

Syllabus for B.F.Sc. to be implemented w.e.f., 2023-24

Semester I

Sl. No.	Course Title	Credit hour
1	Principles of Aquaculture	2(1+1)
2	Taxonomy of Finfish	3(1+2)
3	Taxonomy of Shellfish	2(1+1)
4	Meteorology, Climatology and Geography	2(1+1)
5	Statistical Methods	3(2+1)
6	Fundamentals of Biochemistry	3(2+1)
7	Fundamentals of Microbiology	3(2+1)
8	Soil and Water Chemistry	3(2+1)
9	Fish in Nutrition	1(1+0)
10	Swimming	1(0+1) CNC*
	Total	22(13+9)

1. Principles of Aquaculture 2(1+1)

Theory Basics of aquaculture, definition and scope. History of aquaculture: Present global and national scenario. Aquaculture vs Agriculture. Systems of aquaculture - pond culture, pen culture, cage culture, running water culture and zero water exchange system,. Extensive, semi-intensive, intensive and super intensive aquaculture in different types of water bodies viz., freshwater, brackish water inland saline and marine water. Principles of organic aquaculture. Pre-stocking and post stocking pond management. Carrying capacity of pond, factors influencing carrying capacity. Criteria for selection of candidate species for aquaculture. Major candidate species for aquaculture: freshwater, brackish-water and marine. Monoculture, polyculture and integrated culture systems. Water and soil quality in relation to fish production. Physical, chemical and biological factors affecting productivity of ponds. Importance and scope of aquaculture in hilly areas (Snow Trout, Mahseer, Salmon).

Practicals Aquaculture production statistics- world and India. Aquaculture resources of world and India. Components of Aquaculture farms. Estimation of carrying capacity. Practices on prestocking and post stocking management. Growth studies in aquaculture system. Study on waste accumulation in aquaculture system (NH₃ , Organic matter, CO₂). Analysis of manure.

2. Taxonomy of Finfish 3(1+2)

Theory Principles of taxonomy. Nomenclature, types. Classification and interrelationships. Criteria for generic and specific identification. Morphological, morphometric and meristic characteristics of taxonomic significance. Major taxa of inland and marine fishes up to family level. Commercially important freshwater and marine fishes of India and their morphological characteristics. Introduction to modern taxonomic tools: karyotaxonomy, DNA barcoding, protein analysis and DNA polymorphism.

Practicals Collection and identification of commercially important inland and marine fishes. Study of their external morphology and diagnostic features. Modern taxonomic tools - Protein analysis and electrophoretic studies; Karyotaxonomy - chromosome preparation and identification. DNA barcoding, DNA polymorphism; Visit to fish landing centres to study commercially important fishes and catch composition.

3. Taxonomy of Shellfish 2(1+1)

Theory Study of external morphology and meristic characteristics of crustacea and mollusca. Classification of crustacea and mollusca up to the level of species with examples of commercially important species. Practicals Study of external morphology. Collection, preservation and identification of commercially important prawns, shrimps, crabs, lobsters, bivalves, gastropods, cephalopods from natural habitats. Field visits for collection and study of commercially important shellfishes. 3. Anatomy and Biology of Finfish 3(2+1) Theory Study of external and internal anatomy of important groups of finfish. Study of oral region and associated structures. Digestive system and associated digestive glands. Food and feeding habits of commercially important fishes. Qualitative and quantitative methods of analysis of gut contents. Circulatory system, respiratory system, nervous system, urino-genital system, endocrine system, skeletal systems and sensory organs. Reproductive biology – maturity stages, gonado-somatic index, ponderal index, fecundity, sex ratio and spawning. Eggs and larval stages and developmental biology. Age and growth determination by direct and indirect methods. Fish migration - type and significance. Tagging and marking.

Practicals Study of internal organs – digestive, respiratory, circulatory, urino-genital system, nervous, skeletal systems and endocrine system. Study of food and feeding habits. Analysis of gut contents.

4. Meteorology, Climatology and Geography 2(1+1)

Theory Nature of Atmosphere: weather and climate; composition of atmosphere; structure of atmosphere. Heat energy of atmosphere: process of heat transmission; heating of atmosphere; disposal of insulation; irregular heating of atmosphere. Temperature: Temperature instruments; periodic, horizontal and vertical temperature variations; effects of vertical air motion on temperature. Humidity and water vapour: relationship between temperature and humidity; distribution of water vapour in atmosphere; evaporation, humidity instruments and measurements. Condensation and precipitation: process of conditions of condensation, forms of condensation; precipitation; forms of precipitation, measurement of precipitation; rainfall in India. Clouds and thunderstorms: amount of cloudiness; ceiling; classification of clouds; conditions of cloud formation; reporting and identification of clouds; thunderstorms. Atmospheric pressure: meaning of atmospheric pressure; the laws of Gases; pressure units; pressure instruments; vertical, horizontal and periodic variations; isobars and pressure gradients. Wind: characteristics of wind motion; wind observation and measurement; wind representation; factors affecting wind motion. Terrestrial or planetary winds: ideal planetary wind system; planetary pressure belts. Planetary wind system; secondary winds; monsoon winds; land and sea breeze. Tropical cyclones: storm divisions; pressure and winds; vertical structure of storm centre; hurricane, sea, swell and surge; hurricane warning. Weather forecasting: forecasting process; forecasting from local indications; role of satellite in weather forecasting; synoptic weather charts. Effects of climate change on fisheries sector. Introduction to Geography: shape, size and structure of the earth; concepts of latitude, longitude and great circles; model globe, maps and different types of projections; cartography; landscape. Climatic and geographical aspects of hilly states particularly Uttarakhand.

Practicals Graphic representation of structure of atmosphere; physical layering and compositional layering. Temperature instruments: simple thermometers; Six's Max-Min

Thermometer; thermograph. Isotherms: world mean temperatures-January to July. India mean temperatures - January to July. Humidity measurement: hygrometer; psychrometer; relative humidity; dew point. Condensation: observation and identification of various types of clouds. Depicting sky picture. Precipitation: measurement of rainfall using rain gauge. Mapping Indian monsoons: south-west monsoon and rainfall in June, North-east monsoon and rainfall in December; isohyets. Atmospheric pressure measurement: Fortin's mercurial barometer; Aneroid barometer. Isobars: India mean pressure - Jan to July. Wind observation and measurement: wind vane; cup anemometer. Ideal terrestrial/planetary pressure and wind systems: diagrammatic representation. Geography: The Earth: diagrammatic representation of shape, size, structure, zones, latitudes, longitudes and great circles. Typical landscape mapping; map reading. Geographical terms used in landscape.

5. Statistical Methods 3(2+1)

Theory Definition of statistics, Concepts of population, sample, Census and sample surveys, Classification of data, frequency and cumulative frequency table. Diagrammatic and graphical representation of data - bar diagrams, pie-diagram, histogram, frequency polygon, frequency curve and Ogives. Important measures of central tendency - arithmetic mean median and mode. Relative merits and demerits of these measures. Important measures of dispersion, Range, Mean Deviation, Variance and Standard Deviation. Relative merits and demerits of these measures. Coefficient of variation; Normal Curve, Concepts of Skewness and kurtosis. Definitions of probability, mutually exclusive and independent events, conditional probability, addition and multiplication theorems. Random variable, concepts of theoretical distribution; Binomial, Poisson and Normal distributions and their use in fisheries. Basic concept of sampling distribution; standard error and central limit theorem. Introduction to statistical inference, general principles of testing of hypothesis, types of errors. Tests of significance based on Normal, t, and Chi-square distributions. Bivariate data, scatter diagram, simple linear correlation, measure and properties, linear regression, equation and fitting; relation between correlation and regression, Length weight relationship in fishes; applications of linear regression in fisheries. Methodology for estimation of marine fish landings in India, Estimation of inland fish production in India and problems encountered

Practicals Construction of questionnaires and schedules. Diagrams and frequency graphs. Calculation of arithmetic mean, median, mode, range, mean deviation, variance, standard deviation. Exercises on probability, Binomial and Poisson distributions, Area of normal curve, confidence interval for population mean, Test of hypothesis based on normal, t, and chi-square. Computation of Simple correlation and regression. Fitting of length - weight relationship in fishes

6. Fundamentals of Biochemistry 3(2+1)

Theory A brief introduction to developments in biochemistry and its transformation to molecular biology. Cell structure, water and major molecules of life. Carbohydrate chemistry: Structure, classification, functions (mono, di and polysaccharides) isomerism and mutarotation. Metabolism of carbohydrates: glycolysis, gluconeogenesis, glycogenolysis, glycogenesis, TCA cycle, central role of TCA cycle in metabolism. Protein chemistry: classifications and functions. Classification, structure, function and properties of amino acids. Essential and non essential amino acids. Primary, secondary, tertiary and quaternary structure of proteins. Amphoteric property. Biuret reaction and xanthoproteic reaction. Digestion and absorption of proteins. Classification, structure, functions and properties of lipids. Essential fatty acids and phospholipids. Digestion and absorption of lipids. Lipid autooxidation. Significance of Omega-3 and Omega-6 fatty acids. Enzymes: nomenclature; classification; specificity; mechanism of enzyme action; kinetics and regulation of enzyme activity. Steroid and peptide hormones-chemistry and function. Structure and functions of fat and water soluble vitamins. Vitamins – classification- functions. Minerals – classification – functions. Nucleic acids: Structure function and importance genetic code. Transcription and translation. Protein synthesis. Energy changes in chemical reactions, reversible and irreversible reactions in metabolism.

Practicals Preparation of normal solution of acid and base, buffers and reagents. Qualitative determination of carbohydrates, proteins and lipids. Estimation of total nitrogen and crude protein of fish tissue. Estimation of carbohydrates in foods. Determination of specific gravity of oil. Extraction and estimation of total lipids in fish tissue. Determination of saponification value, iodine value and free fatty acid value.

7. Fundamentals of Microbiology 3(2+1)

Theory Milestones in microbiology. Contributions of Leeuwenhoek, Louis Pasteur, Robert Koch, Alexander Flemming, Joseph Lister, Winogradsky. Microscopy- Principle and construction of brightfield, dark field, phase contrast, stereo, SEM and TEM. Microbial taxonomy –Bergey's and molecular taxonomy Types of Microorganisms: Prokaryotes– Morphology and ultrastructure of bacterial cell. General features, types and importance of viruses, cyanobacteria, actinomycetes, archae, mycoplasma, rickettsiae. Eukaryotes – Diagnostic features and importance of fungi and protozoa. Microbial Techniques - Types of media, types of sterilization - physical and chemical agents, cultivation of microorganisms, staining techniques – simple, differential, structural staining; enumeration of micro-organisms, culture preservation methods. Bacterial metabolism: Nutrient requirements, nutritional types, bacterial photosynthesis and their ecological significance. Microbial growth: Growth phases, measurement of cell growth, factors affecting growth- influence of physico-chemical factors - pH, temperature, moisture, light, osmotic pressure, fermentation - types and significance. Microbial genetics- general principles, genetic recombination, transformation, transduction and conjugation. Plasmids- types and their importance. Mutation –types and significance. Microbial ecology: Introduction and types of interaction, extremophiles and their significance Aquatic Microbiology: Introduction and scope of aquatic microbiology, aquatic environment as habitat for microorganisms - bacteria, cyanobacteria, fungi, algae, parasites and viruses; distribution of microorganisms and their biomass in rivers, lakes, sea and sediment. Influence of physical, chemical and biological factors on aquatic microbes. Microbial biofilms. Role of microbes in the production and breakdown of

organic matter. Role of microbes in sedimentation and mineralization process. Nutrient cycles-carbon, nitrogen, sulphur, phosphorus, iron, and manganese cycles. Sewage microbiology, self purification in natural waters, sewage treatment, drinking water microbiology, sanitary quality of water for aquaculture, bioremediators. Economic significance of aquatic microbes.

