Sanjeev Agrawal Global Educational (SAGE) University, Bhopal

Proposed Scheme and Syllabus for

M.F.Sc. AQUACULTURE

School of Sciences

M.F.Sc. AQUACULTURE

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

The programme M.F.Sc. aquaculture will be developing excellent education and research for development of sustainable aquaculture. The main objectives of this programme are.

1. To promote a greater understanding of the biological, technical and economic importance of fisheries areas.
2. To encourage students to explore the subject by specializing in fisheries and further studies
3. To undertake extension activities to benefit fish farmers of M.P by socio economic uplifment and also to transfer of technology to industry.
4. To promote field and lab oriented research to tackle the emerging problems in fisheries and industry development.

Apart from these main objectives this institution will provide students with all opportunities and skills so that they can take up entrepreneurship in the area of fisheries development. The dedicated teaching staffs devote their time not only to teaching but also to overall development of the students.

PROGRAM OUTCOMES (POs)

- This course will fulfill two **SUSTAINABLE DEVELOPMENT GOAL 2030**

Goal no 2 :**Zero Hunger .**

Increasing income of small scale food producers in particular,pastoralists and fishers including through secure and equal access to knowledge,financial services,markets & and opportunities for value addition and non farm employment.

Goal no 14:**Life below water**

Conserve and sustainably use the oceans,sea and Marine resources for sustainable development.

SDG 14:Indicator fulfilling this course.

- Income from sustainable fisheries
- Support small scale fishers
- Sustainable fishing.
- Protect and restore ecosystem

- Students post graduating with a Master degree in Aquaculture will be trained to involve in higher education and other job opportunities like Fisheries Extension officer, Fishery Manager, Assistant Director Fisheries (ADF), Fish seed Industries, BDO.(ATMA), ICAR Young professional (Various Post), Fisheries field Assistant, NABARD and Processing Plant

etc.

- Students post graduating in Aquaculture with master level dissertation work/pre research experience will ensure their future become a good Researcher and also Field Experts.
- Gain the knowledge about the taxonomy of organisms by using the conventional method and advanced level of molecular methods and characteristic features of soil and water quality.
- The students will be able to learn about the basics of Taxonomy of fresh water and marine water fishes starting from lower tropnic level organisms to higher trophic level organisms. Also will be able select the species which are feasible for fresh water brackish water and marine water aquaculture.
- Students will be made fully skilled in Master of Fishery Science (MFSc) with respect to aquaculture, fisheries management, formulating policies and making crucial developments in fisheries sector/ fishing community.
- The candidates who are willing to upgrade their knowledge in this field also have their up gradation courses like Ph.D. in fisheries science.

CURRICULUM COMPONENTS OF M.F.Sc. Aquaculture

Components	Credits
Program Core (12 Courses)	48
Program Elective (Discipline Specific) (03Courses)	12
Lab (05Courses)	10
Project-Based Learning (PBL) (02Courses)	04
Project (01Courses)	24
Total	**98**

Distribution of credits across all Components

S. No.	Programme core	Programme Elective DSE	Lab GE	Project-Based Learning (PBL)	Project	
					Field	Major
1	16	4	4	2	-	-
2	16	4	4	2	-	-
3	-	-	-	-	-	20
4	16	4	2	-	4	-
Total	**48**	**12**	**10**	**4**	**24**	
Grand Total		**98**				

SCHEME FOR M.F.Sc. AQUACULTURE

	Semester First															
Course Code	**Course Title**	**Contact Hours per Week**			**Credits**	**ESE Duration (Hours)**	**Weightage (Theory)**						**Weightage (Practical)**			**Total**
		L	**T**	**P**			**MSE**	**ASG**	**TA**	**ATTD**	**ESE**	**TOT**	**CE^**	**ESE**	**TOT**	**GT**
AC21M 101	Finfish and Shellfish Biology	4	-	-	4	3	30	05	05	10		100	-	-	-	100
AC21M 102	Fish Breeding and Hatchery Technology	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
AC21M 103	Aquaculture	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
AC21M 104	Fish Nutrition and Feed Technology	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
Refer Table 1	DSE- I	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
AC21M 107	LAB- I Fish Identification	-	-	4	2	2	-	-	-	-	-	-	50	50	100	100
AC21M 108	LAB- II Feed Formulation	-	-	4	2	2	-	-	-	-	-	-	50	50	100	100
PB21M 101	Project Based Learning-I	-	-	4	2	2	-	-	-	-	-	-	50	50	100	100
Total					**26**											**800**

^Two assessment by panel of expert

L-Lecture, T-Tutorial, P-Practical, ESE-End Semester Exam. MSE- Mid Semester Exam, ASG- Assignment, TA- Teacher's Assessment, ATTD-Attendance, TOT-Total, CE-Continuous Evaluation, GT- Grand Total

	Semester Second															
Course Code	**Course Title**	**Contact Hours per Week**			**Credits**	**ESE Duration (Hours)**	**Weightage (Theory)**						**Weightage (Practical)**			**Total**
		L	**T**	**P**			**MSE**	**ASG**	**TA**	**ATTD**	**ESE**	**TOT**	**CE^**	**ESE**	**TOT**	**GT**
AC21M 201	Fisheries Resource Management	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
AC21M 202	Harvest and Post Harvest Technology	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
AC21M 203	Aquatic biology	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
AC21M 204	Fish Health Management	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
Refer Table II	DSE- II	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
AC21M 207	LAB- III Fish Gears Preparation	-	-	4	2	2	-	-	-	-	-	-	50	50	100	100
AC21M 208	LAB- IV Plankton Analysis	-	-	4	2	2	-	-	-	-	-	-	50	50	100	100
PB21M 201	Project Based Learning- II	-	-	4	2	2	-	-	-	-	-	-	50	50	100	100
Total					**26**											**800**

^Two assessment by panel of expert

L-Lecture, T-Tutorial, P-Practical, ESE-End Semester Exam. MSE- Mid Semester Exam, ASG- Assignment, TA- Teacher's Assessment, ATTD-Attendance, TOT-Total, CE-Continuous Evaluation, GT- Grand Total.

	Semester Third															
Course Code	**Course Title**	**Contact Hours per Week**			**Credits**	**ESE Duration (Hours)**	**Weightage (Theory)**						**Weightage (Practical)**			**Total**
		L	**T**	**P**			**MSE**	**ASG**	**TA**	**ATTD**	**ESE**	**TOT**	**CE^**	**ESE**	**TOT**	**GT**
AC21M 301	Project	-	-	40	20	3	-	-	-	-	-	-	250	250	500	500
Total					**20**											**500**

^Two assessment by panel of expert

L-Lecture, T-Tutorial, P-Practical, ESE-End Semester Exam. MSE- Mid Semester Exam, ASG- Assignment, TA- Teacher's Assessment, ATTD-Attendance, TOT-Total, CE-Continuous Evaluation, GT- Grand Total.

	Semester Fourth															
Course Code	**Course Title**	**Contact Hours per Week**			**Credits**	**ESE Duration (Hours)**	**Weightage (Theory)**						**Weightage (Practical)**			**Total**
		L	**T**	**P**			**MSE**	**ASG**	**TA**	**ATTD**	**ESE**	**TOT**	**CE^**	**ESE**	**TOT**	**GT**
AC21M 401	Biostatistics and Instrumentation	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
AC21M 402	Fisheries Economics and Extension.	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
AC21M 403	Aquatic Environment And Biodiversity	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
AC21M 404	Aquaculture And Ecosystem Management	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
Refer Table IV	DSE- III	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
AC21M 407	LAB- V Water Quality Analysis and Instrumentation	-	-	4	2	2	-	-	-	-	-	-	100	100	200	200
FT21M 408	Field Training	-	-	-	4	2	-	-	-	-	-	-	50	50	100	100
Total					**26**											**800**

^Two assessment by panel of expert

L-Lecture, T-Tutorial, P-Practical, ESE-End Semester Exam. MSE- Mid Semester Exam, ASG- Assignment, TA- Teacher's Assessment, ATTD-Attendance, TOT-Total, CE-Continuous Evaluation, GT- Grand Total.

