
	UNIT VI Hatchery technology for different species: Indian major and minor carps, Exotic carps, Catfishes, Tilapia, Masheer, Trout, etc.

	UNIT VII Marine fish seed production: Seabass, milkfish, mullets, sea breams, rabbitfish, grouper, yellowtail, eel, cobia, etc.
	UNIT VIII Hatchery design and management: Criteria for site selection of hatchery and nursery, Design and function of incubators, Jar hatchery, Chinese hatchery and other hatchery systems- design and operation, hatchery protocols, larval rearing stages, rearing technology, packaging and transport of seed.
	UNIT IX Seed supply in aquaculture: Relationship between fry supply and grow-out, Macro-planning of fry production to stimulate grow-out, Marketing and economics of fish seed.
Practical	Study of gonadal development in carps and other cultivable finfishes; Identification of carp and catfish seed; Collection and identification of cultivable brackishwater finfish seed; Packing and transportation of cultivable finfish seed; Induced breeding of fishes through various inducing agents; Evaluation of carp milt and egg; Design and operation of Chinese hatchery; Preparation of brood and larval feed for different cultivable finfish; Rearing of carp spawn and fry; Visit to different finfish hatcheries.

AQC 506 SEED PRODUCTION AND HATCHERY MANAGEMENT OF SHELLFISHES 1+1 Objective	
To provide overall knowledge of seed production and hatchery management of commercially important cultivable crustaceans and molluscs.	
Theory	UNIT I Introduction: Current status; problems and prospects.
	UNIT II Seed resources: Site selection and techniques of collection; identification and segregation of shellfish seed.
	UNIT III Reproductive biology: Gonad anatomy, endocrinology and reproductive mechanisms in prawns, shrimps, crabs, lobsters, mussels, oysters, scallops and clams; age at first maturity; factors affecting maturation and spawning.
	UNIT IV Broodstock: availability; improvement; nutritional requirements; transport; captive rearing and maturation; induced spawning; physical and chemical inducing agents; physiology and techniques of eyestalk ablation.
	UNIT V Seed production: Seed production of commercially important prawns, shrimps, crabs, lobsters, mussels, edible oysters, pearl oyster, scallops, clams and sea cucumber.
	UNIT VI Hatchery technology and management: Site selection and facilities required; culture and use of different live feed in shellfish hatcheries; larval diseases and their management; different chemicals and drugs used; water quality and feed management; Hatchery standards and biosecurity; sanitary and phytosanitary (SPS) measures; better management practices (BMPs); packaging and transport of seed.
	UNIT VII Economics of seed production.
Practical	Layout and design of prawn and shrimp hatcheries; Study of gonad development in different cultivable crustaceans and molluscs; Collection and identification of shellfish seed; Packing and transportation of shellfish seed; Eyestalk ablation technique; Identification of larval stages of shrimp, prawn, crab, mussel and oyster; Culture techniques of microalgae and other live feed used in shellfish hatcheries; Artemia hatching technique; Visit to different shellfish hatcheries; Economic analysis of shellfish hatcheries.

AQC 507 APPLIED GENETICS IN AQUACULTURE 2+1 Objective	
To impart knowledge on genetic basis of inheritance and breeding plans for commercially important fishes.	
Theory	UNIT I Introduction: Origin and advancement in genetics; physical basis of heredity; genetic correlation, domestication and local adaptation.
	UNIT II Chromosome manipulation: Ploidy induction methods - triploidy and tetraploidy, advantages and disadvantages of polyploids, androgenesis and gynogenesis.
	UNIT III Sex determination: Sex differentiation and sex reversal in fishes, sex control and its role in aquaculture.
	UNIT IV Selection: Scope, application and methods of selection, marker assisted selection-biochemical and molecular markers. Molecular tools for stock differentiation for selection.
	UNIT V Hybridization: Heterosis, hybrid vigour, introgression.
	UNIT VI Inbreeding: Methods of estimation, inbreeding depression and consequences, measures to reduce inbreeding in hatcheries.
	UNIT VII Conservation genetics: Genetic resources of India and conservation, endangered species, cryopreservation of fish gametes.
	UNIT VIII Cytogenetics: Importance and karyotyping.
	UNIT IX Fish breeding: History and advancement of fish breeding, mode of reproduction, basic breeding methods and breeding programmes and goals.
	UNIT X Genetic management strategies: Environmental impacts, Lessons from the green revolution, Bioprospecting, GMOs and their detection.
Practical	Estimation of gene and genotype frequencies; Exercises on Hardy-Weinberg equation; Estimation of inbreeding coefficient; Protocol of androgenesis and gynogenesis; Protocol of cryopreservation of milt; Karyotypic studies; Isolation of DNA from fish blood.

AQC 508 NON-FOOD AQUACULTURE 1+1 Objective	
To impart knowledge on ornamental fish production, pearl production, bait fish culture and aquatic ornamental plant propagation.	
Theory	UNIT I Aquarium fish trade: Present status; potential; major exporting and importing countries; species-wise contribution of freshwater and marine fishes; contribution of culture and capture; marketing strategies; anesthetics, packing and transportation.
	UNIT II Breeding techniques: Reproductive biology, captive breeding and rearing of freshwater, brackishwater, marine ornamental fishes and invertebrates.
	UNIT III Aquarium keeping: Design and construction of tanks; species-wise tank size requirement; heating, lighting, aeration and filtration arrangements; decorations used; common aquarium plants and their propagation; Feed, health and water quality management; prophylaxis; quarantine.
	UNIT IV Value addition: Colour enhancement; genetic manipulation and production of new strains; hybrids; acclimatization strategies for marine ornamental fish to freshwater.
	UNIT V Pearl Production: Overview of pearl trade, pearl oysters and mussels of commercial importance; anatomy, biology and seed production, techniques of implantation, method of rearing and harvesting of pearl, Mable pearl production, processing and quality evaluation of pearls, pearl production by tissue culture.

	UNIT VI Bait fish culture: Scope and importance, bait fish species (minnows, silver heads, etc.), farming practices.
	UNIT VII Ornamental aquatic plants: Propagation methods, nutrient and environmental requirement, cropping methods, packing and transport.
Practical	Identification of common freshwater aquarium fishes and breeding trials of selected freshwater fishes; Identification of common brackish water and marine aquarium fishes; Aquarium fabrication, setting and maintenance; Preparation of powdered and pelleted feed for ornamental fishes; Visit to ornamental fish farms; Study of bacterial, viral, fungal diseases of ornamental fishes and their control; Prophylactic and quarantine measures; Nuclei implantation in pearl oyster; Identification of ornamental aquatic plants.

AQC 509 COASTAL AQUACULTURE 2+1 Objective	
To gain knowledge in establishing and managing different fish/shellfish farming systems in coastal waters.	
Theory	UNIT I Introduction: An overview of the status of coastal aquaculture; Present trend and scope in India.
	UNIT II Different farming systems: Cage and pen culture – type, site selection, construction, specifications for different species; Raft and rack culture – site selection, design and construction.
	UNIT III Important cultivable finfishes: Distribution, biology, seed collection, nursery rearing, culture techniques, problems and prospects (seabass, milkfish, mullets, pearlspot, sea breams, rabbitfish, grouper, yellowtail, eel, cobia, salmon, flatfish).
	UNIT IV Culture of marine molluscs and echinoderms: Present status and scope in India, Species cultured (mussels, oysters, pearl oysters, scallops, clams, cockles, abalones, sea cucumber) distribution, biology, practices followed in India, farming methods - off-bottom and on-bottom culture; Problems and prospects.
	UNIT V Culture of crustaceans: Shrimp farming: systems of farming – extensive, semi-intensive and intensive; site selection, infrastructure requirement, design and construction of culture systems, pond preparation, stocking, feed and water quality management, disease prevention and treatment; harvesting and handling; freshwater farming of tiger shrimp, shrimp farming in un-drainable ponds, low and zero water exchange systems; Mud crab fattening, production of soft-shell crabs; Lobster culture; Crayfish culture.
	UNIT VI Seaweed culture: Major seaweed species of commercial importance; methods of culture; farming of agar, algin, carrageenan yielding species; emerging trends in their farming in open seas; Integration with other farming systems.
Practical	Identification of cultivable marine and brackishwater finfish and shellfish; Identification of cultivable seaweeds; Designing of different farming systems – cages, pens, rafts and racks; Visit to coastal aquafarms.

AQC 510 FRESHWATER AQUACULTURE 2+1 Objective	
To gain knowledge on fish and prawn farming in different culture systems.	
Theory	UNIT I Introduction: Present status, problems and scope of fish and prawn farming in global and Indian perspective.
	UNIT II Aquaculture systems: Extensive, semi-intensive and intensive culture of fish, Pen and cage culture in lentic and lotic water bodies, polyculture, composite fish culture.

	UNIT III Fish farming: Nursery and grow-out, pond preparation, stocking, feeding and water quality management in the farming of major and minor carps, magur, singhi, murrels, tilapia, pangasius, freshwater turtle, etc.; Stunted seed production and culture practice.
	UNIT IV Freshwater prawn farming: Monoculture practice of prawn in ponds, all-male culture and its advantages, polyculture with carps, prawn farming in inland saline soils. Nursery rearing, sex segregation, pond preparation, stocking, feeding and water quality management, disease prevention and treatment; harvesting and handling.
	UNIT V Integrated farming systems: Design, farming practices, constraints and economics of IFS of fish with paddy, cattle, pig, poultry, duck, rabbit, etc.
	UNIT VI Wastewater-fed aquaculture: Water treatment methods, species selection, culture practices, harvesting and depuration process.
	UNIT VII Economics of different fish farming systems.
Practical	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

AQC 511 LARVAL NUTRITION AND CULTURE OF FISH FOOD ORGANISMS	
1+1 Objective	
To impart basic understanding of the nutritional requirements of fish/shellfish larvae and knowledge on mass culture and enrichment of live food organisms.	
Theory	UNIT I Larval nutrition: Larval stages, nutritional requirements of fish and shellfish larvae, quality requirements of larval feeds (particle size, digestibility), natural food and its importance in aquaculture, nutritional quality of commonly used fish food organisms, bioenrichment, biofilm/periphyton and its use, culture of single cell proteins and their nutritional quality, formulation and preparation of artificial feeds for larval rearing, microparticulate diets.
	UNIT II Fish food organisms: Bacterioplankton, phytoplankton and zooplankton and their role in larval nutrition.
	UNIT III Mass culture techniques: Methods of collection, maintenance and rearing of fish food organisms, Different media used in culture, Mass culture of fish food organisms and their application in hatcheries, culture of important microalgae, rotifers, artemia, cladocerans, copepods, oligochaetes, nematodes and insect larvae.
Practical	Collection, identification and isolation of live food organisms using various techniques; Preparation of various culture media; Preparation and maintenance of stock microalgal culture; Preparation of artificial feed for rearing finfish and shellfish larvae; Mass culture of microalgae; Mass culture of cladocerans, copepods and rotifers; Culture of Artemia nauplii, infusoria – freshwater and marine; Culture of earthworms and chironomid larvae.

AQC 512 AQUACULTURE ENGINEERING 2+1 Objective	
To learn the basic aspects of successful farm designing for effective management and optimum yield.	
Theory	UNIT I Introduction: Technical components of farm designing, future trends in aquaculture engineering. UNIT VII Feeding system: Different types of feeding equipment, feed control systems, dynamic feeding systems.
	UNIT II Aquaculture facilities: Planning process, site selection and evaluation, design, components and construction of tanks, ponds, cages and hatcheries.
	UNIT III Water intake and outlet: Pipe line, water flow and head loss, pumps.

	UNIT IV Water treatment: Equipment used for water treatment, filters, ultraviolet light, ozone, heating and cooling and other processes of disinfection.
	UNIT V Aeration and oxygenation: Design and fabrication of aerators, oxygen injection system
	UNIT VI Recirculation and water use system: Definition, components and design.
	UNIT VIII Instrumentation and monitoring: Instruments for measuring water quality.
Practical	Visit to aqua farms; Contour survey and mappings; Evaluation of performance of seepage controlling devices; Designing of fresh and brackish water fin and shellfish farms; Designing of fresh and brackish water fin and shellfish hatcheries; Estimation of construction cost of FRP and cement hatchery units, inlets, outlets, sluice gate, monks, hatchery sheds, supply channel and drainage systems, gravitational flow; Design and construction of effluent treatment plant for hatchery; Evaluation of capacity of aeration devices.

AQUATIC ANIMAL HEALTH Course Structure - at a Glance		
CODE	COURSE TITLE	CREDITS
AAH 501*	VIRAL AND BACTERIAL DISEASES OF FINFISH AND SHELLFISH	2+1
AAH 502*	PARASITIC DISEASES OF FINFISH AND SHELLFISH	2+1
AAH 503*	HEALTH MANAGEMENT IN AQUACULTURE	2+1
AAH 504*	SYSTEMIC FISH PATHOLOGY	2+1
AAH 505	FISH IMMUNOLOGY	2+1
AAH 506	MICROBIOLOGICAL TECHNIQUES	1+1
AAH 507	FISH VIROLOGY AND CELL CULTURE	2+1
AAH 508	CLINICAL PATHOLOGY	1+1
AAH 509	NON-INFECTIOUS AND FUNGAL DISEASES	1+1
AAH 510	AQUATIC ENVIRONMENT AND FISH HEALTH	1+1
AAH 511	DIAGNOSTIC TECHNIQUES	1+1
AAH 591	MASTER'S SEMINAR	1+0
AAH 599	MASTER'S RESEARCH	20

* **Compulsory for Master's programme;**

AAH 501 VIRAL AND BACTERIAL DISEASES OF FINFISH AND SHELLFISH 2+1**Objective**

To impart knowledge of viral and bacterial infections, their replication strategies and pathogenesis in fish and shellfish.

Theory	UNIT I Virology: General biology of viral infections, virus classification, virus replication. OIE Notifiable diseases.
	UNIT II Aetiology, pathogenesis, epidemiology, treatment and control, immunology and molecular biology of viruses/viral diseases of finfishes with emphasis on the following: Epizootic haematopoietic Necrosis (EHN), Infectious Haematopoietic Necrosis (IHN), Oncorhynchus Masou Virus (OMV), Viral Encephalopathy and Retinopathy (VER), Spring Viraemia of Carp (SVC), Viral Haemorrhagic Septicaemia (VHS), Lymphocystis and Infectious Pancreatic Necrosis (IPN).
	UNIT III Major viral pathogens of commercially important cultured crustaceans with special reference to shrimp and freshwater prawn: viral and bacterial; Biology, morphology, diagnostic methods, clinical signs and pathological changes associated with these pathogens; Viruses: WSSV, YHV, TSV, IHNV, MBV, HPV, BP, BMN, LOVV, GAV, MrNV.
	UNIT IV Pathogenesis, virulence mechanisms, epidemiology, treatment and control measures of the bacterial diseases of finfish and shell fish with emphasis on Furunculosis, Haemorrhagic septicemia, Columnaris disease, Tail and fin rot, Bacterial gill disease, Vibriosis, Mycobacteriosis, Nocardiosis, Haemophilosis, Edwardsiellosis, enteric red mouth.
	UNIT V Bacterial diseases of shellfish such as Vibriosis; Necrotizing hepatopancreatitis, rickettsial diseases, mycobacteriosis.
Practical	Examination of moribund fish for viral and bacterial diseases; Sampling techniques, culture techniques, bioassay methods; Serological techniques in disease diagnosis, microbial identification.

