Aquaculture				
Courses Offered (V Dean)				
Sr.	**Semester**	**Course No.**	**Title**	**Credits**
1.	**I**	**AQ.111**	**Principles 0f Aquaculture**	**1+1=2**
	Lecture	***THEORY :***		
	1	Basics of Aquaculture- Definition and Scope		
	2	History of Aquaculture.		
	3	Present global and national scenario of aquaculture		
	4	Aquaculture verses Agriculture.		
	5	Systems of Aquaculture - Pond culture, pen culture, cage culture, running water culture, zero water exchange system etc.		
	6	Principles of organic aquaculture		
	7	Extensive, semi-intensive, intensive and supra intensive aquaculture in different types of water bodies viz. Freshwater, brackishwater and inland saline ground water.		
	8	Pre -stocking pond management.		
	9	Stocking and post -stocking pond management.		
		Carrying capacity of pond and factors influencing carrying capacity.		
	10	Criteria for selection of candidate species for aquaculture.		
	11	Major freshwater candidate species for aquaculture		
	12	Major brackishwater and marine candidate species for aquaculture		
	13	Monoculture, polyculture and integrated culture system		
	15	Water and soil quality in relation to fish production.		
	16	Physical, chemical and biological factors affecting productivity of ponds.		
	Practical	***PRACTICAL:***		
	1	Aquaculture production statistics- World & India		
	2	Aquaculture resources of world and India		
	3	Components of Aquaculture farms		
	4	Estimation of carrying capacity		
	5	Study of practices of pre-stocking pond management , Drying, ploughing, Liming, Fertilization, etc.		
	6	Study of practices of pre-stocking pond management , Eradication of aquatic insects		
	7	Study of practices of pre-stocking pond management, Eradication of aquatic weed and predatory fishes		
	8	Study of practices of stocking pond management, Transportation methods		
	9	Study of practices of stocking pond management, Acclimatization methods		
	10	Study of practices of post-stocking pond management Feed management		
	11	Study of practices of post-stocking pond management Health management		
	12	Growth studies in aquaculture system		
	13	Study on waste accumulation in aquaculture system (NH_3,)		

	14	Study on waste accumulation in aquaculture system (Organic matter)		
	15	Study on waste accumulation in aquaculture system (CO_2)		
	16	Analysis of manure		
2.	**I**	**AQ.112**	**Fundamental of Biochemistry**	**2+1=3**
	Lecture	***THEORY :***		
	1	A brief introduction to developments in biochemistry		
	2	Transformation biochemistry to molecular biology		
	3	Cell structure		
	4	Water and major molecules of life		
	5	Cell structure, water and major molecules of life.		
	6	Carbohydrate chemistry: Structure, classification, functions (mono, di and polysaccharides).		
	7	Isomerism and mutarotation		
	8	Metabolism of carbohydrates: glycolysis, gluconeogenesis,		
	9	Metabolism of carbohydrates: glycogenolysis, glycogenesis, TCA cycle		
	10	Central role of TCA cycle in metabolism.		
	11	Protein chemistry: classifications and functions.		
	12	Classification, structure, function and properties of amino acids.		
	13	Essential and non-essential amino acids.		
	14	Primary, secondary, tertiary and quaternary structure of proteins.		
	15	Amphoteric properties of protein.		
	16	Biuret reaction and xanthoproteic reaction.		
	17	Digestion and absorption of proteins.		
	18	Classification, structure, functions and properties of lipids.		
	19	Essential fatty acids and phospholipids.		
	20	Digestion and absorption of lipids.		
	21	Lipid autooxidation.		
	22	Significance of Omega-3 and Omega-6 fatty acids.		
	23	Enzymes: nomenclature; classification; specificity; mechanism of enzyme action; kinetics and regulation of enzyme activity.		
	24	Enzymes: Kinetics and regulation of enzyme activity.		
	25	Steroid and peptide hormones- chemistry and function.		
	26	Structure and functions of fat and water soluble vitamins.		
	27	Vitamins – classification- functions.		
	28	Minerals – classification – functions.		
	29	Nucleic acids: Structure function and importance genetic code.		
	30	Transcription and translation		
	31	Protein synthesis		
	32	Energy changes in chemical reactions, reversible and irreversible reactions in metabolism		
	Practical	***PRACTICAL:***		
	1	General rules of biochemistry laboratory		

	2	Preparation of normal solution of acid and base, buffers and reagents.		
	3	Qualitative determination of carbohydrates		
	4	Qualitative determination of proteins		
	5	Qualitative determination of lipids		
	6	Determination of moisture content		
	7	Estimation of ash and sand content		
	8	Estimation of total nitrogen and crude protein of fish tissue		
	9	Extraction total lipids in fish tissue		
	10	Estimation of total lipids in fish tissue.		
	11	Estimation of carbohydrates in foods.		
	12	Determination of specific gravity of oil.		
	13	Extraction and estimation of total lipids in fish tissue.		
	14	Determination of saponification value, iodine value and free fatty acid value.		
	15	Determination of iodine value		
	16	Determination of free fatty acid value		
	30	Transcription and translation		
	31	Protein synthesis		
	32	Energy changes in chemical reactions, reversible and irreversible reactions in metabolism		
3.	I	CNC.111	Swimming	0+1=1
	Practical	**PRACTICAL:**		
	1	History,		
	2	Hazards in water and safety precautions;		
	3	Pool maintenance and water quality control.		
	4-5	Learning swimming, understanding and practice of ducking the head,		
	6-8	Kicking action, holding breath under water		
	9-11	Various strokes (free style, breast stroke, butterfly, back stroke);		
	12	Competitive swimming-relays and medleys,		
	13	Lap time practice, swimming and floating aids and their uses;		
	14	Diving-styles of diving, rules, regulations and precautions. Methods of life savingin water;		
	15	Boating, canoeing and sailing: types, maintenance,		
	16	Skill development, rules and regulations and practice.		
4.	**II**	**AQ.123**	**Fresh Water Aquaculture**	**2+1=3**
	Lecture	***THEORY :***		
	1	Major species cultured and Traits of important cultivable fresh water finfishes (Carps)		
	2	Major species cultured and Traits of important cultivable finfishes and shellfishes.(Cat fishes)		
	3	Major species cultured and Traits of important cultivable finfishes (Cold water fishes and fresh water shell fishes)		

	4	Production trends and prospects of Freshwater Aquaculture in different parts of the world.
	5	Fresh water aquaculture resources - ponds, tanks, lakes, reservoirs, etc.
	6	Nursery pond management-control of aquatic weeds, insects and algal blooms, predatory and weed fishes, liming, fertilization/manuring, supplementary feeding
	7	Rearing pond management -control of aquatic weeds and algal blooms, predatory and weed fishes, liming, fertilization/manuring, supplementary feeding
	8	Grow-out ponds management-control of aquatic weeds and algal blooms, predatory and weed fishes, liming, fertilization/manuring, use of biofertilizers, supplementary feeding
	9	Water quality management
	10	Selection of fish seed
	11	Conditioning of fish seed
	12	Transportation of seed.
	13	Acclimatisation of seed.
	14	Culture methods of Indian major carps, Medium & minor carps and exotic carps -competition and compatibility
	15	Low-input, medium-input and high-input system of carp aquaculture
	16	Culture methods of cat fishes
	17	Culture methods of cold water fishes
	18	Culture methods of freshwater prawns
	19	Culture methods of mussels (Freshwater pearl culture)
	20	Culture methods of other freshwater exotic species
	21	Wintering ponds, quarantine ponds and isolation ponds
	22	Sewage-fed fish culture
	23	Principles of organic cycling and detritus food chain
	24	Use of agro-industrial waste and biofertilizer in aquaculture
	25	Exotic fish species introduced to India and its impact on indigenous fish fauna
	26	Periphyton based aquaculture system
	27	Species of fish suitable for integrated aquaculture.
	28	Integration of aquaculture with agriculture/horticulture- Paddy cum Fish/Shrimp Culture.
	29	Integration of aquaculture with agriculture/horticulture - sericulture cum fish culture
	30	Integration of aquaculture with agriculture/horticulture – Mushroom cum fish culture
	31	Integration of aquaculture with livestock- Cattle, poultry, Duck cum fish culture
	32	Cultivation of aquatic macrophytes with aquaculture (makahana).
	Practical	***PRACTICAL:***