LIST OF DISCIPLINE SPECIFIC ELECTIVES (DSE)

Table I: Semester One (DSE- I)		
S.No.	**Course Code**	**Course Title**
1.	**AC21M105**	Aquaculture of Ornamental Fishes
2.	**AC21M106**	Live Feed Culture

Table II : Semester Second (DSE- II)		
S.No.	**Course Code**	**Course Title**
1.	**AC21M205**	Sustainable Aquaculture
2.	**AC21M206**	Aquaculture Environment Management

Table IV : Semester Fourth (DSE- III)		
S.No.	**Course Code**	**Course Title**
1.	**AC21M405**	Water Quality and Soil Management in Aquaculture
2.	**AC21M406**	Seed Production and Hatchery of Fin Fishes

Practical Papers

COURSE CODE	Practical	
AC21M 107	LAB- I	Fish Identification
AC21M 108	LAB- II	Feed Formulation
AC21M 207	LAB- III	Fish Gears Preparation
AC21M 208	LAB- IV	Plankton Analysis
AC21M 407	LAB- V	Water Quality Analysis and Instrumentation

SEMESTER – I

Core Course-I

COURSE CODE	FINFISH AND SHELLFISH BIOLOGY	Total Lec.:60
AC21M101		4 – 0 – 0
Learning Objective	To learn functional physiology of Finfish and Shellfish.	
Pre-requisite		
UNIT	CONTENT	HOURS
I	**Diversity and Distribution** 1. Diversity and distribution of freshwater and marine fishes, crustaceans and molluscs. 2. Morphometric and meristic characters of fishes, crustaceans and molluscs. 3. General account of agnatha, holocephali and diponi. 4. Determination of age, growth and length-weight relationship in fishes. 5. Migration in fishes and Adaptation in Fishes.	15
II	**Digestive System** 1. Structure and physiology of digestive system and associated glands of fishes and prawns. 2. Food and feeding habits of fishes and prawns. 3. Qualitative and quantitative estimation of gut contenes, gestro-somatic and hepato-somatic indices in fishes. 4. Digestion of carbohydrates, proteins and lipids in fishes.	10
III	**Respiratory and Circulatory System** 1. Structure and physiology of respiratory system of fish and prawns. 2. Accessory respiratory organs in fishes. 3. Structure and physiology of circulatory system of fishes and prawns. 4. Structure of blood of fishes and its function.	10
IV	**Reproductive System and Excretory System** 1. Structure and physiology of reproductive system of fishes and prawn Reproductive Behavoiur of fishes, Sex determination in Fishes. 2. Gonado-somatic index, gametogenesis, ovulation, fertilization and	15

	embryonic and post-embryonic development in fishes and prawns. 3. Structure and Physiology of Excretory system of fishes and prawns. 4. Osmoregulation and its endocrine control in fishes.	
V	**<u>Nervous System and Endocrine glands</u>** 1. Structure and function of nervous system and sense organs in fishes and prawns. 2. Structure and function of endocrine glands of fishes and Neuroendocrine system of Prawns. 3. Webarian ossicles and sound production in fishes. 4. Biorhythms-circadian, circannual, lunar, tidal. 5. Ecological significance of biorhythms and bioluminescence in fishes.	10
Course Outcomes		
CO1	To understand the identifying characteristics of freshwater and marine water fishes species.	
CO2	To understand behavioral habits, feeding behavior, migration, locomotion and reproduction of each group.	
CO3	Be able to explain the structures and functions of Digestive System, Respiratory systems, Circulatory systems, Reproductive systems and Nervous system in fishes.	
CO4	Be able to explain some of the hormones that act in the process of digestion, their site of production and target organs.	
CO5	Investigate life forms found in fresh water and salt water.	
Reference Books:	Introduction to Fish Physiology-L.S. Smith. Fish Physiology-W.S. Hoar and D.J. Randall. Fish Endocrinology-A.J. Matty. Fishes-An introduction to Icthyology-Peter B. Moyle and Joseph. J. Cech. Physiology of Mollusca (Vol. I & II)- K.M. Wilbur and C.M. Younge. Prawn and prawn Fisheries of India- C.V. Kurian and V.O. Sebastian. Fish and Fisheries- B.N. Yadav	

Core Course-II

COURSE CODE	FISH BREEDING AND HATCHERY TECHNOLOGY	Total Lec.:60
AC21M102		**4 – 0 – 0**
Learning Objective	To understand the basic concept of fish breeding and hatchery.	
Pre-requisites		
UNIT	**CONTENT**	**HOURS**
I	**Broodstock Management** 1. Role of extrinsic and intrinsic factors in the regulation of fish and prawn reproduction. 2. Maintenance of brooders and maturity assessment in fishes and prawns. 3. Transportation of broodstock of fish and prawns. 4. Use of special diets for broodstock development. 5. Hormones and anesthesia used in fish and prawn breeding.	10
II	**Breeding Technology** 1. Induced breeding in fishes (Dry bundh, Bangla bundh, Hypophysation, stripping etc.) 2. Various synthetic compounds, their chemical composition and mechanism of action in fish breeding. 3. Evaluation of carp milt, volume of milt, spermatocrit value, sperm count value, motility value, utilization of cryopreserved milt. 4. Hybridization in fishes, its merits and demerits.	15
III	**Hatchery Technology** 1. Site selection and construction of fish and prawn hatcheries. 2. Types of hatcheries and their operation. 3. Construction of tanks and their management. 4. Stocking density, survival rate and harvesting of post-larvae. 5. Transportation of fish and prawn seed.	10
IV	**Water Quality Management** 1. Source of water : river, reservoir and underground water. 2. Aeration : Types of aeration, their advantages and disadvantages.	10

	3. Monitoring of water quality for hatchery operation and larval rearing of fish and prawn. 4. Nutritional requirement of fish larvae in relation to water quality. 5. Measures to check disease in hatcheries.	
V	**<u>Ornamental Fishes</u>** 1. Types of ornamental fishes (freshwater and marine), their breeding behavior and biology. 2. Oviparous, ovo-viviparous and viviparous fishes, parental care. 3. Maintenance of brood fish, various methods of breeding of aquarium fishes. 4. Aquarium manufacturing and their accessories. 5. Setting and maintenance of freshwater and marine aquaria.	15
Course Outcomes		
CO1	To understand the Role of extrinsic and intrinsic factors in fishes and prawn reproduction.	
CO2	To explain Induced breeding in fishes (Dry Bundh, Bangla bundh, Hypophysation, Stripping etc.)	
CO3	Be able to explain the various types of synthetic compounds, their chemical composition and mechanism of action in fish breeding.	
CO4	Be able to explain the evaluation of carp milt, volume of milt, spermatocrit value, sperm count value, motility value, utilization of cryopreserved milt.	
CO5	To understand the site selection and construction of fish and prawn hatcheries.	
Reference Books:	Principles of Aquaculture- R.R. Stickney. Introduction to Fish Physiology- Dr. Lynwood S. Smith. Fishes-An Introduction to Icthyology- Peter B. Moyle & Joseph J. Cech, Jr. Aquaculture – T.V.R. Pillay. Fish & Fisheries of India – V.G. Jhingram. Breeding and Seed Production of Fin and Shell Fish – Dr. PC. Thomas, DR. Suresh Ch. Rath and Dr. (Mrs.) Kanta Das Mohapatra.	

Core Course-III

COURSE CODE	AQUACULTURE	Total Lec.:60
AC21M103		4– 0 – 0
Learning Objective	To understand traditional methods and recent advancement in farming and knowing about pond management and aquaculture system **.**	
Pre-requisites:		
UNIT	CONTENT	HOURS
I	**Aqua farm Engineering** 1. Definition, history and scope of Aquaculture. 2. Selection of site, designing, layout and construction of aquafarms, soil properties, types of ponds, orientation, shape, size and depth of ponds, design of embankments, water supply and drainage system- open channels, inlet structures, drainage and sluices. 3. Design and construction of hatcheries – carp hatcheries, prawn hatcheries, catfish hatcheries; physical, biological and mechanical filters. 4. Aeration – principles, requirements, types and designs of aeration equipment. 5. Aquaculture apparatus – pumps, (types, design and selection of pumps), automatic feeders, demand feeders and weed control apparatus. 6. Design and construction of cages, pens, flow-through, biofloc and recirculatory systems.	10
II	**Pond Management** 1. Preparation and management of nursery, rearing and stocking ponds. 2. Types of aquatic weeds, algal blooms, insects, predatory and weed fishes and their control. 3. Fertilizers – types, (organic, inorganic and biofertilizers) doses and methods of their application. 4. Feeding strategies and growth monitoring. 5. Physic-chemical parameters and their importance in relation to fish health monitoring.	15
III	**Freshwater Aquaculture** 1. Culturable species of fish and shellfish. Identification of different developmental stages of finfish and	10