AAH 502 PARASITIC DISEASES OF FINFISH AND SHELLFISH 2+1 Objective

To comprehend the taxonomy, morphology, pathology and host-parasite relation of common parasites of aquatic organisms and to understand the significance of parasites in fish health.

Theory	UNIT I Parasite taxonomy and morphology: Protozoan and metazoan parasites of fish and shellfish.
	UNIT II Life cycle of fish and shellfish parasites.
	UNIT III Parasite pathology: Pathology, treatments and control of the disease caused by protozoan parasites: Costia necatrix, Trypanosoma, Trypanoplasma, Ichthyophthirius, Urceolariid ciliates, Microsporidians, Myxozoans.
	UNIT IV Parasite pathology: Pathology treatments and control of the disease caused by Metazoan parasites: Trematodes: Dactylogyrus, Gyrodactylus, Diplozoan, Sanguinicola, Neascus cuticola, Cestodes: Diphyllbothrium latum, Caryophyllaeus, Ligula; Nematodes: Capillaria, Camallanus.
	UNIT V Parasite pathology: Pathology treatments and control of disease caused by Acanthocephalan parasites, Crustacean parasites: Lernae, Argulus, Ergasilus, fish leeches.
Practical	Collection and identification of parasites; Preparation of permanent slides, micrometry and diagrams of parasites; Histopathological slide preparation of parasite-infected tissues; Processing for study of helminths and their larval stages; Examination of intermediate host for larval stages; Processing and study of the arthropods and their larval stages; Fixation staining and study of the protozoans; Examination of biopsy material, examination of tissue sections for parasites.

AAH 503 HEALTH MANAGEMENT IN AQUACULTURE 2+1 Objective	
To understand the essential principles of aquatic animal health management, biosecurity and specific issues associated with the system. To appreciate the significance of national and international instruments in quarantine, disease reporting and surveillance and their application in transboundary movement of aquatic organisms.	
Theory	UNIT I Review of various diseases of finfish and shellfish significant to aquaculture; diagnostic procedures and their application in aquaculture.
	UNIT II Disease monitoring, surveillance, epidemiology, quarantine, certification and import risk analysis.
	UNIT III Prophylaxis, hygiene and therapy of fish and shellfish diseases. UNIT IV Commonly used drugs/chemicals in aquaculture, drug delivery.
	UNIT V Vaccines and vaccination, probiotics and bioremedial measures; immunostimulants and their role.
	UNIT VI Application of health management protocols and biosecurity principles in aquaculture.
	UNIT VII Longterm strategy in health management; Advances in disease control and management; Principles of SPF/SPR.
Practical	Demonstration of different diagnostic tools. Sampling procedures for disease investigation; methods of chemical/drug delivery/application; case study.

AAH 504 SYSTEMIC FISH PATHOLOGY 2+1 Objective	
To understand the various systems of fishes and shrimps with specific reference to their pathological significance.	
Theory	UNIT I Introduction: Anatomy and physiology of teleost Integumentary, musculoskeletal, respiratory, circulatory, reticuloendothelial, renal, excretory and digestive systems.
	UNIT II Pathophysiology: Stress and general adaptation syndrome, inflammatory response, necrosis and types, stages.
	UNIT III Integumentary system: Cuticular, epidermal dermal and hypodermal changes, hyperplasia and ulceration.
	UNIT IV Respiratory system: Lamellar oedema, lamellar hyperplasia and lamellar fusion.
	UNIT V Blood vascular system: Pathology of heart, vessels, blood composition, cellular components of blood and haemopoietic tissue.
	UNIT VI Digestive system: Digestive tract and its pathology; hepatic necrosis, lipid infiltration, hepatic granuloma, cirrhosis, pancreatic atrophy, neoplasia; epithelial sloughing of intestine.
	UNIT VII Excretory system: Kidney and its pathology, renal tubules and collecting ducts.
	UNIT VIII Nervous system: Pathology of brain, spinal cord, peripheral nerves, meninges, sense organs.
	UNIT IX Musculoskeletal and Endocrine system: Pathological changes in red and white muscle bone and cartilages. Endocrine systems and pathology.
	UNIT X Systemic pathology in shrimp: Integument, respiratory, digestive and nervous system and its pathology.
Practical	Necropsy techniques, Systemic pathology of different organs and their identification.

AAH 505 FISH IMMUNOLOGY 2+1 Objective	
To teach basic principles of fish and shellfish immunology.	
Theory	UNIT I Introduction to fish immunology and terminologies; historical developments; Phylogeny of fish immune system.
	UNIT II Lymphoid tissues and cellular components of immune system.
	UNIT III Non specific humoral and cellular defence mechanisms.
	UNIT IV Specific defence mechanisms; Memory function and immunological tolerance.
	UNIT V Complement system, function, components, complement activation.
	UNIT VI Antigens and antigenicity; structure of antibody. Types of antibodies, Theories of antibody formation, Antibody mediated immune response: general characteristics, immunoglobulin classes, structure and function and synthesis.
	UNIT VII Phagocytic systems; Lymphoid systems; Antigen processing and major histocompatibility complex.
	UNIT VIII Cell mediated immune response and its components; Hypersensitivity reactions.
	UNIT IX Invertebrate defence mechanisms.
Practical	Preparation of antigen; Raising of antibodies; Antigen-antibody reactions; Agglutination tests; Precipitation tests: gel diffusion; Immunoelectrophoresis, counter immunoelectrophoresis; Isolation of antibody from serum; ELISA; Western blotting; Isolation of lymphocytes and blastogenesis; Non-specific immune response (NBT and prophenoloxidase).

AAH 506 MICROBIOLOGICAL TECHNIQUES 1+1 Objective	
To comprehend different microbiological techniques used in research.	
Theory	UNIT I Techniques in sterilization; Preparation of media. Safety in microbiology laboratory, bio-safety levels.
	UNIT II Microscopy: bright field, fluorescence, phase contrast, dark field and electron microscope.
	UNIT III Stains, staining and its chemistry.
	UNIT IV Isolation and culture of different types of bacteria; Techniques for identification: biochemical, serological and molecular techniques.
	UNIT V Techniques for isolation and identification of fungi; Basics of mycological and virological techniques.
Practical	Practical on microscopic techniques; Antibiotic sensitivity testing; Identification of microorganisms, anaerobic bacteria, mycological and virological techniques.

AAH 507 FISH VIROLOGY AND CELL CULTURE 2+1 Objective	
To understand classification and structure of viruses and methods of their culture.	
Theory	UNIT I Virus taxonomy, viral structure, viral genetics.
	UNIT II Replication of viruses, host-virus interaction, viral vectors, bacteriophages, propagation of viruses.
	UNIT III Principles of cell culture, development of primary cell culture, maintenance of cell lines.
	UNIT IV Scaling up of cell culture, characterization and preservation of cell lines.
	UNIT V Hybridoma and monoclonal antibody production.
Practical	Virus isolation techniques, virus propagation, viral quantitation, neutralization techniques, electron microscopy, cell culture characterization (counting, staining), karyotyping, cell culture preservation, viable cell counts, MTT assay.

AAH 508 CLINICAL PATHOLOGY 1+1 Objective	
To teach methods in clinical pathology of aquatic organisms.	
Theory	UNIT I Detailed study of normal and abnormal constituents of blood with reference to pathogenic condition.
	UNIT II Stress induced conditions in fishes and their pathology.
	UNIT III Physiological effects of stressors on fish, tolerance level (pH, ammonia, oxygen, temperature, handling stress, crowding, transportation, chemicals and bacterial toxins).
	UNIT IV Cellular response to stress, response to some specific disease.
Practical	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.

AAH 509 NON-INFECTIOUS AND FUNGAL DISEASES 1+1 Objective	
To comprehend the etiology and management of different non-infectious and fungal diseases.	
Theory	UNIT I Studies on the causes, pathogenesis, pathology, diagnosis and differential diagnosis of various diseases due to nutritional imbalance and avitaminosis, anorexia, mineral deficiency and toxicity.
	UNIT II Metabolic diseases in finfish and shellfish. Genetic diseases and neoplastic lesions.
	UNIT III Fungal diseases of finfish and shellfish- External and internal fungal infections.
	UNIT IV Epizootic ulcerative syndrome (EUS) in fishes- Etiology, epidemiology, pathogenesis diagnosis and management.
	UNIT V Fungal diseases of shellfish, larval mycosis, fusarium disease, Crayfish plague.
Practical	Study of gross and histopathological changes due to various metabolic diseases and nutritional disorders. Isolation of fungal pathogens.

AAH 510 AQUATIC ENVIRONMENT AND FISH HEALTH 1+1 Objective	
To comprehend the basic principles of aquatic animal health management in relation to their environment.	
Theory	UNIT I Environmental variables related to fish health; Water quality and sediment characteristics.
	UNIT II Nature and type of pollutants. Impact of pollutants on environment and fish health.
	UNIT III Biological indicators and indices of water quality. Sanitation in aquaculture systems.
	UNIT IV Algal blooms and environmental microflora. Microbial toxins.
	UNIT V Probiotics and bioremedial measures. Nitrogen balance in aquatic ecosystem.
Practical	Estimation of major pollutants using spectrophotometry. Hematological, histopathological and biochemical analysis of fish exposed to specific pollutants. Testing the efficacy of aquaculture sanitizers.

AAH 511 DIAGNOSTIC TECHNIQUES 1+1 Objective

To learn the principles and protocols of diagnostic tests used in the diagnosis of fish diseases.

Theory	UNIT I 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.
	UNIT II Culture media for isolation of pathogens, non-selective, enriched, enrichment and selective media. Inoculation and purification techniques. Staining methods.
	UNIT III 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.
Practical	Methods for examination and analysing 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.

FISH GENETICS AND BREEDING <u>Course Structure - at a Glance</u>		
CODE	COURSE TITLE	CREDITS
FGB 501*	PRINCIPLES OF GENETICS AND BREEDING	2+1
FGB 502*	POPULATION GENETICS	2+1
FGB 503*	QUANTITATIVE GENETICS	2+1
FGB 504*	PRINCIPLES OF SELECTION AND SELECTION	2+1
FGB 505	FISH BREEDING	2+1
FGB 506	FISH GENETIC RESOURCES AND CONSERVATION	2+1
FGB 507#	MOLECULAR AND IMMUNOGENETICS	1+1
FGB 508	MOLECULAR GENETICS	1+1
FGB 509	CYTOGENETICS	1+1
FGB 510#	BIOINFORMATICS	1+1
FGB 511	COMPUTER APPLICATIONS IN FISH GENETICS	1+1
FGB 512#	CELL AND TISSUE CULTURE	1+1
FGB 591	MASTER'S SEMINAR	1+0
FGB 599	MASTER'S RESEARCH	20

* Compulsory for Master's programme;

FGB 501 PRINCIPLES OF GENETICS AND BREEDING 2+1 Objective	
To understand the basic principles of genetics and breeding and their application to fisheries management and aquaculture.	
Theory	UNIT I Historical development of genetics and physical basis of heredity; Mendelian principles: scope, limitation, probability of Mendelian inheritance; Modifications to Mendelian ratios.
	UNIT II Genetic variation: Causes and measurement; Chromosome theory of inheritance: genetic basis of determination of sex.
	UNIT III Chromosome manipulation: Ploidy induction, sex reversal, gynogenesis and androgenesis; Multiple alleles.
	UNIT IV Linkage and crossing over, recombination, interference.
	UNIT V Modern concept of gene; DNA as genetic material, genetic code and protein synthesis, transfer and regulation of genetic information.
	UNIT VI Pleiotropy; Penetrance; Gene and genotypic frequency and factors affecting them, application of selection for performance improvement.
	UNIT VII Mutation: natural and induced, mutagens fate of mutant allele in the population; Cross breeding and genetic drift.
Practical	Exercises on Mendelian laws, multiple alleles and epistasis; Practical demonstration of chromosome manipulations, Linkage and crossing over, ploidy induction; Induction of gynogenesis and androgenesis; Sex reversal.

FGB 502 POPULATION GENETICS 2+1 Objective	
Understanding the concepts of population and its structure for fisheries management and aquaculture.	
Theory	UNIT I Genetics of population: Individual vs. population, genetic structure of random mating populations.
	UNIT II Hardy Weinberg principles: Test of equilibrium, application and properties of equilibrium populations; Change in gene frequency under migration, mutation and selection; Effect of small population on gene
	UNIT III Estimation of HW principle/equilibrium using various population genetic tools: phenotypic, protein, and DNA markers.
	UNIT IV Coefficient of genetic differentiation – FST, RST, QST, GST - their relative merits and demerits, Genetic similarity and distance.
	UNIT V Genetic bottleneck and concept of Mutation drift equilibrium; Null alleles; Theory of path coefficients and analysis.
	UNIT VI Basis of relationships: Independent and correlated causes; Inbreeding: types, methods of estimation and consequences; Genetic drift; Effective population size.
Practical	Exercises on various statistical procedures with emphasis on non-parametric distributions; Estimation of gene and genotype frequencies; Estimation of effect of mutation, migration and selection on equilibrium; Equilibrium in sex linked genes; Estimation of effective population size, rate of inbreeding, inbreeding coefficient, path coefficient; Building of pedigree files; Statistical analysis in relation to genetic stock structure analysis with dominant and co-dominant markers; Type I and Type II markers, protein, mtDNA and nuclear DNA markers, EST markers.

FGB 503 QUANTITATIVE GENETICS 2+1 Objective	
Understanding the concepts of quantitative genetics and its applications.	
Theory	UNIT I Quantitative genetics: Scope and applications; Polygenes and major genes; Polygenic segregation and linkage.
	UNIT II Quantitative and qualitative traits: Mode of inheritance and continuous variation; Components of phenotypic value: population mean, genotypic value, average effect of gene and gene substitution.
	UNIT III Breeding value: Dominance and interaction deviations; Components of variation: additive and non additive interaction; Biometrical relationship among relatives.
	UNIT IV Genetic parameters: Introduction, repeatability, heritability and genetic, phenotypic and environment correlations.
	UNIT V Selection: Effect on population structure, intensity of selection, response to selection, methods of selection; Genetic gain and correlated response; Utilisation of non-additive genetic variance.
	UNIT VI Heterosis: Theories and estimation; Maternal effects; Diallele crossing; General and specific combining ability; Recurrent and reciprocal recurrent selection; Scale effects and their estimation; Progeny testing.
Practical	Properties of Variance, Covariance, Correlation and regression; ANOVA in genetic parameter estimation; Analysis of genetic variance; Estimation of heritability by half-sib, full-sib and mid-parent analyses; Repeatability and their accuracies; Estimation of genetic gain and their relative efficiencies; Procedures for estimating breeding values; Analysis of diallele crossing.