Practicals Handling of microscopes, Wet mount, smear and hanging drop preparations
Micrometry Determination of size of micro organisms (ocular, stage micrometers). Tools and techniques in sterilization methods: Filtration, dry heat, moist heat, chemical agents
Cultivation technique: Media preparation, Isolation -pure culture, subculture. Observation of fungi, blue-green algae, and protozoans. Staining techniques for bacteria- simple, differential, structural and Biochemical tests: Indole, methyl red, Voges Proskauer, citrate test, oxidase test, catalase tests. Collection of water and sediment samples for microbiological analysis, Winogradsky cylinder, Isolation, identification and enumeration of various groups of microorganisms from different water bodies including aquaculture systems. Study of bacteria involved in nutrient cycles. Biofilms, water testing for potability, enumeration of coliform. Antibiotic sensitivity of bacteria - antibiotic sensitivity test – disc diffusion method.

8. Soil and Water Chemistry 3(2+1)

Theory Analytical chemistry: principles, applications and types. Classical methods of analytical chemistry, volumetry and gravimetry. Solutions: Standard solutions, titration, indicators, dilute solutions, units of concentration: standard curve; nomograph. Chemistry of water: the water molecule, properties of pure water, fresh water and sea water. Composition of waters: surface water, ground water and sea water. Dissolved gasses: Factors affecting natural waters. Acid, base, salts: Hydrogen ions, modern concept of pH and buffer. Water analysis: collection and preservation of water samples. Measurement of temperature, transparency, turbidity, determination of pH, electrical conductivity, salinity, chlorinity, total solids (TDS, TSS, TVS, TVDS), dissolved oxygen, free carbon dioxide, total alkalinity, total hardness, Calcium, Magnesium, Inorganic Nitrogen (Ammonium and Nitrate) and phosphorus. Water quality criteria/ requirements for Aquaculture. Soil Chemistry: origin and nature of soils. Physical properties of soil; soil colour, texture, structure, pore size, bulk density, water holding capacity. Soil types and their distribution. Soil chemistry: soil colloids, cation exchange, organic carbon, Carbon - Nitrogen ratio, soil fertility. Soil reaction: acidity, alkalinity, conductivity, redox - potential. Submersed soils: wet lands, peat soils, fluxes between mud and water, methane and hydrogen sulphide formation. Saline soils, Alkali soils, acid sulphate soils, iron pyrites, soil reclamation. Soil analysis: collection and preparation of soil samples. Determination of soil texture, water holding capacity, pH, conductivity, organic carbon, nitrogen, phosphorus, lime requirement. Soil and water amendments: lime manures, fertilizers, micronutrients, zeolites, alum, gypsum. Environmental ameliorative: chlorination, deodorizers, bacterial formulation. Soil quality criteria/ requirements for aquaculture. Water quality parameters for hill stream culture.

Practicals Principles of Titrimetry, Gravimetry, Potentiometry, Conductometry, Refractometry, Colourimetry, Turbidimetry, Spectrophotometry (UV, Visible, Flame, AAS), computerized instrument system. Demonstration: demonstration of laboratory glass wares and equipment used in water and soil analysis. Water analysis: measurement of temperature, turbidity, determination of pH and EC. Determination of salinity, Chlorinity, Total solids, Redox potential, DO, Free CO₂. Determination of total alkalinity, hardness. Determination of inorganic nitrogen, and phosphorus
Soil analysis: Determination of soil texture, soil pH, conductivity, soil available nitrogen, available phosphorus, and organic carbon.

9. Fish in Nutrition 1(1+0)

Theory Composition of fish with emphasis on nutritional value. Concept of Biological value, Protein Efficiency ratio, Net protein utilization. Amino acids of fish and shellfishes and importance of essential amino acids. Fish lipids: fatty acids, nutritional quality. Role of fish lipids in human nutrition. Non-protein nitrogen substances in fishes. Vitamins in fish: water soluble, fat soluble, significance in human nutrition. Minerals in fish: micro- and macro-elements, trace elements, significance in human nutrition. Other functional bio-molecules in fish – peptides, collagen and squalene. Effect of different kinds of cooking fish ie. curry, frying, steaming, smoking, fermentation on nutrition value. Nutritional value of hill stream fishes.

10. Swimming 1(0+1) Compulsory Non-Credit Course (CNC)*

Practicals History, hazards in water and safety precautions; pool maintenance and water quality control. Learning swimming, understanding and practice of ducking the head, kicking action, holding breath under water and various strokes (free style, breast stroke, butterfly, back stroke); competitive swimming-relays and medleys, lap time practice, swimming and floating aids and their uses; diving-styles of diving, rules, regulations and precautions. Methods of life saving in water; Boating, canoeing and sailing: types, maintenance, skill development, rules and regulations and practice.

Semester II

Sl. No.	Course Title	Credit hour
1	Fresh Water Aquaculture	3(2+1)
2	Anatomy and Biology of Finfish	3(2+1)
3	Limnology	3(2+1)
4	Marine Biology	3(2+1)
5	Inland Fisheries	3(2+1)
6	Food Chemistry	3(2+1)
7	Information and Communication Technology	2(1+1)
8	Aquaculture in Reservoirs	2(1+1)
9	Aquaculture Engineering	3 (2+1)
10	Physical Education, First Aid & Yoga Practices	1(0+1) CNC*
	Total	25(16+9)

1. Fresh Water Aquaculture 3(2+1)

Theory Major Species cultured production trends and prospect in different parts of the world. Freshwater aquaculture resources-ponds, tanks, lakes, reservoirs etc. Nursery, rearing and growout ponds preparation and management-control of aquatic weeds and algal blooms, predatory and weed fishes, liming, fertilization/manuring, use of biofertilizers, supplementary feeding. Water quality management. Selection, transportation and acclimatization of seed. Traits of important cultivable fish and shellfish and their culture methods-Indian major carps, exotic carps, air breathing fishes, cold water fishes, freshwater prawns, mussels. Wintering ponds, quarantine ponds and isolation ponds. Sewage-fed fish culture. Principles of organic cycling and detritus food chain. Use of agro-industrial waste and biofertilizer in aquaculture. Composite fish culture system of Indian and exotic carps-competition and compatibility. Exotic fish species introduced to India. Culture of other freshwater species. Medium and minor carps, catfish and murrels. Species of fish suitable for integrated aquaculture. Integration of aquaculture with agriculture/ horticulture. Integration of aquaculture with livestock. Cultivation of aquatic macrophytes with aquaculture (makahana). Paddy cum Fish/Shrimp Culture. Culture of important fish in hilly areas.

Practicals Preparation and management of nursery, rearing and grow-out ponds. Study on effect of liming, manuring and fertilization on hydrobiology of ponds and growth of fish and shellfishes. Collection, identification and control of aquatic weeds, insects, predatory fishes, weed fishes and eggs and larval forms of fishes. Algal blooms and their control. Estimation of plankton and benthic biomass. Study of contribution of natural and supplementary feed to growth. Workout of economics of different culture practices. Estimation of live stock requirement / Unit in integrated aquaculture Design of paddy plot for paddy-cum-fish culture. Design of Fish and Shrimp Culture, livestock shed on pond embankment, Economics of different integrated farming systems.

2. Anatomy and Biology of Finfish 3(2+1)

Theory Study of external and internal anatomy of important groups of finfish. Study of oral region and associated structures. Digestive system and associated digestive glands. Food and feeding habits of commercially important fishes. Qualitative and quantitative methods of analysis of gut contents. Circulatory system, respiratory system, nervous system, urino-genital system, endocrine system, skeletal systems and sensory organs. Reproductive biology – maturity stages, gonado-somatic index, ponderal index, fecundity, sex ratio and spawning. Eggs and larval stages and developmental biology. Age and growth determination by direct and indirect methods. Fish migration - type and significance. Tagging and marking. Adaptations in hill stream fishes.

Practicals Study of internal organs – digestive, respiratory, circulatory, urino-genital system, nervous, skeletal systems and endocrine system. Study of food and feeding habits. Analysis of gut contents. Estimation of age and growth by direct and indirect methods. Classification of maturity stages. Estimation of fecundity. Study of developmental stages. Tagging and marking.

3. Limnology 3(2+1)

Theory Introduction to limnology: inland water types, their characteristics and distribution; ponds and lakes; streams and rivers; dynamics of lentic and lotic environments. Lakes - their origin and diversity. Famous lakes of the world and India; nature of lake environment; morphometry, physical and chemical conditions and related phenomena; biological relations: influence of physical and chemical conditions on living organisms in inland waters. Plankton: planktonic organisms; classification of plankton; distribution of plankton: geographic, vertical, horizontal and seasonal distribution of phytoplankton and zooplankton; seasonal changes of body form in planktonic organisms; food of planktonic organisms; primary productivity: Aquatic plants: characteristics, classification, zonation, seasonal variations, quantity produced chemical composition distribution in different waters, limnological role. Nekton: composition, distribution, movements. Benthos: classification; periphyton; zonation; distribution; movements and migration; seasonal changes in benthos, profundal bottom fauna. Biological productivity: circulation of food material; classification of lakes based on productivity; laws of minimum; biotic potential and environmental resistance; quantitative relationships in a standing crop; trophic dynamics; successional phenomena; indices of productivity of lakes; artificial enrichment. Lotic environments: running waters in general; physical conditions; classification of lotic environments, biological conditions; productivity of lotic environments. influence of currents; plant growth; plankton; nekton; benthos; temporary and head waters streams; ecological succession.

Practicals Morphometry of lakes, ponds and streams. Determination of physical characteristics of lentic water bodies. Determination of chemical characteristics of lentic water bodies. Determination of physical characteristics of lotic water bodies. Determination of chemical characteristics of lotic water bodies. Collection and identification of fresh water phytoplankton. Enumeration and biomass estimation of freshwater phytoplankton. Estimation of primary productivity in fresh water bodies. Collection and identification of fresh water zooplankton. Enumeration and biomass estimation of fresh water zooplankton. Collection and identification of benthos from lakes and ponds, streams and canals. Collection and identification of nekton/aquatic insects from freshwater bodies. Collection and identification of aquatic plants from different fresh water bodies. Field visit to lotic and lentic water bodies.

4. Marine Biology 3(2+1)

Theory Introduction to Marine Biology: Divisions of marine environment- pelagic, benthic, euphotic, aphotic divisions and their subdivisions. Life in oceans - general account of major groups of phytoplankton, sea weeds, major zooplankton groups. Environmental factors affecting life in the oceans-salinity, temperature, light, currents, waves, tides, oxygen, and carbon dioxide. Vertical migration of zooplankton, Phytoplankton-Zooplankton relationship, geographical and seasonal variation in plankton production, plankton and fisheries. Inter tidal ecology: Rocky shore, sandy shore and mud flats, zonations, communities, and the adaptation. Mud banks: formation, characteristics. Estuaries: Classification, Physico-chemical factors, Biota and productivity, examples of some Indian Estuaries. Boring and fouling organisms. Nekton outline, composition of nekton, habitats of nekton. Bioluminescence and indicator species, Blooms, Red tides: cause and effects.

Practicals Study of common instruments used for collection of phytoplankton, zooplankton and benthos. Collection, preservation and analysis of phytoplankton, zooplankton, sea weeds, Collection preservation and analysis of inter tidal organisms

5. Inland Fisheries 3(2+1)

Theory Freshwater fishery regions of the world and their major fish species composition. Global inland fish production data. Capture fishery resources of India. Potential of inland water bodies with reference to respective state. Problems in the estimation of inland fish catch data. Fishing crafts and gears. Major riverine and estuarine systems of India. Major brackish water lakes and their fisheries. Fisheries of major reservoirs / natural lakes of India. Flood-plain capture fishery present status of their exploitation and future prospects. Cold water fisheries of India particularly Uttarakhand..

Practicals Analysis of species composition of commercial catches at landing and assembling centers, sampling and familiarization of commercially important groups. Observations and experimental operations of selected fishing crafts and gears in inland / estuarine waters. Maintenance of records on catch data. Visit to Dept. of fisheries, lakes and reservoirs, net making yards.