	1	Preparation and management of nursery pond		
	2	Preparation and management of rearing pond		
	3	Preparation and management of grow out pond		
	4	Study on effect of liming, manuring and fertilization on hydrobiology of ponds and growth of fish and shellfishes		
	5	Collection, identification and control of aquatic weeds		
	6	Collection, identification and control of aquatic insects		
	7	Collection, identification and control predatory and weed fishes: eggs and larval forms of fishes		
	8	Algal blooms and their control		
	9	Estimation of plankton and benthic biomass.		
	10	Study of natural and supplementary feeding in freshwater aquaculture		
	11	Workout of economics of different culture practices- Carp culture		
	12	Workout of economics of different culture practices- Catfish culture		
	13	Workout of economics of different culture practices- Prawn culture		
	14	Estimation of livestock requirement / Unit in integrated aquaculture		
	15	Design of paddy plot for paddy-cum-fish culture. Design of Fish and Shrimp Culture, livestock shed on pond embankment,		
	16	Economics of different integrated farming systems		
	32	Cultivation of aquatic macrophytes with aquaculture (makahana).		
5.	**II**	**AQ.124**	**Aquaculture in Reservoirs**	**1+1=2**
	Lecture	***THEORY :***		
	1	Definition of reservoirs in India; nature and extent of reservoirs, topography and species diversity; importance of morpho-edaphic index in reservoir productivity		
	2	Classification of reservoir; factors influencing fish production; trophic phases in reservoir; pre-impoundment and post-impoundment stages and their significance in establishment of reservoirs fisheries.		
	3	Salient features of reservoir limnology and their significance to fisheries development.		
	4	Management of small, medium and large reservoirs; present status and future prospects in reservoirs fish production.		
	5	Fisheries of some important reservoirs; recent advances in reservoirs fisheries management.		
	6	Conservation measures in reservoir fisheries.		
	7	Fish stocking in Reservoirs		
	8	Role of cage and pen culture in enhancement of fish production from reservoirs		
	9	History of cage culture		
	10	Advantages of cage culture; selection of suitable site of cage culture		
	11	Cage materials, designs, shape, size and fabrication; cage frames and supporting system		

	12	Integration of cage culture with other farming systems.		
	13	History of pen culture. economics of cage and pen culture.		
	14	Pen materials, fabrication; breeding of fish in pen; rearing of spawn in pen; grow-out from pens		
	15	Suitable species for culture in cages and pens		
	16	Constraints in cage and pen culture.		
	Practical	***PRACTICAL:***		
	1	Preparation of charts on the present situation of reservoirs fisheries productivity: Small reservoirs		
	2	Preparation of charts on the present situation of reservoirs fisheries productivity: Medium reservoirs		
	3	Preparation of charts on the present situation of reservoirs fisheries productivity: large reservoirs		
	4	Preliminary observations on hydrobiological parameters of the selected reservoir: Physical and chemical factors		
	5	Preliminary observations on hydrobiological parameters of the selected reservoir: Biological factors		
	6	Detailed case studies of selected reservoirs on the changing trends in capture fisheries profile: Small reservoirs		
	7	Detailed case studies of selected reservoirs on the changing trends in capture fisheries profile: Medium reservoirs		
	8	Detailed case studies of selected reservoirs on the changing trends in capture fisheries profile: large reservoir		
	9	Drawing inferences from the analysis of data and suggestions for the sustainable development of reservoirs fisheries.		
	10	Case studies on cage and pen culture: Site selection for cage and pen culture		
	11	Case studies on cage and pen culture: Designing and layout of cage culture		
	12	Case studies on cage and pen culture: Fabrication of cages and pens		
	13	Case studies on cage and pen culture: Feeding rate, growth and health monitoring		
	14	Case studies on cage and pen culture- Repair and maintenance of cages and pen		
	15	Field visit to cage culture to acquaint with construction details and operation.		
	16	Field visit to pen culture site to acquaint with construction details and operation.		
6.	**III**	**AQ.215**	**Ornamental Fish Production and Management**	**1+1=2**
	Lecture	***THEORY :***		
	1	World trade of ornamental fish and export potential.		
	2	Different varieties of exotic fishes.		
	3	Different varieties of indigenous fishes.		

	4	Principles of a balanced aquarium.		
	5	Fabrication, setting up and maintenance of freshwater and marine aquarium.		
	6	Water quality management, Water filtration systems - biological, mechanical and chemical, Types of filters.		
	7	Aquarium plants and their propagation methods.		
	8	Lighting and aeration, aquarium accessories and decoratives.		
	9	Aquarium fish feeds, Dry, Wet and live feeds.		
	10	Broodstock management, Breeding and rearing of ornamental fishes: Live bearer		
	11	Broodstock management, Breeding and rearing of ornamental fishes: Eggs layers		
	12	Application of genetics and biotechnology for producing quality strains.		
	13	Management practices of ornamental fish farms		
	14	Common diseases and their control.		
	15	Conditioning, packing, transport and quarantine methods.		
	16	Trade regulations and Wild Life Act in relation to ornamental fishes.		
	Practical	***PRACTICAL:***		
	1	Identification of common ornamental fishes and plants.: indigenous species		
	2	Identification of common ornamental fishes and plants.: Exotic species		
	3	Identification of common ornamental fishes and plants.: Ornamental plants		
	4	Identification of common ornamental fishes and plants.: Marine ornamental fishes		
	5	Fabrication of all glass aquarium.		
	6	Setting-up of aquarium tank		
	7	Maintenance of an aquarium tank.		
	8	Aquarium accessories and equipments.		
	9	Conditioning and packing of ornamental fishes.		
	10	Preparation of feed.		
	11	Setting up of breeding tank for live bearers		
	12	Setting up of breeding tank for barbs, gold fish and tetras etc.		
	13	Setting up of breeding tank for Cichlids &Gouramies		
	14	Setting up of breeding tank for fighters and cat fishes		
	15	Identification of fish diseases and prophylactic measures.		
	16	Assignment		
7.	**III**	**AQ.216**	**Fish Food Organisms**	**1+1=2**
	Lecture	***THEORY :***		
	1	Introduction to Fish food organisms		
	2	Candidates species of phytoplankton as live food organisms of freshwater and marine species.		
	3	Candidates species of zooplankton as food organisms of freshwater and marine species		

	4	Trophic potential - Proximate composition of live feed
	5	Biology, culture requirement, and methodology of culture of important live food organism: Green algae
	6	Biology, culture requirement, and methodology of culture of important live food organism: Blue-green algae (spirulina)
	7	Biology, culture requirement, and methodology of culture of important live food organism: Diatoms
	8	Biology, culture requirement, and methodology of culture of important live food organism: Infusoria
	9	Biology, culture requirement, and methodology of culture of important live food organism: rotifers
	10	Biology, culture requirement, and methodology of culture of important live food organism: Cladocerons
	11	Biology, culture requirement, and methodology of culture of important live food organism: Tubifex worm
	12	Biology, culture requirement, and methodology of culture of important live food organism: Brine shrimp
	13	Biology, culture requirement, and methodology of culture of important live food organism: Chironimids
	14	Biology, culture requirement, and methodology of culture of important live food organism: Earthworm
	15	Bait fish and forage fish: Types and candidate species
	16	Role of biofilm in aquaculture
	Practical	***PRACTICAL:***
	1	Introduction to culture of fish food organisms
	2	Qualitative and quantitative analysis of plankton - Collection and Preservation of Plankton
	3	Qualitative and quantitative analysis of plankton- Qualitative estimation
	4	Qualitative and quantitative analysis of plankton- Quantitative Estimation
	5	Identification Of Common Aquatic Flora And Fauna- Freshwater Fauna
	6	Identification of common aquatic flora and fauna : Brackishwater and marine flora and fauna
	7	Isolation and culture of microalgae: Important media used for algal culture:
	8	Isolation and culture of microalgae: Isolation of pure algal strains by agar plating
	9	Isolation and culture of microalgae: Mass culture of algae
	10	Culture of cladocerans: Stock culture
	11	Culture of cladocerans: Mass culture
	12	Culture of microworms
	13	Culture of infusoria
	14	Decasulation of artemia cyst
	15	Hatching of artemia cyst
	16	Evaluation of live food organism

8.	**III**	**AQ.217**	**GENETICS AND BREEDING**	**1+1=2**
	Lecture	***THEORY :***		
	1	Principles of genetics and breeding.		
	2	Gene and chromosome as a unit of inherritance, structure of genetic material.		
	3	Mendel's law of inheritance – complete and incomplete dominance, monohybrid and dihybrid ratios. Gene interactions – dominant and recessive epistasis.		
	4	Pleiotropism. Lethal genes. Mutation. Sex - linked genes, sex influenced and sex limited traits. Linkage and crossing over. Introduction to population genetics.		
	5	Hardy- Weinberg law and its significance.		
	6	Chromosomal structure and aberrations. Chromosome manipulation techniques- androgenesis, gynogenesis and polyploidy and identification of ploidy.		
	7	Sex determination		
	8	Cross breeding (hybridization) – types of cross breeding, heterosis and design of cross breeding programmes, hybridization in different fishes.		
	9	Quantitative genetics – quantitative traits, polygenic traits, heritability.		
	10	History and present status of selective breeding programs in aquaculture.		
	11	Selection methods and mating designs. Design for selective breeding for Qualitative traits		
	12	Selection methods and mating designs. Design for selective breeding for Quantitative traits		
	13	Inbreeding and its consequences.		
	14	Domestication methods.		
	15	Seed certification and quarantine procedures.		
	16	Cryopreservation of gametes.		
	Practical	***PRACTICAL:***		
	1-4	Problems on Mendelian inheritance (qualitative genetics) - monohybrid and dihybrid ratios and epistasis.		
	5-6	Problems on quantitative traits, response to selection and heritability.		
	7	Estimation of rate of inbreeding.		
	8	Estimation of heterosis.		
	9	Mitotic and meiotic chromosome preparation.		
	10-11	Demonstration of protocol of androgenesis, gynogenesis and polyploidy.		
	12-13	Problems on gene and genotypic frequency.		
	14	Gamete cryopreservation protocols		
	15-16	Quality evaluation of fish milt.		
9.	**IV**	**AQ.228**	**Coastal Aquaculture and Mariculture**	**2+1=3**
	Lecture	***THEORY :***		