FGB 504 PRINCIPLES OF SELECTION AND SELECTION METHODS 2+1 Objective	
To learn the application of genetic tools for genetic improvement of aquatic species.	
Theory	UNIT I Selection: Scope, application, role of genetics in fish selection and breeding; National and International scenario of selective breeding programmes in fish.
	UNIT II Selection: Basis of selection, genetic gain; Response to selection and factors affecting response; Accuracy of selection; Selection limits; Renewed selection gain; Bidirectional selection; Aids to selection; Methods of selection; QTL and MAS.
	UNIT III Construction of selection indices; Sire and dam evaluation; Realized heritability, repeatability and genetic correlations.
	UNIT IV Mating systems and genetic consequences; Inbreeding depression: causes and methods to overcome; Selection for threshold characters; Small stock and inbreeding effects; Out breeding: crossbreeding, utilization of heterotic effects.
	UNIT V Application of genetic parameter information in formulation of breeding plans; Stock improvement plans; Development of new strains/synthetic population; Crossbreeding and hybridization.
	UNIT VI Selection and mating designs for select traits: growth, disease resistance, color enhancement, fin characters,; Application of markers in selection programmes, status and their relevance.
	UNIT VII Development of breeding plans for different population sizes and environments; Trends in fish breeding research. Domestication and inadvertent selection; Genotype x Environment interaction and its role in fish/shellfish breeding.

Practical	Estimation of genetic parameters; and construction of selection indices; Estimation of genetic, phenotypic and environmental correlations; Analysis of GCA and SCA; Estimation of heterosis and inbreeding depression; Estimation of G X E interaction; Designing and conducting the challenge test for disease resistance. Selection: basis of selection, genetic gain; Response to selection and factors affecting response; Accuracy of selection; Selection limits; Renewed selection gain; Bidirectional selection; Aids to selection; Methods of selection; QTL and MAS.
------------------	--

FGB 505 FISH BREEDING 2+1 Objective	
To learn the applications of genetic techniques for stock improvement.	
Theory	UNIT I Historical development of fish breeding and domestication; Current status of aquaculture in world and India; Tagging and maintaining breeding records.
	UNIT II Performance: Growth, disease resistance, productive and reproductive traits and their inheritance; Study of growth curves and their components; Influence of non-genetic factors on growth.
	UNIT III Endocrine control of reproduction; Synchronization of spawning.
	UNIT IV Effect of breeding programme on genetic diversity of farmed animals; Present status of breeding, cross breeding in aquaculture; Broodstock management; Inbreeding depression and heterosis in various economic characters; Role of Breeders' associations in national breeding programmes.
	UNIT V National breeding policy; Economic analyses of national breeding programmes.
	UNIT VI Reproductive cycle, sex determination, age of maturity, hormone induced ovulation; Gonad developmental stages in fin/shellfish and levels of hormonal intervention; Seed quality and fish seed certification; Biosecurity.
Practical	Tagging methods; Construction of growth curves; Standardization of the performance records for genetic parameters estimations, Record keeping of stock; Breeding plan and design of breeding programme from successful case studies; Morphometric analysis; Practicals on synchronization of spawning.

FGB 506 FISH GENETIC RESOURCES AND CONSERVATION 2+1 Objective	
To impart knowledge on application of genetic principles in conservation and management of aquatic resources.	
Theory	UNIT I Fish genetic resources: Survey and distribution; Genetic diversity –importance, estimation and influencing factors.
	UNIT II Characterization and evaluation: Taxonomical, biochemical and molecular tools; Threatened aquatic species of India and world.
	UNIT III Conservation and preservation of aquatic species: Issues and strategies, endangered species as per the guidelines of IUCN; Breeding strategies of threatened species for restocking and live gene bank.
	UNIT IV Data bank and Gene bank: Concepts, objectives, resources, uses; Institutes and Societies associated with conservation; Impact of inbreeding on genetic diversity and conservation; Evolutionary potential and heritability.
	UNIT V Importance of mutation, migration and their interaction with selection in conservation; Application of molecular genetic tools for management of small population for conservation.

	UNIT VI Genetics and management of wild and captive populations; Genetic management for reintroduction; In-situ and ex-situ conservation; Cryopreservation of sperm, eggs and embryos.
	UNIT VII Effective population size and population structure; Factors threatening indigenous species; IPR issues and patenting of genetic resources; Regulations regarding introduction of exotic germplasm; Export import rules and regulations on conservation of aquatic genetic resources; Fish quarantine – status, procedures, scope and significance; Convention on Biodiversity and Biodiversity Authority of India.
Practical	Tagging methods for population; Estimation of gene and genotypic frequencies; Estimation of genetic diversity and relatedness using molecular information; Application of molecular genetic markers for estimation of effective population size, rate of inbreeding and genetic bottleneck; Analysis of genetic variance in population; Morphometric analysis of stocks; Milt quality analysis; Cryopreservation of milt.

FGB 507 MOLECULAR AND IMMUNOGENETICS 1+1 Objective	
To acquaint the students with techniques used to estimate genetic variation among individuals and populations for various purposes and DNA diversity generated by somatic recombination of immunoglobulin genes.	
Theory	UNIT I Biochemical markers: Allozyme polymorphism and its application in estimating population genetic parameters.
	UNIT II Molecular markers: RAPD, RFLP, AFLP, EST, SNP, Minisatellites and Microsatellites and application in population genetic analysis and gene mapping, FISH – principle and application.
	UNIT III Analysis: Interpretation of gels and data analysis using various softwares. DNA sequence polymorphism and related software for alignment and analysis.
	UNIT IV Immunogenetics: Molecular biology of Ig synthesis, genetic basis of antibody diversity, humoral B-cell immunoglobulins, T-cell receptors and MHC.
Practical	Biochemical markers: Allozyme polymorphism. Molecular Markers: RAPD, RFLP, AFLP, Minisatellites and Microsatellites. Interpretation of gels and data analysis.

FGB 508 MOLECULAR GENETICS 1+1 Objective	
To understand the basic concepts of molecular genetics	
Theory	UNIT I Gene structure of DNA, replication, Protein synthesis; Operon concept, genetics of mitochondria and plasmids, transposons and intervening sequences, minisatellites and macro satellites.
	UNIT II Mutations: Molecular mechanism of spontaneous and induced mutations, site directed mutagenesis, recombination in bacteria, fungus and virus.
	UNIT III Recombination: Molecular mechanism of genetic recombination, transduction, transformation and conjugation.
	UNIT IV Genetic code, mechanism of translation and its control, post translation modification. Control of gene expression in prokaryotes and eukaryotes.
Practical	DNA isolation, Plasmid isolation, Gel electrophoresis and its type, AGE, PAGE, SDS-PAGE, PCR, Cloning.

FGB 509 CYTOGENETICS 1+1 Objective	
To understand chromosome as the basic unit of heredity	
Theory	UNIT I Introduction, historical background, importance, improved cytogenetic techniques.
	UNIT II Chromosome theory of inheritance: chromosomal models and their ultra structure; Chromosomal movements and position effect.
	UNIT III Sex determination and differentiation, sex chromatin and Lyon's hypothesis; Chromosome numbers in fish and karyotyping.
	UNIT IV Chromosomal aberrations: Genetic and evolutionary implications; Chromosome banding techniques; FISH.
	UNIT V Cytogenetics and evolution; Genotoxicity assays (single cell electrophoresis, MNT, SCE).
Practical	Preparation of chromosome spreads; Karyotyping; Banding techniques; MNT, SCE, Comet Assay.

FGB 510 BIOINFORMATICS 1+1 Objective	
To learn the application of information technology for the fish genetics studies.	
Theory	UNIT I Introduction to bioinformatics: history, definition, scope and applications; Fields related to bioinformatics.
	UNIT II Data base: mining tools, submission of DNA sequences; Sequence alignment and database searching, similarity search, FASTA, BLAST.
	UNIT III Information networks: internet; Gene bank sequence database, EBI-net; NCBI, Genome net.
	UNIT IV Genomics: genome diagnostics, genome projects, genome analysis.
	UNIT V Proteomics: protein information resources, primary and secondary protein data bases, analysis packages, predictive methods, ESTs.
	UNIT VI Phylogenetic analysis; Comparative genome analysis; Microarray bioinformatics.
Practical	Internet search: retrieving information from different data base like NCBI, protein information sources; Preparation of data base; Use of genome analysis packages: genetics data base; Searching by similarity; Phylogenetic analysis; Accessing and submission to gene banks; BLAST, sequence alignments, comparisons. Data base: mining tools, submission of DNA sequences; Sequence alignment and database searching, similarity search, FASTA, BLAST.

FGB 511 COMPUTER APPLICATIONS IN FISH GENETICS 1+1 Objective	
To comprehend the use of software packages for genetic data analyses	
Theory	UNIT I File Transfer Protocols; Work stations; Application of spreadsheets in maintaining fish breeding records; Fish breeding data bases.
	UNIT II Introduction to various computer packages used in genetic analyses: SAS, AsREML, PEST, SelAction; Hendersons' models in breeding experiments.
	UNIT III Software for molecular genetics data analysis; Bioinformatics; Bioinformatic applications and tools in fish genetics and breeding; 'R' statistical package.

Practical	Data input, import, export, modification; Spread sheet in breeding data management; Use of ML and Reml packages for various component estimation; Estimation of genetic parameters using various statistical packages like SAS, AsREML, PEST;, SelAction; Molecular data analysis using softwares like GENEPOP.
------------------	---

FGB 512 CELL AND TISSUE CULTURE 1+1 Objective	
To impart knowledge on cell and tissue culture techniques and their application in health management, gene banking and genetic characterization.	
Theory	UNIT I Introduction: Structure and Organization of animal cell; Equipments and materials for animal cell culture technology.
	UNIT II Cell lines and media: Primary and established cell line cultures; media supplements – their metabolic functions; serum and protein free defined media and their application.
	UNIT III Cell culture: Basic techniques of cell culture in vitro; development of primary cultures, cell separation, maintenance of cell lines; biology of cultured cells, transformation and differentiation of cell cultures.
	UNIT IV Characterization of cell lines: Measurement of viability and cytotoxicity assays; measuring parameters of growth; karyotyping, isozyme assays, cryopreservation, assessment of contaminants.
	UNIT V Cell cloning: Micromanipulation, cell transformation, application of fish cell culture, scaling-up of cell culture.
	UNIT VI Cell hybridization: Somatic cell fusion, hybridoma technology, Production and Application of monoclonal antibodies.
Practical	Principles of sterile techniques and cell propagation; Preparation of different cell culture media; Primary cell culture techniques; Establishing cell lines: isolation, characterization identification of cell lines; Pure culture techniques; Maintenance and preservation of cell lines; Propagation of cells in suspension cultures; Hybridoma technology: strategy and techniques; Production of monoclonal antibodies.

FISH PROCESSING TECHNOLOGY Course Structure - at a Glance		
CODE	COURSE TITLE	CREDITS
FPT 501*	TECHNOLOGY OF FREEZING AND STORAGE	2+1
FPT 502*	THERMAL PROCESSING OF FISHERY PRODUCTS	2+1
FPT 503*	QUALITY ASSURANCE, MANAGEMENT AND CERTIFICATION	2+1
FPT 504*	APPLIED FISH BIOCHEMISTRY	2+1
FPT 505	TECHNIQUES IN MICROBIOLOGY	1+1
FPT 506	CURED, DEHYDRATED AND SMOKED FISHERY PRODUCTS	1+1
FPT 507	HANDLING, STORAGE AND TRANSPORT OF FRESH FISH	1+1
FPT 508	TECHNOLOGY OF MINCE-BASED FISH PRODUCTS	1+1
FPT 509	ADDITIVES IN FISH PROCESSING	1+1
FPT 510	FISH BY-PRODUCTS AND WASTE UTILIZATION	1+1
FPT 511	MICROORGANISMS OF PUBLIC HEALTH SIGNIFICANCE	1+1
FPT 512	DESIGN, MAINTENANCE OF FISH PROCESSING PLANTS AND INSTRUMENTATION	1+1
FPT 513	PACKAGING OF FISH AND FISHERY PRODUCTS	1+1
FPT 591	MASTER'S SEMINAR	1+0
FPT 599	MASTER'S RESEARCH	20

* Compulsory for Master's programme;

FPT 501 TECHNOLOGY OF FISH FREEZING AND FROZEN STORAGE 2+1**Objective**

To give detailed insight into various aspects of freezing of fish.

To provide understanding on chemical, bacterial and sensory changes during freezing.

Theory	UNIT I Freezing: Structure of water and ice, Influence of solutes on the structure of water and ice, phase equilibria and freezing curves of pure water and binary solutions, freezing curve for fish. Determination of freezing points from time- temperature plots, calculation of freezing time.
	UNIT II Crystallization, homogeneous and heterogeneous nucleation, super cooling, crystal growth, eutectic point, location of ice crystals in tissue, physical changes during freezing.
	UNIT III Technological aspects of freezing: Slow and rapid freezing, Methods of freezing, comparison of various freezing methods, selection of a freezing method, product processing, packaging and different types of freezers.
	UNIT IV Chemical treatment prior to freezing: antioxidants, cryoprotectants and other additives, theories of cryopreservation, glazing.
	UNIT V Frozen storage: Physical and chemical changes - freezer burn and recrystallisation, different types of recrystallisation.
	UNIT VI Chemical changes in lipids, proteins and nucleotides, freeze denaturation and theories on denaturation, changes in pH, bacterial changes, sensory changes, texture, taste, odour, effect of post-mortem condition on sensory qualities.
	UNIT VII Water holding capacity, time temperature tolerance, temperature and duration of storage on quality and shelf life.
	UNIT VIII Arrangements within a cold storage, handling and stacking systems, space requirement, precautions to reduce temperature increase in a cold storage.
	UNIT IX Filleting of fish, treatments, glazing, packaging and freezing. Processing of prawns, lobster, squid, cuttle fish, crab etc. for freezing.
	UNIT X Different methods of thawing frozen fish, advantages and disadvantages. Recent advances in fish thawing.
Practical	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. Studies on physical, chemical and sensory changes.

FPT 502 THERMAL PROCESSING OF FISHERY 2+1 PRODUCTS Objective

To provide information on various aspects of thermal / heat processing.

To compare cold sterilization with thermal processing.

To impart knowledge on various types of packaging techniques and materials used in thermal processing.

Theory	UNIT I Principles of thermal processing. Mechanism of heat transfer: conduction, convection, radiation and dielectric and microwave heating, unsteady state of transfer, heat resistance of bacteria and spores, decimal reduction time, thermal death time, "Z" and "F" values, 12D concept, heat penetration, cold point, can size, shape, contents etc. on heat penetration, determination of process time. Significance of thermal death curve, graphical, formula, nomogram methods – F0 value, cook value, D value, integrated F value and their inter-relationship. Heating equipment.
	UNIT II Classification of foods: low acid, medium acid and acidic foods, absolute sterility, statistical sterility, commercial sterility, pasteurisation and

	sterilisation.
	UNIT III Canning process, steps involved, process flow, additives, HTST processing and aseptic canning, principles and process details, canning machinery and equipment, canning process for fish/shellfish, value added and ready to use canned products.
	UNIT IV HACCP and Safety of canned foods and unreliability of post process sampling of canned foods to ensure sterilization. Status of a batch of canned foods identifying CCPs and their monitoring by specially trained personnel.
	UNIT V Spoilage of canned food, physical, chemical and microbial, Thermobacteriology, death of bacteria, autosterilisation bacteriology of canned/heat processed fishery products, examination of cans and seams.
	UNIT VI Canning plant location: Practical considerations, canning plant facilities, layout design.
	UNIT VII Flexible packing, retort pouch processing of fish and fishery products principles and techniques. Combination and synergistic effects.
	UNIT VIII Hurdle technology: Combination with heat, heat and hydrostatic pressure, heat and low pH, heat and NaCl and nitrite, combination with ionising radiation, irradiation and hydrostatic pressure, irradiation and NaCl, irradiation and other adjuncts, heat and irradiation, irradiation and low temperature, low pH and specific acids, low aw and adjuncts like Nisin to reduce severity of heat processing.
	UNIT IX Irradiation: Radiation sources, units, dose levels, radappertization, radicidation, radurization, effects of irradiation on protein, lipids, vitamins, bacteriological aspects, physical properties, shelf life and irradiated fish products.
Practical	Evaluation of pasteurisation and sterilisation, determination of TDT and F value Examination of canned foods, can seams, testing sterility, isolation of Bacillus and Clostridium Spp., spore staining, heat penetration curve and cooling curve, canning operations for different fish/shellfish products. Double seam profile, Heat Penetration Curve, F0 Value, Z value, Process time, Canning of table fishes, Bivalves, Crustaceans in different containers, Operation of over pressure autoclave, Canned culinary preparations, Examination of canned fishery products.