6. Food Chemistry 3(2+1)

Theory Composition of food and nutritional value. Moisture in foods. Biological oxidation, electron transport chain, P/O ratio; oxidative phosphorylation. Carbohydrates: Naturally occurring polysaccharides in foods. Seaweed polysaccharides – sources and uses. Browning reactions – enzymatic and non-enzymatic. Lipids: metabolism of lipids, oxidation of fatty acids, lipoproteins; VLDL and HDL and their importance. Proteins: metabolism, deamination, decarboxylation, metabolic fate of amino acids, nitrogen balance. Deamination reactions and nitrogen excretion with special reference to fish. Fish muscle proteins, chemical changes in muscle during contraction. Proteins in foods, role in hydration- native and denatured proteins, gel formation, functional properties of proteins, changes during heat treatment and processing, texturised proteins. Chemistry of taste, flavour and odour components in foods, flavour intensifiers, synthetic flavouring substances. The taste of fish and shellfish. Food additives - types and their chemical nature, emulsifiers and antimicrobial additives, sequestrants, flavour potentiators surface active agents; non-nutritive sweeteners, colour additives in food. Assessment of quality of food by instrumental and chemical methods. Nutritive value of foods. Energy value and energy requirements and their estimation. Water, electrolytic and acid-base balance.

Nutritive value of proteins PER, BV digestibility coefficient, NPU values, pepsin digestibility. Role of fibre in human nutrition.

Practicals Estimation of moisture, crude protein, fat, ash (including acid soluble) in fish sample. Determination of energy value of fish. Estimation of glucose and salt content in foods. Colorimetric method of estimation of proteins and carbohydrates. Use of pH meter. Estimation of freshness quality indices such as TVBN, TMA, alpha-amino nitrogen, PV, FFA, TBA value of fish. Estimation of fibre in foods.

7. Information and Communication Technology 2(1+1)

Theory IT and its importance. IT tools, IT-enabled services and their impact on society; computer fundamentals; hardware and software; input and output devices; word and character representation; features of machine language, assembly language, high-level language and their advantages and disadvantages; principles of programming- algorithms and flowcharts; Operating systems (OS) - definition, basic concepts, introduction to WINDOWS and LINUX Operating Systems; Local area network (LAN), Wide area network(WAN), Internet and World Wide Web, HTML and IP; Introduction to MS Office - Word, Excel, Power Point. Audio visual aids - definition, advantages, classification and choice of A.V aids; cone of experience and criteria for selection and evaluation of A.V aids; video conferencing. Communication process, Berlo' s model, feedback and barriers to communication

Practicals Exercises on binary number system, algorithm and flow chart; MS Word; MS Excel; MS Power Point; Internet applications: Web Browsing, Creation and operation of Email account; Analysis of fisheries data using MS Excel. Handling of audio visual equipments. Planning, preparation, presentation of posters, charts, overhead transparencies and slides. Organization of an audio visual programme.

8. Aquaculture in Reservoir 2(1+1)

Theory Definition of reservoirs in India; nature and extent of reservoirs, topography and species diversity; importance of morpho-edaphic index in reservoir productivity and classification; factors influencing fish production; trophic phases in reservoir; pre-impoundment and postimpoundment stages and their significance in establishment of reservoirs fisheries. Salient features of reservoir limnology and their significance to fisheries development; management of small, medium and large reservoirs; present status and future prospects in reservoirs fish production. Fisheries of some important reservoirs; recent advances in reservoirs fisheries management; conservation measures in reservoir fisheries. Fish stocking in Reservoirs Role of cage and pen culture in enhancement of fish production from reservoirs; history of cage culture, advantages of cage culture; selection of suitable site of cage culture; cage materials, designs, shape, size and fabrication; cage frames and supporting system. Integration of cage culture with other farming systems. History of pen culture, pen materials, fabrication; breeding of fish in pen; rearing of spawn in pen; grow-out from pens. Suitable species for culture in cages and pens; constraints in cage and pen culture; economics of cage and pen culture. Culture practices in reservoirs of hilly areas.

Practicals Preparation of charts on the present situation of reservoirs fisheries productivity; detailed case studies of selected reservoirs on the changing trends in capture fisheries profile; drawing inferences from the analysis of data; suggestions for the sustainable development of reservoirs fisheries. Case studies on cage and pen culture; field visit to cage and pen culture site to acquaint with construction details and operation.

9. Aquaculture Engineering 3(2+1)

Theory Fish Farm- Definition, objectives, types of farms; fresh water, brackish water and marine farms. Selection of site for aqua farm- site selection criteria, pre-investment survey viz., accessibility, physical features of the ground, detailed survey viz., site condition, topography, soil characteristics. Land Surveying- definition, principles of surveying, classification of surveying, instruments used for chaining, chaining on uneven or sloping ground and error due to the incorrect chain length. Chain surveying- definitions, instruments used for setting out right angles, basic problems in chaining, cross staff survey. Compass surveying - definitions, bearing, meridians, whole circle bearing system, reduced bearing system, theory of magnetic compass, prismatic compass. Leveling - definitions, methods of leveling, leveling instruments, terms and abbreviations, types of spirit leveling. Plane table surveying- instruments required, working operation, methods. Contour surveying- definition, contour interval, characteristics of contour, contouring methods and uses of contour. Calculation of area of regular and irregular plane surfaces, Trapezoidal and Simpson's rule, volume of regular and irregular shape as applied to stacks and heaps, calculation of volume of pond. Earth work calculations- excavation, embankment, longitudinal slope and cross slope, calculation of volume of earth work as applied to roads and channels. Soil and its properties- classification of soil; soil sampling methods; three phase system of soil, definitions of soil properties and permeability of soil. Ponds - classification of ponds; excavated ponds, embankment ponds, barrage and diversion ponds; rosary system and parallel system. Planning of fish ponds, layout planning, materials planning, manual planning, comparison of square and rectangular ponds, large and small ponds; Types of ponds; nursing ponds, rearing ponds and stocking ponds. Design of ponds, pond geometry; shape, size, bottom slope of pond etc., construction ponds viz., marking, excavation etc., Dykes, types of dykes viz., peripheral dykes, secondary dyke, design of dykes, construction of dykes. Water distribution system- canal, types of canals; feeder canal, diversion canal etc., Pipe line system, Water control structures- types of inlet and out let and their construction. Water budget equation, Pond drainage system; seepage and the methods used for seepage control, evaporation; factors affecting evaporation, erosion of soil in dykes and its control. Site selection, planning and construction of coastal aqua farms. Brackish water fish farms- tide fed, pump fed farms, site selection - topography, tidal amplitude, soil and water sources etc., Hatcheries- site selection, infrastructural facilities; water supply system, main hatchery complex viz., Layout plan and design of hatcheries- brood stock ponds, artemia hatching tanks, sheds etc, Raceway culture system- site selection, layout plan, types of raceway culture system viz., parallel system, series system etc., Aerators- principles, classification of aerators and placement aerators. Pumpspurpose of pumping, types, selection of pump, total head, horse power calculation. Filters- types and constructions.

Practicals Evaluation of potential site for aquaculture. Land survey – chain surveying, compass surveying, leveling, plane table surveying and contouring; soil analysis for farm construction. Design and layout plan of fresh water and brackish water farms and hatcheries. Design of farm structure: ponds, dykes and channels. Earth work calculations and water requirement calculation. Visit to different types of farms.

10. Physical Education, First Aid & Yoga Practices 1(0+1) Compulsory Non-Credit Course (CNC)*

Practicals Introduction to physical education: definition, objectives, scope, history, development and importance; physical culture; Meaning and importance of Physical Fitness

and Wellness; Physical fitness components -speed, strength, endurance, power, flexibility, agility, coordination and balance; Warming up - General & Specific & its Physiological basis; Test and measurement in 390 391 Report of the ICAR Fifth Deans' Committee Report of the ICAR Fifth Deans' Committee physical education; Training and Coaching - Meaning & Concept; Methods of Training; aerobic and an aerobic exercises; Calisthenics, weight training, circuit training, interval training, Fartlek training; Effects of Exercise on Muscular, Respiratory, Circulatory & Digestive systems; Balanced Diet and Nutrition: Effects of Diet on Performance; Physiological changes due to ageing and role of regular exercise on ageing process; Personality, its dimensions and types; Role of sports in personality development; Motivation and Achievements in Sports; Learning and Theories of learning; Adolescent Problems & its Management; Posture; Postural Deformities; Exercises for good posture. Yoga; Introduction to - Asanas, Pranayam, Meditation and Yogic Kriyas; Role of yoga in sports; Governance of sport in India; Important national sporting events; Awards in Sports; History, latest rules, measurements of playfield, specifications of equipments, skill, technique, style and coaching of major games(Cricket, football, table Tennis, Badminton, Volleyball, Basketball, Kabaddi and Kho-Kho) and Athletics Need and requirement of first aid. First Aid equipments and up keep. Handling and transport of injured traumatized persons. Emergency procedure for suffocation, demonstration of artificial respiration. Treatment of injuries (wounds and bleeding)–methods of dressing and bandages; first-aid procedure for injured bones. Handling unconsciousness; Treatment of burns and scalds. Emergency procedure for poisoning with special references to snakebite. Injuries I accidents in fishing, fish processing factories, chemical laboratories and their treatments. Shock injuries to muscles and joints and treatments. Sports injuries and their treatments

Semester III

Sl. No.	Course Title	Credit hour	External (Theory)	Internal (Theory + Practical)	Total
1	Physiology of Finfish and Shellfish	3(2+1)	50	30+20=50	100
2	Fish Food Organisms	2(1+1)	50	30+20=50	100
3	Aquatic Ecology, Biodiversity and Disaster Management	3(2+1)	50	30+20=50	100
4	Fishery Oceanography	2(1+1)	50	30+20=50	100
5	Ornamental Fish Production and Management	2(1+1)	50	30+20=50	100
6	Freezing Technology	2(1+1)	50	30+20=50	100
7	Genetics and Breeding	2(1+1)	50	30+20=50	100
8	Fish Immunology	2(1+1)	50	30+20=50	100
9	Fisheries Economics	3(2+1)	50	30+20=50	100
10	Aquatic Mammals, Reptiles and Amphibians	1(1+0)	50	50+0=50	100
	Total	22(13+9)	500	320+180=500	1000

1. Physiology of Finfish and Shellfish 3(2+1)

Theory Water as a biological medium. Gas exchange; Circulation; Excretion; Osmoregulation; Reproductive physiology; Muscle physiology; Sense organs; Energy and nutrient status of food; Nitrogen balance; Standard and active metabolism; Energy utilization; Effect of environmental factors on physiology of fin and shellfishes. Stress related physiological changes. Structure and functions of important endocrine glands.

Practicals Estimation of oxygen consumption, Osmoregulation, ammonia excretion and carbon dioxide output. Influence of temperature and salinity on metabolism. Haematology of fin and shellfishes. Histological techniques.

2. Fish Food Organisms 2(1+1)

Theory Candidate species of phytoplankton and zoo-plankton as live food organisms of freshwater and marine species. Trophic potentials - proximate composition of live feed. Biology, culture requirements and methodology of important live food organisms; Green algae, blue-green algae, spirulina, diatoms, infusoria, rotifers, cladocerans, tubifex, brine shrimp, chironomids. Culture of earthworms, bait fish and forage fish.

Practicals Methods of collection and identification of different live food organisms. Laboratory scale culture of selected live food organisms (green algae, spirulina, chetoceros, rotifer, Moina, copepod). Evaluation of live food organisms. Decapsulation and hatching method of brine shrimp cyst.

3. Aquatic Ecology, Biodiversity and Disaster Management 3(2+1)

Theory Aquatic environment, Flora and fauna: Components of aquatic systems, Aquatic productivity, nutrient cycles, energy flow, food chain. Animal associations: Symbiosis, commensalisms, parasitism, prey-predator relationship, host parasite relationship. Aquatic

biodiversity-its importance, species diversity, genetic diversity, habitat diversity, diversity indices. Ecological and evolutionary processes. Ecological niches – lagoons, estuaries, mangroves, coral reefs, flood plains, coastal wet lands, bheels, oxbow lakes. Threats to biodiversity- habitat destruction, introduction of exotic species, Conservation of habitats, marine parks and sanctuaries. Conservation programmes for endangered species, ex situ and in situ conservation, captive breeding and management of endangered species. Various national and international conventions and regulations concerning biodiversity, including use of selective gears and exclusion devices. Disaster Management in Fisheries: Basic concepts: Hazard, risk, vulnerability, disaster, capacity building. Multi-hazard and disaster vulnerability of India. Types of natural and manmade hazards in fisheries and aquaculture - cyclones, floods, droughts, tsunami, El-nino, algal blooms, avalanches, pollution, habitat destruction, over fishing, introduction of exotic species, landslides, epidemics, loss of bio-diversity etc. Causes, characteristics and effects of disasters. 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 nonstructural mitigation measures. During disaster: response and recovery systems at national, state and local, coordination between different agencies, international best practices. Postdisaster: Methods for assessment of initial and long term damages, reconstruction and rehabilitation. Prevalent national and global management practices in disaster management. Agencies involved in monitoring and early warnings at district, state, national and global levels. Sea safety and health. Acquaintance with fire-fighting devices. Life saving appliances and first-aid. Uses of distress signals and technologies. Relief and rehabilitation measures, trauma counselling.