	1	An over view of sea farming and shore based aquaculture in different parts of world: Global aquaculture production
	2	Resources for shore based aquaculture and sea farming in India.
	3	Traits of important cultivable fish and shellfish: Sea bass, mullet, milkfish, grouper, snappers, ayu, pearlspot , etc
	4	Traits of important cultivable fish and shellfish: Tiger shrimp, white shrimp, Vennamei shrimp, mud crab,
	5	Traits of important cultivable fish and shellfish: Mussel & clam species
	6	Traits of important cultivable fish and shellfish: Edible & pearl oyster species
	7	Traits of important cultivable fish and shellfish: seaweeds
	8	Seed resources of fin fish and shell fishes
	9	Traditional (bheries, Gheries) shore based aquaculture systems in India
	10	Traditional shore based aquaculture systems in India: Pokali fields in kerala
	11	Traditional (gaznis and khazans) shore based aquaculture systems in India
	12	Site selection for coastal aquaculture and mariculture
	13	Farm designing for coastal aquaculture
	14	Extensive, semi-Intensive, intensive aquaculture practices of commercially important species of fish and shellfish.: Culture of Sea bass
	15	Extensive, semi-Intensive, intensive aquaculture practices of commercially important species of fish and shellfish: Culture of Mullet
	16	Extensive, semi-Intensive, intensive aquaculture practices of commercially important species of fish and shellfish. Culture of Milk fish
	17	Extensive, semi-Intensive, intensive aquaculture practices of commercially important species of fish and shellfish. Culture of Grouper
	18	Extensive, semi-Intensive, intensive aquaculture practices of commercially important species of fish and shellfish. Culture of shrimp
	19	Extensive, semi-Intensive, intensive aquaculture practices of commercially important species of fish and shellfish. Culture of Mud crab
	20	Extensive, semi-Intensive, intensive aquaculture practices of commercially important species of fish and shellfish. Culture of clam
	21	Extensive, semi-Intensive, intensive aquaculture practices of commercially important species of fish and shellfish. Culture of mussel
	22	Extensive, semi-Intensive, intensive aquaculture practices of commercially important species of fish and shellfish. Culture of oyster

	23	Extensive, semi-Intensive, intensive aquaculture practices of commercially important species of fish and shellfish. Culture of pearl oyster		
	24	Extensive, semi-Intensive, intensive aquaculture practices of commercially important species of fish and shellfish. Culture of sea weed		
	25	Methods of aquaculture - cages		
	26	Methods of aquaculture - Rafts, racks, poles and ropes		
	27	Water and soil quality management: Important water quality parameters		
	28	Water and soil quality management: Management including reclamation of acid sulphate soil		
	29	Estimation of growth, survival and pond productivity		
	30	Modern practices of shrimp farming in India		
	31	Economic analysis of modern shrimp farming		
	32	Sea ranching.		
	Practical	***PRACTICAL:***		
	1	Identification of important cultivable fishes: Fin fishes		
	2	Identification of important cultivable fishes: Crustaceans		
	3	Identification of important cultivable fishes: Mollucs		
	4	Collection and identification of commercially important seed of fish .		
	5	Collection and identification of commercially important seed of shellfishes		
	6	Types of fertilizers- pond preparation.		
	7	Seed selection and quality		
	8	Techniques of acclimatization of fish seed		
	9	Water quality parameters.		
	10	Estimation of seed survival.		
	11	Pond biomass estimation.		
	12	Material, apparatus and machinery for shore based aquaculture and sea farming.		
	13	Material, apparatus and machinery sea farming.		
	14	Estimation of feed intake.		
	15	Growth and health monitoring.		
	16	Fouling organism in cages and pens.		
10.	**IV**	**AQ.229**	**Fish Nutrition and Feed Technology**	**2+1=3**
	Lecture	***THEORY :***		
	1	Fundamentals of fish nutrition and growth in fish.		
	2	Principal nutrients and nutritional requirements of cultivable fish and shellfish.		
	3	Principal nutrients and nutritional requirements of cultivable fish and shellfish (protein requirement)		

	4	Principal nutrients and nutritional requirements of cultivable fish and shellfish (Fat/Lipid requirement)
	5	Principal nutrients and nutritional requirements of cultivable fish and shellfish (carbohydrate requirement)
	6	Principal nutrients and nutritional requirements of cultivable fish and shellfish (Vitamin requirement)
	7	Method of feed formulation (pearson square method) Feed formulation .
	8	Method of feed formulation (Best buy ingredient method)
	9	Method of feed formulation (Simultaneous equation and linear programming method)
	10	Feed manufacturing
	11	Forms of feed : wet feeds, moist feeds, dry feeds, mashes, pelleted feeds, floating and sinking pellets.
	12	Forms of feed : Spray dried diet, Micro-bound diet, micro encapsulated diet, flake diet)
	13	Feed additives : binders, antioxidants, Anti microbial agents enzymes, pigments, growth promoters, feed stimulants.
	14	Feed additives: Anabolic agents, enzymes, pigments, growth promoters, Chemo attractants and feed stimulants.
	15	Feed additives: Probiotics and immune-stimulants
	16	Feed storage: Role of moisture and heat
	17	Feed storage: Microbial, insect/rodent damage
	18	Feed storage: Chemical changes during storage and storage time of selected feed stuff
	19	Feed storage, use of preservatives and antioxidants.
	20	Feed evaluation - Feed conversion ratio, feed efficiency ratio, protein efficiency ratio, net protein utilization and biological value.
	21	Nutritional qualities of feed stuff: Chemical characteristics, digestibility studies
	22	Nutritional qualities of feed stuff: water stability and sinking rate, performance of cultured species, Field evaluation, etc
	23	Different types of feeding devices
	24	Method of feeding: Hand feeding, bag feeding, Automatic feeders
	25	Feeding frequency and feeding rate
	26	Different types of feed ingredients: Ingredients of animal origin
	27	Different types of feed ingredients: Ingredients of plant origin
	28	Anti nutritional factors in feed ingredients: Natural, contaminants, and artificial antagonist
	29	Feed digestion: Digestive fluid and enzymes,
	30	Protein, Fat, Carbohydrate and Microbial digestion
	31	Factors affecting digestibility and digestibility estimation
	32	Nutritional deficiency diseases
	Practical	***PRACTICAL:***

	1	Proximate composition: analysis of feed ingredients and feeds.(Protein Estimation- Digestion)		
	2	Proximate composition: analysis of feed ingredients and feeds.(Protein Estimation- Extraction and estimation)		
	3	Proximate composition: analysis of feed ingredients and feeds.(Fat Estimation)		
	4	Proximate composition: analysis of feed ingredients and feeds.(Moisture Estimation)		
	5	Proximate composition: analysis of feed ingredients and feeds.(Ash Estimation)		
	6	Preparation of artificial feeds using locally available feed ingredients.(Feed formulation exercise)		
	7	Preparation of artificial feeds using locally available feed ingredients.(Feed formulation exercise)		
	8	Preparation of artificial feeds using locally available feed ingredients.(Weighing, Grinding, mixing, pelleting and drying)		
	9	Calculation of feeding rate and feeding frequency		
	10	Method of feeding		
	11	Determination of sinking rate and stability of feeds.		
	12	Determination of storage effect on feed quality -Protein associated changes		
	13	Determination of storage effect on feed quality –Fat associated changes		
	14-16	Students Project Work: Testing and evaluation of formulated fish feeds on fish growth and survival		
11.	**IV**	**AQ.221**	**Shellfish Hatchery Management**	**1+1=2**
	Lecture	***THEORY :***		
	1	Natural seed resources of shell fishes; site selection and collection methods		
	2	Life cycle of important shellfishes: *Penaeusmonodon, Penaeusindicus*and *Macrobrachiumrosenbergii, Scylla serrata* and Lobster.		
	3	Life cycle of important shellfishes: Edible oyster and Pearl oyster, Holothurians		
	4	Life cycle of important shellfishes: , horse shoe crab, *Sepia, Loligo,* Cray fish, etc.		
	5	Sexual maturity and breeding seasons of different species: *Penaeusmonodon , Penaeusindicus, Macrobrachiumrosenbergii, Crab ,* Lobster, Oyster, Mussel etc		
	6	Maturation stages of *Macrobrachiumrosenbergii and Penaeusmonodon*		
	7	Induced maturation in *Penaeusmonodon* by eye-stalk ablation		
	8	Reproductive hormones in crustaceans		
	9	Broodstock management of *Macrobrachiumrosenbergii and Penaeusmonodon*		
	10	Breeding and hatchery management of *Macrobrachiumrosenbergii*		
	11	Breeding and hatchery management of *Penaeusmonodon*		
	12	Breeding and hatchery management of crabs, lobster, mussel, oyster, etc		