	shellfish of commercially important species. 2. Methods of carp culture – history, present status and global scenario. Status of carp culture in India. 3. Methods of catfish culture – present status, global scenario and problems and prospects of catfish culture, culture of Magur and Singhi in India. 4. Methods of coldwater fish culture – present status and global scenario of coldwater fish culture, culture of trout and mahaseer in India. 5. Methods of prawn culture – present status and global scenario of *Macrobrachium rosenbergii* and *M. malcolmsonii* culture.	
IV	**Mariculture** 1. Brackishwater culture in India, culturable species of finfish and shellfish and their seed production. 2. Mariculture in India, culturable species of finfish and shellfish and their seed production. 3. Extensive, modified extensive, semi-intensive, intensive and super-intensive shrimp culture. 4. Fish culture in Lagoons (Pulicat and Chilka) and backwaters. 5. Propagation of seaweeds of commercial importance. (*Glasilaria, Sargasum*, red algae etc.)	15
V	**Aquaculture System** 1. Culture System – mono, poly and composite; semi-intensive, intensive, super-intensive, cage, pen, recirculatory aquaculture system, biofloc and raceway cultures. 2. Integrated fish culture – trapa/paddy/cattle/poultry/duck/piggery-cum-fish culture etc. and their role in the development of rural economy. 3. Sewage – fed – fish culture – quality of sewage, sewage treatment, fish species, culture methods and constraints. 4. Pearl culture – pearl forming species (Oysters and mussels), nature and artificial pearl formation.	10
Course Outcomes		
CO 1	To understand selection of site designing, layout, construction of aqua farms, soil properties, types of ponds their orientation, shape, size and depth of pond, design of embankments, water supply and drainage system- open channels, inlet structures, drainages and sluices.	
CO 2	To understand the preparation and management of nursery, rearing and stocking ponds.	
CO 3	To understand the freshwater Aquaculture- Culturable species of finfish and shellfish ,	

	their identification, Developmental stages, and commercial importance.
CO 4	To understand the All Culture Systems (Mono, Poly, composite; intensive, Semi-intensive , Extensive, Cage , Pen, Raceways Cultures and IntegratedFish Farming Like Trapa/paddy/cattle/poultry/duck/piggery-cum-fish culture and also the pearl culture.
CO 5	To understand the Sewage water treatment and Sewage-fed-fish culture, culture methods, fish species and constraints.
Reference Books:	Principles of Aquaculture – R.R. Stickney. Planning of Aquaculture Development (an introductory guide) – FAO Publication. Fundamentals of Aquaculture Engineering – T.B. Lawson. Simple Methods for Aquaculture – soil and Freshwater Fish Culture – FAO Publication. Aquaculture – Principles and Practice – T.V.R. Pillay. A symposium on Fish Culture – Vadapalli Satyanarayan. The Role of Aquaculture in World Fisheries – Hegg Berget.

Core Course-IV

COURSE CODE	FISH NUTRITION AND FEED TECHNOLOGY	Total Lec.:60
AC21M104		4 – 0 –0
Learning Objective	To create basic understanding on the nutritional requirements of fish/shellfish and feed manufacture.	
Pre-requisites		
UNIT	CONTENT	HOURS
I	**Biomolecules** 1. Carbohydrates – monosaccharide's, polysaccharides, oligosaccharides, their structure and functions. 2. Lipids – fatty acids, phospholipids, cholesterol and steroids, their structure, functions, oxidation and synthesis. 3. Proteins – amino acids their structure and functions. 4. Nucleic acids – Purines and pyramidines, their structure and functions. 5. Enzymes – classification, structure, functional relationship, kinetics, inhibitiors, ecoenzymes and co-factor.	10
II	**Nutritional Requirements** 1. Carbohydrates : source and functions, gross energy requirement and factors altering energy requirements. 2. Lipids – sources and functions, essential fatty acids, phospholipids and steroids lipids requirements, negative aspects of lipids. 3. Proteins – source and functions, nitrogen balance, amino acids and their quantitative requirements. 4. Vitamins – water and fat soluble vitamins, functions, deficiency, hypo and hyper-vitaminosis. 5. Minerals – importance, deficiency and hyper dosage syndromes. 6. Nutritional requirements of larvae, adults and broodstock.	15
III	**Feed Formulation** 1. Feed formulation strategies and methods, types of feed and their ingredients, (conventional and non-conventional). 2. Antinutritional factors in feed ingredients and their effects on finfish and shellfish, methods of removal of antinutrients. 3. Binders, antioxidents, attractants, mould inhibitors and anabolic agents.	10

	4. Formulation of feed for larvae, fry, fingerlings, adult and brood stock. 5. Micro-particulate and micro-encapsulated diets. 6. Formulation of nutritionally balanced and cost effective diets.	
IV	**<u>Feed Manufacture</u>** 1. Feed manufacture process – types of machinery, feed mills and their management. 2. Processing and manufacture of different types of feeds. 3. Farm made aqua feeds, probiotics. 4. Extrusion feed technology – principles, machineries and processing. 5. Quality control, feed storage, feeding strategies, ration and frequency and dispensing methods.	10
V	**<u>Live Feed Culture</u>** 1. Natural food organisms, their culture and importance. 2. Azolla culture – taxonomy and distribution, composition, environmental factors, growth and production and its role as a biofertilizer. 3. Rotifer culture – methods, media, species, factors affecting production and its applications. 4. Artemia culture – taxonomy, distribution, collection method, lifecycle and culture. 5. Microalgal culture – methods, culturable species (*Spirulina, Chlorella, etc.),* factors affecting production and its application.	15

Course Outcomes	
CO 1	To understand Feed manufacture process – types of machinery, feed mills and their management and Processing and manufacture of different types of feeds.
CO 2	To understand Quality control, feed storage, feeding strategies, ration and frequency and dispensing methods.
CO 3	Students will gain making process of Farm made aqua feeds.
CO 4	To understand Feed manufacture process – types of machinery, feed mills and their management and Processing and manufacture of different types of feeds.
CO 5	Students will understand Quality control, feed storage, feeding strategies, ration and frequency and dispensing methods.
Reference Books:	Principles of Aquaculture – R.R. Stickney. Nutrition and feeding in Fish – C.B. Cowey et al. Freshwater Aquaculture – R.K. Rath. AOAC. Aquaculture Feed – R. Paulraj. Biomolecules – S.R. Mishra.

Discipline Specific Electives-I

COURSE CODE	Aquaculture of Ornamental Fishes	Total Lec.: 45
AC21M105		3– 0 –0
Learning Objective	To impart knowledge on ornamental fish and aquatic ornamental plants propagation.	
Pre-requisites		

UNIT	CONTENT	HOURS
I	Global status of ornamental fish trade, present status and prospects of ornamental fish farming and trade in India, Indian ornamental fish diversity and its status. Marketing strategies,anesthetics, packing and transportation.	10
II	Aquarium keeping (freshwater & marine): Design & construction of aquariumgarden pool, species compatibility, aquarium maintenance and care.	05
III	Captive Breeding techniques of commercially important indigenous and marine ornamental fishes.	05
IV	Common aquarium plants and invertebrates. Gadgets used in freshwater and marine aquarium, role of aerators, filters (UV, trickling and biofiltration), protein skimmers, ozonizer, thermostatic heater, chiller, lighting. Medicines and chemicals used in the ornamental fish industry.	15
V	Prerequisite for establishment of ornamental fish breeding, culture unit for entrepreneurship development.Socio-economic upliftment of women through backyard ornamental fish farming.	10

Course Outcomes	
CO1	Awareness on the potential ornamental fishes and their breeding habits.
CO2	An idea about indigenous ornamental fishes.
CO3	Knowledge on equipments used in aquariums.
CO4	Knowledge on novel designs of aquarium keeping and maintenance.
CO5	Importance of water quality and other parameters in aquarium keeping.

Reference Books:

Axelrod HR &Vorderwinkler W. 1978. *Encyclopaedia of Tropical Fishes*. TFH Publ.

Axelrod HR &Sweenen ME. 1992. *The Fascination of Breeding Aquarium Fishes*. TFH.

Handbook of Fisheries and Aquaculture. 2006. ICAR.

Mills D. 1981. *Aquarium Fishes*. Kingfisher Books.

Sanford G & Crow R. 1991. *The Manual of Tank Busters*. Salamander Books.

Spotte S. 1979. *Fish and Invertebrate Culture*. John Wiley & Sons.

Thabrow De WV. 1981. *Popular Aquarium Plants*. Thornbill Press.