FPT 503 QUALITY ASSURANCES, MANAGEMENT AND 2+1 CERTIFICATION	
Objective	
To understand various aspects of quality assurance system, quality management and national / international certification system. To learn factory sanitation and hygiene, water quality and standard	
Theory	UNIT I Quality management, total quality concept and application in fish trade.
	UNIT II Quality assessment of fish and fishery products - physical, chemical, organoleptic and microbiological quality standards.
	UNIT III Inspection and quality assurance: Fish inspection in India, process water quality in fishery industry, product quality.
	UNIT IV Water quality and standards.
	UNIT V Sensory evaluation of fish and fish products, basic aspects, different methods of evaluation, taste panel selection and constitution, statistical analysis.
	UNIT VI HACCP and Good manufacturing practices. HACCP principles, practical aspects of planning and implementation, verification, validation and

	UNIT VII National and International standards: ISO 9000: 2000 series of quality assurance system, Codex alimentarius, USFDA and EU regulations for fish export trade, IDP and SAT formations in certification of export worthiness of fish processing units, regulations for fishing vessels, pre-processing and processing plants, EU regulations. ISO 22000:2006.
	UNIT VIII Factory sanitation and hygiene: National and international requirements, SSOP, Sanitary and Phytosanitary measures.
	UNIT IX Food laws in India, integrated food law.
Practical	Evaluation of fish / fishery products for organoleptic, chemical and microbial quality. Methods for analysis for bacterial quality parameters, chemical parameters and filth. Evaluation of sanitary conditions in fish processing units. Analysis of typical hazards. Study of correction and corrective action. SQC: Introduction, statistical principles involved, process control, control charts, variable and attribute control charts, Acceptance sampling, basic ideas, sampling by attributes single and double sampling plans, Basic concepts of decision making. Familiarization with water quality analysis.

FPT 504 APPLIED FISH BIOCHEMISTRY 2+1 Objective

To impart knowledge on macro and trace constituents and nutritive value of fish. To create basic understanding about toxins and toxic substances and their toxic effects. To give a detailed insight into experimental techniques used in food analysis.

Theory	UNIT I Seafood proteins: Classification. Sarcoplasmic proteins: Heme proteins, Myoglobin, Hemocyanins, parvalbumins, antifreeze proteins, pigments, enzymes- hydrolases, oxidoreductases, and other enzymes.
	UNIT II Myofibrillar proteins: Myosin – isolation, sub-unit composition, actin, allergins, tropomyosin, troponins, paramyosin, connectin.
	UNIT III Stroma proteins: Connective tissue in the muscle, collagen in fish muscle and skin: location, characteristics of seafood collagen, collagen on the quality of seafoods, gaping.
	UNIT IV Functional properties of seafood proteins: Solubility, emulsification, viscosity, water holding, stability, gelation, texture profile analysis.
	UNIT V Changes in proteins during processing: Denaturation- At high and low temperatures and kinetics, dissociation / aggregation / coagulation, reversibility, significance to processing and quality. Hydrolysis and hydrolysates: Process and applications, proteinases.
	UNIT VI Post mortem biochemical changes, rigor mortis, K-value, TMAO and its decomposition products, demethylase.
	UNIT VII Non-protein nitrogenous compounds: Free amino acids, peptides, nucleotides, guanidins, urea, quaternary ammonium compounds etc.
	UNIT VIII Seafood lipids: Composition and nutritive value, lipid types and their variations, lipid fractionation, estimation of lipid fractions, triglycerides, phospholipids, non-saponifiables including sterols and vitamins. Polyunsaturated fatty acids and prostaglandins- beneficial effects on human
	UNIT IX Fatty acid composition of fish liver and body oils, auto-oxidation of fatty acids, rancidity, lipases and phospholipases, pro- and anti-oxidants, oxidation indices, lipid-protein interactions, oxidized lipids-protein interactions and their impact on quality.
	UNIT X Macro and trace elements in fish and shellfish; Vitamins and Minerals of nutritional significance, toxic metals and their harmful effects and metallothionines.

	UNIT XI Flavour and pigments; amines, volatile fatty acids, carbonyls, sulphur containing compounds, carotenoids, isoprenoids in fish.
	UNIT XII Biogenic amines, Aflatoxins in cured fish.
	UNIT XIII Principles and methods involved in the separation and analysis of fish muscle constituents: Thin layer, paper and column chromatography, spectrophotometry, colorimetry, flame photometry, atomic absorption spectrophotometry, paper, disc and slab electrophoresis.
Practical	Molarity, normality, acid-base, redox titration, buffers. Lipids – Fractionation by TLC and other chromatographic techniques. Fatty acid composition by GLC, Amino acid analysis by HPLC. Protein purification methods: (NH ₄) ₂ SO ₄ /solvent precipitation. Ultracentrifugation, dialysis and ultrafiltration, gel filtration, electrophoresis, PAGE and SDS-PAGE, Marine polysaccharides for food use, molecular biology techniques in fish and bacterial identification, and topical subjects.

FPT 505 TECHNIQUES IN MICROBIOLOGY 1+1 Objective	
To learn basic techniques in Microbiology.	
Theory	UNIT I Safety in Microbiology laboratory – Prevention of contamination, aerosol sampling, disinfection and evaluation of disinfectants.
	UNIT II Microscopy – bright-field, fluorescence, phase-contrast, dark ground and electron microscope.
	UNIT III Staining techniques – Types of stains and chemistry of staining.
	UNIT IV Sterilisation – Principles of various physical and chemical methods of sterilisation.
	UNIT V Nutritional requirements of microorganisms – constituents of growth media, requirement of fastidious organisms alternate nutrition, different types.
	UNIT VI Isolation, enumeration, preservation and maintenance of cultures - growth curve, different types of cultures, population estimation techniques.
	UNIT VII Routine tests for identification of bacteria - morphological, cultural, biochemical and serological. Anaerobic bacteria - methods of anerobiosis. Basics of mycological and virological techniques. Introduction to molecular techniques in Microbiology.
Practical	Microscopic techniques, isolation, enumeration and identification of microorganisms, serological techniques, anaerobic bacteria, mycological, virological and molecular techniques.

FPT 506 CURED, DEHYDRATED, SMOKED FISHERY 1+1 PRODUCTS Objective

To create understanding on various scientific preservation techniques of fish.

To impart knowledge on changes during storage of products.

Theory	UNIT I Free and bound water in foods, water activity and sorption behaviours of foods, storage characteristics, microbial spoilage, effects of water activity on chemical deterioration, enzymatic reaction, non-enzymatic browning, lipid oxidation, reaction between lipids and proteins, dry fish, control of micro-
	UNIT II Principles of drying and dehydration: Psychometrics, drying calculation, constant rate and falling rate, drying time in air, moisture transport mechanism, natural drying, solar drying and mechanical drying. Different types of dryers: tunnel drier, vacuum drier, drum drier, solar drier etc.
	UNIT III Freeze drying, preparation and its nutritive value.
	UNIT IV Dehydration of fish products: dehydration ratio, precautions to be taken in fish drying; denaturation of fish protein.
	UNIT V Cured fish, types of salt curing, use of salt, factors affecting salt uptake by fish, lean and fatty fish, whole, gutted or split open, type and size of salt crystals, source of salts and impurities in salts, effect of impurities on salt penetration, temperature of salting.
	UNIT VI Spoilage of dried / cured fish, physical, chemical and microbiological changes, methods to prevent / control spoilage, extension of shelf life.
	UNIT VII Fermented products: different methods of fermentation, indigenous products and their principles of preservation.
	UNIT VIII Smoke curing, chemistry of smoke, composition and properties, smoking methods: cold and hot method, use of smoke liquids, production of smoke, type of wood used, methods of smoke generation, carcinogens in smoke, smoke kilns.
	UNIT IX Marinades: Principles; processing of cold, cooked and fried marinades, shelf life and spoilage.
	UNIT X Fish and shellfish pickles: production, shelf life.
	UNIT XI Packaging requirements for dry, cured and fermented products.
Practical	Preparation of dried, cured and fermented fish products, examination of salt, protein, moisture in dried / cured products, examination of spoilage of dried / cured fish products, marinades, pickles, sauce.

**FPT 507 HANDLING, STORAGE AND TRANSPORT OF 1+1 FRESH FISH
Objective**

To teach scientific techniques of handling, storage and transport of fresh fish.

To teach various post harvest changes during chill storage of fish.

Theory	UNIT I Structure of fish myosystems, Postmortem changes - Structural and chemical.
	UNIT II Fish as raw material for processing: Body structure, physical properties, shape, specific weight, bulk weight, angle of slip, weight composition.
	UNIT III Factors affecting quality of fresh fish: intrinsic and extrinsic factors.
	UNIT IV Handling of fish onboard fishing vessels, Unit operations.
	UNIT V Unloading fish, Fish pumps.
	UNIT VI Post-harvest Fishery losses, Methods to reduce losses.
	UNIT VII Handling of fish in landing centers, defects and modifications needed.

	UNIT VIII Chill storage of fish: Heat load calculation, storage methods. insulated boxes and insulation thickness, different types of ice, physical, chemical, microbiological and sensory changes during chill storage, iced storage shelf life, cold shock, physical, chemical and sensory methods of analysis.
	UNIT IX Different types of ice and their advantages.
	UNIT X Sous-vide technology.
	UNIT XI Melanosis and its prevention, discolouration in aquatic products, non-enzymatic browning.
	UNIT XII Depuration of bivalves.
	UNIT XIII Transportation: Live fish/shell fish, Transportation of raw fish to local markets and processing centres, Improvements needed in transportation, Refrigerated transport systems, Classification of transport vehicles, Cold chain.
Practical	Chill storage studies: Chemical, physical and sensory analysis, determination of shelf life. Handling of fish, bivalves, prawns, mollusks, Depuration, treatment with chemicals, evaluation of freshness of fish.

FPT 508 TECHNOLOGY OF MINCE BASED FISH 1+1 PRODUCTS Objective	
To provide knowledge on basic principles and advanced technologies in processing of mince based fish products.	
Theory	UNIT I Composition of muscle proteins in fish and their role in emulsification and elasticity formation.
	UNIT II Factors influencing denaturation of muscle proteins and their theories. Methods to testing protein denaturation.
	UNIT III Factors influencing elasticity formation and theories of gel formation. Minced meat preparation from different varieties of fresh water and marine water fishes.
	UNIT IV Improvement of colour of meat using bleaching and certain additives. Use of anti-denaturants to prevent denaturation of proteins of fish mince during storage. Changes in meat during mincing and mixing operations and cooking and setting phenomena.
	UNIT V Technology of processing and preservation of gel forming fish flour (AFPP), its property and utilisation. Unit operations in analog product preparation- Crab sticks analogs, moulded lobsters and crabs.
	UNIT VI Battered and breaded products: different types and their preparation, nutritional and economic significance of products.
	UNIT VII Use of emulsifiers, binders, seasonings, spices, antioxidants, smoke extract, Preservatives, natural and artificial casings, nitrites and nitrates. Fortification of fish products with vitamins and minerals. Quality standards and recent developments.
Practical	Measurement of viscosity of fish proteins by Ostwald viscometer, effect of water washing on the quality of meat, colour fixation of red colour meat and estimation of nitrite. Studies on setting of fish meat. Estimation of starch in the final paste product. Fundamentals of controlled stress Rheometer. Effect of two stage heating of fish sol on gel strength.

FPT 509 ADDITIVES IN FISH PROCESSING 1+1 Objective	
To familiarize with the use of different additives, their effects, levels and detection.	
Theory	UNIT I Introduction to food additives-definition-technical benefits of food additives-intentional and incidental additives.
	UNIT II Relationship of great revolutions in history to the development of food additives – Agricultural Revolution-Industrial revolutions – urbanization.
	UNIT III Intentional additives – use of specific nutrients as food additives – Requirements and considerations. Minerals, vitamins, amino acids and nutrient concentrates as additives, Incidental additives.
	UNIT IV Policy considerations in the use of food additives. Flavours and colour as additives.
	UNIT V Antioxidants – Mechanism of antioxidants; commercial antioxidants and selections.
	UNIT VI Analytical methods for antioxidants.
	UNIT VII Acidulants in food processing; Sequestrants in food processing; Polyphosphates in fish processing.
Practical	Determination of food additives such as preservatives, antioxidants, curing agents, chelating agents, acidulants and phosphates in various food products. Detection of certain intentional and unintentional food additives in foods.

FPT 510 FISH BY-PRODUCTS AND UTILIZATION OF 1+1 FISHERY WASTE Objective	
To provide information on various fish by-products, utilization of fishery wastes and their nutritional value.	
Theory	UNIT I Fish meal: Production - dry and wet process, machinery, control of quality of products, specifications, packaging and storage.
	UNIT II Fish body and liver oils: Extraction, purification, preservation and storage, industrial and nutritional applications of fish oils. Vitamin A and D.
	UNIT III Essential fatty acid functions of fish oils, poly-unsaturated fatty acid (PUFA), production of concentrates of polyunsaturated fatty acids, preparation of fatty alcohol and amides.
	UNIT IV Utilisation of shark: Processing of shark meat, removal of urea in meat, filleting, curing and dehydration, extraction of shark liver oil, Vitamin A, D, squalene, ambergris, curing and tanning of shark skin, shark cartilage.
	UNIT V Shrimp waste, crab shell and squilla utilisation: Resources and composition, conventional uses, feeds and manure, conversion to useful materials like chitin, chitosan, glucosamine hydrochloride, shrimp extract, commercial production, production and use of protein isolates from squilla and shrimp waste.
	UNIT VI Fish protein concentrate: Different methods of production, functional properties, different types of FPC, texturised products and comparison of FPC to fish meal.
	UNIT VII Fish silage: Acid silage and fermented silage, advantages over fish meal, nutritional value of silage.
	UNIT VIII Fish hydrolysates: Production and utilisation, biochemical composition and importance in food and nutrition.
	UNIT IX Miscellaneous by-products: Fish maws and isinglass, pearl essence, fertilizer, beche-de-mer, processing of snail meat and jelly fish.
Practical	Preparation of fish meal, FPC, fish oils, chitin, chitosan, glucosamine hydrochloride, fish maws, isinglass, agar, alginic acid, , glue, pearl essence, fish sauce.