	13	Food and feeding of larval stages of *Macrobrachiumrosenbergii*		
	14	Food and feeding of larval stages of *Penaeusmonodon*		
	15	Food and feeding of larval stages of *Crab, Oyster, Mussel etc*		
	16	Health management in hatcheries.		
	Practical	***PRACTICAL:***		
	1	Identification of brood stock and maturity stages of important crustaceans.		
	2	Identification of brood stock and maturity stages of important molluscs		
	3	Breeding and larval rearing of *Macrobrachiumrosenbergii*		
	4	Breeding and larval rearing of *Macrobrachiumrosenbergii*and*Penaeusmonodon*		
	5	Identification of larval stages of *Macrobrachiumrosenbergii*		
	6	Identification of larval stages of *Penaeusmonodon*		
	7	Identification of larval stages of mud Crab		
	8	Identification of larval stages of Oyster		
	9	Identification of larval stages of Mussel		
	10	Demonstration of eyestalk ablation in *Penaeusmonodon*.		
	11	Collection, packing and transportation of shrimp / prawn seed and brood stock.		
	12	Practice in the operation of shrimp and prawn hatcheries.		
	13	Observations on gonadal maturation of *Macrobrachiumrosenbergii*.		
	14	Observations on gonadal maturation of *Penaeusmonodon*.		
	15	Water treatment and management in shrimp and prawn hatcheries.		
	16	Different chemicals and drugs used in shrimp / prawn hatcheries.		
12.	**V**	**AQ.312**	**Finfish Hatchery Management**	**2+1=3**
	Lecture	***THEORY :***		
	1	Freshwater and marine fish seed resources.		
	2	Natural breeding of finishes.		
	3	Selection of riverine spawn collection sites, gears used and methods of collection.		
	4	Spawn quality and quantity indices, advantages and disadvantages of riverine seed collection.		
	5	Sexual maturity and breeding season of various cultivable species.		
	6	Development of gametes in male and female.: Ovarian development		
	7	Spermatogenesis and Oogenesis		
	8	Types of fish egg and embryonic development.		
	9	Bundh breeding: wet and dry bundhs, carp breeding operation in bundhs, collection and hatching of eggs, factors involved in bundh breeding, advantages and disadvantages of bundh breeding.		
	10	Comparison between Wet bund and dry bund		
	11	Induced breeding of warm water finfishes, environmental factors affecting spawning and breeding, sympathetic breeding.		
	12	Hypophysation of fishes, fish pituitary gland - its structure.		

	13	Broodstock management		
	14	Transportation of brood fishes.		
	15	Synthetic hormones used for induced breeding of carps.		
	16	Different types of fish hatcheries - Traditional, Chinese, glass jar and modern controlled hatcheries.		
	17	Designing of circular hatchery for seed production of IMC		
	18	Causes of mortalities of eggs and spawn, treatment of eggs.		
	19	Spawn rearing techniques.		
	20	Use of anesthetics in fish breeding and transport.		
	21	Breeding techniques for Indian major carps and exotic carps		
	22	Breeding techniques for Cold water fishes: Mahseer, Trout		
	23	Breeding techniques for Tilapia		
	24	Breeding techniques for cat fishes		
	25	Breeding techniques for Mullet		
	26	Breeding techniques for Milk fish		
	27	Breeding techniques for Pearl spot		
	28	Breeding techniques for Sea bass, Sea horse and grouper		
	29	Breeding techniques for pacu, cobia, popanos, etc		
	30	Breeding techniques for other indigenous species		
	31	Multiple breeding of carps.		
	32	Cryopreservation of fish gametes.		
	Practical	**PRACTICAL:**		
	1	Study of maturity stages in fish.		
	2	Collection and preservation of fish pituitary gland,		
	3	Preparation of hypophysial extract.		
	4	Calculation of fecundity.		
	5	Brood stock maintenance and selection of brood fishes for injection.		
	6	Histological studies of ovary		
	7	Histological studies testes.		
	8	Different fish hatchery systems.		
	9	Study of fish eggs and embryonic developmental stages.		
	10	Identification of eggs, spawn, fry and fingerlings of different species.		
	11	Fish seed and broodstock transportation.		
	12	Use of anesthetics, disinfectants and antibiotics in fish breeding.		
	13	Water quality monitoring in fish hatcheries and nurseries.		
	14	Cryopreservation of fish gametes.		
	15	Breeding of common finfishes.		
	16	Larval rearing common finfishes.		
13.	**VI**	**AQ.323**	**Introduction to Biotechnology and Bioinformatics**	**1+1=2**
	Lecture	***THEORY :***		

	1	Biotechnology**:** Introduction to Biotechnology –scope and importance in fisheries/aquaculture;
	2	Structural organization of prokaryotic and eukaryotic cell.
	3	Nucleic acids -structure, function and types,
	4	Concepts of gene and genetic code, transcription and translation, mutations and their implications.
	5	Post transcriptional modification and RNA processing.
	6	Gene regulation and expression in prokaryotes and eukaryotes; DNA sequencing, Operons.
	7	Genetic engineering- Restriction enzymes; Gene isolation; Cloning vectors; Probes; Recombinant DNA technology – vaccines..
	8	Transgenic fish and Gene transfer technology, Animal Cell Culture, Hybridoma technology
	9	Molecular and immunological techniques – PCR; immunoblotting; ELISA; Principle of hybridization; Northern blotting; Western blotting; Southern blotting; DNA fingerprinting; Restriction fragment length polymorphism., Biosensors.
	10	Molecular and immunological techniques – PCR; immunoblotting; ELISA; Principle of hybridization; Northern blotting; Western blotting; Southern blotting; DNA fingerprinting; Restriction fragment length polymorphism., Biosensors.
	11	Molecular and immunological techniques – PCR; immunoblotting; ELISA; Principle of hybridization; Northern blotting; Western blotting; Southern blotting; DNA fingerprinting; Restriction fragment length polymorphism., Biosensors.
	12	Concept of bioremediation of water, bioprocess engineering and bioprospecting.
	13	Bioinformatics**:** Introduction to Bioinformatics;
	14	Biological Databases and tools :
	15	Introduction; Types of biological databases; Primary and secondary databases; PDB, NCBI, formats and contents;
	16	Sequence retrieval, manipulation; Primer design; Restriction mapping; ORF finding; EMBOSS, Molecular visualization Sequence analysis.
	Practical	**PRACTICAL:**
	1	Study of structure of prokaryotes Cells
	2	Study of structure of Eukaryotes Cells
	3	Study on Model of protein Synthesis,
	4-6	Study of models of rDNA Technology,
	7-9	Study of models of Cell CultureTechnology,
	10-11	Isolation of Nucleic Acids
	12	Study of Restriction enzymes
	13	Study of Gel Electrophoresis
	14	Study of ELISA test

	15-16	DNA sequence analysis and comparison.

Aquaculture				
Courses Offered (VI Dean)				
Sr.	**Semester**	**Course No.**	**Title**	**Credits**
1.	**I**	**AQ.111**	**Freshwater Aquaculture**	**2+1=3**
	Lecture	***THEORY :***		
	1	Major species cultured and Traits of important cultivable fresh water finfishes (Carps).		
	2	Major species cultured and Traits of important cultivable finfishes and shellfishes.(Cat fishes).		
	3	Major species cultured and Traits of important cultivable finfishes (Cold water fishes and fresh water shell fishes).		
	4	Production trends and prospects of Freshwater Aquaculture in different parts of the world.		
	5	Fresh water aquaculture resources - ponds, tanks, lakes, reservoirs, etc.		
	6	Nursery pond management-control of aquatic weeds, insects and algal blooms, predatory and weed fishes, liming, fertilization/manuring, supplementary feeding etc.		
	7	Rearing pond management -control of aquatic weeds and algal blooms, predatory and weed fishes, liming, fertilization/manuring, supplementary feeding etc.		
	8	Grow-out ponds management-control of aquatic weeds and algal blooms, predatory and weed fishes, liming, fertilization/manuring, use of biofertilizers, supplementary feeding etc.		
	9	Water quality management.		
	10	Selection of fish seed.		
	11	Conditioning of fish seed.		
	12	Transportation of seed.		
	13	Acclimatisation of seed.		
	14	Culture methods of Indian major carps, exotic carps.		
	15	Low-input, medium-input and high-input system of carp aquaculture.		
	16	Culture methods of cat fishes.		
	17	Culture methods of cold water fishes.		
	18	Culture methods of freshwater prawns.		
	19	Culture methods of mussels (Freshwater pearl culture).		
	20	Culture methods of other freshwater species - Medium and minor carps, catfishes and murrels.		
	21	Wintering ponds, quarantine ponds and isolation ponds.		
	22	Sewage-fed fish culture.		
	23	Principles of organic cycling and detritus food chain.		
	24	Use of agro-industrial waste and biofertilizer in aquaculture.		
	25	Composite fish culture system of Indian and exotic carps-competition and compatibility.		