Practicals Collection of species of fishes and other organisms and studying the assemblages of organisms of rocky, sandy and muddy shores, lentic and lotic habitats. Observation of adaptive characters and interrelationships like commensalisms, symbiosis, parasitism and predation. Field visits to mangroves, marine parks, sanctuaries, coral reefs, rivers, hills, streams, lakes and reservoirs. Working out biodiversity indices.

4. Fishery Oceanography 2(1+1)

Theory Introduction to Oceanography: classification; expeditions national and international. Earth and the ocean basin, distribution of water and land; relief of sea floor; Major feature of topography and terminology; major divisions. Relief in Indian oceans. Ocean Waves: definition and terms; classification, Difference between surface and long waves; wave theories; surface wave generation; spreading growth; Beaufort Scale; spilling and breaking waves; long waves, Tsunamis, Seiches, internal waves. Ocean Tides: Definition; Tidal phenomenon, elementary tidal definition; tidal inequalities; tide producing forces types of tides tidal bores, tide prediction. Ocean Currents: Definitions and features; measurements of currents; direct and indirect methods forces acting on sea waters; drift currents Ekman spirals, upwelling, sinking, gradient currents; thermohaline circulation; characteristics; course; and significance of some major ocean currents of the world. El-Nino. Physical properties of sea water: Salinity and chlorinity; temperature; thermal properties of sea water; colligative and other properties of sea water; Residence time of constituents in seawater. Properties of sea ice; transmission of sound; absorption of radiation; eddy conductivity; diffusivity and viscosity. General distribution of temperature, salinity and density: Salinity and temperature of surface layer (SST), subsurface; distribution of temperature

and salinity; The T-S diagram; water masses of Indian oceans. Chemistry of sea water: Constancy of composition; elements present in sea water; artificial sea water; dissolved gases in sea water; CO₂ system and alkalinity; inorganic agencies affecting composition of sea water distribution of phosphorus, nitrogen compounds, silicates and manganese in the oceans, factor influencing their distribution.

Practicals Field visits and operation of oceanographic instruments- Nansen reversing water sampler, Bathythermograph, Grabs, Corers, Current meters, Tidal gauges, Echo-sounder. Measurement of temperature, Transparency, pH. Determination of DO, Salinity, Ammonia, Nitrate, Nitrite, Phosphate and Silicate in sea water

5. Ornamental Fish Production and Management 2(1+1)

Theory World trade of ornamental fish and export potential. Different varieties of exotic and indigenous fishes. Principles of a balanced aquarium. Fabrication, setting up and maintenance of freshwater and marine aquarium. Water quality management. Water filtration system- biological, mechanical and chemical. Types of filters. Aquarium plants and their propagation methods. Lighting and aeration. Aquarium accessories and decorative. Aquarium fish feeds. Dry, wet and live feeds. Breeding and rearing of ornamental fishes. Broodstock management. Application of genetics and biotechnology for producing quality strains. Management practices of ornamental fish farms. Common diseases and their control. Conditioning, packing, transport and quarantine methods. Trade regulations and wild life act in relation to ornamental fishes. Development of ornamental fish production as cottage industry in hilly states. Ornamental fishes in hilly areas.

Practicals Identification of common ornamental fishes and plants. Fabrication of all-glass aquarium. Setting up and maintenance of Aquarium accessories and equipment. Conditioning and packing of ornamental fishes. Preparation of feed. Setting up of breeding tank for live bearers, barbs, goldfish, tetras, chichlids, gouramis, fighters and catfishes. Identification of ornamental fish diseases and prophylactic measures.

6. Freezing Technology 2(1+1)

Theory Introduction to freezing technology; characteristics of fish and shellfish; changes in fish after death, spoilage of fish, spoilage and pathogenic microorganism. Handling of fresh fish; sanitation in processing plants. Principles of low temperature preservations. Chilling of fish – methods and equipment for chilling; icing – quality of ice, ice making; refrigerated or chilled sea water, chilling rate; spoilage of fish during chilled storage; use of antibiotics and chemicals. Freezing of fish fundamental aspects; heat units; freezing point depression, eutectic point; freezing rate; methods of freezing, freeze drying, physico– chemical changes that occur during freezing, mechanism of ice crystal formation; preparation of fish for freezing. Changes that occur during frozen storage – microbiological, physical and chemical changes, protein denaturation, fat oxidation, dehydration, drip; protective treatments – polyphosphate, glazing, antioxidants, packaging; thawing of frozen fish – methods of thawing. Transportation of frozen fish, cold chain, quality control, HACCP in freezing industry.

Practicals Sanitation and plant housekeeping; chilling and freezing equipment, instruments; packages and product styles; methods of icing fish; cooling rate; preservation by chilled sea water; freezing and thawing curves; freezing of different varieties of fish and shellfish; estimation of drip; determination of quality changes during frozen storage; inspection of frozen fishery products; visits to ice plants, cold storages and freezing plants.

7. Genetics and Breeding 2(1+1)

Theory Principles of genetics and breeding, Gene and chromosome as basis of inheritance, Mendel's law of inheritance – complete and incomplete dominance, monohybrid and dihybrid ratios. Gene interactions – dominant and recessive epistasis. Pleiotropism. Lethal genes. Mutation. Sex - linked genes, sex influenced and sex limited traits. Linkage and crossing over. Introduction to population genetics. Hardy- Weinberg law and its significance. Chromosomal structure and aberrations. Chromosome manipulation techniques - androgenesis, gynogenesis and polyploidy and identification of ploidy. Sex determination. Cross breeding (hybridization) – types of cross breeding, heterosis and design of cross breeding programmes, hybridization in different fishes. Quantitative genetics – quantitative traits, polygenic traits, heritability. History and present status of selective breeding programs in aquaculture. Selection methods and mating designs. Design for selective breeding. Inbreeding and its consequences. Domestication methods. Seed certification and quarantine procedures. Cryopreservation of gametes.

Practicals Problems on Mendelian inheritance (qualitative genetics) - monohybrid and dihybrid ratios and epistasis. Problems on quantitative traits, response to selection and heritability. Estimation of rate of inbreeding and heterosis. Mitotic and meiotic chromosome preparation. Demonstration of protocol of androgenesis, gynogenesis and polyploidy. Problems on gene and genotypic frequency. Gamete cryopreservation protocols and quality evaluation of fish milt.

8. Fish Immunology 2(1+1)

Theory Introduction, brief history to immunology. Types of immunity: Innate and adaptive immunity, cell mediated and humoral immunity, cells and organs of the immune system. Antigens – structure and types. epitopes, haptenes. Antibody – fine structure, classes with structure and functions, antigenic determinants on immunoglobulins. MHC complex – types, structure, and functions. Antigen-antibody interactions- principle, antigenrecognition by B-cells and T cells. Antigen-antibody reaction - Precipitin reactions, agglutination reactions, Microorganisms associated with fishes in health and disease. Defense mechanism in finfish and shellfish- specific and non specific immune system. Pathogenicity and virulence. Sources of infection, transmission of disease producing organisms, portals of infection. Immunity to bacteria, fungi and parasites Role of stress and host defense mechanism in disease development. Vaccines - types of vaccines – whole cell vaccine, purified macromolecules, recombinant – vector, DNA vaccines and multivalent subunit vaccines, modes of vaccine administration. Serological methods in disease diagnosis. Immunostimulants –types, mechanism of action, modes of administration. Immunoassays, immunodiffusion, ELISA, immunofluorescence, neutralization, radioimmunoassay, serotyping.

Practicals Collection, separation and identification of fish leucocytes. Separation of blood plasma and serum. Differential counting - RBC and WBC by Haemocytometer. Study of different types of leukocytes and isolation of macrophages. Precipitin reactions - Agglutination test, immunogel diffusion, double immuno diffusion, radial immuno diffusion assay, ELISA. Methods of vaccine preparation and techniques of fish immunization.

9. Fisheries Economics 3(2+1)

Theory Introduction to fisheries economics, basic economic terminologies – micro and macroeconomics, positive and normative economics, environmental economics, resource, scarcity, farm-firm relationships, production Contribution of fisheries sector to the economic

development of the country. Micro-economics: theories of demand, supply; market – equilibrium price, consumption, utility, Consumer surplus. Elasticity – price, income, cross, application of elasticity in fisheries managerial decision. Farm production economics – production functions in capture and culture fisheries; Costs and returns –breakeven analysis of fish production system; concepts of externalities and social cost; factors of production, marginal cost and return, law of diminishing marginal return, returns to scale, economies of scale and scope, revenue, profit maximization, measurement of technological change, farm planning and budgeting. Significance or importance of marginal cost. Macro-economics: Introduction to national income, accounting, measurement and determinants of national income, contribution of fisheries to GNP and employment; balance of payments, economic growth and sustainable development. Introduction to GATT and WTO. WTO Framework – Key Subjects - Agreement on Sanitary and Phytosanitary Measures (SPS), Seafood Export Regulations; Non-Tariff Barriers (NTBs) and Agreement on Anti-Dumping Procedures. Fisheries Subsidies and WTO. Fisheries Trade and Environment; protests against globalisation and WTO. Intellectual Property Rights (IPR) and different forms. Patents and patenting process, Agreement on TRIPS. Bio-piracy. GMOs in fisheries. Salient features of Indian Patent (Amendment) Act 2005. Overview of Patents in Indian fisheries sector.

Practicals Demand and supply functions of fish market – determination of equilibrium price for fish and fisheries products, calculation of price, income and cross elasticities. Production function – production with one or two variable inputs. Shifting demand and surplus curve and its importance in fish price. Economic analysis on cost, return and breakeven of any two production units like fish farm / shrimp farm / seed production unit /fish processing plant / export unit.

10. Aquatic Mammals, reptiles and amphibians 1(1+0)

Theory Selected aquatic mammal, reptile, amphibian and birds species of India relevant to fisheries: taxonomic status, identification characters, distribution, abundance, habitat, exploitation, threats and conservation. Biology of aquatic animals: Cetaceans (whales, dolphins, porpoises and narwal), Sirenia (manates and dugongs), Carnivora (seals, sea lions walruses, polar bear and otter), Sea turtles, tortoise, crocodiles, sea/freshwater snakes and amphibians. IUCN criteria – Red list, Wild Life (Protection) Act.

Semester-IV

Sl. No.	Course Title	Credit hour	External (Theory)	Internal (Theory + Practical)	Total
1	Coastal Aquaculture and Mariculture	3(2+1)	50	30+20=50	100
2	Therapeutics in Aquaculture	2(1+1)	50	30+20=50	100
3	Fish Nutrition and Feed Technology	3(2+1)	50	30+20=50	100
4	Fish Canning Technology	2(1+1)	50	30+20=50	100
5	Fish Packaging Technology	2(1+1)	50	30+20=50	100
6	Fish and Shellfish Pathology	3(2+1)	50	30+20=50	100
7	Fishing Craft Technology	2(1+1)	50	30+20=50	100
8	Fisheries Extension Education	2(1+1)	50	30+20=50	100
9	Shellfish Hatchery Management	2(1+1)	50	30+20=50	100
10	Communication Skills and Personality Development	1(0+1)	0	0+100=100	100
	Total	22(12+10)	450	270+280=550	1000

1. Coastal Aquaculture and Mariculture 3(2+1)

Theory An overview of sea farming and shore-based aquaculture in different parts of the world. Resources for shore-based aquaculture and sea farming in India. Traits of important cultivable fish and shellfish (seabass, mullet, milkfish, grouper, cobia, snappers, ayu, pearlspot, tiger shrimp, white shrimp, mud crab, mussel, clam, oysters (edible and pearl oyster), lobster, seaweeds, Seed resources. Shore based aquaculture system: traditional (pokkali, bheries, gazanis, khazans), semi- intensive, intensive aquaculture practice of commercially important species of fish and shellfish. Methods of Shellfish Culture rafts, racks, cages, poles and ropes., Water and soil quality management. Estimation of growth, survival and pond productivity. Seaweed culture, Pearl culture, Sea ranching.