Discipline Specific Electives-I

COURSE CODE	Live Feed Culture	Total Lec.:45
AC21M106		3-0-0
Learning Objective	To understand the nutritional requirements of finfish and shellfish larvae, mass culture and enrichment of live food organisms.	
Pre-requisites		
UNIT		HOURS
I	Study the nutritional requirement of fishes and shell fishes. Body composition of fish and shellfish. Varieties of live feed and their importance. Natural food for different fishes and shellfishes. Necessity of live food for larval development and culture of fish and shell fishes. Prospects of live feed culture. Nutritive value of live feed.	10
II	Major Classes and genera of Cultured Algal species. Various Physico-Chemical Parameters affecting the Algal growth. Growth dynamics. Algal culture techniques: Batch culture, Continuous culture, Semicontinous culture; Algal production and outgrowth, Harvesting and preserving micro algae. Nutritional value of microalgae, use of micro algae in aquaculture, Replace diet for live algae.	10
III	Culture of Rotifers: Introduction, Morphology, Biology Life History of Rotifers and Strain differences. General rotifer culture: Various factors affecting culture of Rotifer, Preparation of Stock culture. Nutritional value of cultured rotifer, harvesting and cultured rotifers. Artemia culture: Introduction, Biology and Ecology of Artemia. Culture of Naupli, Its nutritional quantity and its application. Pond production of Artemia.	9
IV	Production of copepods: Introduction Lifecycle, Biometric, Nutritional quality, Culture techniques, Use of resting eggs, Application in Larviculture. Nematode culture Trochophora larvae: Introduction, Production of Trochophora larvae, Quality controlled of the produced Trochophora larvae, Cryopreservation. Cladocerans Culture: Biology and Life cycle of cladocerans, Nutritional value of cladocerans, Feeding and nutrition of cladocerans, Mass culture of	8

	cladocerans, Production and use of resting eggs , use of cladocerans.	
V	Duckweed culture: Introduction, The plants and its habitat, Growing duckweed and its nutritive value, Growth Conditions, Management system for duckweed culture, use of duckweed in fish nutrition. Azolla culture: Introduction, Classification, Characteristics (Importance and environment requirements), Production, Chemical composition, Use as aqua feed. Sea weed Culture: Introduction, Uses of Seaweed, Sea weed Resource in India, Methods of Sea weed Farming in India.	8

Course Outcomes	
CO1	Importance of live feeds in fish nutrition.
CO2	To understand Varieties of live feed and their importance.
CO3	Knowledge on Nutritional value of microalgae, use of micro algae in aquaculture, Replace diet for live algae.
CO4	Students will understand Sea weed Culture.
CO5	To understand Natural food for different fishes and shellfishes and the Necessity of live food for larval development and culture of fish and shell fishes.
Reference Books:	CIFE. 1993. *Training Manual on Culture of Live Food Organisms for AQUA Hatcheries*. Central Institute of Fisheries Education, Versova, Mumbai. Finn RN & Kapoor BG. 2008. *Fish Larval Physiology*. Science Publ. Hagiwara A, Snell TW, Lubzens E & Tamaru CS. 1997. *Live Food in Aquaculture*. Proceedings of the Live Food and Marine Larviculture Symposium. Kluwer. MPEDA. 1993. *Handbook on Aqua Farming - Live Feed. Micro Algal Culture.* MPEDA Publication. Muthu MS. 1983. *Culture of Live Feed Organisms*. Tech. Paper 14.Summer Institute in Hatchery Production of Prawns Seeds. CMFRI,Cochin. Ojha JS. 2005. *Aquaculture Nutrition and Biochemistry*. Daya Publ.

Practical Papers

AQUACULTURE PRACTICALS- SEMESTER -I

Course Code. AC21 M 107	**PRACTICALS LAB-1**	**60**
1.	Morphometric and meristic characters and identification fishes, crustaceans and molluscs.	
2.	Determination of age, growth and length-weight in fishes	
3.	Qualitative and quantitative estimation of gut contents(GaSI)	
4.	Hepato-somatic indices in fishes.	
5.	Haematology of Fishes	
6.	GSI	
7.	Fecundity	
8.	Identification of different stages of gonadal maturation	
9.	Weberian Ossicles	
10.	Hypophysation (Extraction of fish pituitary)	
11.	Evaluation of carp milt, volume of milt, spermatocrit value	
12.	Types of hatcheries and their operation	
13.	Stocking density and survival rate during culture system	

Course Code AC21M108	**PRACTICALS LAB-2**	**60**
1	Preparation and management of nursery, rearing and stocking ponds	
2	Identification and collection of aquatic weeds	
3	Types of Fertilizers	
4.	Feeding strategies and growth monitoring	
5.	Identification of different stages of fish and shellfish	
6.	Methods of carp culture, catfish culture and prawn culture	
7.	To understand mariculture practices	
8.	cage, pen, raceway cultures and Integrated fish culture	
9.	Sewage – fed – fish culture	
10.	Carbohydrates, protein and lipid test	
11.	Feed Formulation	
12	Feed manufacturing	
13.	Live feed culture (azolla, rotifer microalgae, infusoria)	

Project Based Learning I

COURSE CODE	PROJECT BASED LEARNING
PB21M101	**2**
Learning Objective	• Integrating the knowledge and skills of various courses on the basis of multidisciplinary projects. • Develop the skill of critical thinking and evaluation. • To develop 21st century success skills such as critical thinking, problem solving, communication, collaboration and creativity/innovation among the students. • To enhance deep understanding of academic, personal and social development in students. • Employ the specialized vocabularies and methodologies.
General Guidelines:	• PBL will be an integral part of UG/PG Programs at different levels. • Each semester offering PBL will provide a separate Course Code, two credits will be allotted to it. • Faculty will be assigned as mentor to a group of 30 students minimum by HoS. • Faculty mentor will have 4 hours/week to conduct PBL for assigned students. • Student will select a topic of their choice from syllabus of any course offered in respective Semester (in-lines with sustainable development goals). • Student may work as a team maximum 3 or minimum 2 members for single topic. • For MSE, student's performance will be assessed by panel of 2 experts either from other Department/school, or from same department/school based on chosen topic. This will be comprised of a presentation by student followed by viva-voce. It will be evaluated for 30 marks. • 20 marks would be allotted for continuous performance assessment by concerned guide/mentor. • For ESE, student will need to submit a project report in prescribed format, duly signed by concerned guide/mentor and head of the school. The report should be comprised of following components: 1. Introduction 2. Review of literature 3. Methodology 4. Result and Discussion 5. Conclusion and Project Outcomes 6. References • In ESE, viva-voce of students will be conducted on the basis of report, by one external and one internal faculty which is of 50 Marks. Student will need to submit three copies for 1. Concerned School 2. Central Library 3. Self. The integrity of the report should be maintained by student. Any malpractice will not be entertained. • Writing Ethics to be followed by student, a limit of 10 % plagiarism is permissible. Plagiarism report is to be attached along with the report. • Project could be a case study/ analytical work /field work/ experimental work/ programming or as per the suitability of the program.

SEMESTER – II

Core Course-I

COURSE CODE	FISHERIES RESOURCE MANAGEMENT	Total Lec.:60
AC21M201		**4 – 0– 0**
Learning Objective	To gain knowledge on fisheries resource management.	
UNIT	**CONTENT**	**HOURS**
I	**Inland Fisheries Resources** 1. Inland fisheries resource of India and scope for their exploitation and production. 2. River systems – Major river systems (Ganga, Brahamputra,Indus, Narmada, Tapti, East and West coast rivers) and their fisheries. 3. Lakes – Origin, classification, distribution, ecology and fisheries with special reference to Upper and Lower lakes, Dal lake and Bhimtal. 4. Reservoirs – Large, medium and small reservoirs of India (Govind Sagar, Hirakund, Mettur, Rehand and Nagarjuna Sagar), their ecology and fisheries. Fish ways, fish passes and fish ladders, measures to increase the production of reservoirs. 5. Recent advancements in reservoir management and present status of reservoirs of M.P. (Newly constructed Reservoirs of Narmada,Gandhi Sagar, Tawa, Bargi, Halali).	15
II	**Brackishwater Fisheries Resources** 1. Brackishwater resources of India and scope for their exploitation and production. 2. Brackishwater lakes (Chilka and Pulicat), their ecological characteristics (soil, water and biota) and fisheries. Impact of aquatic pollutions on fish health and fisheries with special reference to Ganga and Narmada rivers and Chilka lake. 3. Estuaries – Origin, distribution and classification, scope for exploitation and production. 4. Fisheries of estuaries – Hoogly-Matlah, Godavari, Krishna, Adyar and Vellar. Backwater fisheries with special reference to Kerala.	15
III	**Marine Fisheries Resources** 1. Marine fisheries resources, scope for their exploitation and production. 2. Coastal capture fisheries – inshore and offshore fisheries of Indian ocean, Exclusive Economic Zone (EEZ).	10