	26	Exotic fish species introduced to India and its impact on indigenous fish fauna.		
	27	Species of fish suitable for integrated aquaculture.		
	28	Integration of aquaculture with agriculture/horticulture- Paddy cum Fish/Shrimp Culture.		
	29	Integration of aquaculture with agriculture/horticulture - sericulture cum fish culture.		
	30	Integration of aquaculture with agriculture/horticulture – Mushroom cum fish culture.		
	31	Integration of aquaculture with livestock- Cattle, poultry, Duck cum fish culture.		
	32	Cultivation of aquatic macrophytes with aquaculture (makahana).		
	Practical	***PRACTICAL:***		
	1	Preparation and management of nursery pond.		
	2	Preparation and management of rearing pond.		
	3	Preparation and management of grow out pond.		
	4	Study on effect of liming, manuring and fertilization on hydrobiology of ponds and growth of fish and shellfishes.		
	5	Collection, identification and control of aquatic weeds.		
	6	Collection, identification and control of aquatic insects.		
	7	Collection, identification and control predatory and weed fishes: eggs and larval forms of fishes.		
	8	Algal blooms and their control.		
	9	Estimation of plankton and benthic biomass.		
	10	Study of natural and supplementary feeding in freshwater aquaculture.		
	11	Workout of economics of different culture practices- Carp culture.		
	12	Workout of economics of different culture practices- Catfish culture.		
	13	Workout of economics of different culture practices- Prawn culture.		
	14	Estimation of livestock requirement / Unit in integrated aquaculture.		
	15	Design of paddy plot for paddy-cum-fish culture. Design of Fish and Shrimp Culture, livestock shed on pond embankment.		
	16	Economics of different integrated farming systems		
2.	**Semester**	**Course No.**	**Title**	**Credits**
	1	**SEC.111**	**Aquarium Making, Decoration and Management**	**0+2=2**
	Practical	***PRACTICAL:***		
	1	Identification of Indigenous Ornamental Fish Species		
	2	Identification of Exotic Ornamental Fish Species		
	3	Identification of Common Ornamental Aquatic Plants		
	4	Identification of Common Marine Ornamental Fish Species		
	5	Collection and Identification of Local Ornamental Fish from Natural Resources		

	6	Collection and Identification of Local Aquarium Plants from Natural Resources		
	7	Steps in the Fabrication of an All-Glass Aquarium		
	8	Common Aeration Equipment for Aquariums		
	9	Different Types of Filters Used in Aquariums		
	10	Different Types of Lighting Equipment and Settings for Aquariums		
	11	Decorative Objects for Aquarium Design		
	12	Equipment and Kits for Water Quality Monitoring (Heaters, pH Meter, DO Meter, TDS Meter, etc.)		
	13	Substrate Selection for Various Aquarium Types		
	14	DIY Aquarium Decorations: Design and Creation		
	15	Routine Aquarium Maintenance (Cleaning Glass, Filters, and Substrate)		
	16	Conditioning and Packing of Ornamental Fish		
	17	Procedure for Acclimating New Fish to an Aquarium		
	18	Determining Stocking Density for Aquarium Fish		
	19	Ensuring Compatibility Among Aquarium Fish		
	20	Preparation of Ornamental Fish Feed: Wet and Dry		
	21	Live Feed for Aquarium Fish and Larvae		
	22	Setting Up a Breeding Tank for Livebearers		
	23	Setting Up a Breeding Tank for Barbs, Goldfish, and Tetras		
	24	Setting Up a Breeding Tank for Cichlids and Gouramis		
	25	Setting Up a Breeding Tank for Fighters		
	26	Aqua-scaping Techniques for Aquariums		
	27	Identification of Fish Diseases and Preventative Measures		
	28	Establishing a Quarantine Facility for Aquarium Units		
	29	Study of maturity stages in fish.		
	30	Preparation of Bankable Projects for Aquarium-Based Businesses		
	31-32	Field Visit to an Aquarium Shop/Public aquarium for Practical Exposure and report writing		
3.	**Semester**	**Course No.**	**Title**	**Credits**
	II	**AQ.122**	**Fish and Shellfish Breeding and Hatchery Management**	**2+1=3**
	Lecture	**Theory**		
	1	Freshwater and marine fish seed resources.		
	2	Natural breeding of finfishes. Selection of riverine spawn collection sites, gears used and methods of collection. Spawn quality and quantity indices. Advantages and disadvantages of riverine seed collection.		
	3	Sexual maturity and breeding season of various cultivable species. Development of gametes in male and female. Fish egg and embryonic development.		

	4	Methods of breeding; bundh breeding - wet and dry bundhs, collection and hatching of eggs, factors involved in bundh breeding, advantages, and disadvantages of bundh breeding.
	5	Induced breeding of warmwater finfishes, environmental factors affecting spawning, sympathetic breeding.
	6	Fish pituitary gland – its structure, collection, preservation, and preparation of extract for injection, dosages, and methods of injection.
	7	Brood-stock management and transportation of brood fish.
	8	Synthetic hormones used for induced breeding of carps.
	9	Different types of fish hatcheries-traditional, Chinese, glass jar and modern controlled hatcheries.
	10	Causes of mortalities of eggs and spawn and remedies. Spawn rearing techniques.
	11	Use of anesthetics in fish breeding and transport.
	12	Breeding techniques for Indian major carps and exotic carps.
	13	Breeding techniques for Cold water fishes: Mahseer, Trout.
	14	Breeding techniques for Cat fishes.
	15	Breeding techniques for Mullet, Milk fish.
	16	Breeding techniques for Pearl spot, Tilapia.
	17	Breeding techniques for Sea bass, grouper.
	18	Breeding techniques for pacu, cobia, popanos and indigenous species.
	19	Off-season and multiple breeding of carps.
	20	Natural seed resources, site selection and collection methods.
	21	Life cycle of important shellfish (*Penaeus monodon, P. indicus, Macrobrachiumrosenbergii, P. vannamei, Scylla serrata*, lobster, edible, oyster, pearl oyster).
	22	Life cycle of important shellfish (fresh water mussel, holothurians, horseshoe carb, Sepia, Loligo, cray fish etc.).
	23	Sexual maturity and breeding seasons of different species.
	24	Maturation stages of *Macrobrachiumrosenbergii, Penaeus monodon* and *P. vannamei*.
	25	Induced maturation in *Penaeus monodon, P. vannamei*and *P. indicus* by eye stalk ablation.
	26	Reproductive physiology. Reproductive hormones in crustaceans.
	27	Brood stock management of *Penaeus monodon* and *Macrobrachiumrosenbergii*.
	28	Breeding and hatchery management of *P. monodon* and *M. rosenbergii*.
	29	Breeding and hatchery management of crabs.
	30	Breeding and hatchery management of mussels, edible and pearl oysters.
	31	Food and feeding of larval stages of important shellfishes.
	32	Health management in hatcheries.
	Practical	***PRACTICAL:***

	1	Study of maturity stages in fish.		
	2	Collection and preservation of fish pituitary gland and preparation of PG extract, Hypophysation.		
	3	Calculation of fecundity.		
	4	Brood stock maintenance and selection of brood fishes for injection.		
	5	Different fish hatchery systems.		
	6	Study of fish eggs and embryonic developmental stages and identification of eggs, spawn, fry and fingerlings of different species.		
	7	Preparation and management of fish nursery.		
	8	Fish seed and broodstock transportation. Use of anesthetics, disinfectants and antibiotics in fish breeding.		
	9	Water quality monitoring in fish hatcheries and nurseries.		
	10	Breeding and larval rearing of common finfishes.		
	11	Identification of brood stock and maturity stages of important crustaceans and molluscs.		
	12	Breeding and larval rearing of *Macrobrachiumrosenbergii, Penaeus monodon,* and *P. vannamei*.		
	13	Identification of larval stages of important crustaceans and molluscs.		
	14	Demonstration of eyestalk ablation in *Penaeus monodon*.		
	15	Collection, packing and transportation of shrimp/prawn seed and brood stock.		
	16	Water treatment and management in shrimp and hatcheries. Different chemicals and drugs used in shrimp/ prawn hatchery.		
4.	**Semester**	**Course No.**	**Title**	**Credits**
	1I	**SEC.123**	**Fish Breeding and Hatchery Operation**	**0+2 =2**
	Practical	***PRACTICAL:***		
	1	Study of maturity stages in fish.		
	2	Collection and preservation of fish pituitary gland,		
	3	Preparation of hypophysial extract.		
	4	Calculation of fecundity.		
	5	Brood stock management		
	6	Fish seed and brood stock transportation.		
	7	Use of anesthetics, disinfectants and antibiotics in fish breeding.		
	8	Designing and Layout of a typical catfish hatchery		
	9	Designing and Layout of a typical cold water fish hatchery		
	10	Designing and Layout of a typical marine or brackishwater fish hatchery		
	11-17	Designing and Layout of carp hatchery		
		Site selection		
		Estimation of brood fish requirement		
		Calculation of area required for brood fish rearing tank		