Practicals Identification of important cultivable species. Collection and identification of commercially important seed of fish and shellfishes. Types of fertilizers - Pond preparation. Seed selection, quality and acclimatization. Water quality parameters. Estimation of seed survival. Pond biomass estimation. Material, apparatus and machinery for shore-based aquaculture and sea farming. Estimation of feed intake. Growth and health monitoring. Fouling organisms in cages and pens.

2. Therapeutics in Aquaculture 2(1+1)

Theory Scope and current scenario of therapeutics in aquaculture. Chemotherapy: History, definition, terms used and classification of AMA. Antibacterial agents, mode of action, general principles, classification, Antibiotics, different classes and their mode of action, properties etc. Antibiotic resistance. Antiseptics and disinfectants. Antiparasitics: Ectoparasites, Endoparasites and Protozoans. Antibiotics used in aquaculture Biologics: Immuno-stimulants and Vaccines-Principles in preparation/formulation, mechanism of action. Drug formulation for

aquaculture-Principles in preparation/formulation, mechanism of action, drug leaching, stabilizer, binders and dosage. Therapeutants in aquaculture: Classification, pesticides, fungicides/ algicides, hormones, anaesthetics, flesh color enhancers, Chemicals of therapeutic value, Law priority aquaculture drugs. Drugs used for structural material and substances for maintenance, substances connected with zoo technical practices, list of the drugs used in aquaculture with therapeutics

Practicals Regulations of drug use. Introduction to antimicrobials, preparation of potassium permanganate solution, preparation of weak Tincture Iodine. Minimum inhibitory concentration(MIC). Fiveplate screening test for the detection of antibiotic residue. Calculation of different disinfectants dosage in treating fish ponds. Generic name, patent name, dosage and indications of various aquaculture drugs used in fish health.

3. Fish Nutrition and Feed Technology 3(2+1)

Theory Fundamentals of fish nutrition and growth in fish. Principal nutrients and nutritional requirements of cultivable fish and shellfish. Nutritional energetics: definition and forms of energy partitioning. Methods of feed formulation and manufacturing. Forms of feeds: wet feeds, moist feeds, dry feeds, mashes, pelleted feeds, floating and sinking pellets. Feed additives: binders, antioxidants, enzymes, pigments, growth promoters, feed stimulants. Feed storage: use of preservatives and antioxidants. Feed evaluation: feed conversion ratio, feed efficiency ratio, protein efficiency ratio, net protein utilization and biological value. Feeding devices and methods. Nonconventional feed ingredients and antinutritional factors. Digestive enzymes, feed digestibility. Factors affecting digestibility. Nutritional deficiency diseases.

Practicals Proximate composition analysis of feed ingredients and feeds. Preparation of artificial feeds using locally available feed ingredients. Determination of sinking rate and stability of feeds. Effect of storage on feed quality.

4. Fish Canning Technology 2(1+1)

Theory Introduction to canning and its historical developments. Advantages of canning in relation to other preservation methods. Raw materials and sub materials, their characteristics and suitability for canning. Classification of foods based on pH, commercial sterility, Absolute sterility, pasteurisation and sterilization. Canning process, process flow steps involved HTST and aseptic canning. General steps in canning procedure and importance, preparation of raw material, packing, pre-cooking, exhausting, seaming, retorting, cooling labelling and storage. Principles of thermal processing. Heat resistance of micro organisms, heat penetration studies, mechanism of heat transfer. Cold spot and its importance, convection and conduction type of packs. Process calculation by general/ graphical methods, estimation of Fo value of the process (D-value, Z-Value TDT, F-value, lethal rate). Commercial sterilization, 12-D concept. Canning of commercially important fin fishes, shell fishes and cephalopods. Spoilage of canned foods, types, causes and preventive measures. Quality standards, plant layout, hygiene and sanitation and waste disposal. Types of packaging materials for canned foods, metal containers (Tin Plate, TFS, Aluminium cans) and retortable pouches.

Practicals Types of cans, canning equipments and layout of cannery. Canning of different varieties of fish and shellfish. Cutout test of canned products. Examination of can double seam. Heat resistance of bacteria. Heat penetration in canned food, thermal process calculation by general method. Study of spoilage condition in canned products. Familiarization with various packaging materials and container for fish products.

5. Fish Packaging Technology 2(1+1)

Theory Introduction to packaging, Importance of packaging in fish processing, functions, objectives and requirements. Packaging materials, basic and laminates, principles of their manufacture and their identification. Properties of packaging materials and their use in protective packaging with special reference to food. Printing for packaging and print identification. Closures of packaging, heat seals bottle closure. Principles of packaging fresh produce handling and transportation. Packaging for retail sale and storage. Packaging equipment and machinery. Package design, evaluation and testing. Flexible packaging materials, rigid containers, thermoform containers, glass containers, corrugated fiber boards, duplex cartons, edible packaging materials. Laminations and co-extrusions. Retort pouch packaging - advantages and disadvantages. Biodegradable films, vacuum packaging, active packaging, MAP, Polymeric Packaging. Packaging requirements of fresh fish, Frozen fish, Canned Fish. Transport worthiness of packaging materials, accelerated shelf testing. Materials and their safe use in food contact application. Safety and legislation aspects of packing. Labeling and bar coding.

Practicals Determination of grammage of paper and board, bursting strength, burst factor, punctures resistance, water proofness, stiffness of the board, ring stiffness of paper and board, flat crush, tensile strength and elongation at break of plastic films, density of plastic films, breaking length, impact strength of plastic films, tearing strength of paper and plastic films, water vapour transmission rate, oxygen transmission rate, heat seal strength, suitability of plastic films for food contact applications, evaluation of retort pouch, identification of plastic films

6. Fish and Shellfish Pathology 3(2+1)

Theory Significance of finfish and Shellfish diseases in aquaculture. Host, Pathogen and Environment Interaction. Disease development process. Stress in aquaculture and its role in disease development. Pathological processes: Cellular response to injury, Inflammatory response to diseases, Pathogenicity mechanism of parasite, bacteria, virus and fungus. Case history and clinical sign in disease diagnosis. Role of physical (injuries, health, cold) chemical (pH, salinity, toxins, ammonia, nitrogenous waste, endogenous chemicals and metabolites, free radicals, oxidants) soil and water parameters in fish health. Nutritional diseases . Non-infectious diseases.

Practicals Live and post mortem examination of fish and shellfish. Pathology of organ systems. Histopathology of normal and diseases fish and shellfish, Diagnosis of abiotic fish diseases.

7. Fishing Craft Technology 2(1+1)

Theory Introduction: History & development of fishing crafts. Traditional fishing crafts of India. Classification of fishing crafts based on fabrication dimension, nature of fishing, depth of operation. History & development of mechanization of fishing crafts. Basic geometric concepts and important terminologies of fishing vessel. Form coefficients, properties of irregular shapes. Calculation of longitudinal and transverse sectional area of fishing craft by using Trapezoidal rule and Simpson's rules. State of equilibrium; Volume of displacement; centre of gravity (CG); centre of buoyancy (CB); vertical centre of gravity (VCB); longitudinal centre of gravity (LCB). Stability of fishing vessels- longitudinal and transverse. Various equilibrium of ships-stable, unstable and neutral; Light weight, Dead weight, Tonnage system; Gross Registered Tonnage (GRT), Net Registered Tonnage (NRT). Boat building materials: Choice of construction materials: Wood, properties, advantages and disadvantages. Deck fitting. Maintenance of fishing vessels. fouling and boring organisms; seasoning and preservation of wood. Constructional details of boat: Offset tables; Mould lofting; Backbone assembly of wooden boat. Constructional

details of Steel, FRP, Ferro Cement and Aluminum boats. Introduction of Outboard and inboard engines.

Practicals Studies on traditional fishing crafts; Introduction to drawing and drawing instruments; Lettering, Geometrical construction, Curves. Projections; Projection of points, planes and Projection of solids; lines plan drawing; Drawing of back bone assembly; U & V bottom hull of wooden boat; General view of boat; Drawing of sheer plan, body plan and half breadth plan; Types of marine engines and their installation of engines. Visit to boat building yard and dry dock.

8. Fisheries Extension Education 2(1+1)

Theory Introduction to extension education and fisheries extension - concepts, objectives and principles; extension education, formal and informal education; History and role of fisheries extension in fisheries development. Fisheries extension methods- individual, group and mass contact methods and their effectiveness, factors influencing their selection and use; characteristics of technology, transfer of technology process; important TOT programs in fisheries; role of NGOs and SHGs in fisheries; Fisheries co-management; Adoption and diffusion of innovations, adoption and diffusion process, adopter categories and barriers in diffusion of fisheries innovations; Extension program planning and evaluation - steps and importance; participatory planning process. Basic concepts in rural sociology and psychology and their relevance in fisheries extension; social change, social control, social problems and conflicts in fisheries; gender issues in fisheries; theories of learning, learning experience, learning situation

Practicals Collection of socio-economic data from fishing villages; study of social issues/problems through participatory and rapid rural appraisal techniques, stake holders analysis and needs assessment; assessment of development needs of community and role of formal and non – governmental organizations through stakeholder analysis; case studies on social/gender issues and social conflicts in fisheries. Case studies on extension programs and Success stories. Practical exercises on conducting fish farmers meet.

9. Shellfish Hatchery Management 2(1+1)

Theory Natural seed resources, site selection and collection methods. Life cycle of important shellfish (*Penaeus monodon*, *P. indicus*, *Macrobrachium rosenbergii*, *P. Vannamei*, *Scylla serrata*, lobster, edible, oyster, pearl oyster, fresh water mussel, holothurians, horse-shoe crab, Sepia, Loligo, cray fish etc.). Sexual maturity and breeding seasons of different species. Maturation stages of *Macrobrachium rosenbergii* and *Penaeus monodon*. and *P. Vannamei*. Induced maturation in *Penaeus monodon* and *P. Vannamei* *P. Indicus* by eye stalk ablation. Reproductive physiology. Reproductive hormones in crustaceans. Brood stock management of *Penaeus monodon* and *Macrobrachium rosenbergii*. Breeding and hatchery management of *Penaeus monodon* and *Macrobrachium rosenbergii*. Breeding and hatchery management of crabs/lobster, mussel, edible and pearl oyster. Food and feeding of larval stages of important shellfishes. Health management in hatcheries.

Practicals Identification of brood stock and maturity stages of important crustaceans and mollusks. Observations on gonadal maturation of *Penaeus monodon* and *Macrobrachium rosenbergii*. Breeding and larval rearing of *Macrobrachium rosenbergii* and *Penaeus monodon* *P. Vannamei*. Identification of larval stages of important crustaceans and mollusks. Demonstration of eyestalk ablation in *Penaeus monodon*. Collection, packing and transportation of

shrimp/prawn seed and brood stock. Practice in the operation of shrimp and prawn hatcheries. Water treatment and management in shrimp and prawn hatcheries. Different chemicals and drugs used in shrimp/ prawn hatchery.

10. Communication Skills and Personality Development 1(0+1)

Practicals Structural and functional grammar; meaning and process of communication, verbal and nonverbal communication; listening and note taking, writing skills, oral presentation skills; field diary and lab record; indexing, footnote and bibliographic procedures. Reading and comprehension of general and technical articles, précis writing, summarizing, abstracting; individual and group presentations, impromptu presentation, public speaking; Group discussion. Organizing seminars and conferences.