FPT 511 MICROORGANISMS OF PUBLIC HEALTH 1+1 SIGNIFICANCE	
To acquaint students regarding bacteria, virus and parasites; food-borne diseases and their prevention.	
Theory	UNIT I Infection and immunity; diseases and their classification, spreading and contamination, host resistance.
	UNIT II Bacteria of public health significance in fish/fishery products/environments -Salmonella, Clostridia, Staphylococcus, E. coli, Streptococcus, Vibrio, Aeromonas, Listeria, Yersinia, Bacillus. Laboratory techniques for detection and identification of food poisoning bacteria.
	UNIT III Food-borne bacterial infections. Food infections by Salmonella, Clostridium perfringens, Vibrio parahaemolyticus, Enteropathogenic E. coli, Aeromonas hydrophila etc., the nature of causative agent, its source, incidence, foods involved, the diseases, conditions for outbreak and prevention. The etiology of diseases: Conditions for outbreak and prevention.
	UNIT IV Botulism and staphylococcal food poisoning, organism responsible and their origin, growth and toxin production, nature of toxins, incidence of poisoning, foods involved.
	UNIT V Food borne non-bacterial infections and intoxications: Aflatoxins, patulin, ochratoxin and other fungal toxins found in food, toxin producer, source, nature of toxin, toxicity and significance in foods.
	UNIT VI Virus and Parasites found in foods.
Practical	Laboratory techniques to detect and identify pathogens in fish - E.coli, Staphylococcus aureus, Streptococcus faecalis, Clostridium perfringens, Clostridium botulinum, Salmonella, Listeria, Vibrio cholera, Vibrio parahaemolyticus, V. vulnificus, Animal bio-assay of bacterial toxins.

FPT 512 DESIGN, MAINTENANCE OF FISH PROCESSING 1+1 PLANTS AND INSTRUMENTATION Objective	
To expose the students to design, maintenance of fish processing plant, machinery and the instruments used in fish processing plants.	
Theory	UNIT I Plant design: Fundamentals of processing plant design: Site selection, design and preparation of layout of processing plants - freezing plant, cold storage, canning plant, dryers etc.
	UNIT II Functions and construction of refrigeration system: Tests and inspection, Operation and handling, P-H diagram and basic calculation - Application of P-H diagram, size and required power of compressor, maintenance of refrigerating machine, troubles and causes.
	UNIT III Preventive maintenance of machinery and equipment of fish processing plants, IQF, Canning plant, sausage plant, artificial dryers, smoking chambers etc., safety controls for freezing and canning plant.
	UNIT IV Effluent treatment: Legislation and standards of effluent discharge, water pollution control measures in the food industry, waste water treatment process; dissolved air floatation, sedimentation, chemical treatment, biological treatment, aeration, carbon adsorption, granular media filtration and sludge handling. Boilers - Classification and selection of boilers, Boiler mounting and
	UNIT V Measurement techniques; Sensors, active and passive sensors, characteristic of sensors for the measurement of temperature, relative humidity, aw value, gel strength, moisture, freshness, pH, conductivity, DO, redox potential, salinity, air velocity, solar energy and brine concentration.
	UNIT VI Thermometers: Different types of thermometers, characteristics and application.

	UNIT VII Instrumentation techniques: General configuration of instrumentation system. Instrumentation for measurement of aw value, temperature, pH, freshness, gel strength, salinity, brine concentration.
	UNIT VIII Thermal properties of foods: Calorie, heat loss, heat gain, specific heat, Newton's laws of cooling, heat transfer, latent heat, laws of fusion, thermal conductors, thermal diffusivity.
Practical	Design and Maintenance of Fish Processing Plants; Operation and maintenance of machinery and equipment for cold storage plant, freezing plant, canning plant, sausage making, dryers, boilers etc. Assembly of a refrigeration unit and charging refrigerant. Instrumentation; Measurement of temperature inside cold storage / freezer, fish during freezing and thawing. Estimation of Gel strength. Measurement of solar radiation, air velocity, air temperature. Measurement of salinity, conductivity, pH. Estimation of water activity.

FPT 513 PACKAGING OF FISH AND FISHERY PRODUCTS 1+1 Objective	
To learn about different packaging materials, their appropriate use and benefits.	
Theory	UNIT I Food packaging, its purposes and procedures; technological aspects of packaging fishery products; packing of fresh and frozen fish for consumers; packaging for transport, shipping and institutional supplies; packaging standards for domestic and international trade.
	UNIT II Packaging materials; basic films and laminates, their manufacture and identification; resistance of packaging materials; development of protective packaging for fishery products.
	UNIT III Methods of testing for packaging materials for their physical properties; containers and their testing and evaluation; package designs; resistance of packages to hazards in handling; transport and storage.
	UNIT IV Modified atmosphere packaging, controlled packaging and aseptic packaging.
	UNIT V Labelling and printing of packaging materials.
Practical	Assessment of quality parameters such as moisture permeability, grease resistance, thickness/guage of basic plastic films and laminates. Quality assessment of paper and board and the products prepared from them. Evaluation of packages with regard to the resistance to handling, transportation and storage.

FISHERIES EXTENSION Course Structure - at a Glance		
CODE	COURSE TITLE	CREDITS
FEX 501*	PERSPECTIVES AND PRACTICES OF FISHERIES EXTENSION	2+1
FEX 502*	EXTENSION COMMUNICATION AND METHODS	2+1
FEX 503*	PARTICIPATORY APPROACHES IN FISHERIES EXTENSION	2+1
FEX 504*	TRAINING FOR HUMAN RESOURCE DEVELOPMENT	2+1
FEX 505	COMMUNITY MOBILISATION AND ORGANISATIONAL DEVELOPMENT	1+1
FEX 506	DIFFUSION AND ADOPTION OF INNOVATIONS IN FISHERIES	1+1
FEX 507	MULTIMEDIA CREATIONS AND APPLICATIONS	0+2
FEX 508	PLANNING AND MANAGEMENT OF DEVELOPMENT PROGRAMMES	1+1
FEX 509	HUMAN RESOURCE MANAGEMENT	1+1
FEX 510	GENDER, LIVELIHOOD AND DEVELOPMENT	1+1
FEX 511	DEVELOPMENT JOURNALISM	1+1
FEX 512	INDIGENOUS TRADITIONAL KNOWLEDGE IN FISHERIES	1+1
FEX 513	COMMUNITY BASED DISASTER MANAGEMENT	1+1
FEX 591	MASTER'S SEMINAR	1+0
FEX 599	MASTER'S RESEARCH	20

* Compulsory for Master's programme ;

FEX 501 PERSPECTIVES AND PRACTICES OF FISHERIES 2+1 EXTENSION**Objective**

To gain insights into different concepts, principles, praxis, recent changes and emerging challenges in fisheries extension. To acquire skills required to practice various fisheries extension approaches.

Theory

UNIT I Overview of fisheries and aquaculture sector in India and world; Special characteristics of fisheries sector and its stakeholders; Understanding extension education, research, and service; Overview of fisheries research, development and extension systems in India; Scope and importance of fisheries and aquaculture extension.

UNIT II Critical review of philosophy, principles, concepts, and practices of fisheries extension systems and approaches; Teaching, learning and co-learning; Epistemology of knowledge in fisheries – ITK vis-à-vis lab generated knowledge.

UNIT III Fisheries extension – advantages and limitations of present welfare and subsidy oriented extension systems; Development and extension approaches as practiced by public agencies like Department of Fisheries, KVKs, Agricultural Technology Management Agency (ATMA), NGOs, FAO, Bay of Bengal Programme (BOBP-IGO), and by the private sector; participatory fisheries extension approaches.

UNIT IV Aquaculture extension system - review of extension approach as practiced by DoF, FFDA, and BFDA; Market led extension approaches; Importance of Information and Communication Technology (ICT) in fisheries extension system.

Practical

Exercises on development of extension and field manuals; Exercises on participatory learning / co-learning; Case study of extension approaches practiced by select State Departments of Fisheries, FFDA's / BFDA's, select NGOs, AMUL model; case study of market led extension approaches like e-choupal choupal, Agri Business Clinics, etc.; Critical review of experiences and lessons from fisheries extension practices from across the world; case study on the use of ICT for fisheries development; Field exposure by visiting established extension projects.

FEX 502 EXTENSION COMMUNICATION AND METHODS 2+1 Objective

To learn different communication strategies used in mass, group and personal contact methods of extension programme. To get hands on training in application of extension methods and communication aids.

Theory	UNIT I Communication - meaning, process, theories and models; Traditional communication; Individual, group and mass communication, levels of communication; non-verbal communication; AV aids – selection and use.
	UNIT II Communicator -role of communicator in extension education, communicator's behaviour; communication skills; fidelity of communication; communication competence and empathy; communication effectiveness and credibility; improving oral and written communication; message – meaning, dimensions, characteristics, treatment and effectiveness, distortion of message; simulation exercises; channels of communication – meaning, dimensions, classification, selection, efficiency, credibility, use; audience or receivers; feedback; communication behaviour; social network – homophily and heterophily.
	UNIT III Communicating with fishers and fish farmers; barriers in communication; communication and social change; futuristic shape of communication technologies.
	UNIT IV Recent communication technologies – Internet based technologies, video and teleconferencing, computer assisted instructions, Information kiosks, Village Resource Centres, Community networks, WAN, MAN, AGRINET, e-Governance; Cyber extension and e-learning.
Practical	Exercises in written and oral communication; documenting and presenting success stories in fisheries, AV aids - rationale and preparation of AV aids with local resources; public speaking and presentation skills; organising meetings, guided discussions; organizing field demonstrations and field-days; preparation of information, education and communication materials on various aspects of fisheries; instructional video and ICT; Practicing tele and video conferencing, case study of a community radio, tele-centres and farmer discussion groups; designing a website on fisheries and aquaculture; developing a script and shooting a video film as an extension aid; Development and use of e-learning modules.

FEX 503 PARTICIPATORY APPROACHES IN FISHERIES 2+1 EXTENSION**Objective**

To gain knowledge on participatory approaches in fisheries extension programmes.

To gain practical experience in participatory approaches and techniques.

Theory	UNIT I Participatory approaches for aquatic resources management and development: need, importance and guiding principles; Community mobilization methods - Farmer-First Approach; Trickle Down System – concept, method and processes; Knowledge Driven Extension System – concept and method.
	UNIT II Community based fisheries management and Fisheries co-management – concept, origin, importance, types, method, processes, stakeholder rights, responsibilities and participation, institutional mechanisms, implementation constraints, experiences from other countries; conflict resolution and management; Public-Private-Community Partnership.
	UNIT III Participatory Learning Approach (PLA) including role-plays, case studies, brainstorming, and ranking of priority issues, discovery-based experiential learning, participatory education methods like FGD; Participatory appraisal techniques - census mapping, resource mapping, social mapping; selection of participatory methods and their uses; Farmer Field Schools for Aquaculture.
Practical	Conducting Participatory Rural Appraisal in select villages and developing action plans; Conducting focused group discussion and developing action plan; Facilitating group formation based on the felt needs and to implement the action plans / plan of work; Reviewing national and international case studies on participatory approach to aquaculture research and development; case studies and simulation exercises on fisheries co-management / community based fisheries management.

FEX 504 TRAINING FOR HUMAN RESOURCE 2+1 DEVELOPMENT Objective

To learn the design and methods of conducting training programmes for the trainers, fishers and fish farmers.

To acquire hands-on practice in use of training aids and tools.

Theory	UNIT I Human Resource Development – Concept and significance; Education, learning and training; Instructional design and educational technology; Theories of learning -radical behaviorism, cognitivism, constructivism; training and development; Gender sensitive training.
	UNIT II Types of Training -Induction, on-the-job, off-the-job, in-service, customized, inception, trainers’, participatory, web-based, fishers/fish farmers’, farmer-led, vocational and echo-training; Training tools like T-Group, Fish bowl exercise, ice-breakers, team-building exercises and games; workshop and writeshop.
	UNIT III Preparation of Training Manuals- content writing; Training cycle - training need assessment, developing training objectives and outcome, developing training modules and lesson plan, logistic management and evaluation of training programme, follow-up and action plan.
	UNIT IV Facilitating Community Mobilization Process - Perception of service delivery system, level of expertise and capacity amongst the community to facilitate such services, willingness of the community to match individual interests with community interest, facilitation of resources for mobilizing community; Promoting Public-Private-Community Participation.

Practical	Training need assessment for different clientele groups; Designing training tools and manuals on fisheries; Organising and conducting fisheries training programmes; Evaluation of training; Impact studies in terms of results (output, outcome and impact); Team building exercises.
------------------	--

FEX 505 COMMUNITY MOBILISATION AND ORGANISATION 1+1 DEVELOPMENT Objective
--

To gain insights into the relevant know-how on the structure and functions of community institutions. To acquire competency and confidence to bring about desirable social change by organizing communities.

Theory	UNIT I Sociological and psychological perspectives of social institutions, culture, community and community organization; functions of community; rural sociology and its relevance to extension education; social stratification; social changes, conflict in rural society.
	UNIT II Communities as vehicles of change; community mobilization - entering, submerging, empowering and governance; outreach, community centres and services; models of community organization in developing countries; social action; challenges in mobilization, advocacy, coalition building and networking, facilitation and mediation; role of NGOs.
	UNIT III Rural development – rural context and livelihood, rural poverty, policies, programmes and interventions; rural local self governance – Panchayati Raj; rural-urban migration, social problems, displacement and rehabilitation; rights of indigenous communities; community participation for natural resources management; strategies of developmental intervention; international processes and implications for local communities; leader and leadership – types, role, theories and its implication for development; motivation – theories, types and importance; social perceptions, influence and relationships; attitudes; emotion
Practical	Approach to and strategies of community organizing – study of specific cases/illustrations of strategies and efforts on a range of issues that have been effective; exercises on community organisation; identification of village leaders and their role in community development; cases on social, cultural and technological changes; Preparing investigative report of fishing/fish farming village considering culture, language, values, norms, institutions, social organization, groups, social stratification, social conflict, etc.

FEX 506 DIFFUSION AND ADOPTION OF INNOVATIONS 1+1 IN FISHERIES Objective

To impart knowledge on diffusion of fisheries innovations.

To be able to critically analyse the innovation decision processes in the fisheries sector.

Theory	UNIT I Elements of diffusion; diffusion research – history, typology, contributions and criticisms; generalising diffusion via meta research; innovations in fisheries – innovation development process, socio-economic status, equality and innovation development, converting research into practice; Critique on Rogers’ innovation decision process, innovation attributes and
	UNIT II Opinion leadership – meaning, characteristics, types and their measurement; diffusion networks; social learning theory; Change agent – meaning, roles, factors of success, change agent contact; centralised and decentralised diffusion systems; innovation in organisations - contract farming – merits and demerits; consequences of innovations – model and classification, equality in the consequences; recent studies in innovation decision process.