		Calculation of the dimension of the spawning pool		
		Calculation of the dimension of the incubation pool		
		Calculation of area required for nursery tank		
	18	Hatchery setup and pre-breeding management		
	19	Selection of brood fish		
	20	Sexual dimorphism in commercially important fishes		
	21	Methods of hormonal injections		
	22	Operation of the spawning pool		
	23	Operation of the incubation pool		
	24	Study of embryonic developmental stages of fishes		
	25	Estimation of the number of eggs present incubation pool, fertilization rate, hatching rate, and spawn recovery		
	26	Method of fish striping (Wet striping and dry striping)		
	27	Water quality monitoring in fish hatcheries		
	28	Identification of larval stages of different species		
	29	Visit to fish hatchery		
	30-32	Preparation of a bankable project for the establishment of the fish hatchery		
5.	**Semester**	**Course No.**	**Title**	**Credits**
	III	**AQ.213**	**Coastal Aquaculture and Mariculture**	**2+1=3**
	Lecture	***THEORY :***		
	1	An over view of sea farming and shore based aquaculture in different parts of world: Global aquaculture production		
	2	Resources for shore-based aquaculture and sea farming in India.		
	3	Traits of important cultivable fish and shellfish: Sea bass, mullet, milkfish, grouper, snappers, ayu, pearlspot , etc		
	4	Traits of important cultivable fish and shellfish: Tiger shrimp, Vennamei shrimp, mud crab.		
	5	Traits of important cultivable fish and shellfish: Mussel & clam species		
	6	Traits of important cultivable fish and shellfish: Edible & pearl oyster species		
	7	Traits of important cultivable fish and shellfish: seaweeds		
	8	Traditional (bheries, Gheries) shore based aquaculture systems in India		
	9	Traditional shore based aquaculture systems in India: Pokali fields in kerala		
	10	Traditional (gaznisand khazans) shore based aquaculture systems in India		
	11	Site selection for coastal aquaculture and mariculture		
	12	Farm designing for coastal aquaculture		

	13	Extensive, semi-Intensive, intensive aquaculture practices of commercially important species of fish and shellfish.: Culture of Sea bass
	15	Extensive, semi-Intensive, intensive aquaculture practices of commercially important species of fish and shellfish: Culture of Mullet
	16	Extensive, semi-Intensive, intensive aquaculture practices of commercially important species of fish and shellfish. Culture of Milk fish
	17	Extensive, semi-Intensive, intensive aquaculture practices of commercially important species of fish and shellfish. Culture of Grouper
	18	Extensive, semi-Intensive, intensive aquaculture practices of commercially important species of fish and shellfish. Culture of shrimp
	19	Extensive, semi-Intensive, intensive aquaculture practices of commercially important species of fish and shellfish. Culture of Mud crab
	20	Extensive, semi-Intensive, intensive aquaculture practices of commercially important species of fish and shellfish. Culture of clam
	21	Extensive, semi-Intensive, intensive aquaculture practices of commercially important species of fish and shellfish. Culture of mussel
	22	Culture of oyster
	23	Culture of sea weed
	24	Methods of aquaculture - cages
	25	Methods of aquaculture - Rafts, racks, poles and ropes
	26	Water and soil quality management: Important water quality parameters
	27	Water and soil quality management: Management including reclamation of acid sulphate soil
	28	Estimation of growth, survival and pond productivity
	29	Modern practices of shrimp farming in India
	30	Sea ranching.
	31	Pearl culture
	32	Economic analysis of modern shrimp farming
	Practical	***PRACTICAL:***
	1	Identification of important cultivable fishes: Fin fishes
	2	Identification of important cultivable fishes: Crustaceans
	3	Identification of important cultivable fishes: Mollucs
	4	Collection and identification of commercially important seed of fish .

	5	Collection and identification of commercially important seed of shellfishes		
	6	Types of fertilizers- pond preparation.		
	7	Seed selection and quality		
	8	Techniques of acclimatization of fish seed		
	9	Water quality parameters.		
	10	Estimation of seed survival.		
	11	Pond biomass estimation.		
	12	Material, apparatus and machinery for shore based aquaculture and sea farming.		
	13	Material, apparatus and machinery sea farming.		
	14	Estimation of feed intake.		
	15	Growth and health monitoring.		
	16	Fouling organism in cages and pens.		
6.	**Semester**	**Course No.**	**Title**	**Credits**
	IV	**AQ.224**	**Fish Nutrition and Feed Technology**	**2+1=3**
	Lecture	***THEORY :***		
	1-2	Fundamentals of fish nutrition and growth in fish.		
	3	Principal nutrients and nutritional requirements of cultivable fish and shellfish (protein requirement).		
	4	Principal nutrients and nutritional requirements of cultivable fish and shellfish (Fat/Lipid requirement).		
	5	Principal nutrients and nutritional requirements of cultivable fish and shellfish (carbohydrate requirement).		
	6	Principal nutrients and nutritional requirements of cultivable fish and shellfish (Vitamin requirement).		
	7-8	Nutritional energetics: definition and forms of energy partitioning.		
	9-10	Methods of feed formulation and manufacturing.		
	11	Forms of feeds: wet feeds, moist feeds, dry feeds, mashes, pelleted feeds, floating and sinking pellets..		
	12	Forms of feed : Spray dried diet, Micro-bound diet, micro encapsulated diet, flake diet).		
	13	Feed additives : binders, antioxidants, Anti microbial agents, enzymes.		
	14	Feed additives: pigments, growth promoters, Chemo attractants and feed stimulants.		
	15	Feed additives: Probiotics and immune-stimulants.		
	16	Feed storage: Role of moisture and heat.		
	17	Feed storage: Microbial, insect/rodent damage.		
	18	Feed storage: Chemical changes during storage and storage time of selected feed stuff.		
	19	Feed storage, use of preservatives and antioxidants.		

	20	Feed evaluation - Feed conversion ratio, feed efficiency ratio.
	21	Feed evaluation - protein efficiency ratio, net protein utilization and biological value.
	22	Feeding devices.
	23	Feeding methods-Hand feeding, bag feeding, Automatic feeders.
	24	Different feeding strategies.
	25	Feeding frequency and feeding rate.
	26	Different types of feed ingredients: Ingredients of animal origin.
	27	Different types of feed ingredients: Ingredients of plant origin.
	28	Non-conventional feed ingredients.
	29	Antinutritional factors in feed ingredients.
	30	Feed digestion: Digestive fluid and enzymes.
	31	Digestibility and factors affecting digestibility.
	32	Nutritional deficiency diseases.
	Practical	***PRACTICAL:***
	1	Proximate composition: analysis of feed ingredients and feeds. (Protein Estimation- Digestion).
	2	Proximate composition: analysis of feed ingredients and feeds. (Protein Estimation- Extraction and estimation).
	3	Proximate composition: analysis of feed ingredients and feeds. (Fat Estimation).
	4	Proximate composition: analysis of feed ingredients and feeds. (Moisture Estimation).
	5	Proximate composition: analysis of feed ingredients and feeds. (Ash Estimation).
	6	Preparation of artificial feeds using locally available feed ingredients. (Feed formulation exercise).
	7	Preparation of artificial feeds using locally available feed ingredients.(Weighing, Grinding, mixing, pelleting and drying).
	8	Calculation of feeding rate and feeding frequency.
	9	Formulation and preparation of moist feed by using locally available ingredients.
	10	Determination of sinking rate and stability of feeds.
	11	Determination of storage effect on feed quality -Protein associated changes
	12	Determination of storage effect on feed quality – Fat associated changes.
	13	Estimation of the digestible energy content of the feed.
	14	Estimation of the gross energy content of feed.
	15	Equipments and machineries used in feed production.
	16	Visit to commercial feed plant.

7.	Semester	Course No.	Title	Credits
	IV	**AQ.225**	**Breeding and Culture of Ornamental Fish**	**1+1=2**
	Lecture	***THEORY :***		
	1	World trade of ornamental fish and export potential.		
	2	Different varieties of exotic fishes.		
	3	Different varieties of indigenous fishes.		
	4	Principles of a balanced aquarium.		
	5	Fabrication, setting up and maintenance of freshwater and marine aquarium.		
	6	Water quality management, Water filtration systems - biological, mechanical and chemical, Types of filters.		
	7	Aquarium plants and their propagation methods.		
	8	Lighting and aeration, aquarium accessories and decoratives.		
	9	Aquarium fish feeds, Dry, Wet and live feeds.		
	10	Broodstock management, Breeding and rearing of ornamental fishes: Live bearer		
	11	Broodstock management, Breeding and rearing of ornamental fishes: Eggs layers		
	12	Application of genetics and biotechnology for producing quality strains.		
	13	Management practices of ornamental fish farms		
	14	Common diseases and their control.		
	15	Conditioning, packing, transport and quarantine methods.		
	16	Trade regulations and Wild Life Act in relation to ornamental fishes.		
	1	World trade of ornamental fish and export potential.		
	2	Different varieties of exotic fishes.		
	3	Different varieties of indigenous fishes.		
	4	Principles of a balanced aquarium.		
	5	Fabrication, setting up and maintenance of freshwater and marine aquarium.		
	6	Water quality management, Water filtration systems - biological, mechanical and chemical, Types of filters.		
	7	Aquarium plants and their propagation methods.		
	8	Lighting and aeration, aquarium accessories and decoratives.		
	9	Aquarium fish feeds, Dry, Wet and live feeds.		
	10	Broodstock management, Breeding and rearing of ornamental fishes: Live bearer		
	11	Broodstock management, Breeding and rearing of ornamental fishes: Eggs layers		
	12	Application of genetics and biotechnology for producing quality strains.		
	13	Management practices of ornamental fish farms		