Semester-V

Sl. No.	Course Title	Credit hour	External (Theory)	Internal (Theory + Practical)	Total
1	Finfish Hatchery Management	3 (2+1)	50	30+20=50	100
2	Anatomy and Biology of Shellfish	2 (1+1)	50	30+20=50	100
3	Pharmacology	3 (2+1)	50	30+20=50	100
4	Fish Toxicology	2 (1+1)	50	30+20=50	100
5	Marine Fisheries	3(2+1)	50	30+20=50	100
6	Fisheries Co-operatives and Marketing	2(1+1)	50	30+20=50	100
7	Fishing Gear Technology	2(1+1)	50	30+20=50	100
8	Fish Population Dynamics and Stock Assessment	3(2+1)	50	30+20=50	100
9	Coastal Zone Management	2(1+1)	50	30+20=50	100
10	Microbial and Parasitic Diseases of Fish and Shellfish	3 (2+1)	50	30+20=50	100
	Total	25(15+10)	500	300+200=500	1000

1. Finfish Hatchery Management 3(2+1)

Theory Freshwater and marine fish seed resources. 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. Sexual maturity and breeding season of various cultivable species. Development of gametes in male and female. Fish egg and embryonic development. 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. Induced breeding of warm water finfishes, environmental factors affecting spawning, sympathetic breeding. Hypophysation of fishes. Fish pituitary gland – its structure, collection, preservation and preparation of extract for injection, dosages and methods of injection. Brood-stock management and transportation of brood fish. Synthetic hormones used for induced breeding of carps. Different types of fish hatcheries-traditional, Chinese, glass jar and modern controlled hatcheries. Causes of mortalities of eggs and spawn and remedies. Spawn rearing techniques. Use of anesthetics in fish breeding and transport. Breeding techniques for Indian major carps, exotic carps, mahaseers, trouts, tilapias, catfishes, grey-mullets, milk fish, pearl spot, sea bass, sea hourse, groupers, pacu, cobia, pompanos and indigenous fishes, etc. Off-season and multiple breeding of carps.

Practicals Study of maturity stages in fishes. Collection and preservation of fish pituitary gland, preparation of PG extract, Hypophysation. Calculation of fecundity. Brood-stock maintenance and selection of breeders for injection. Histological studies of ovary and testes. Different fish hatchery systems, study of fish eggs and embryonic developmental stages. Identification of eggs, spawn, fry and fingerlings of different species. Preparation and management of fish nursery. Fish seed and brood-stock transportation, use of anesthetics, disinfectants and antibiotics in fish

breeding. Water quality monitoring in fish hatcheries and nurseries. Breeding and larval rearing of common finfishes.

2. Anatomy and Biology of Shellfish 2(1+1)

Theory Study of external and internal organization of commercially important crustaceans and molluscs. Digestive, respiratory, circulatory, nervous and reproductive systems. Food and feeding habits, growth, moulting, length – weight relationship. Reproductive biology, larval stages. Age and growth determination by direct and indirect methods.

Practicals Study of Internal Organs commercially important crustaceans and mollusks. Study of Digestive, respiratory, circulatory, nervous and reproductive systems. Study of food and feeding habits - analysis of gut contents, age and growth, length - weight relationship and condition. Reproductive biology: maturity stages, spawning periodicity, fecundity and larval stages

3. Pharmacology 3(2+1)

Theory Introduction to Pharmacology: History, Importance, Terms and Definitions, Drug development, Screening and Nomenclature, Scope of pharmacology in fishes. Route of Administration and Method of application to fish. Source of Drugs. Pharmacotherapeutic classification of drugs. Pharmacokinetics: Biological membrane, absorption, distribution, biotransformation and Excretion of drugs. Factors influencing drug metabolism. Pharmacodynamics: Principles of drug action, concept of drug receptor, nature, chemistry, classification. Functions of receptor. Transducer mechanism, second messenger, non receptor mediated action. Dose Response Relationship, half life withdrawal period, potency, efficacy, threshold dose, therapeutic dose, maximal dose, toxic dose, lethal dose. Factors modifying drug action, Adverse drug effects, drug interaction and Bioassay of drugs. Salient features in drug acting on digestive system, nervous system and cardiovascular system. Drugs used in fish transportation. Recent advances in Pharmacology, biostatistics in experimental Pharmacology, Pharmaceutical industry.

Practicals Introduction to Pharmacy, Metrology, Prescription Writing, Preparation of drug solution, Source and chemical nature of drugs, Incompatibility, Pharmaceutical technology, Bioassay of drugs, Animal models in Pharmacological experiments, Methods of application of drugs in fish

4. Fish Toxicology 2(1+1)

Theory General Toxicology: Definitions, Branches of Toxicology, Historical developments, Classification of poison. Types of poisoning- Toxicity testing - Chronicity factor, Untoward effects, Common causes, Diagnosis of poisoning, Factors modifying toxicity, Toxicokinetics, Toxicodynamics, General approaches to diagnosis and treatment of poisoning. Systemic Toxicology: Toxicity caused by metal and non-metals, Phytotoxins- Toxic principles of various alkaloids and toxic plants, Drug toxicity and toxicity caused by agrochemicals. Mycotoxins, Bacterial toxins. Collections and dispatch of specimens in Toxicological cases, Toxicity of drugs in Aquaculture: Maximum Residual Limits (MRL) of various drugs and chemicals in fish Metabolism of toxic substances by aquatic organisms.

Practicals Detection of heavy metal poisoning. Spot tests for metals. Group reaction for metals- Arsenic, Antimony, Lead (Pb), Mercury (Hg), Zinc (Zn), Barium (Ba), Iron (Fe^{3+}), Copper (Cu), Ammonia (ammonium ions) NH_4^+ + Chloride (Cl^-), Phosphate (PO_4) Sulphate (SO_4) Fluoride (F^-), Qualitative detection of Nitrite and Nitrate, Detection of hydrocyanic acid,

Detection and Estimation of Mycotoxins, Test for detection of alkaloids, Estimation of LD50 and ED50 Demonstration of drug toxicity

5. Marine Fisheries 3(2+1)

Theory Classification and definition of fishery zones and fishery resources of world. Overview of marine fisheries resources of the world and India. Major exploited marine fisheries of India, their developmental history and present status. Important pelagic - demersal fish, shellfish and seaweed resources of India. Traditional, motorized and mechanized fisheries according to major gears. Potential marine fishery resources of the India's EEZ. GIS and Remote sensing in marine capture fishery.

Practicals Visit to fish landing centres, Observation and analysis of catches by major crafts and gears. Field collection of fishes, crustaceans, molluscs and seaweeds and record keeping of relevant data. Participation in fishing cruises. GIS and remote sensing in marine capture fishery.

6. Fisheries Co-operatives and Marketing 2(1+1)

Theory Principles and objectives of co-operation, co-operative movement in fisheries in India, structure, functions, status and problems of fisheries co-operatives management in relation to resources, production and marketing. Role of credit for fisheries development, credit requirements of fishers, source and type of credit/finance, micro-credit, indigenous and institutional finance, structure of institutional finance in fisheries; returns, risk bearing ability and recovery in fisheries sector; role of NABARD in fisheries development; role of insurance in fish and shrimp farming and industry. Basic accounting procedures, profit and loss account. Introduction to marketing management; core marketing concepts: market structure, functions and types, marketing channels and supply chain, marketing margins, marketing environment, marketing strategies, product development and product mix, consumer behavior and marketing research. Fish markets and marketing in India, demand and supply of fish, market structure and price formation in marine and inland fish markets; cold storage and other marketing infrastructure in India; export markets and marketing of fish and fishery products; Trade liberalization and fisheries markets. Integrated marketing approach in fisheries. Sea food export case study on product and market diversification- export and import policies (fisheries). New product development and market segmentation. Export and import policies relevant to fisheries sector. Role of Cooperative sector support for fisheries marketing in Uttarakhand.

Practicals Developing questionnaire and conducting market surveys, analysis of primary and secondary market data. Exercises on equilibrium price for fish and fishery products; estimation of demand and supply using simple regression. Analysis of credit schemes of banks and the government. Case studies of cooperatives. Visit to co-operative societies, commercial banks and fish markets and organizations dealing with marketing of fish and fishery products. Pattern and Performance of India's Seafood Exports; Case studies on product and market diversification. Case studies on competitiveness of Indian fish and fish products

7. Fishing Gear Technology 2(1+1)

Theory Development fishing gears and Fishing Technology: Evolution of Fishing gears; Mechanization of Fishing; Basic classification of fishing gears- Principle, Subsidiary and Auxiliary gears. Classification of fishing gears and methods: FAO classification of fishing gear and methods of the world; International Standard Statistical Classification of Fishing gear (ISSCFG). Fishing gear materials: Natural materials and Synthetic netting materials and their

classification. Types and important synthetic materials used in fishing gears. Raw-materials for synthetic material; Preparation of nylon (PA 6.66) material; Different types of fibres- continuous fibre; monofilament, staple and split fibers and production of single yarns. Identification of synthetic fishing gear materials: Visual observation, water test, solubility test, burning test and melting point test Construction of twisted netting materials: Yarn, single yarns, folded yarns, netting twine, cable netting twine and cable netting twine of higher order; Construction of ropes and their higher order; construction of braided netting twines. Yarn numbering system - direct system: Tex system Denier system and calculation of resultant tex value. Indirect system : British count, metric count, runnage system and their conversion. Methods of Preparation of knotted and knotless webbing; advantage and disadvantages of knotted and knotless webbings. Shape of mesh: diamond; square hexagonal and their measurement. Properties of netting material: physical properties- Density, twist and amount of twist, Breaking strength-tenacity, & tensile strength, breaking length, abrasion resistance, elasticity, extensibility, water absorption &, shrinkage, sinking velocity, weather resistance, melting point and visibility. Chemical and Biological properties. Floats – buoys – its materials, types their properties; Classification of floats: based on shape and materials; calculation of buoyancy. Sinkers – types, materials, properties- negative buoyancy. Factors to be considered while designing /selection of fishing gears; Biological, Environmental, oceanographical, Vessel characteristics and mesh size regulation. Choice of netting materials for trawl, gillnet and purse seine. Classification of trawl gears. 2 seam trawl; 4 seam trawl and wing trawl. Design and construction of wing trawl. Rigging of trawl gear: Arrangements of bridles, sweep lines and attachment of ground gears: tickler chain, bobbins and rock hoppers and attachment of otter board. Fishing gears used in hill streams.

Practicals Study of net making tools; Knots and hitches used in net making. Methods of net making: Hand braiding- Chain mesh method and loop methods of net making. Shaping of webbing: baiting, creasing and reducing mesh size step by step. Tailoring method: T and N direction of webbing; T-cuts, N-cuts, B-cuts and their combination. Joining of net pieces. Net mounting – hanging coefficient, hung depth and their calculation. Selvedging. Methods of net mounting: reeving, stapling and norselling. Mending and net shooter techniques.

8. Fish Population Dynamics and Stock Assessment 3(2+1)

Theory The concept of population and unit stock. Biological structure of fisheries resource in space and time. Indicators of dynamics in a fishery resource. Characteristics of unit and mixed stock. Data requirements for stock assessment. Segregation of stocks. Principles of stock assessment. Population age structure. Theory of life tables. Von Bertalanffy growth parameters. Graphical models. Monte Carlo simulation model and ECOPATH model. Estimation of total fishing and natural mortality. The concept of yield, yield in number and yield in weight, yield per recruit, yield curve. Yield models. The concept of Maximum Sustainable Yield and Maximum Economic Yield. Biological symptoms of under-fishing and over-fishing. Growth over-fishing and recruitment over-fishing. Eumetric fishing. Open access fisheries. Fisheries regulations. CPUE. Trawl selection and gillnet selection. Analytical models of fish stocks.

Practicals Study of length – weight relationship, segregation of stock using direct methods. Study of analytical models: Beverton and Holt model. VBGF, Pauly's integrated methods, graphical models. Estimation of Z, F and M. estimation of net selectivity coefficient. Fitting of surplus production model: Schaeffer model, Fox model. Study of yield isopleth diagrams. Micro-computer packages ELEFAN, FISAT.