	3. Fisheries of important finfishes – Sardine, Indian mackerel, Bombay duck, Tuna, Pomfret, Perches and Mullets. 4. Fisheries of important shellfishes – Shrimps (white & tiger), Lobsters, Crabs and Molluscs (Pearl oysters and edible oysters). 5. Fisheries of minor groups of fishes – Eels, catfishes, silver bellies, ribbon fishes, seer fishes, elasmobranches and soles.	
IV	**Coldwater Fisheries Resources and Remote Sensing** 1. Important coldwater fishes of India (indigenous and exotic) and their distribution. 2. Mahaseer and trout fisheries and their importance. 3. Remote sensing – Concepts and principles, Remote sensing sensors. Optical methods. 4. Satellite measurements of temperature (via. Thermal I.R.), Visual interpretation of remotely sensed data and interpretation of microwave measurements (geographic currents, waves and surface winds).	10
V	**Fisheries resource Management and Conservation** 1. Anthropogenic activities and their effects on fisheries. 2. Threatened and endangered fish species of India. 3. Measures for management and conservation. 4. Laws for safeguarding biodiversity and management.	10

Course Outcomes	
CO1	To understand Inland fisheries resource of India ,scope for their exploitation and production.
CO2	Students will understand Fisheries of important finfishes – Sardine, Indian mackerel, Bombay duck, Tuna, Pomfret, Perches and Mulletsand also the Fisheries of important shellfishes – Shrimps (white & tiger), Lobsters, Crabs and Molluscs (Pearl oysters and edible oysters).
CO3	To understand Reservoirs – Large, medium and small reservoirs of India (Govind Sagar, Hirakund, Mettur, Rehand and Nagarjuna Sagar), their ecology and fisheries. Fish ways, fish passes and fish ladders, measures to increase the production of reservoirs.
CO4	Students knowing about Brackishwater lakes (Chilka and Pulicat), their ecological characteristics (soil, water and biota) and fisheries. Impact of aquatic pollutions on fish health and fisheries with special reference to Ganga and Narmada rivers and Chilka lake.
CO5	To understand Marine fisheries resources, scope for their exploitation and production.
Reference Books:	Fish and Fisheries of India – V.G. Jhingram. Marine Biology – S.N. Prasad. Marine Fisheries – D.V. Bal and K.V. Rao. Ornamental Fishes – V.K. Dey (MPEDA Publication). A textbook of Aquatic Biology – B.B. Fassett and Arvind Kumar.

Core Course-II

COURSE CODE	HARVEST AND POST HARVEST TECHNOLOGY	Total Lec.:60
AC21M202		4– 0-0
Learning Objective	To impart essential knowledge and skills regarding advanced technologies of harvest and post harvest.	

UNIT	CONTENT	HOURS
I	**Fishing Crafts** 1. Different types of traditional and mechanical vessels and their operations. 2. Fishing craft materials (wood, steel, FRP and ferrocement), boat designing, construction and maintenance, prevention from fauling and wood borers. 3. Different types of deck equipment (derricks, boom, Gallows blocks), lifting gears (winches, power block, hauler, wire rope etc.). 4. Fish finding equipment (sonar, ecosounder, ecofinder, nat zoned) and application of satellite imaging, inboard and outboard motors (OBM) and their operations. 5. Basic principles of navigation and seamanship. Reading tide tables, compass and signaling. Use of radar and radio telephone, global positioning system (GPS).	15
II	**Fishing Gears** 1. Different types of gear materials – twine, rope, yam, mesh size regulation. 2. Design and fabrication of fishing gears. 3. Principles and operations of different gears of inland water (hook and line, gill net, drag net, cast net and fishing traps). 4. Principles and operations of different gears of marine water (Shore seine, purse seine, boat seine, trawl net and jigging), modernization of fishing methods; Turtle Exclusive Device (TED).	10
III	**Biochemical Composition and Fish Spoilage** 1. Chemical composition of fish and shrimp – moisture, ash, carbohydrates, proteins and lipids and their estimation. 2. Rigor mortis – freshness test, biochemical change and spoilage. *3.* Role of microbes in food spoilage, microbial analysis of (*Vibrio, Salmonella,Shigella, Staphylococcus etc.) fish and fish products.* 4. Fish food poisoning – characteristics and chemical features of food poisoning caused by *Vibrio, Salmonella, Brucella,*	10

	Shigella and Staphylococcus sp. 5. Study of psychrophyllic and mesophyllic microbes (bacteria and fungi) of processed fish and fish products.	
IV	**Preservation Technology** 1. Methods of fish preservation – drying, smoking, chilling, freezing, salting and canning. Handling and transportation of fresh fish. 2. Methods of ice production, storage and calculation of ice requirement for fish storage. 3. Freezing methods – Air-blast, plate freezer and cryogenics, freezing curve, flow chart, grading, packing and storage of frozen products, drip loss and thawing of frozen fish. 4. Canning – with special reference to tuna, mackerel etc., types of cans, polypacks and bases (brine, oil, sauce etc.), canning of freshwater fish.	10
V	**Quality Assurance** 1. Composition of the muscle proteins and their role in emulsification and elasticity formation. Factors influencing elasticity formation and theories of gel formation. 2. Minced meat from different varieties of freshwater and marine fishes. Improvement of colour of meat by bleaching and certain additives. 3. Value added prodects – fish fingers, fish flakes, soup, powder, breaded and battered minced products etc. 4. Byproducts – fish meal, fish oil, isinglass, fish finrays, chitosan, surgical sutures and other byproducts. 5. Standards of sanitation and hygiene, concepts of food safety in fish industry. Hazard Analysis and Critical Control Point (HACCP). Quality control system, various national and international standards on fishery products (BS-5750 and ISO 9000	15

Course Outcomes	
CO1	Students will understand about Fishing craft materials.
CO2	The students will be able to learn about the methods of fish preservation.
CO3	Gain the knowledge about the Fish finding equipment
CO4	Students will understand about Composition of the muscle proteins and their role in emulsification and elasticity formation.
CO5	Students will understand about byproducts.
Reference Books:	Postharvest Technology of Fish and Fish products – K.K. Balachandran. Fish processing and Preservation – C.L. Cutting Fish Handling and Processing – C.H.O. Bugese. Fish and Fish Products – A.L. Winton and K.B. Winton.

	Control of Fish Quality – J.J. Comiel Introduction to Fish Technology – J.M. Regenstein.

Core Course-III

COURSE CODE	AQUATIC BIOLOGY	Total Lec.:60
AC21M203		**4 – 0 – 0**
Learning Objectives	To impart knowledge on aquatic biology and microorganisms with reference to their role in the aquatic environment.	
UNIT	**CONTENT**	**HOURS**
I	**Freshwater and Marine Ecology** 1. Definition, principles and role of ecology in aquatic ecosystem. 2. Abiotic and biotic characteristics of freshwater, brackish water and marine environment. 3. Adaptations in fishes. 4. Oceanography in relation to fishery science. 5. Chemical composition of seawater; waves, tides and influence of tides on fihery.	10
II	**Productivity** 1. Primary productivity, gross and net productivity, qualitative and quantitative analysis of plankton. 2. Plankton and their role in aquatic ecosystem in relation to fisheries. 3. Benthos and macrovegetations – types and their role in aquatic ecosystem. 4. Methods of collection, preservation and identification of major types of benthos and macrovegetations of freshwater.	15
III	**Trophic Dynamic Ecology** 1. Energy flow, ecological efficiency, ratios within trophic levels, organic particulate matters and their role in productivity. 2. Influence of physical factors of the sea on the transformation of matter in marine environment. 3. Food web structure, utilization and transfer of energy from one trophic level to other. 4. Food conversion and its application to ecology. 5. The biomass and trophic dynamism in pelagic communities.	15
IV	**Aquatic Microbiology** 1. Types of microbes – non-cellular, prokaryotic and eukaryotic microbes and their structure. 2. Isolation, culture and identification techniques of microbes and their enumeration methods (SPC, MPN, TCC and biomass determination). 3. Microbial physiology – Diffusion, osmosis, transport (active and passive) and group translocation, microbial nutrients and culture media (Natural, synthetic and differential media). 4. Factors affecting growth of microbes, population growth curve, its mathematical expression and microbial control (physical and	10

	chemical). 5. Cynobacteria and antagonistic characteristics of microbes and their evaluation.	
V	**<u>Aquatic Pollution</u>** 1. Waste waters and their treatment (Primary, Secondary and Tertiary). 2. Determination of Biological and Chemical Oxygen Demand (BOD & COD). 3. Pollutants- Sewage, pesticides, oils, metals ,radioactive wastes, Biomedical wastes etc. Common transport processes of pollutants in aquatic Environment; dispersal of pollutants, algal blooms and their management, Methods of pollution surveys. 4. Biodegradable materials (cellulose, hemicelluloses, liginin, xenobiotics and recalcitrants) and their degradation. 5. Types of pollutions and measures for their abatement.	10
Course Outcomes		
CO 1	The biology of aquatic organisms will be fully understood by the students and capable of distinguishing the biology of each group of organisms and the statistical approach of fishery science will be applied.	
CO 2	Gram staining of bacteria.	
CO 3	Different types of bacterial inoculation and cultivating techniques.	
CO 4	To understand about waste waters and their treatment	
CO 5	Knowing about plankton.	
Reference Books:	Methods for Physical and Chemical Analysis of Freshwater – H.L. Golterman. APHA Animal Ecology and Distribution of Animals – V.B. Rastogi and M.S. Jayaraj. Pesticide Impact on Fish Metabolism – K.R.S. Sambasiva Rao. Water and Waste water Technology – Mark J. Hammer Water Pollution and Fish Physiology – Alan G. Heath. Pond Aquaculture Water Quality Management – C.E. Boyd and C.S. Tucker. Limnological Analysis – Robert G. Wetzel and Gene E. Likens.	