Practical	Case study of the diffusion process of select fisheries innovations; Analysing the factors influencing adoption and rejection of fisheries technologies and practices; case studies of select innovation diffusion models like AMUL, Grameen Bank, and WADI-NABARD/BAIF; case study of decision making pattern in fisher villages and the role of men, women and youth; case studies on opinion leaders and change agents in transfer of fisheries technologies; field visit to study select models of ToT.
------------------	---

FEX 507 MULTIMEDIA CREATIONS AND APPLICATIONS 0+2 Objective	
To acquire competence and hands-on skills on preparation and application of various multimedia tools.	
Practical	Multimedia Environment - Multimedia hardware devices, Multimedia software tools, Multimedia content creation and integration process; Graphics and effects – scanner, other image capture methods; Image editing and 2D Animation using Photoshop; Vector graphics using Corel Draw; Digital Audio - Basic features and digitization, audio recording and dubbing, audio card, non-linear editing and mixing of different audio formats, audio editing and composing of music, special effects; Script development and Story board preparation; Digital Video - analog and digital video, video recording, capturing and conversion into different video file formats, video editing, special effects; Organization of content -choice of media, categorization of photographs, queuing of audio and video clips, logical sequencing, text entry; Multimedia Authoring - concepts, navigation planning and hyper linking; User friendly tools - MS Office Power point, Macromedia Director; Preparation of multimedia presentation; CD/DVD writing, labeling and presentation.

FEX 508 PLANNING AND MANAGEMENT OF FISHERIES 1+1 DEVELOPMENT PROGRAMMES Objective	
To understand different aspects of planning processes. To acquire competency to plan, implement, monitor and evaluate extension and development programmes.	
Theory	UNIT I Importance, principles and processes in developing extension programmes; Planning for sustainable development, Economic Planning- types of planning; Planning strategies at various levels- Top down and bottom up approaches. Panchayati Raj institutions; Execution of various programmes, Plan allocation and performance of fisheries over the different plan-periods in India.
	UNIT II Project preparation and project appraisal in terms of social benefit analysis, shadow prices; Project Management Techniques - PERT and CPM; Logical Framework Approach (LFA), Stakeholder analysis; Participatory Monitoring and Evaluation (PROME); People’s participation in extension programmes, significance, importance and approaches.
	UNIT III Critical analysis of Agriculture, Fisheries and Rural Development Programmes; design, operation, institutional mechanism and socio-cultural and economic impact of programmes such as NREGA; labour market relations; Fisheries development vis-à-vis fisheries for development; Livelihood Frameworks.
Practical	Need assessment, setting objectives, developing plan of work, Success indicators, Impact assessment of fisheries development programmes, SWOT analysis; Exercises on PERT and CPM Presentation of Fisheries and Aquaculture policies of select countries; Study visits to selected extension project areas – DOE, KVKs, SAUs, and ICAR institutes.

FEX 509 HUMAN RESOURCE MANAGEMENT 1+1 Objective	
To familiarize the students with the basic concepts of Human Resource Management with special reference to organizations in fisheries sector.	
Theory	UNIT I Concept of management: Definition, Management process (planning, organising, staffing, leading and controlling), Managerial levels and roles. Evolution of management theories: Scientific management school, Classical organization theory school, Behavioural school, Management science school.
	UNIT II Concept of Human Resource Management(HRM), Primary activities of HRM (staff, training and development, motivation, maintenance), HR process (HRP, recruitment, selection, socialization, training and development, performance appraisal, promotion, transfer, demotion, separation).
	UNIT III HR out sourcing, Understanding equal opportunity: Guarding against discriminatory practices, glass ceiling, Managing careers: Concept of career, individual and organisational perspective, career development versus employee development, internal, external events and career stages, mentoring and
	UNIT IV Compensation dynamics: Contracts for compensation, efficiency wages, wage earning and sharing, ownership options, screening, signalling, designing of contract, types of rewards, job evaluation and establishing pay structure, executive, international and special compensation plans, employee benefits, safety and health programmes, labour relations and collective bargaining. Corporate social responsibility.
Practical	Applying management functions in a real setting; developing managerial games; creativity and problem solving techniques; understanding different perceptions and avoiding perceptual distortions; analysing different needs of a diverse work place; performance evaluation; psychometric testing; developing training module for leadership and motivation; exercises on time management.

FEX 510 GENDER, LIVELIHOOD AND DEVELOPMENT 1+1 Objective	
To gain knowledge on issues related to gender, livelihood and development. To understand the trade off between gender, livelihood and development.	
Theory	UNIT I Theoretical foundations of gender: Social construction of gender, patriarchy, family and household; Gender and Livelihood - Concept of livelihood, work, access and control of natural resources, Livelihoods in transition; Gender and Development - women in development (WID), women and development (WAD) gender in development (GID), gender and
	UNIT II Indicators of status- Physical Quality of Life Indices (PQLI), Human Development Index (HDI); Rural-urban migration; Impact of fisheries development on men and women, Development strategies, Integrated model of development, microfinance, SHGs, vocational training and development , equality, constitutional protection; Planning and development for change.
Practical	Developing case studies on social and gender issues in fisheries; Case studies on Rural –urban migration; Assessment of the social indicators – PQLI and HDI; Evaluation of the performance of the SHGs; Exercises on social and gender sensitive policies; Case studies on gender relations in fisheries / rural development programmes such as NREGA.

FEX 511 DEVELOPMENT JOURNALISM 1+1 Objective	
To gain critical awareness and reflective ability necessary to identify, articulate and analyse major issues in fisheries development. To gain knowledge on the different skills applicable in journalism.	
Theory	UNIT I Media industry, concepts and theories in practice of news writing; relating theories of journalism to professional practice; Development journalism – meaning, principles, importance and scope; Basics of news production – gathering and selecting news, writing news for newspapers, magazines, farm bulletins and folders, editorial writing, feature writing, headline and cutline writing, news collection and interview, photography and art, copyediting and proofreading, word processing, computer layout and design.
	UNIT II Editing and design - introduction to news selection and emphasis; techniques and skills for editing print news media; critical analysis of layout and design conventions of print news media.
	UNIT III Magazine journalism - profile and feature writing; Radio and television journalism - principles and practices of gathering, writing and producing news for radio and television; Photo journalism - visual language, skills and techniques; New media journalism – websites and blogs, writing, editing and site design skills for online journalism; Responsible journalism - fairness and balance, libel, and the commercial nature of the media, constructive criticism; advertisements – principles and practice; careers in journalism.
Practical	Identification, articulation and analysis of major issues related to fisheries development; critical analysis of fisheries related news stories and feature articles from development magazines / news papers; Gathering and writing news stories, feature articles and editorials; Designing, editing and publishing campus news letters; interface with editors of journals and magazines; Critical analysis of fisheries related radio news stories; Producing radio news items for broadcast; digital photography and image editing; designing and developing a theme based website / blog; Visits to select printing presses, media organizations and news agencies.

FEX 512 INDIGENOUS TRADITIONAL KNOWLEDGE 1+1 IN FISHERIES Objective	
To learn different indigenous knowledge systems and their importance in fisheries.	
Theory	UNIT I Indigenous knowledge - historical perspective, terminologies, concepts, systems, Importance, Relevance and roles in fisheries sector; Reasons for the non adoption of technical knowledge; Indigenous vis-a-vis scientific knowledge.
	UNIT II Types of indigenous knowledge; Information, practices and technologies; Beliefs, tools, materials, documentation, validation and dissemination of ITK; Peoples' Biodiversity Register; Accessing the indigenous knowledge; Constraints of indigenous knowledge, conserving ITK.
	UNIT III Issues in protection of traditional knowledge / ITK - understanding Indian Biological Diversity Act and National Biodiversity Authority, - limits to benefit sharing – IPR, PIC, TRIPS vs. CBD; Blending indigenous knowledge and modern technologies.
Practical	Documentation of ITK in fisheries; Development of case studies of ITK in fisheries; Institutions and NGOs involved in ITK collection and validation.

FEX 513 COMMUNITY BASED DISASTER MANAGEMENT 1+1 Objective

To familiarize with different disasters and their impact.

To get acquainted with the strategies and methods to cope up with disasters.

Theory	UNIT I Basic concepts: Hazard, risk, vulnerability, disaster, capacity building. Multi-hazard and disaster vulnerability of India.
	UNIT II Types of natural and manmade hazards in fisheries and aquaculture - cyclones, floods, droughts, tsunami, El-nino, la nina, algal blooms, avalanches, pollution, habitat destruction, over fishing, introduction of exotic species, landslides, epidemics, loss of bio-diversity.
	UNIT III Climate change and global warming; Issues related to depletion of water resources; Causes, characteristics and impact of various disasters.
	UNIT IV Management strategies: pre-disaster, during disaster and post-disaster; Pre-disaster - prevention, preparedness and mitigation; different ways of detecting and predicting disasters; early warning, communication and dissemination, community based disaster preparedness, structural and non-structural mitigation measures; During disaster: response and recovery systems at national, state and local, coordination between different agencies, international best practices; Post-disaster: Methods for assessment of initial and long term damages, reconstruction and rehabilitation.
	UNIT V Prevalent national and global management practices in disaster management. Agencies involved in monitoring and early warnings at district, state, national and global level; Sea safety and health.
Practical	Methods for assessment of initial and long term damages. Preparedness in pre, during and post disasters. Acquaintance with fire-fighting devices. Life saving appliances and first-aid. Operation and usage of communication channels and media. Uses of distress signals and technologies. Relief and rehabilitation measures, trauma counseling. Field visits and case studies. Group discussion.

FISHERIES ENGINEERING AND TECHNOLOGY
Course Structure - at a Glance

CODE	COURSE TITLE	CREDITS
FET 501*	ADVANCED FISHING GEAR TECHNOLOGY	2+1
FET 502*	ADVANCED FISHING CRAFT TECHNOLOGY	2+1
FET 503*	RESPONSIBLE FISHING	2+1
FET 504*	REFRIGERATION AND ELECTRICAL ENGINEERING	2+1
FET 505	MARINE ENGINEERING	1+1
FET 506	AQUACULTURAL ENGINEERING	1+1
FET 507	ENGINEERING GRAPHICS	0+1
FET 508	FISHING HARBOUR AND FLEET MANAGEMENT	1+1
FET 509	ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL	1+1
FET 510	SEA SAFETY AND DISASTER MANAGEMENT	1+0
FET 511	FISH PROCESSING MACHINERY	1+1
FET 512	ACOUSTICS, NAVIGATION AND SEAMANSHIP	1+1
FET 591	MASTER'S SEMINAR	1+0
FET 599	MASTER'S RESEARCH	20

* Compulsory for Master's programme;

FET 501 ADVANCED FISHING GEAR TECHNOLOGY 2+1 Objective

To learn advanced fishing gear technology, design modification of existing fishing gears and selectivity studies of various fishing gears.

Theory	UNIT I Fishing gear design – Conventional and current practice for the representation of fishing gear by scale drawing; The use of computers in the scale drawing of fishing gear to determine the defects in gear, design to develop new gears.
	UNIT II Selection of fishing gear, analysis of the parameters of specific fishing gears and the derivation of empirical relationships for use in the design process.
	UNIT III Design of bottom, mid-water and surface trawl; gill nets and tangle nets; types of gill nets-single-walled gill nets, framed gill nets tangle nets and their technical characteristics, two and three walled trammel nets, combined gill nets; traps – their classification and general principles of construction.
	UNIT IV Design of stake nets; fyke nets; purse seine, hooks and lines, long lines and trolling gear.
	UNIT V Attraction of fish – fishing with electricity; Light fishing, fish pumps; operation and mechanization of long lining.
	UNIT VI Factors to be considered in gill netting in selection of meshes for the different fishes. Aided fishing using the modern electronic devices like echo sounder, Sonar and trawl eye.
	UNIT VII The selectivity of trawl fishing gears, design of otter boards for various types of trawl fishing.
	UNIT VIII Case studies relating towed, surrounding and static fishing gear and their energy consumption.
	UNIT IX Fishing gear testing – full scale and model testing in flume tanks, methods of testing a fishing gear.
	UNIT X The influence of design features on the overall economic performance of fishing gears.
Practical	Exercises on scale drawing of different types of fishing gears. Use of cadnet programme in the design of trawl gears. Model net calculations, Calculations of energy requirements of different gears. Onboard experience of different fishing methods. Use of net monitoring instruments. Study of fishing gears through models of nets and field study. Making sketches. Reading of gear designs. – Trawl nets, Purse seines, Gill net and Long line. Familiarization with design drawing soft ware. Design of otter boards and other accessories. Survey of gears and preparation of designs according to scale by taking measurements from a net.

FET 502 ADVANCED FISHING CRAFT TECHNOLOGY 2+1 Objective	
To understand advanced aspects of fishing craft such as better design and modification of existing craft layout.	
Theory	UNIT I Different types of fishing crafts-purse seiner, trawler, stern and side trawler, long liner, gill netter, etc; main differences in the method of construction and design; consideration regarding the speed and other fishing requirements. Deck layout and deck equipments of fishing vessels based on the fishing method; Planning internal capacities of fish hold, engine room, crew accommodation, fuel tanks and freshwater tanks.
	UNIT II Engine installation in fishing vessels; engine bearers for wooden boats; alignment of shaft; stern gear assembly; length of shafts; intermediate shafts; reverse and reduction gear assembly.
	UNIT III Principles of operating steering arrangement; remote control; mast and derrick arrangements; fish hold; - Rudder principles; helm – design details. Principal dimensions of a boat. Importance of shape of under water hull,classification and description of hull forms based on shape and speed –
	UNIT IV Theory of waves; rolling, pitching and heaving; wall sides formula; resistance and motion – wave and eddy creating resistance, fluid resistance. Safety and stability aspects of fishing vessels – factors affecting stability, stability information to be carried on vessels, hydrostatic curves, and static stability curves and safety measures on fishing vessels.
	UNIT V Barnaby’s tables; speed length ratios; effects of wetted surfaces on speed; angle of entrance, parallel body, propeller action; types of propellers; design data; D/P values. Powering of fishing boats, different types of resistance and their calculations, power requirements of various types of fishing boats, auxiliary power, propulsive efficiency, type of propellers, and use of kort nozzle.
	UNIT VI Rudder design and principles of operation; model test etc. Boat fastenings and fittings used in boat construction.
	UNIT VII Biodeterioration of wood – marine fouling and boring organisms, preventive measures.
	UNIT VIII Raw materials, properties and construction of FRP, Aluminum, Ferro-cement and Steel boats. Corrosion – types, fundamentals, measurement and preventive measures.
	UNIT IX Construction of a wooden boat – Various stages of construction, description of various machines and tools used in boat building yard, layout of a typical wooden boat building yard.
	UNIT X Inspection of fishing boat under construction and in operation. Care and maintenance of wooden boats – factors causing damage, hull protection methods and maintenance schedule
Practical	Visit to boat building yards for on – the – spot study of different stages of wooden boat construction and to study the layout. Identification of various tools and machines used in boat building. Study of various stages of boat construction with the help of boat models and making their sketches. Calculation of various dimensions; Study of deck lay outs of different types of fishing vessels and preparation of sketches; Visit to dry dock

FET 503 RESPONSIBLE FISHING 2+1 Objective	
To learn various responsible fishing techniques which cause less damage to the environment and biodiversity and to understand methods for reducing bycatch in trawl net.	
Theory	UNIT I Scope and objectives of FAO Code of conduct for Responsible Fisheries. Articles of CCRF-Description of the code.
	UNIT II Elaboration of Article 8-Fishing operations; By-catch and discards – Definitions, bycatch reduction devices, Turtle excluder devices, finfish and shrimp excluder devices.
	UNIT III Selective fishing gear and practices – Selectivity of trawls, gill nets and lines-Environmental friendly fishing – Energy conservation and resource enhancement.
	UNIT IV Fish Aggregation devices (FADs) – Objectives and types of FADs. Design and construction of FADs.
	UNIT V Energy optimization in fisheries – methods of energy conservation in fish harvesting.
	UNIT VI Application of Remote sensing and PFZ and GIS in fisheries.
	UNIT VII Illegal, Unregulated and Unreported fishing methods (IUU); Destructive and prohibited fishing systems and practices.
	UNIT VIII Eco friendly fishing methods and fishing gears.
	UNIT IX Effect of fishing on nontarget species – Effect of bottom trawl on benthic fauna and habitats. Conservation methods issues and implications for biodiversity.
Practical	Study of design and operation of BRDs and TEDs; Preparation of document listing and prohibited fishing practices; compilation of package of practices for energy conservation; Interpretation of SST and Ocean colour charts, study of Potential Fishing Zone (PFZ) maps; problems on fishing gear selectivity; studies on impact of various fishing gears on environment and biodiversity.