9. Coastal Zone Management 2(1+1)

Theory Estuaries, Wet lands and Lagoons, Living resources – Non living resources. Principles of remote sensing: orbits, electromagnetic radiation, diffraction, electro-optical, and microwave systems. Data Input, Data Management, Data Quality. Remote Sensing for Coastal Management. Geographical Information System (GIS): Definition, Concepts, Data Acquisition and Data Management. Applications of GIS in aquatic resource identification. Coastal Regulation Zone (CRZ) Act, Coastal regulation zones for main land and islands – Environmental policies, planning, administrative and regulations. CRZ mapping. Integrated Coastal Zone Management (ICZM); concept, application and case studies. Communication, research, integration, institutional arrangements, regulations, stakeholder participation, the role of the private sector in ICZM. Impacts of human activities on coastal and ocean areas: Challenges related to climate change, expanding tourism, declining fisheries, intensive shipping and biodiversity protection. Problems related to sectors such as tourism and fisheries in the ICZM context; Analysis of multiple use management problems typical for the coastal areas with the maritime industry. Environmental Impact Assessment (EIA): Principles and process. EIA of coastal industries. Evaluation and Methodology; Social Impact Assessment and other developmental activities.

Practicals Field visit to different coastal environments to study erosion of beaches, Identification of ecologically sensitive areas and protection, Study of CRZ, ICZM along the coastal belt, Study on implementation and violation of CRZ, Study of application of remote sensing and GIS, Project preparation of EIA.

10. Microbial and Parasitic Diseases of Fish and Shellfish 3(2+1)

Theory General characteristics, life cycle, diagnosis, prevention and treatment of parasitic, bacterial, fungal and viral diseases of finfish (important cultivable species like Carps, trout, Mahseer and salmon) and shellfish. OIE listed diseases. Disease surveillance and reporting. Quarantine and health certification in aquaculture. Health management strategies in Aquaculture: Vaccines, Immuno-stimulants, Bioremediation, Probiotics, Crop rotation, Good and Best management practices. SPF and SPR stocks –development and application. Bio-security principles, Sanitary and phytosanitary Agreement, Disease control through environmental management. Importance of Biofilm, Biofloc, Periphyton in aquatic Health Management, Zoonotic diseases. Principles of disease diagnosis, conventional, molecular and antibody based diagnostic methods, Rapid diagnostic methods.

Practicals General procedure for disease diagnosis. Methods of sampling fish and shellfish for disease diagnosis. Taxonomy, lifecycle and identification of fish and shellfish parasites. Sampling, preparation of media and culture of pathogenic bacteria: Techniques for bacterial classification. Techniques in disease diagnosis: Microbiological, haematological, Histopathological, immunological, molecular techniques and Biochemical tests. Agglutination test; Challenge tests; purification of virus; Stress related study of fish and shellfish; Disease treatment.

Semester VI

Sl. No.	Course Title	Credit hour	External (Theory)	Internal (Theory + Practical)	Total
1	Introduction to Biotechnology and Bioinformatics	2(1+1)	50	30+20=50	100
2	Refrigeration and Equipment Engineering	3(2+1)	50	30+20=50	100
3	Fisheries Policy and Law	1(1+0)	50	50+0=50	100
4	Aquatic Pollution	2(1+1)	50	30+20=50	100
5	Fishing Technology	2(1+1)	50	30+20=50	100
6	Fish Products and Value Addition	3(2+1)	50	30+20=50	100
7	Microbiology of Fish and Fishery Products	3(2+1)	50	30+20=50	100
8	Navigation and Seamanship	2(1+1)	50	30+20=50	100
9	Fish By-Products and Waste Utilization	2(1+1)	50	30+20=50	100
10	Fisheries Business Management and Entrepreneurship Development	1(1+0)	50	50+0=50	100
	Total	21(13+8)	500	340+160=500	1000

1. Introduction to Biotechnology & Bioinformatics 2(1+1)

Theory Biotechnology: Introduction to Biotechnology –scope and importance in fisheries/aquaculture; Structural organization of prokaryotic and eukaryotic cell. Nucleic acids -structure, function and types, Concepts of gene and genetic code, transcription and translation, mutations and their implications. Post transcriptional modification and RNA processing. Gene regulation and expression in prokaryotes and eukaryotes; DNA sequencing, Operons. Genetic engineering Restriction enzymes; Gene isolation; Cloning vectors; Probes; Recombinant DNA technology – vaccines. Transgenic fish and Gene transfer technology, Animal Cell Culture, Hybridoma technology. Molecular and immunological techniques – PCR; immunoblotting; ELISA; Principle of hybridization; Northern blotting; Western blotting; Southern blotting; DNA fingerprinting; Restriction fragment length polymorphism., Biosensors. Concept of bioremediation of water, bioprocess engineering and bioprospecting. Bioinformatics: Introduction to Bioinformatics; Biological Databases and tools : Introduction; Types of biological databases; Primary and secondary databases; PDB, NCBI, formats and contents; Sequence retrieval, manipulation; Primer design; Restriction mapping; ORF finding; EMBOSS, Molecular visualization Sequence analysis.

Practicals Study of structure of prokaryot and Eukaoryt Cells. Study on Model of protein Synthesis, Study of models rDNA Technology, Cell Culture, Isolation of Nucleic Acids, Restriction enzymes, Gel Electrophorus, ELISA, DNA sequence analysis and comparison.

2. Refrigeration and Equipment Engineering 3(2+1)

Theory Fundamentals: Force, work, power, energy, volume, pressure, temperature. Heat, specific heat, sensible heat, latent heat, comparison between heat and work-A path function. Thermodynamics: Laws of Thermodynamics, Laws of perfect gases, Thermodynamic processes, Application of First and Second law of Thermodynamics in refrigeration, Thermodynamics cycle, entropy, enthalpy. Refrigeration: History of refrigeration, Definition, principle, classification, Types of refrigeration systems i.e., Air refrigeration, vapour absorption refrigeration system. Vapour compression refrigeration system. Refrigeration plant: Layout of refrigeration plant, Construction. Insulating materials used for the cold storage construction, Frozen product storage capacity of cold storage, usage of Anteroom. Refrigeration systems: Vapour compression refrigeration system advantages and disadvantages as compared to other refrigeration systems, Types of Vapour compression refrigeration cycles i.e., Theoretical Vapour compression refrigeration cycle, Actual refrigeration cycle. Compressors: Definition, Types of compressor, construction, working principle advantages and disadvantages. Evaporator: Definition, Types of Evaporator, construction, working principle advantages and disadvantages. Condenser: Definition, Types of Condenser, Cooling Towers, construction, working principle, advantages and disadvantages. Expansion valve: Definition, Types of Expansion valve, construction, working principle advantages and disadvantages. Refrigerant: Primary refrigerant, secondary refrigerant, properties, ideal refrigerant, leakage detection. Study of auxiliary equipment: Receiver, oil charging, refrigerant charging, gas purging, oil draining, types of defrosting. Ice-plant: Ice plant planning Brine tank construction, preparation of brine, Types of ice, Storing of ice, Equipments used in ice plants. Freezers: Definition, Design and construction of freezers i.e. Plate freezer, Blast freezer, Tunnel freezer, spray or immersion freezers, refrigerated fish rooms and fish hold. Alternative refrigeration technique arrangements used onboard the fishing vessel i.e., Refrigerated sea water (RSW), Chilled sea water (CSW). Refrigerated transport. Cooling load: Unit of refrigeration, coefficient of performance (C.O.P), Refrigeration effect, study and use of Psychometric chart. Cooling load estimation, introduction, components of cooling load, heat gain through walls, roofs, products, occupants, lighting equipments Theory of machines: Transmission of power, friction wheels, shaft, gears, belt and Chain drive. Study of equipments used in fish processing with particular reference to canning, sausage, freeze drying and irradiation. Maintenance: Definition, Types of maintenance, general maintenance of freezing plant, cold storage and ice plant.

Practical Drawing of Refrigeration and Fish processing machineries plant layout, Graphically represented symbols used in refrigeration, Handling and operation of compressors, condensers, evaporators expansion valves, low and high pressure switches. Study of auxiliary equipments: Receiver, oil charging, refrigerant charging, gas purging, oil draining, types of defrosting. Power transmission line diagram of different fish processing machineries. Visit to processing plant refrigeration plant, Visit to ice plant, Visit to fishing harbor to study the fish hold, refrigerated fish rooms. Calculation on refrigeration effect and cooling load.

3. Fisheries Policy and Law 1(1+0)

Theory Introduction to public administration, principles of organization and management of public enterprise. Central and State responsibilities for fisheries development, organizational set up of fisheries administration at the Centre and state levels. Present relevance of past fisheries

policies and recent policies in fisheries sector. Functions and powers of functionaries of department of fisheries, corporations and cooperatives. Different central and state level fisheries institutions. Role of Central and State Government in the regulatory activities of Aquaculture and fisheries. Implementation of community based resource management plans. Historical review of fisheries development and management in India and world. International agencies / organizations for promotion of fisheries worldwide. Fisheries legislation: Overview of fisheries and aquaculture legislations in India. Indian Fisheries Act, 1897. Environmental legislation; Water Act, Air Act and Environmental (Protection) Act. International environmental legislation and its impact on fisheries. Laws relating to conservation and management of fishery resources in marine and inland sectors. Recent changes in land reforms. Land reforms legislation as applicable to aquaculture. Judicial judgments relating to Aquaculture. Objectives, functions and authority of fishery regulatory agencies like Coastal Regulatory Zone (CRZ) and Aquaculture Authority of India. Brackish water aquaculture act, Marine fisheries policy, Laws relating to fish products and marketing. International Law of the Seas and international commissions on fisheries and their impact. Fisheries policies of Uttarakhand state.

4. Aquatic Pollution 2(1+1)

Theory Introduction to aquatic pollution, the sources of pollutants, toxic organic compounds and their impacts in the aquatic organisms and the abiotic environment, Classification of pollution physical, chemical and biological classification of water pollution- description of terminologies. Sewage and domestic wastes- composition and pollution effects- sewage treatment and its reuse. Agricultural wastes- organic detritus, nutrients, Adverse effects of oxygen demanding wastes: importance of dissolved oxygen; Oxygen demand; BOD; COD; Oxygen budget; Biological effects of organic matter. Excessive plant nutrients: Eutrophication; Red tides and fish kills. Pesticide types and categories; inorganic pesticides, Organo-chlorine compounds, Organo-phosphorous compounds; Polychlorinated biphenyls (PCBs); Bioaccumulation and impact on aquatic fauna and human health; toxicology. Heavy metals: Interaction of heavy metals with water and aquatic organisms. Bioremediation and Phytoremediation. Oil pollution; Crude oil and its fractions; Sources of oil pollution; Treatment of oil spills at sea; Beach Cleaning; Toxicity of Petroleum Hydrocarbons; Ecological Impact of Oil pollution- Case studies. Microbial pollution: Types of aquatic microbes; autotrophs and heterotrophs; saprotrophs and necrotrophs; Sewage Fungus Complex; Transmission of Human Pathogenic Organisms; Zoonosis; Development of Antibiotic Resistance and its impact; Biofilms and Biorrosion; Radioactivity and background radiation of earth: Radionuclide polluting, special effects of radioactive pollution. Thermal pollution and its effects, Physical and chemical nature of possible effluents from major industries in India. Monitoring and control of pollution: Biological indicators of pollution. Solid waste management.

Practicals Physical characteristics of polluted waters; Colour, Odour, Turbidity. Determination of pH, salinity, alkalinity, hardness, BOD, COD, Hydrogen sulphide, Phosphates, Ammonia, Nitrates, Heavy metals and Oil and grease in water. Determination of pH, conductivity, organic carbon, nitrogen, phosphorus, heavy metals in sediments. Study of pathogenic and coliform bacteria. Bacteriological quality of water; Colliform tests, IMVIC test, standard plate count, methods of enumerating bacterial biomass in waters and waste waters. Pollution flora and fauna: indicator species- algae, protozoa and insect larva. Methods of pesticide residue analysis in waters and fish tissue; bioassay and toxicity study.