	14	Common diseases and their control.		
	15	Conditioning, packing, transport and quarantine methods.		
	16	Trade regulations and Wild Life Act in relation to ornamental fishes.		
	Practical	***PRACTICAL:***		
	1	Identification of common ornamental fishes and plants.: indigenous species		
	2	Identification of common ornamental fishes and plants.: Exotic species		
	3	Identification of common ornamental fishes and plants.: Ornamental plants		
	4	Identification of common ornamental fishes and plants.: Marine ornamental fishes		
	5	Fabrication of all glass aquarium.		
	6	Setting-up of aquarium tank		
	7	Maintenance of an aquarium tank.		
	8	Aquarium accessories and equipments.		
	9	Conditioning and packing of ornamental fishes.		
	10	Preparation of feed.		
	11	Setting up of breeding tank for live bearers		
	12	Setting up of breeding tank for barbs, gold fish and tetras etc.		
	13	Setting up of breeding tank for Cichlids &Gouramies		
	14	Setting up of breeding tank for fighters and cat fishes		
	15	Identification of fish diseases and prophylactic measures.		
	16	Assignment		
8.	**Semester**	**Course No.**	**Title**	**Credits**
	IV	**AQ.225**	**Breeding and Culture of Ornamental Fish**	**1+1=2**
	Lecture	***THEORY :***		
	1	Introduction to Fish food organisms		
	2	Candidates species of phytoplankton as live food organisms of freshwater and marine species.		
	3	Candidates species of zooplankton as food organisms of freshwater and marine species		
	4	Trophic potential - Proximate composition of live feed		
	5	Biology, culture requirement, and methodology of culture of important live food organism: Green algae		
	6	Biology, culture requirement, and methodology of culture of important live food organism: Blue-green algae (spirulina)		
	7	Biology, culture requirement, and methodology of culture of important live food organism: Diatoms		
	8	Biology, culture requirement, and methodology of culture of important live food organism: Infusoria		

	9	Biology, culture requirement, and methodology of culture of important live food organism: rotifers		
	10	Biology, culture requirement, and methodology of culture of important live food organism: Cladocerons		
	11	Biology, culture requirement, and methodology of culture of important live food organism: Tubifex worm		
	12	Biology, culture requirement, and methodology of culture of important live food organism: Brine shrimp		
	13	Biology, culture requirement, and methodology of culture of important live food organism: Chironimids		
	14	Biology, culture requirement, and methodology of culture of important live food organism: Earthworm		
	15	Bait fish and forage fish: Types and candidate species		
	16	Role of biofilm in aquaculture		
	Practical	***PRACTICAL:***		
	1	Introduction to culture of fish food organisms		
	2	Qualitative and quantitative analysis of plankton - Collection and Preservation of Plankton		
	3	Qualitative and quantitative analysis of plankton- Qualitative estimation		
	4	Qualitative and quantitative analysis of plankton- Quantitative Estimation		
	5	Identification Of Common Aquatic Flora And Fauna- Freshwater Fauna		
	6	Identification of common aquatic flora and fauna :Brackishwater and marine flora and fauna		
	7	Isolation and culture of microalgae: Important media used for algal culture:		
	8	Isolation and culture of microalgae: Isolation of pure algal strains by agar plating		
	9	Isolation and culture of microalgae: Mass culture of algae		
	10	Culture of cladocerans: Stock culture		
	11	Culture of cladocerans: Mass culture		
	12	Culture of microworms		
	13	Culture of infusoria		
	14	Decasulation of artemia cyst		
	15	Hatching of artemia cyst		
	16	Evaluation of live food organism		
9.	**Semester**	**Course No.**	**Title**	**Credits**
	V	**AQ.317**	**Fish Genetics and Breeding**	**1+1=2**
	Lecture	***THEORY :***		
	1	Principles of genetics and breeding.		
	2	Gene and chromosome as a unit of inherritance, structure of genetic material.		

	3	Mendel's law of inheritance – complete and incomplete dominance, monohybrid and dihybrid ratios. Gene interactions – dominant and recessive epistasis.		
	4	Pleiotropism. Lethal genes. Mutation. Sex - linked genes, sex influenced and sex limited traits. Linkage and crossing over. Introduction to population genetics.		
	5	Hardy- Weinberg law and its significance.		
	6	Chromosomal structure and aberrations. Chromosome manipulation techniques- androgenesis, gynogenesis and polyploidy and identification of ploidy.		
	7	Sex determination.		
	8	Cross breeding (hybridization) – types of cross breeding, heterosis and design of cross breeding programmes, hybridization in different fishes.		
	9	Quantitative genetics – quantitative traits, polygenic traits, heritability.		
	10	History and present status of selective breeding programs in aquaculture.		
	11	Selection methods and mating designs. Design for selective breeding for Qualitative traits.		
	12	Selection methods and mating designs. Design for selective breeding for Quantitative traits.		
	13	Inbreeding and its consequences.		
	14	Domestication methods.		
	15	Seed certification and quarantine procedures.		
	16	Cryopreservation of gametes.		
	Practical	***PRACTICAL:***		
	1-4	Problems on Mendelian inheritance (qualitative genetics) - monohybrid and dihybrid ratios and epistasis.		
	5-6	Problems on quantitative traits, response to selection and heritability.		
	7	Estimation of rate of inbreeding.		
	8	Estimation of heterosis.		
	9	Estimation of inbreeding coefficient.		
	10	Preparation of Selection index for the selective breeding program.		
	11	Mitotic and meiotic chromosome preparation.		
	12-13	Demonstration of protocol of androgenesis, gynogenesis and polyploidy.		
	14	Problems on gene and genotypic frequency.		
	15	Gamete cryopreservation protocols and quality evaluation of fish milt.		
	16	Study of risk factors in cryopreservation technique.		
10.	**Semester**	**Course No.**	**Title**	**Credits**
	VI	**AQ.328**	**Fish Biotechnology and Bioinformatics**	**1+1=2**
	Lecture	***THEORY :***		
	1	Biotechnology: Introduction to Biotechnology –scope and importance in fisheries/aquaculture.		

	2	Structural organization of prokaryotic and eukaryotic cell.
	3	Nucleic acids -structure, function and types.
	4	Concepts of gene and genetic code, transcription and translation, mutations and their implications.
	5	Post transcriptional modification and RNA processing.
	6	Gene regulation and expression in prokaryotes and eukaryotes; DNA sequencing, Operons.
	7	Genetic engineering- Restriction enzymes; Gene isolation; Cloning vectors; Probes; Recombinant DNA technology – vaccines.
	8	Transgenic fish and Gene transfer technology, Animal Cell Culture, Hybridoma technology.
	9	Molecular and immunological techniques – PCR; immunoblotting; ELISA; Principle of hybridization; Northern blotting; Western blotting; Southern blotting; DNA fingerprinting; Restriction fragment length polymorphism., Biosensors.
	10	Molecular and immunological techniques – PCR; immunoblotting; ELISA; Principle of hybridization; Northern blotting; Western blotting; Southern blotting; DNA fingerprinting; Restriction fragment length polymorphism., Biosensors.
	11	Molecular and immunological techniques – PCR; immunoblotting; ELISA; Principle of hybridization; Northern blotting; Western blotting; Southern blotting; DNA fingerprinting; Restriction fragment length polymorphism., Biosensors.
	12	Concept of bioremediation of water, bioprocess engineering and bioprospecting.
	13	Bioinformatics**:** Introduction to Bioinformatics.
	14	Biological Databases and tools : Introduction.
	15	Types of biological databases; Primary and secondary databases; PDB, NCBI, formats and contents.
	16	Sequence retrieval, manipulation; Primer design; Restriction mapping; ORF finding; EMBOSS, Molecular visualization Sequence analysis.
	Practical	***PRACTICAL:***
	1	Study of structure of prokaryotes Cells.
	2	Study of structure of Eukaryotes Cells.
	3	Study on Model of protein Synthesis.
	4-6	Study of models of rDNA Technology.
	7-9	Study of models of Cell Culture Technology.
	10-11	Isolation of Nucleic Acids.
	12	Study of Restriction enzymes.
	13	Study of Gel Electrophoresis.
	14	Study of ELISA test.
	15-16	DNA sequence analysis and comparison.
	1	Study of structure of prokaryotes Cells.