Core Course-IV

COURSE CODE	FISH HEALTH MANAGEMENT	Total Lec.:60
AC21M204		**4 – 0 – 0**
Learning Objective	To comprehend the basic principles of aquatic animal health management in relation to their environment.	
Pre-requisites		
UNIT	**CONTENT**	**HOURS**
I	**Disease Diagnosis** 1. Stress Physiology: stress response, stress hormones and stress adaptations in fishes. 2. Epizootiological, post-mortem and clinical diagnosis. 3. Bacteriological methods of fish disease diagnosis. 4. Mycotic methods of fish disease diagnosis. 5. Histopathological, immune-histopathological and haematological methods of fish disease diagnosis.	10
II	**Non Infectious Disease** 1. Nutritional fish diseases – symptoms, diagnosis and remedial measures. 2. Neoplastic fish diseases – classification, origin, diagnosis, types and factors involved and their possible control. 3. Protozoan fish diseases – symptoms, classification, distribution, life cycle of potent parasitic fish protozoans and their remedial measures. 4. Crustacean fish diseases – symptoms, classification, distribution and life cycle of potent crustacean parasites and their remedial measures. 5. Helminth fish diseases – symptoms, classification, distribution and life cycle of potene parasitic fish helminthes and their remedial measures.	10
III	**Microbial Disease** 1. Viral pathogens of finfish and shellfish, their general biology and taxonomy, isolation and identification. 2. Bacterial fish diseases – bacterial pathogens, their characteristics and distribution, symptoms, prophylactic and therapeutic measures. 3. Fungal fish diseases – mycotic pathogen and their characteristics, life cycle of potent aquatic fungi, symptoms prophylactic and therapeutic measures. 4. Microbial and parasitic diseasesb of shellfish and their control. 5. Aquatic pathogens in relation to human health (zoonosis) EUS and WSS.	10

	6. Mode of transmission of microbial diseases.	
IV	**Fish Immunology** 1. Immune system – Non-specific (innate immune response) and specific immune systems, cellular and molecular interaction. 2. Structure, type and function of fish immunoglobulin and theories of antibody formation. 3. Antigenicity, precipitation, agglutination, immobilization and autoimmunity. 4. Hybridoma technology – mono and polyclonal antibodies and their applications; antagonism and antimicrobial agents. 5. Haematopoetic tissue, primaty and secondary lymphoid organs, inflammation, encytation and granuloma formation.	15
V	**Fish Vaccination** 1. General principles of fish vaccination and optimizing factors for vaccination. 2. Strategies for fish vaccination, production of non-adjuvant (live or dead), vaccines and their applications, route of vaccine administration. 3. Adjuvants – present scienario of adjuvants and their role in immunomodulation of fish, production of adjuvant vaccine. 4. Present status and future prospects of phage therapy in aquaculture.	15
Course Outcomes		
CO 1	Different types of Protozoan diseases in fishes and their management.	
CO 2	Studies on fish immunology and fish vaccination.	
CO 3	Nutritional deficiency diseases and their management.	
CO 4	Genetically and environmentally induced diseases in fish.	
CO 5	Different types of diagnostic tools in fish disease management.	
Reference Books:	Bacterial disease of fish – V. Inglis et al. Bacterial Fish Pathogens Disease in Farmed and Wild Fish – B. Austin and D.A. Austin. Essential Immunology – 1. Roitt. Fish Diseases and Disorders – Vol. I – III, P.T.K. Woo. Fish Diseases – W. Ahne. Health Maintenance of Cultured Fishes, Principal Microbial Disease – J.A. Plumb. The Fish Immune System (organism, pathogen and environment) – G. Lwama.	

Discipline Specific Electives-II

COURSE CODE	SUSTAINABLE AQUACULTURE	Total Lec.:45
AC21M205		3-0-0
Learning Objective	To gain in depth knowledge and field exposure on sustainable aquaculture practices.	
Pre-requisites:		

UNIT	CONTENT	HOURS
I	Present scenario and problems: Trends in global and Indian aquaculture; different farming systems; intensive systems and constraints - environmental degradation and disease outbreaks.	10
II	Sustainability and development: Systems approach and its application in aquaculture with special reference to resource-poor systems; Role of aquatic resources in food and nutrition; Aquatic resource and livelihood systems.	10
III	Environmental issues: Exotic species introduction; escapement; contamination of indigenous gene pool; salinization of soil and water; environmental impact; over exploitation of wild stocks; mangrove deforestation.	10
IV	Socio-economic issues: Conflicts over water and land use; conflicts of interest between aqua farmers and fishermen; resistance from local public; anti-dumping duties.	05
V	Strategies for sustainability: Sustainability concept; food security; biosecurity; organic farming; integrated farming; responsible aquaculture; rotational aquaculture; bioremediation; role of biotechnology, traceability. Application of renewable energy in aquaculture - solar energy, wind, and tidal energy, Seed certification, Sustainable use of antibiotics.	10

Course Outcomes	
CO 1	Aquaculture scenario in Indian and global context.
CO 2	Ecological concepts like productivity, carrying capacity, food chain and food web.
CO 3	Basic understanding of agriculture, aquaculture and fisheries.
CO 4	Aquatic resource and livelihood systems.

CO 5	Pond fertilization and biological food production.
Reference Books:	Bardach JE. 1997. Sustainable Aquaculture. John Willey & Sons. Bardach JE, Rhyther JH & Mc. Larney WO. 1972. Aquaculture Farming and Husbandry of Freshwater and Marine Organisms. John Wiley & Sons. 14 Beets WC. 1990. Raising and Sustaining Productivity of Small-Holder Farming Systems in the Tropics. Agbe Publ. Edwards P, Little DC & Demaine H. (Eds.). 2002. Rural Aquaculture. CABI. FAO 2001. Planning and Management for Sustainable Coastal Aquaculture Development. FAO.

Discipline Specific Electives-II

COURSE CODE	AQUACULTURE ENVIRONMENT MANAGEMENT	Total Lec.: 45
AC21M206		3– 0-0
Learning Objective	Knowledge on effective soil and water quality management practices.	
Pre-requisites:	None.	

UNIT	CONTENT	HOURS
I	Soil and water interaction: Physical and chemical properties of soil and water, productivity vs nutrient quality and quantity of soil and water, aquatic microorganismsand their role incarbon, nitrogen, phosphorus and sulphur cycles.	10
II	Soil and water quality standards,organic and inorganic fertilizers, fertilizer grade, source, rate and frequency of application, biofertilizers, use of treated sewage for pond fertilization, ecological changes taking place after fertilization, primary and tertiary production, utilization of bioactive compounds by microorganisms.	10
III	Soil and water quality management: Cat clay/pyrite soil, seepage and its control, zero waterexchange system, water filtration devices, aeration, chlorination, ozonization and uv radiation.	10
IV	Eutrophication, algal bloom control, aquatic weed management, waste water treatmentpractices.	5
V	Water quality management in culture and hatchery practices, waste dischargestandards. Role of micro-organisms in aquatic animal health and pond management.	10

Course Outcomes	
CO 1	Connecting investigations to solve the problems arise aquaculture practice and environment.
CO 2	Apply the concepts aquaculture to benefit of society.
CO 3	Contribute the sustainable development of aquaculture to save the environment
CO 4	Apply the knowledge of aquaculture in various aspects of environment / industry.
CO 5	Development ethical and working concept of environmental friendly and aqua practice based on inputs of biotechnology, microbiology and genetics.

Reference Books:

Adhikari S & Chatterjee DK. 2008. *Management of Tropical Freshwater Ponds*. Daya Publ.

APHA, AWWA, WPCF. 1998. Standard Methods for the Examination of Water and Wastewater, 20th Ed.

Boyd, C. E. and Tucker, C. S. 1992. Water Quality and Pond Soil Analysis for Aquaculture, Alabama Agricultural Experimental Station, Auburn University.

Boyd CE. 1979. *Water Quality in Warm Water Fish Ponds*. Auburn University.

ICAR. 2006. *Handbook of Fisheries and Aquaculture*. ICAR.