FET 504 REFRIGERATION & ELECTRICAL 2+1 ENGINEERING Objective	
To impart knowledge on engineering aspects of refrigerators, freezers and heat-load calculation etc and to teach electrical aspects of fishing vessel.	
Theory	UNIT I Principles of refrigeration – Vapour Compression system, Vapour adsorption system – Refrigeration cycle.
	UNIT II Application of Refrigeration in fisheries Refrigeration in sea food processing plant coefficient of Performance (CoP).
	UNIT III Types of freezers and their efficiency, Heat load calculations – Insulations. Frosting and defrosting in freezers and cold stores.
	UNIT IV Refrigeration in Factory Trawlers. Refrigerated Transport.
	UNIT V Sources of energy; General structure of electrical power systems, Power transmission and distribution via overhead lines and underground cables, Steam, Hydel, Gas and Nuclear power generation.
	UNIT VI Principal and application of DC Networks, single phase AC Circuits, three phase AC circuits, magnetic, transformers, induction motor, DC Motors etc.
	UNIT VII Electrical Measuring Instruments: DC PMMC instruments shunt and multipliers, multimeters, moving iron ammeters and voltmeters, dynamometer, wattmeter, AC watt-hour meter, extension of instrument ranges.

	UNIT VIII Principles and working; electronic components; Audio; R.F. circuits; electron tubes, transistors; principles of electronic circuits; amplifiers, oscillators, rectifier, tuned circuits – transmission of reception.
	UNIT IX Classification of waves according to frequency and their propagation through different media.
	UNIT X Principles of working of radio, radio telephone, radio direction finder, echo sounder, sonar, radar, GPS etc.
Practical	Visit to refrigeration plants, heat load calculations. Handling and operation of refrigeration equipments – compressor, condenser, evaporator, liquid return system, gas purging, oil drain, oil charging, refrigerant charging, defrosting; ice making and harvesting; study of various automatic control devices; expansion valves, L.P. and H.P. switches, solenoid valves. Study of various types of fish processing machineries; electrical motors, transformers, GPS, SONAR etc.

FET 505 MARINE ENGINEERING 1+1 Objective	
To learn engineering aspects of marine engines for effective utilization during fishing and propulsion system of fishing vessels.	
Theory	UNIT I Engine characteristics – capacity of cylinders, IHP, BHP, FHP, BMEP, torque determinations; SFC values. IC engines – working cycles – Indicator diagrams – Performance number – Supercharging – Engine performance curves – Dual-fuel engines. Handling of IC engine and maintenances – Engine and boiler room arrangements – Steering gears – auxiliary engines – Heat exchangers – Propeller Shaft driver steam generators.
	UNIT II Compression ratio and thermal efficiency; volumetric efficiency; mechanical efficiency different ratings – continuous, peak, intermittent. Fuel and lubricant – Strokes – Cooling method – Running characteristics – Size weight – Power requirement.
	UNIT III Propulsion system – Combinations of engine, power transmission and propeller.
	UNIT IV Function of main engine, friction, clutch, hydraulic coupling, gearbox, thrust; bearing, shafting, propeller.
	UNIT V Auxiliary machinery systems – Requirements of a winch, windlass, line and net hauler – estimation of their driving torque and power; Operation of a hydraulic steering gear; Rudder torque. Floating offshore structures – Diving underwater vehicles. Diving – Underwater vehicles. Estimation of power requirement for various types of fishing – Efficiency group of fishing techniques – Resistance group of fishing methods – Computation of engine
Practical	Study of basic machine parts, shafts, keys, couplings, levers, joints, pulleys, belts, gears and bearings. Study of Engine parts, engine testing, disassembling and assembling a running condition marine engine; study of marine diesel engines, fuel consumption testing with load; Propeller calculations using the computers; calculations related to engine power.

FET 506 AQUACULTURAL ENGINEERING 1+1 Objective	
To familiarize engineering aspects of fish farm and hatchery, farm machinery operation and maintenance.	
Theory	UNIT I Site selection for aquaculture; surveying and leveling, earthwork calculations. Design of dykes, sluice, channels.
	UNIT II Tide fed farms; studies on water supply; aquaculture in open systems- design of cages, rafts, pens, rakes, ropes etc.

	UNIT III Fluid mechanics, pumps, flow estimation and measurement; aquaculture in ponds, raceways and tanks.
	UNIT IV Recirculating aquaculture system; aeration, sterilization and disinfection, ponds, tanks and other impounding structures; filtration. Aeration – Gases in water. Gas transfer – Theory of oxygenation – Types of aerations. Efficiency of Aerators. Recirculation and water – Reuse systems – water exchange – water reuse methods – Recirculation – Advantage – Designs of re-use systems.
	UNIT V Fundamentals of concrete; building materials, cement, RCC. Engineering aspects of fish and shrimp hatchery. Farm machinery operation and maintenance. Pond sealing techniques. Shapes roof design – Load carrying system. Floors, walls, ventilation.
	UNIT VI Automatic feeding system – Feed dispensers – Demand feeders. Design and construction of aquaculture system pond construction – water transportation system – Pump houses – Inlet and outlet structures – Water treatment plants.
Practical	Visit to hatcheries and farms; Instruments used in aquaculture; Operations of aerators, filters, water supply systems. Calculations related to earth requirement aerated efficiency and pump selection. Pump installations .Design of pump house. Computation of water requirement, pump, and pumping rates.

FET 507 ENGINEERING GRAPHICS 0+1 Objective

To gain knowledge on practical aspects of computer aided engineering graphic.

Practical	UNIT I Introduction to engineering graphics – Drawing instruments and their use – Different types of lines – Lettering & dimensioning – Familiarisation with current India Standard Code of Practice for Engineering Drawing. UNIT II Introduction to scales. Introduction to orthographic projections – Horizontal, vertical and profile planes – First angle and third angle projections – Projection of points in different coordinates – Projections of lines inclined to one of the reference planes. UNIT III Projections of lines inclined to both the planes – True lengths of the lines and their angles of inclination with the reference planes – Traces of lines. Projection of plane laminae of geometric shapes inclined one of the reference planes – inclined to both the planes – auxiliary projections. UNIT IV Projections of polyhedra and solids of revolution – Frustum – projection of solids with axis parallel to one of the planes and parallel or perpendicular to the other plane – Projections with the axis inclined to one of the planes. Projections of solids with axis inclined to both the planes – Projection of spheres. Sections of solids by planes perpendicular to at least one of the reference planes – True shapes of sections, Developments.
------------------	---

FET 508 FISHING HARBOUR AND FLEET MANAGEMENT 1+1 Objective

To learn fishing harbour Engineering, fishing fleet management and manning regulations.

Theory	UNIT I FAO classification of fishing vessels. Indigenous fishing boats of India – fishing boats of maritime states of India, fishing boats used in the inland and brackish waters, account of mechanized boats introduced in India.
	UNIT II Personnel management, planning of fishing cruises. Fishing fleet capacity, fleet registration, fleet insurance, seaworthiness assessment, tonnage measurements.
	UNIT III Statutory rules and regulations under MSA, classified societies, manning regulations and requirements; regulations to prevent collisions at sea.

	UNIT IV Classification and functions of fishing harbour. Facilities – waterside and landside facilities, services and utilities provided, layout of a modern fishing harbour, stages in the planning of fishing harbours. Dredging. Economic evaluation on fishing harbour project.
	UNIT V Dry docks and slipway –Fishing harbour management and maintenance.
Practical	Visit to dry dock; Visit to fishing harbour, study of boats with the help of boat models and making sketches; Visit to various vessel types of fishing vessel.

FET 509 ENVIRONMENTAL ENGINEERING AND POLLUTION 1+1 Objective	
To understand engineering aspects of environment to protect the environment from pollution.	
Theory	UNIT I Introduction – Quality of water – Quantity of water – conveyance of water .– treatment of water – filtration of water – Disinfections of water – water softening.
	UNIT II Distribution system of water. Collection and conveyance of refuse – pumps .– sewage disposal – primary and secondary treatment of sewage.
	UNIT III Environmental Pollution – Ecological Balances – Ozone layer – Green House effect – Fossil Fuels. Atmosphere pollution – water pollution. Marine oil pollution – Cause – Oil filtering equipment. Oil record book and controlling monitoring of marine pollution. Bunkering. MORPOL regulations.
	UNIT IV Air pollution – Control of Air pollution. Air pollution causes, Setting chambers, Cyclone Filters. Solid waste disposal. Sources of Pollutants – Classification. Air- pollution – Emission of harmful touchils. Littering of the sea – Plastics – Foods – Papers – Metals – Garbage – Regulation.
	UNIT V Low cost waste treatment systems and their Design. Ballest water management in ships. Discharge of ballast water – Problems of ballast water – Log book maintenance – Managing ballast water. Waste water and treatment, Industrial waste water management – Solid waste disposal. Environment and corrosion, Mathematical modeling for environment pollution control.
Practical	Visit to various pollution control stations. Familiarization of pollution control instrument. Pollution control in Fishing harbours. Pollution control in aquacultural farms.

FET 510 SEA SAFETY AND DISASTER MANAGEMENT 1+0 Objective	
To learn theoretical aspects of sea safety and disaster management, water warning signal and bad weather preparations.	
Theory	UNIT I Introduction to sea safety – Safe navigation procedures for fishing vessels; Distress signals; Distress signals.
	UNIT II Accidents associated with marine environment-crossing surf, bad weather, poor visibility storms, loss of power at sea, loss of way, grounding, collisions. Injuries from fish, animals and machinery. Man overboard and capsizing.
	UNIT III Signals for fishing vessel safety; agencies involved in fishing vessel rescue operations. Keeping watch at sea – Preventing collusions – Heavy weather preparations crow management.
	UNIT IV Fire onboard and Fire fighting equipments. First aid at sea; Weather warning signals and weather reporting system for fishing vessels; Bad weather preparations for fishing vessels.
	UNIT V Stranding and beaching of fishing vessels and refloatation procedures; Measures to enhance sea safety; International conventions related to sea safety.

	UNIT VI Types of natural and man made hazards in fisheries – Cyclone, tsunami etc. Characteristics and impact of various disasters. Preparedness for disasters at sea. Mass evacuation, storm shelters and survival platforms.
--	--

FET 511 FISH PROCESSING MACHINERY 1+1 Objective	
To familiarize with engineering aspects of various equipments related to fish processing and design and layout of factory vessels and processing factories.	
Theory	UNIT I Theory of machines; mechanisms; transmission of power; friction wheels; toothed gears; belt drive.
	UNIT II Processing equipments on board the fishing vessels. Belt drivers, graders, deskinner, freezers, and canning machineries.
	UNIT III Study of fish meal plant equipments; freeze drying and dehydrating equipments.
	UNIT IV Types of boilers and their auxiliary equipments used in fish processing industries.
	UNIT V Twin screw extruders, driers, grading two filtering machines, Packing machines–Equipment Maintenance and safety.
Practical	Study of various types fish processing machineries; calculation of power requirements. Study of boilers and its operation, canning equipments, Twin screw extruders.

FET 512 ACOUSTICS, NAVIGATION AND SEAMANSHIP 1+1 Objective	
To understand engineering aspects of fish acoustics equipment, navigation and seamanship for fishing vessel safety.	
Theory	UNIT I Basic principles of acoustic fish detection. Acoustic surveys, acoustic equipments used in fishing.
	UNIT II Echo sounder – major components, specifications and uses; Sonar – specifications, types; instruments used for evaluation of underwater gear performance.
	UNIT III Global positioning system (GPS); vessel monitoring systems (VMS); communication systems – VHF, SSB, Immarsat system; safety devices – SART, EPIRB, GMDSS.
	UNIT IV Navigation – types, navigational equipments, RADAR, Radio direction finder, Decca, LORAN, OMEGA, Autopilot, Fixing of vessel position, Navigational charts, Satellite; Navigator - Navigation and fishing lights, distress signals; Rules of the Road.
	UNIT V Ship and its main parts; ropes – their types, handling; strength and preservation; knots and splices; measurement of speed; maintenance of log sheet; anchoring mooring; steering; rolling and pitching; Morse code; accidents; marine compass and its uses; sextant; chart reading positions – simple position lines.
Practical	Chart work; operation of echo sounder, Sonar, GPS, Radar and communication systems like VHF, SSB; familiarization with safety devices like SART, EPIRB and GMDSS; identification and study of navigation and fishing lights, distress signals and navigational equipments like compass, chronometer, aneroid barometer, sextant and logs.

FISHERIES RESOURCE MANAGEMENT Course Structur - at a Glance		
CODE	COURSE TITLE	CREDITS
FRM 501*	INLAND FISHERIES RESOURCES	2+1
FRM 502*	MARINE FISHERIES RESOURCE MANAGEMENT	2+1
FRM 503*	MARINE ECOSYSTEMS, BIODIVERSITY AND CONSERVATION	2+1
FRM 504*	TROPICAL FISH STOCK ASSESSMENT	2+1
FRM 505	FISHERIES REGULATIONS	2+1
FRM 506	REMOTE SENSING AND GIS FOR FISHERIES MANAGEMENT	1+1
FRM 507#	INTEGRATED COASTAL ZONE MANAGEMENT	2+1
FRM 508	AQUATIC FLORAL RESOURCES	2+1
FRM 509	FEEDING AND REPRODUCTIVE BIOLOGY OF FINFISH AND SHELLFISH	2+1
FRM 510	DEVELOPMENTAL BIOLOGY OF FINFISH AND SHELLFISH	2+1
FRM 511	FISHING AND ALLIED TECHNOLOGIES	2+1
FRM 512	MODERN TECHNIQUES IN ICHTHYOTAXONOMY	2+1
FRM 591	MASTER'S SEMINAR	1+0
FRM 599	MASTER'S RESEARCH	20

* Compulsory for Master's programme;

FRM 501 INLAND FISHERIES RESOURCES 2+1 Objective	
To understand the present exploitation and future potential of inland Fisheries. To learn the methodologies for assessments of Inland Fisheries Resources.	
Theory	UNIT I Categorization of different freshwater fisheries resources: Ponds, lakes, bheels, tanks, estuaries, brackish water lagoons, wetlands, biosphere reserves and mangroves and derelict water bodies their problems and management aspects.
	UNIT II Bheel fisheries resources of India: Open and closed bheels, productivity conditions, Capture scenario, prospects of culture based systems.
	UNIT III Riverine fisheries resources: Present trend of dwindling fisheries resources, direct and Indirect effects of human intervention in rivers, habitat modification and improvement (rehabilitation of channels and flood plains), protection and restoration of fish movements (different types of fish passes and enhancement of fish migration), management and repair of riverine vegetation, stock enhancement strategies like introduction of new species, pre- and post-stocking management, potential risk of stocking.
	UNIT IV Cold water fisheries of India: Present trends, problems due to habitat destruction, management aspects, prospects of sports fisheries in India.
	UNIT V Reservoir Fisheries: Classification of reservoirs, present productivity levels, management practices.
	UNIT VI Estuarine fisheries: classification of estuaries- present productivity level-potential; Problem – management practices.
	UNIT VII Assessment of carrying capacity of different inland water bodies; Water budgeting. Community participation in fishery resource management.
Practical	Freshwater fish identification – tagging – different types of tags – Visit to nearest freshwater body; catching methods – catch data analysis on major freshwater resource – Estuaries - Reservoirs – Major lakes - of India – Biodiversity indices – Gear selectivity.