5. Fishing Technology 2(1+1)

Theory Structure of various commercial fishing gears. Rigging of fishing gears: Bridles, sweep lines, otter boards, floats and ground gears arrangements. Otter door: Different types of otter doors. Behavior of otter doors in water: Angle of attack, angle of heel and angle of tilt. Fishing accessories – thimbles, shackles, C-links, rings, G-links, Kelly’s eye, stopper, bottle screw, Deck layout of different fishing vessels. Trawling: Beam trawling; otter trawling; side trawling; twin trawling out rig trawling bull trawling and mid water trawling. Constructional details of single boat purse seine; two boat purse seine and method of operation. Types of gill net – constructional details of simple gill net, trammel gill net, stick held gillnet, frame gillnet and vertical line gillnet, Operation of gillnet: set gillnetting; drift gillnetting; bottom, mid water and pelagic gillnetting Line fishing: Types of hooks; structure and size of hooks. Constructional details of long line, tuna long line, vertical long line, pole & line and trolling line. Operation of long line: set and drift long lining: bottom, mid water and pelagic long lining; jigging. Operation of beach seine, boat seine and traps. Selectivity in fishing gear and by catch reducing devices. Deck equipments – types of winches, net haulers, line haulers, triple drum, gurdy, power blocks, fish pumps. Fishing equipment: Fish finder, GPS navigator, sonar, net sonde, gear monitoring equipment.

Practicals Survey of fishing gears; Trawl; gillnet; long line and purse seine fishing gears. Rigging of trawl, purse seine, gillnet and hook & line. Commercial fishing techniques: Bottom trawling; purse seining; gillnetting and line fishing. Cast net fishing and trap fishing.

6. Fish Products and Value Addition 3(2+1)

Theory Principle of fish preservation and processing. Processing of fish by traditional methods– salting, sun drying, smoking, marinating and fermentation. Theory of salting, methods of salting–wet salting and dry salting. Drying and dehydration- theory, importance of water activity in relation to microbial growth. Sun drying and artificial drying- solar dryer. Packaging and storage of salted and dried fish. Different types of spoilage in salt cured fish. Quality standard for salted and dry fish. Fish preservation by smoking-chemical composition of wood smoke and their role in preservation. Methods of smoking and equipments used for smoking. Carcinogenic compound in wood and method store move them. Hurdle technology in fish preservation and processing. Marinaded and fermented fish products–role of acid sin marinades, Fish and prawn pickles, fish sauce and Fish paste, traditional Indian fermented products. Fermented fish products of Southeast Asia. Principles and methods of preparation of various fish paste products like fish sausage, fish ham, surimi, fish cake, kamaboko etc. Fish muscle structure, my ofibriller protein and their role in elasticity formation. Extruded products – theory of extrusion, equipments used, advantages of extruded products, methods of preparation of extruded products. Value addition. Diversified fish products: battered and braided products-fishfinger, fish cutlet, fish wafer, and fish soup powder etc. And imitation products. HACCP safe products production.

Practicals Preparation of salted fish, dried fish and smoked fish by different methods. Quality assessment of salted, dried and smoked fish. Preparation of prawn & fish pickles. Preparation of fermented fish sauce and marinaded products. Preparation of surimi and surimi based products. Preparation of diversified and value added fish products. Quality assessment of market sample of dried and fermented fish products.

7. Microbiology of Fish and Fishery Products 3(2+1)

Theory Introduction and history of microorganisms in foods. Role and significance of microorganisms in nature and in foods. Sources and types of microorganisms in fish and fishery products. Factors (intrinsic and extrinsic) affecting the growth and survival of microorganisms in food. Enumeration of microorganisms in food by conventional and rapid techniques. Microbial principles of fish preservation and processing by application of low temperature, high temperature, drying, irradiation and chemicals. Microbiology and spoilage of fresh, semi processed and processed fish and fishery products. Indicators of microbiological quality of fish and fishery products. Food borne pathogens involved in infective and intoxication type of food poisoning – *Vibrio cholerae*, *Vibrio parahaemolyticus*, *E. coli*, *Salmonella*, *Listeria monocytogenes*, *Clostridium botulinum*, *C. perfringens*, *Campylobacter* and *Staphylococcus aureus* – their occurrence, growth, survival, pathogenicity and prevention. Other biological hazards associated with fish and fishery products- marine toxins-shellfish toxins, scombroid toxins, ciguatera toxins and puffer fish toxins; mycotoxins, parasites and viruses.

Practicals Sampling and processing of samples for microbiological investigation. Enumeration of microorganisms associated with finfish, shellfish, water and ice. Testing of water for potability. Isolation and identification of pathogenic bacteria associated with fish and fishery products - *Vibrio cholerae*, *Vibrio parahaemolyticus*, *E. coli*, *Salmonella*, *Listeria monocytogenes* and faecal streptococci. Biochemical tests for characterization of bacteria. Molecular methods for the detection of pathogenic microorganisms. Determination of MIC and MCC of chemical preservatives.

8. Navigation and Seamanship 2(1+1)

Theory Principles of navigation –terms and definitions, finding positions and method of position fixing magnetic Compass-parts and functions, cardinal, inter cardinal, three letter and lay points pelorus and azimuth mirror, method of observation. Sextant -parts and functions, finding adjustable and non adjustable errors and principles and use. Hand lead line –construction and markings and method of taking soundings. Types of speed logs –patent log, impeller log, Types of marine charts, Mercator and gnomonic projections great circles and rumba lines, chart collections and chart readings, chart observation and fixing positions. The IALA-buoy age systems, cardinal and lateral marks, meaning of shapes, colours and lights top marks and explanation of approaching, international code of signals, flag signals mars code and storm signals general system, brief system and extended system ,storm signals stations Indian coasts, Fog signals, types and methods .Distress signals, methods, types and communication international regulations for preventing collision at sea and recognition of lights and shapes at sea. Observation of radar and parts and functions of radar, aneroid barometer, parts and functions of echo sounder, and sonar, observation of GPS Principles of seamanship- Causes fire at sea, fire prevention on board the vessel and method of fire fighting at sea and recommended fire fighting appliances, Life saving appliances –life jackets, life buoys and method of operations and contents, SART and EPIRB. Observations of storms, formation of storms and method of locating the eye of the storms and method of escaping from the center of the storms as per buys ballet law. Preparing vessel to face heavy weather. Temporary repairs for leaks constructions of steering system and rigging emergency jury rudder. Types of anchors and their applications. selection of suitable anchorage , procedure for anchoring anchor watch and procedure to combating dragging of anchor, method of standing moor and running moor, open moor berthing

procedures, axial thrust , transverse thrust mooring and securing the vessel to the jetty rigging fenders and gangways , and method of leaving vessels from the berth.

Practicals Anchoring, coming alongside the berth and leaving, practicing the different types of knots and wire splices, use of magnetic compass, GPS, Echo-sounder. CHART WORK-Finding positions by latitudes and longitudes by position lines by cross bearing, horizontal sextant, angles, vertical sextant angle and by running fix, finding position by speed, distance and time findings set and drift of current and findings course made good speed made good and steering course and finding position by counter acting the current observation of RADAR.

9. Fish By-Products and Waste Utilization 2(1+1)

Theory Fish meal. Dry reduction and wet reduction methods – specification – packaging and storage. Fish oil – body oil – liver oil – extraction – purification – preservation – storage – application. Shrimp wastes – chitin – chitosan-production – uses. Fish protein concentrate. Fish hydrolysate, partially hydrolyzed and deodorized fish meat,functional fish protein concentrate and their incorporation to various products. Fish silage – acid silage – fermented silage – application. Fish maws, shark leather, fish glue, fish gelatin, isinglass, pearl essence, shark finrays, beach-de-mer. Biochemical and pharmaceutical products. Utilization of seaweeds: agar agar, algin, carrageenan.

Practicals Preparation of fish meal, fish body oil, fish liver oil, fish maws, isinglass, fish silage, ensilage, fish glue, fish gelatin, fattice, pearl essence, chitin, chitosan and fish manure. Preparation of acid and fermented silage. Preparation of fish protein concentrate and fish hydrolysate.

10. Fisheries Business Management and Entrepreneurship Development 1(1+0)

Theory Concept of entrepreneurship; entrepreneurial and managerial characteristics; managing an enterprise; motivation and entrepreneurship development; importance of planning, monitoring, evaluation and follow up; managing competition; entrepreneurship development programs; Generation, incubation and commercialization of ideas and innovations. Government schemes and incentives for promotion of entrepreneurship. Preparation of enterprise budget for integrated fish farming. Fiscal and monetary policies and its impact on entrepreneurship. Infrastructural and other financial requirement for fishery entrepreneurship Government policy on Small and Medium Enterprises (SMEs) / SSIs. Venture capital. Contract farming and joint ventures, publicprivate partnerships. Overview of fisheries inputs industry. Characteristics of Indian fisheries processing and export industry. Introduction to fish business management-Concept of management, management process (planning, organising, staffing, leading and controlling), Organizational behaviour, human resource planning, new dimensions in fish business environment and policies. Accounting procedures of fish business entity. Emerging trends in fish production, processing, marketing and exports. Assessing overall business environment in the Indian economy. Overview of Indian social, political and economic systems and their decision making by individual entrepreneurs. Globalisation and the emerging business /entrepreneurial environment. Social Responsibility of Business.

Semester VII

Sl. No.	Course Title	Credit hour	External (Theory)	Internal (Theory + Practical)	Total
1	Student READY Programme In-plant attachment (for 8 weeks)*	10 (0+10)	0	0+100=100	100
	Rural Fisheries Work Experience Prog. (for 8 weeks)*	8(0+8)			
	Study Tour (in and outside State) (for 4 weeks)	2(0+2)			
	Total	20(0+20)	0	0+100=100	100

Semester VIII

Sl. No.	Course Title	Credit hour	External (Theory)	Internal (Theory + Practical)	Total
1	Quality assurance of Fish and Fishery Products	3(2+1)	50	30+20=50	100
2	Student READY Experiential Module (concurrent with the semester) This will include capacity building and skill development of the students in planning, development, formulation, monitoring and evaluation of project for entrepreneurial proficiency. Skill Development (for one week) Experiential Learning Programme	5(0+5) 12(0+12)	0	0+100=100	100
3	Project Work (As decided by concerned department of Colleges/ Institutes)	2(0+2)			
4	Seminar	1(0+1)	0	0+100=100	100
	Total	23(2+21)	50	30+320=350	400

*CNC= Compulsory non-credit course.

Total Credit Hours 180 (84+96) +2 Compulsory Non-Credit Course

1. Quality Assurance of Fish and Fishery Products 3(2+1)

Theory Quality dimensions of seafood – sensory, intrinsic, quantitative and affective parameters. Preharvest and post harvest factors affecting quality. Assessment of quality changes in fresh and iced fish. Quality changes during processing. Importance of quality, definitions and terminologies. Application of HACCP concept in surveillance and quality assurance programmes for raw, frozen, canned, cured, irradiated, cooked and chilled, modified atmosphere packaged

and freeze dried products. Risk assessment, principles of plant hygiene and sanitation, pest control, personnel hygiene, planning and layout, equipment construction and design. Food laws and standards, national and international legislation, mandatory and non mandatory standards. Role of export inspection council & export inspection agency and MPEDA in fish and fishery products. Executive instructions on fish and fishery products, Legislation for export quality assurance in India. Certification system for fish & fishery products. Legal basis for monitoring products related EU requirements. Scheme for approval and monitoring of establishments/factory vessels/ freezer vessels processing/storing fish & fishery products for export. Complaint handling procedure on fish and fishery products. Interpretation of test reports and limits on chemical residues. GOI notifications on fish and fishery products. General requirements for export of fish and fishery products to the EU. International regulatory framework for fish safety and quality. Prerequisites to HACCP, Labelling for product traceability and Labelling requirements- National and international, legislation on labelling, components of traceability code-nutrition facts and nutrition labelling, specific requirements of nutrition labelling, food meant for specific age group and convalescing people. EU legislation on traceability of fish and fish products, Assessment of food safety programmes, The HACCP for seafood industries and protection of food from adulterants. Standards for sea foods.FSSA, FDA, ISO.Use of additives in seafood processing as quality enhancers. Seafood safety, authenticity, traceability. Waste management in seafood processing.

Practicals Assessment of quality of fresh fish by sensory, biochemical, and instrumental methods. Chlorination and Hardness estimations. Quality analysis of canned, frozen, cured and pickled fish products. Quality tests for tin and corrugated containers. Assessment of plant, equipment sanitation and personnel hygiene. Detection of filth and extraneous matter in traditional processed products.