Parsons TR, Maita Y &Lalli CM. 1984. *A Manual of Chemical and Biological Methods for Seawater Analysis*. Pergamon Press.

Rajagopalsamy CBT &Ramadhas V. 2002. *Nutrient Dynamics in Freshwater Fish*

	Culture System. Daya Publ. Sharma LL, Sharma SK, Saini VP & Sharma BK. (Eds.). 2008. *Management of Freshwater Ecosystems*. Agrotech Publ. Academy.

Practical Papers

COURSE CODE	LAB III	Practical : 60
AC21M207		2

- Design and fabrication of fishing gears.
- Identification of different types of gear materials.

COURSE CODE	LAB IV	Practical : 60
AC21M208		2

- Collection of plankton
- Identification of plankton
- Qualitative and Quantitative Analysis of Plankton

Project Based Learning II

COURSE CODE	PROJECT BASED LEARNING
PB20B201	
Learning Objectives:	• Integrating the knowledge and skills of various courses on the basis of multidisciplinary projects. • Develop the skill of critical thinking and evaluation. • To develop 21st century success skills such as critical thinking, problem solving, communication, collaboration and creativity/innovation among the students. • To enhance deep understanding of academic, personal and social development in students. • Employ the specialized vocabularies and methodologies.
General Guidelines:	• PBL will be an integral part of UG/PG Programs at different levels. • Each semester offering PBL will provide a separate Course Code, two credits will be allotted to it. • Faculty will be assigned as mentor to a group of 30 students minimum by HoS. • Faculty mentor will have 4 hours/week to conduct PBL for assigned students. • Student will select a topic of their choice from syllabus of any course offered in respective Semester (in-lines with sustainable development goals). • Student may work as a team maximum 3 or minimum 2 members for single topic. • For MSE, student's performance will be assessed by panel of 2 experts either from other Department/school, or from same department/school based on chosen topic. This will be comprised of a presentation by student followed by viva-voce. It will be evaluated for 30 marks. • 20 marks would be allotted for continuous performance assessment by concerned guide/mentor. • For ESE, student will need to submit a project report in prescribed format, duly signed by concerned guide/mentor and head of the school. The report should be comprised of following components: 1. Introduction 2. Review of literature 3. Methodology 4. Result and Discussion 5. Conclusion and Project Outcomes 6. References • In ESE, viva-voce of students will be conducted on the basis of report, by one external and one internal faculty which is of 50 Marks. Student will need to submit three copies for 1. Concerned School 2. Central Library 3. Self. The integrity of the report should be maintained by student. Any malpractice will not be entertained. • Writing Ethics to be followed by student, a limit of 10 % plagiarism is permissible. Plagiarism report is to be attached along with the report. • Project could be a case study/ analytical work /field work/ experimental work/ programming or as per the suitability of the program.

FOURTH SEMESTER

Core Paper-I

COURSE CODE	**BIOSTATISTICS AND INSTRUMENTATION**	**Total Lec: 60**
AC21M401		**4 – 0 – 0**
Learning Objective	To gain the knowledge about biostatistics and instrument used in aquaculture.	
Pre-requisites:		
UNIT	**CONTENT**	**HOURS**
I	**Fisheries Statistics** 1. Elementary statistics – Definition, scope, objectives and applications of statistics in fisheries. Collection, presentation and interpretation of data. 2. Mean, Mode and Median, Standard Deviation, Standard Error, Variance, ANOVA and measures of dispersion and central tendency. 3. Population statistics- Concept of sample and population, characteristics of a sample, probability calculation in relation to fisheries, normal and binomial distribution. 4. Test of significance based on t-test, X2 test (chi squre test), f-test, linear regression, correlation, fitting of curves (first degree), index number. 5. Sample survey, census, sampling techniques, statistical tools used in fishery economics, need for empirical and quantitative analysis.	15
II	**Microscopy** 1. Structure, principles and applications of compound microscope. 2. Structure, principles and applications of dark – field and phase – contrast microscope. 3. Structure, principles and applications of fluoresecent microscope. 4. Structure, principles and applications of electron microscope – Transmission Electron Microscope (TEM) and Scanning Electron Microscope (SEM). 5. Preparation of specimen for microscopy, autoradiography.	10
III	**Centrifugation and Spectrography** 1. Structure, principles and applications of centrifuges. 2. Spectrophotometer – structure, principles and applications, determination of Optical Density (OD) of various samples. 3. UV-VIS spectrophotometer and fluroscence spectroscopy. 4. Structure, principles and applications of Atomic Absorption Spectrometer (AAS).	10

	5. Structure, principles and applications of Electron Spin Resonance (ESR) and mass spectrometers.	
IV	**Chromatography, Electrophoresis, ELISA and PCR** 1. Structure, principles and applications of paper, gas and ion exchange chromatography. 2. Structure, principles and applications of High Performance Liquid Chromatography (HPLC), molecular sieve and affinity chromatography. 3. Structure, principles and applications of paper, Gel Polyaccralamide Gel Electrophoresis (PAGE) & Sodium Dodecile Sulphate (SDS-PAGE) vertical (submarine), gradient gel electrophoresis. 4. Principles and applications of ELISA. 5. Principles and applications of PCR.	15
V	**Computer Application** 1. Fundamentals of computers. 2. Disk Operating System (DOS) commands. 3. Microsoft (MS) Excel as a means to calculate mean, mode, median, standard deviation, regression and plot curve fitting. 4. Internet : applications and advantages.	10
Course Outcomes		
CO1	Statistical analysis using excel.	
CO2	Correlation and regression analysis of fishery data by computer program or software.	
CO3	Analysis of biological data using statistical tools and its representation using appropriate computer tool.	
CO4	Thorough understanding of components of computer.	
CO5	Gain the knowledge about instrument used in aquaculture.	
Reference Books:	Biostatistics – Mahajan. Fisheries Statistics – R.S. Biradar. Instrumental Methodes of Analysis – H.H. Willard et al. Biochemical Methods – S. Sadasivam and A. Manickam. Elements of Biostatistics – S. Prasad.	

Core Paper-II

COURSE CODE	FISHERIES ECONOMICS AND EXTENSION	Total Lec: 60
AC21M402		4 – 0 – 0
Learning Objective	To understand fisheries economics and extension.	
Pre-requisites:		
UNIT	CONTENT	HOURS
I	**Fundamental Economics** 1. Definition and scope of economics in relation to fisheries. 2. Law of equimarginal return, production, economics of composite, integrated, intensive and semi-intensive culture system. 3. Exhaustible resource – the theory of optimal depletion, uncertainly and depletion, renewable resources- a model of optimal use, the common property problem. 4. Role of economics in the study of resource and environmental problems. 5. Economics of fish hatcheries and grow-out.	10
II	**Fish Marketing** 1. Law of demand and supply, price determination, price rise causes, consequences and remedies. 2. Markets – definition, functions, structure of fish markets in India. 3. Problems of fish marketing in India, Export of fish and fishery products, trends and problems, role of MPEDA in export of fish and fishery products. 4. Economics of fish farm vis-à-vis level of management. 5. Fish seed industry – production and marketing of fish and shellfish seed (spawn, fry, fingerling and PL-20) in India.	15
III	**Fishery Administration and Development** 1. Administration – fishery administration at the Centre and States, its functions and organizational set up. 2. Fisheries legislation of Government of India and different	15

	States, Historical background and present status of legislation. 3. Exclusive Economic Zone (EEZ) and Coastal Regulation Zone (CRZ), their effect in fishery economy. 4. Financial assistance – Financial assistance available to the fishery sector from Government, commercial banks, NABARD, its structure and functions in relation to fisheries economics, co-operatives and other institutional organizations. 5. Project formulation, monitoring, evaluation and calculation of profitability.	
IV	**Extension Programme** 1. Historical prespective, concept, philosophy, principles and objectives of extension. Collection of facts, situation analysis and problem identification. 2. Importance of extension programme and characteristics of a good programme. 3. Participation of organizations and involvement of people in programme planning. 4. Leadership and teamwork in extension.	10
V	**Training Strategy and Communication** 1. Training strategy in transfer of technology in aquaculture, role of farmer, extension and research linkage. 2. Concept and function of communication and his/her importance in extension work. 3. Communication models and channels, feed back in communication. 4. Role and effects of communication channels in extension education and problem of communication – types and nature. 5. Innovations and their rate of adoption, characteristics of adoption categories.	10
Course Outcomes		
CO1	An overall idea of economic principles applicable in fisheries.	
CO2	Theories of production, demand, supply and return in terms of fishery industry.	
CO3	Concepts and theories of business applicable in fisheries industry.	
CO4	Management strategies in marketing, finance, production, administration and industrial relations.	
CO5	Extension and role of tourism for promoting economic growth in fisheries sector.	
Reference Books:	Applied Economics and Commercial Geography – K. Trivedi. Aquaculture Economics – Y.C. Shaung. Aquaculture Economics Abstract – N.E. Emmanuel. Economics of Fisheries Technologies – Dr. Darsi Vishnu Sankar Rao and Dr. V.T. Raju.	