FRM 502 MARINE FISHERIES RESOURCE MANAGEMENT 2+1 Objective	
To know the present level of exploitation of marine resources and to impart knowledge on conservation measures. To learn the recent methodologies of sustainable exploitation of renewable resources.	
Theory	UNIT I Major fishing nation of the world, major fishing regions, present trend of marine capture fisheries.
	UNIT II Important finfish and shellfish resources in demersal and pelagic systems; conservation strategies.
	UNIT III Principles of management of fisheries resources objectives of management, issues and challenges of managing multi-gear fisheries.
	UNIT IV Mud bank fishery- wedge bank fishery-Commonly used tools for input and output regulation.
	UNIT V Sustainability: Principles, social economic ecological biological and legal issues Fisheries co-management.
	UNIT VI Marine Biodiversity of selected areas including coral reef conservation.
	UNIT VII Fisheries and fishing methods in open waters: 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.
	UNIT VIII Conservation aspects: Biodiversity principles, categorization of species into endangered; Indeterminate and extinct varieties- managing the highly exploited fishery resources.

	UNIT IX Case studies of fisheries conflicts depending on problems in different states.
Practical	Marine fishery resources – visit to nearest marine landing center – length frequency analysis – catching method – catch data analysis on marine fishery resources of India– closed season studies – gear selectivity.

FRM 503 MARINE ECOSYSTEMS, BIODIVERSITY AND 2+1 CONSERVATION	
Objective	
To study the biodiversity of flora and fauna and its assessment using the various biodiversity indices for conservation of aquatic resources. To understand the ecological impacts on various resources.	
Theory	UNIT I Biology of selected endangered species of sponges, corals, gastropods, bivalves, sea cucumbers, fishes, sea snakes, turtles, birds and marine mammals.
	UNIT II IUCN criteria – Red List, Wild life protection act, International treaties and conventions, Marine Protected Areas, Sanctuaries and Biosphere reserves. Establishment of National marine parks, in situ and ex situ conservation.
	UNIT III Marine and Coastal Ecosystems – Overview; physico-chemical environment; ecological notions; plankton; benthos, mangroves; sea grasses and corals.
	UNIT IV Human impact on ecosystem.
	UNIT V Marine biodiversity: threats, planning and management, tools for conservation.
Practical	Identification of scheduled aquatic organisms- Predators of endangered animals. Observation of stranded marine mammals, corals, seafans and other endangered aquatic Organisms, Visit to various aquatic ecosystem for recording the biodiversity and richness indices, Conservation planning.

FRM 504 TROPICAL FISH STOCK ASSESSMENT 2+1 Objective	
To understand the application of various models to estimate fish population. To get an idea of the interaction of tropical fish population in the ecosystem.	
Theory	UNIT I Stock concept.
	UNIT II Estimation of growth parameters and mortality rates.
	UNIT III Virtual population methods.
	UNIT IV Gear selectivity. Sampling of commercial catches.
	UNIT V Yield per recruit model.
	UNIT VI Surplus production model. Swept area method - Box model.
	UNIT VII Stock recruitment relationship – Stochastic model – estimation of technical reference point MSY and other yield base reference point.
	UNIT VIII Multispecies, ecosystem and economic and social reference points. Eumetric fishing.
	UNIT IX Ecopath and Ecocism models.
Practical	Data collection and estimation of growth and mortality parameters. Gear selection – Yield per recruit – Analytical and holistic models – growth parameters – Cohort analysis – Jones method. Gill net, trawl selectivity – Swept area method. MSY- Stock recruitment relationship.

FRM 505 FISHERIES REGULATIONS 2+1 Objective	
To understand the importance of enforcement of fisheries regulations and policies.	
Theory	UNIT I Fisheries regulatory and developmental setup in Centre and States and their spheres of responsibility; need for fisheries management; regulatory, legal and enforcement regimes.
	UNIT II Monitoring, Control and Surveillance (MCS) systems for capture fisheries: definition; components; role in fisheries management; design considerations; operational procedures such as data collection, fisheries patrols, boarding, inspection procedures, verification of catches, verification of position, transshipment, Port State control and FAO “flagging arrangement”, and fisheries prosecutions.
	UNIT III Regulatory and developmental issues concerning deep sea fishing – Guidelines for operation.
	UNIT IV Indian deep sea fishing vessels in Indian EEZ. Maritimes Zones of India Act 1981 (Regulation of fishing by Foreign vessels). Draft Marine Fisheries Policy.
	UNIT V Marine fisheries legislations in various States of India; Land Reforms
	UNIT VI International Law of the Sea: Historical perspectives; international negotiations and settlements over open seas; conflict management; shared stocks.
	UNIT VII Code of Conduct for Responsible Fishing.
	UNIT VIII Management needs associated with aquaculture development; Coastal Regulation Zone (CRZ) in the context of aquaculture. Sustainability, Integrated Coastal Zone Management and ecosystem management.
	UNIT IX Inland Fisheries Regulation and Development: Inland fisheries governance, Inland Fisheries Act, Inland property regime, leasing policies for waterbodies. Issues of property rights in Inland water bodies.
	UNIT X National Water Policy; water needs for agriculture, industry, potability and fisheries, fishing rights in open waters; and role of fisheries cooperatives, aqua/ecotourism. Concepts and implication of Interlinking of rivers on fisheries and biodiversity.
Practical	Given a real life or imaginary set of MCS situation data for a specific area, to formulate a management plan (with the help of prevailing legislation) with the following objectives : (1) Resource (2) Environment (3) Biodiversity (4) Technology (5) Society (6) Economics and (7) Conflicts; compilation of these into an overall management plan. Visit to appropriate Government/NGO and preparation of working report. Mesh size studies for trawl, gillnets and purse seine. Comparative studies on the Fisheries Acts of any two states of India and preparation of a report.

FRM 506 REMOTE SENSING AND GIS FOR FISHERIES 1+1 MANAGEMENT Objective	
To know the satellite information and its application in fisheries resource management.	
Theory	UNIT I Basic terms and concepts; Electromagnetic radiation and its properties, atmospheric interactions, target interactions.
	UNIT II Sensor platforms – boats, balloons, air-crafts and satellites, Sensor systems
	UNIT III Environmental satellites – The Landsat series, NOAA and IRS; Digital image processing and interpretation.
	UNIT IV Elements of GIS, Application of remote sensing and GIS to fisheries and aquaculture planning and development.
Practical	Study of satellite information, interpretation of satellite pictures for resource management, case studies on remote sensing and GIS applications.

FRM 507 INTEGRATED COASTAL ZONE MANAGEMENT 2+1 Objective	
To impart knowledge on the coastal resources, integrated coastal zone management strategies and disaster management.	
Theory	UNIT I Coastal resources: Coastal natural resources systems: flora and fauna, trophic relationship, nutrient production, cycle and transport; Mangrove ecosystem - species diversity and distribution of mangroves in India, Other inter-tidal system- Seagrass system, Coral reef system, Sandy beach system, Lagoon and estuary system.
	UNIT II Developmental activities and biodiversity loss: Ecological issues, Non-sustainable development, Pollution, threats to biodiversity, habitat destruction, Depletion of fisheries resources, impacts of global environment changes, Multiple uses of the Coastal Zone, Urban settlement, Industrial development, waste disposal, Shore protection works, ports and marine transportation. Land transportation infrastructure, Water control and supply projects, sea fisheries, Aquaculture, Coastal forest industries, Coastal agriculture, industries.
	UNIT III Coastal Zone Management: Integrated Coastal Zone Management (ICZM): its need and benefits, Principles, Goals and objectives of the ICZM programme; Scope, Extent of jurisdiction, Boundaries of the coastal zone, policies and planning for coastal resource management; Management mechanisms- Pollution control, Protected areas (sanctuaries, marine parks and biosphere reserves), Protection from natural hazards; Socioeconomic impacts and its assessment, Disaster management for coastal environment.
	UNIT IV Coastal tourism: Beach resorts, restaurants and parks within the coastal zone as per existing rules and regulations. Impact of pollution on coastal resources.
Practical	Analysis of soil and water characteristics of coastal areas where man made impacts have established; Assessment of damages of water quality; Collection, preservation and identification of coastal biological communities; Survey of different coastal zones; Visit to the protected areas.

FRM 508 AQUATIC FLORAL RESOURCES 2+1 Objective	
To gain in-depth knowledge on the categorization, utilization, conservation and management of aquatic floral resources.	
Theory	UNIT I Taxonomy and phenology of freshwater microphytes and macrophytes; their importance in resource management.
	UNIT II Brackishwater flora – micro and macrophytes; their taxonomy, phenology and ecological importance and conservation practices.
	UNIT III Marine algal resources; Taxonomy, biodiversity, life history, ecological and economical importance and conservation techniques.
	UNIT IV Seagrass resources; Taxonomy, biodiversity, life history, ecological and economical importance and conservation techniques.
	UNIT V Commercially important aquatic floral resources.-Agar-algin-phytocolloids- food grade algal resource- other uses like pollution treatment, fodder, fertilizer production, etc.
Practical	Collection and identification of freshwater and brackishwater plants and seaweeds. Phenological observations of aquatic flora, seaweed resources and preparation of charts – Herbaria preparation.

FRM 509 FEEDING AND REPRODUCTIVE BIOLOGY OF 2+1 FINFISH AND SHELLFISH Objective

To study the role of feeding and reproductive biology in the context of fisheries resources. To learn the application of biological inferences for the management of finfish and shellfish resources.

Theory	UNIT I Food of different types of fin and shell fishes.
	UNIT II Feeding types- filter feeders, carnivores, omnivores and their trophic levels. – Ontogenic changes in feeding- Forage theory- Mismatch hypothesis of Cushing.
	UNIT III Morphological and anatomical adaptation for feeding; feeding behavior of wild and cultured species.
	UNIT IV Techniques in the analysis of gut contents and indices, digestion rates, food consumption rates etc.
	UNIT V Mode of reproduction: Asexual, hermaphroditism, protoandric, protogynic, sexual.
	UNIT VI Reproductive cycles - Semelparity and iteroparity-maturation and spawning periodicity and maturity stages.
	UNIT VII Factors influencing reproduction-Biotic and abiotic.
	UNIT VIII Migration- various types of spawning migration.
	UNIT IX Assessment of mean trophic level and prey - predator relationship.
Practical	Morphological and anatomical features of fin fishes and shellfishes with different feeding habits. Analysis of gut contents. Use of indices in feeding, digestion and food consumption rates of fishes. Identification of spawning season, maturity stages, estimation of gonadosomatic index and intraovarian periodicity.

FRM 510 DEVELOPMENTAL BIOLOGY OF FINFISH AND 2+1 SHELLFISH Objective

To impart knowledge on the collection and identification of eggs and larvae of commercially important finfish and shellfish.

Theory	UNIT I Identification of eggs and larvae of commercially important finfishes, crustaceans, molluscs and echinoderms.
	UNIT II Quantitative samplings of fish eggs and larvae; spatial and temporal distribution, dispersion of eggs and larvae in food webs, effect of environmental parameters on eggs and larvae.
	UNIT III Natural food of shell fish and finfish larvae from egg to adult (commercially important shellfishes and finfishes).
Practical	Identification of commercially important species of crustacean, molluscan eggs and larvae, spat. Morphometry of eggs and larvae of finfishes, identification keys. Quantitative sampling- shellfish and finfish larvae; food and feeding habits of larval stages of shell and fin fishes.

FRM 511 FISHING AND ALLIED TECHNOLOGIES 2+1 Objective	
To gain knowledge on the design, fabrication and operation of fishing gear and operation of fish finding equipments.	
Theory	UNIT I Design, fabrication and operation of various fishing gears: trawls (pelagic and bottom), purse seine, gillnets, trammel nets, dol nets, FADs (Floating and bottom – artificial reefs), traps and lines.
	UNIT II Harvesting methods in inland water bodies and their improvisation: Gillnets, cast nets, lines, dragnets, bag nets etc.
	UNIT III Destructive and prohibited fishing practices.
	UNIT IV By-catch reduction devices: Definition of bycatch, types of bycatch reduction devices and the principles of operation.
	UNIT V Turtle Excluder Devices: Definition, types of TEDs – soft and hard types, materials used for their construction and maintenance.
	UNIT VI Acoustics: Acoustic surveys for fishing, acoustic aids in fishing and acoustic measurements.
	UNIT VII Safety at sea: Safety devices – Accidents associated with marine environment, boat design and navigation, mitigation measures.
	UNIT VIII GMDSS and other safety devices. Advanced communication Systems – VHF, SSB, INMARSAT System.
	UNIT IX Vessel Monitoring Systems (VMS): Importance, uses, role in fisheries management.
	UNIT X Satellite navigation system: GPS – Components of GPS, working, functions, hand held GPS, important applications of GPS in fisheries and aquaculture.
	UNIT XI Fishing harbours: Classification, facilities, layout of a typical fishing harbour, stages in the planning of fishing harbours.
	UNIT XII Code of Conduct for Responsible Fishing (CCRF): Articles of CCRF, Elaboration of Article 8: Fishing Operations.
Practical	Drawing and reading gear designs - Field visits to fishing harbour and preparation of drawing of its lay out - Training onboard fishing vessels in fishing techniques, familiarization with navigation and communication equipments - Study of layout and operation of a fish landing centre; Study of fish aggregating devices -Familiarization with various safety devices.

FRM 512 MODERN TECHNIQUES IN ICHTHYOTAXONOMY 2+1 Objective	
To enable the students in differentiating genera/ species up to stock level using classical, molecular and computer based techniques.	
Theory	UNIT I Identification of stocks based on classical and modern taxonomical methods.
	UNIT II Classical taxonomy – morphometrics – meristics.
	UNIT III Modern taxonomical tools – Electrophoretic studies (muscle myogen, eyelens protein, enzyme pattern and serology), Karyotyping.
	UNIT IV Molecular markers – PCR, RAPD, RFLP, Microsatellites, mini satellites and Mitochondrial DNA, and their application in fish phylogenetic studies.
Practical	PAGE – Muscle myogen, eyelens proteins, enzymes of different species of finfishes; fish chromosomes preparation and identification DNA Isolation and quantification, PCR techniques Statistical software used in fish molecular studies.