	2	Study of structure of Eukaryotes Cells.		
	3	Study on Model of protein Synthesis.		
	4-6	Study of models of rDNA Technology.		
	7-9	Study of models of Cell Culture Technology.		
	10-11	Isolation of Nucleic Acids.		
	12	Study of Restriction enzymes.		
	13	Study of Gel Electrophoresis.		
	14	Study of ELISA test.		
	15-16	DNA sequence analysis and comparison.		
11.	**Semester**	**Course No.**	**Title**	**Credits**
	VII	**AQ.419**	**Open-Water Aquaculture**	**2+1=3**
	Lecture	***THEORY :***		
	1	Global and Indian Scenario of Open Water Aquaculture: Status, Utilization, and Prospects for Production Enhancement		
	2	Open Water Limnology: Key Features and Significance in Fisheries Development		
	3	Management, Conservation, and Future Prospects of Open Water Fisheries		
	4	Role of Cage Culture in Enhancing Fish Production in Open Water Bodies		
	5	History, Advantages, and Applications of Cage Culture in Fisheries		
	6	Site Selection, Cage Materials, and Structural Design for Cage Culture		
	7	Construction of Cages: Bioengineering Challenges and Solutions		
	8	Species Selection and Rearing Techniques in Cage Culture		
	9	Constraints and Challenges in Cage Culture Practices		
	10	Economic Aspects and Profitability of Cage Culture		
	11	Integration of Cage Culture with Other Farming Systems		
	12	History and Development of Pen Culture		
	13	Pen Materials, Fabrication, and Structural Design		
	15	Fish Breeding and Seed Rearing in Pen Culture		
	16	Grow-out Systems and Species Selection in Pen Culture		
	17	Challenges and Constraints in Pen Culture Practices		
	18	Economic Aspects and Viability of Pen Culture		
	19	Species Selection, Quality, and Stocking Strategies in Pen		
	20	Natural Feed Enhancement Techniques for Open Water Aquaculture		
	21	Supplementary Feeding Strategies in Cages and Pens		
	22	Stock Assessment Methods in Open Water Aquaculture		
	23	Harvesting Techniques and Post-Harvest Management in Open Water Systems		
	24	Conflicts of Open Water Aquaculture with Irrigation, drinking and Hydroelectric Projects		

	25	Environmental Impact of Open Water Aquaculture: Salinity Intrusion and Effluent Discharge		
	26	Eutrophication and Chemical Contaminants in Open Water Aquaculture		
	27	Destruction of Natural Habitats: Paddy Fields, Mangroves, and Ecosystem Disturbances		
	28	Social Issues and Resource Conflicts in Open Water Aquaculture		
	29	Ranching in Open Waters: Concept and Applications		
	30	Impact of Climate Change on Open Water Aquaculture		
	31	Role of Indigenous and Exotic Fish Species in Open Water Aquaculture		
	32	Policy, Regulations, and Governance in Open Water Aquaculture		
	Practical	***PRACTICAL:***		
	1	Preparation of charts on the present situation of open water fisheries productivity: Small, medium and large reservoirs		
	2	Preparation of charts on the present situation of fisheries productivity: Rivers, lakes and estuaries		
	3	Preparation of charts on the present situation of fisheries productivity: Floodplain and wetlands, Backwaters and Lagoons		
	4	Preliminary observations on hydrobiological parameters of the selected rivers: Physical and chemical factors		
	5	Preliminary observations on hydrobiological parameters of the selected reservoirs: Biological factors		
	6	Detailed case studies of selected reservoirs on the changing trends in capture fisheries profile: Small reservoirs		
	7	Detailed case studies of selected backwaters on the changing trends in capture fisheries profile		
	8	Detailed case studies of selected lagoons/ esturies on the changing trends in capture fisheries profile		
	9	Drawing inferences from the analysis of data and suggestions for the sustainable development of reservoirs fisheries.		
	10	Case studies on cage and pen culture: Site selection for cage and pen culture		
	11	Case studies on cage and pen culture: Designing and layout of cage culture		
	12	Case studies on cage and pen culture: Fabrication of cages and pens		
	13	Case studies on cage and pen culture: Feeding rate, growth and health monitoring		
	14	Case studies on cage and pen culture- Repair and maintenance of cages and pen		
	15	Field visit to cage culture to acquaint with construction details and operation.		
	16	Field visit to pen culture site to acquaint with construction details and operation.		
12.	**Semester**	**Course No.**	**Title**	**Credits**

	VII	**AQ.411**	**Smart Aquaculture Production Systems**	**3(2+1)**
	Lecture	***THEORY :***		
	1	Introduction: An overview of global aquaculture production, demand-consumption scenario and emerging trends.		
	2	Present status, Constraints and future prospects in India and the world.		
	3	Aquaculture practices indifferent parts of the world, Enhancing carrying capacity in culture systems.		
	4	Biofloc technology: Principles of biofloc.		
	5	Biofloc technology: Different carbon sources.		
	6	Biofloc technology: Design of aeration system and biofloc reactor.		
	7	Biofloc technology: Biofloc reactor.		
	8	Biofloc technology: Carrying capacity, C: N ratio.		
	9	Biofloc technology: Harvesting of biofloc, Biofloc quality and quantity.		
	10	Biofloc technology: Biofloc as feed ingredient.		
	11	Biofloc technology: Stocking of fish and shellfish species.		
	12	Bioremediation in wastewater aquaculture.		
	13	Minimal water exchange aquaculture systems: Principles of closed system farming, RAS, Components.		
	14	Minimal water exchange aquaculture systems: Design of mechanical and biological filters for the water reuse system,		
	15	Minimal water exchange aquaculture systems: Sludge removal,disposal of wastes and control of pollution to the environment.		
	16	Minimal water exchange aquaculture systems: Design of RAS, biofiltration and Nitrifiers.		
	17	Minimal water exchange aquaculture systems: Suitable cultivable species for indoor culture systems, polyhouses.		
	18	Aquaponics: Principles, Components and Design of different aquaponics systems.		
	19	Aquaponics: Components in aquaponics, ratio of fish and plants		
	20	Aquaponics: Water quality and system maintenance, Resource utilization, Nutrient recycling and zero discharge of nutrients.		
	21	Running water systems: Flow-through system.		
	22	Running water systems: Raceways (IPR).		
	23	Running water systems: IMTA.		
	24	Running water systems: Partitioned Aquaculture Systems (PAS).		
	25	Running water systems: Aquamimicry systems.		
	26	Other farming methods: Cluster farming.		
	27	Other farming methods: Organic farming.		
	28	Other farming methods: Satellite farming.		
	29	Other farming methods: Co-operative farming.		

	30	Other farming methods: Conservation aquaculture.		
	31	Network of production and marketing aspects.		
	32	Economics of super intensive farming systems, Advantages and disadvantages.		
	Practical	***PRACTICAL:***		
	1	Design of biofloc systems.		
	2	Fabrication of biofloc systems.		
	3	Performance evaluation of biofloc systems.		
	4	Different equipment in closed grow-out system: Aerators.		
	5	Different equipment in closed grow-out system: Biofilters.		
	6	Different equipment in closed grow-out system: RAS.		
	7	Different equipment in closed grow-out system: Raceways.		
	8	Different equipment in closed grow-out system: IMTA.		
	9	Different equipment in closed grow-out system: IMTA and PAS.		
	10	Different equipment in closed grow-out system: Aquaponics systems.		
	11	Plankton and microbial analysis of biofloc.		
	12	Studies on different C: N ratio.		
	13	Nutrient analysis in aquaponics.		
	14	Visit to hatcheries with super-intensive models.		
	15	Identification and understanding the network of the systems; Market analysis for the produces.		
	16	Analysis of economic advantages- Case studies.		
13.	**Semester**	**Course No.**	**Title**	**Credits**
	VIII	**AQ.317**	**Coldwater Aquaculture and Recreational Fisheries**	**1+1=2**
	Lecture	***THEORY :***		
	1	Introduction: Status of coldwater fisheries in World with special reference to India		
	2	Biology, breeding and culture of trouts*Oncorhynchus mykiss, Salmo trutta fario, Schizothoraichthysesocinus, S. longipinnis, S. niger, Schizothoraxrichadsonii*).		
	3	Biology, breeding and culture of mahseer *(Tor putitora, Tor tor, Tor khudree)*.		
	4	Biology, breeding and culture of common carp *(Cypinus carpio cummunis, Cyprinus carpio specularis)*.		
	5	Specific environmental parameters pertaining to cold water fish culture and metabolic interaction		
	6	Feeds suitable for cold water aquaculture.		
	7	Culture of cold-water fishes: Construction and management of cold-water fish farms.		

	8	Culture of cold-water fishes: Effect of exotic fish introduction on indigenous fish fauna.
	9	Culture of cold-water fishes: Polyculture of exotic carp in mid hill region based on three Chinese carps.
	10	Culture of cold-water fishes: Post-harvest and harvest issues in trout with regards to cold water species
	11	Culture of cold-water fishes: Special factors for consideration in cold water fish seed production and nursery rearing.
	12	Introduction to sport fisheries: Sports fishes and their life history
	13	Equipment for sports fishing, fishing methods, area suitable for sports fishing, etc.
	14	Management and conservation of sports fisheries through aquaculture
	15	Sport fisheries and tourism, Recreational aquaculture
	16	Potential and Innovative Strategies for the Development of coldwater aquaculture in India- problems encountered in fisheries development of rivers supporting cold water fisheries.
	Practical	***PRACTICAL:***
	1	Identification of coldwater fish species-trouts.
	2	Identification of coldwater fish species-mahseer.
	3	Identification of coldwater fish species-common carps.
	4	Primary and secondary sexual characters in cold water fishes-trouts.
	5	Primary and secondary sexual characters in cold water fishes-mahseer.
	6	Primary and secondary sexual characters in cold water fishes-common carp.
	7	Different breeding methods for cold water fishes-trouts.
	8	Different breeding methods for cold water fishes-Mahseer and common carp.
	9	Identification of larval stages of trout.
	10	Identification of larval stages of mahseer.
	11	Preparation of hatchery layout for coldwater fishes-trouts.
	12-13	Preparation of hatchery layout for coldwater fishes-mahseer
	14	Preparation of hatchery layout for coldwater fishes-common carp
	15	Studies on different types of sports fishing equipment.
	16	Visit to coldwater fish hatcheries and farms.