	Fisheries Economics – R. Jayaraman. Principles of Economy – M.L. Seth. Economics of Aquaculture – R.K.P. Singh

Core Paper-III

COURSE CODE	AQUATIC ENVIRONMENT AND BIODIVERSITY	Total Lec: 60
AC21M403		4– 0 – 0
Learning Objective	To acquaint the students with the theoretical and practical aspects of the aquatic environment and biodiversity.	
Pre-requisites:		
UNIT	CONTENT	HOURS
I	**Aquatic Environment** Concepts in aquatic environment: Aquatic environment/ecosystem – components-structure and functions;	10
II	**Microbes and Aquatic Environment** Principles and applications of bioprocesses – bioremediation, biofertilization, biofilms, bio-leaching, biocorrosion, bio-fouling; Microorganisms as bioindicators, bioremediators and biosensors; Microbial biomass production - single cell protein; Bioprospecting.	15
III	**Biodiversity** Biodiversity – Definition and concept; Factors influencing aquatic biodiversity; Types of biodiversity - Species diversity in different ecosystems, Genetic Diversity, and Habitat Diversity; Biodiversity indices and their significance; Concepts of Index of Biotic Integrity (IBI); Economic appraisal of biodiversity; Global diversity patterns and loss of biodiversity.	15
IV	**Ecological concepts** succession, homeostasis, natality and mortality, r and k selection; Concepts of habitat and ecological niche; carrying capacity.	10
V	**Environmental concerns** Environmental concerns – population explosion, industrialization, urbanization, and natural calamities; Overexploitation of resources; Environmental stresses; Global Warming; Ozone Depletion.	10
Course Outcomes		
CO1	Understanding how aquatic ecosystems respond to the natural and anthropogenic impact.	
CO2	Able to formulate goals and objectives in aquatic ecosystems management.	

CO3	experienced in ecological management and the basics of decision-making principles
CO4	Gain a basic understanding of the diversity of fishes, their place in the tree of life, and how they illustrate basic concepts in biodiversity and evolution (especially form and function, adaptation).
CO5	Access, synthesize, and evaluate primary literature in fishes-related science.
Reference Books:	Carter RWG. 1998. *Coastal Environments: An Introduction to the Physical,* *Ecological and Cultural Systems of Coastlines*. Academic Press. Kormondy E.J. 1986. *Concepts of Ecology*. Prentice-Hall. Park CC. 1980. *Ecology and Environmental Management*. Butterworths. Simon J, Kaiser MJ & Reynolds JD. 2001. *Marine Fisheries Ecology*. Blackwell.

Core Paper-IV

COURSE CODE	AQUACULTURE AND ECOSYSTEM MANAGEMENT	Total Lec: 60
AC21M404		4 – 0 – 0
Learning Objective	To impart knowledge on interactions between aquaculture and the environment.	
Pre-requisites:	None	
UNIT	CONTENT	HOURS
I	**Aquaculture and Ecosystem Relationship** Ecosystems and productivity, biotic interaction within ecosystems and ecological homeostasis.	10
II	**Climate** Weather elements of concern in aquaculture, Green house gases, global warming and their impact.Impact of environment on aquaculture: Raw water source, physical and chemical characteristics, contaminants and pollutants (algae, pathogens, heavy metals, pesticides) and their effect on productivity	15
III	**Impact of Aquaculture on Environment** Waste water discharge, its quality and quantity; impacts of effluents on ecosystems, chemical degradation of soil and water.	10
IV	**Environment Monitoring** Problems and preventive measures of antibiotic and drug residues, salination of soil and water, Eutrophication, Environment impact assessment and environmental audit, Biosensors in aquatic environment, toxicity assessment, Ecolabelling and traceability.	15
V	**Environment Management** Introduction of exotics and escape of farmed fish, Pathogens in aquatic environment, Safety of aquaculture products, Role of microbes in aquatic environment; assessment of probiotic impact in aquaculture.	10
Course Outcomes as per Bloom's Taxonomy		
CO1	Knowledge gained-concept on the environment, aquaculture, and fisheries.	
CO2	Detailed understanding of different forms of ecology and their importance on proper maintenance at the present era.	
CO3	Learning the different concepts of ecosystem management	

CO4	Learning the impact of aquaculture on environment
CO5	To understand about the waste water.
Reference Books:	Holmer M, Black K, Duarte CM, Marba N & Karakassis I. (Eds.). 2008. Aquaculture in the Ecosystem. Daya Publ. House. Lagler KP, Bardach JE, Miller RR & Passino MDR. 1977.Ichthyology. John Wiley & Sons. Midlen & Redding TA. 1998.Environmental Management for Aquaculture. Chapman & Hall. Nikolsky GV. 2008. The Ecology of Fishes. Academic Press. Upadhyay AR. 2004. Aquatic Plants for the Wastewater Treatment. Daya.

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Discipline Specific Elective III

COURSE CODE	WATER QUALITY AND SOIL MANAGEMENT IN AQUACULTURE	Total Lec.: 45
AC21M405		**3-0-0**
Learning Objective	To learn effective water and soil quality management practices.	
Pre-requisite		
UNIT	**CONTENT**	**HOURS**
I	Soil and water interaction: Physical and chemical properties of soil and water, Productivity vs nutrient quality and quantity of soil and water; aquatic microorganisms and their role in carbon, nitrogen, phosphorus and sulphur cycles and impact on aquatic habitats and species.	10
II	Soil and water quality monitoring: soil and water quality standards; soil and water quality monitoring and management.	05
III	Fertilizers and manures: Different kinds of fertilizers and manures, fertilizer grade, source, rate and frequency of application, Biofertilizers, Use of treated sewage for pond fertilization, Ecological changes taking place after fertilizing, Primary production, degradation of molecules in aquatic environment, Utilization of bioactive compounds by microorganisms.	15
IV	Role of microorganisms in fish production, fish health and fish safety; Microbial load and algal blooms.	05
V	Soil and water quality management: Cat clay/pyrite soil, seepage, water treatment, water filtration devices, aeration, chlorination, ozonization and UV radiation, Algal bloom control, eutrophication, Aquatic weed management, Waste water treatment practices, Water quality management in hatcheries, Waste discharge standards.	10
Course Outcomes		
CO1	Exposure on chemical analyses.	
CO2	Preparation of chemicals and weighing.	
CO3	Digital pH meter and its use in determination of soil and water pH.	
CO4	Estimation of primary productivity by dissolved oxygen method.	
CO5	To determine alkalinity and dissolved oxygen.	
Reference Books:	Adhikari S & Chatterjee DK. 2008. *Management of Tropical Freshwater Ponds*. Daya Publ. APHA, AWWA, WPCF. 1998. Standard Methods for the Examination of Water and Wastewater, 20th Ed. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, Washington, D. C. Boyd, C. E. and Tucker, C. S. 1992. Water Quality and Pond Soil Analyses for Aquaculture, Alabama Agricultural Experimental Station, Auburn University. Boyd CE. 1979. *Water Quality in Warm Water Fish Ponds*. Auburn University. ICAR. 2006. *Handbook of Fisheries and Aquaculture*. ICAR.	

	Parsons TR, Maita Y & Lalli CM. 1984. *A Manual of Chemical and Biological Methods for Seawater Analysis*. Pergamon Press. Rajagopalsamy CBT & Ramadhas V. 2002. *Nutrient Dynamics in Freshwater Fish Culture System*. Daya Publ. Sharma LL, Sharma SK, Saini VP & Sharma BK. (Eds.). 2008. *Management of Freshwater Ecosystems*. Agrotech Publ. Academy.

Discipline Specific Elective III

COURSE CODE	SEED PRODUCTION AND HATCHERY OF FINFISHES	Total Lec:45
AC21M406		**3 – 0 – 0**
Learning Objective	To learn seed production and hatchery management of commercially important cultivable fishes.	
Pre-requisites:		
UNIT	**CONTENT**	**HOURS**
I	Introduction: History, constraints and current status of natural seed collection and hatchery seed production.	5
II	Reproductive biology: Physiology and morphology; Molecular and physiological basis of reproduction, Overview of current developments in reproductive biology.	10
III	Gamete maturation and development: Spermatogenesis and oogenesis, Hormonal pathways and mode of control.	5
IV	Induced spawning: Methods of natural and artificial fertilization, GnRH, evaluation of milt and egg, cryopreservation technique, use of different synthetic hormones and analogues for induced spawning, Egg staging, Stripping and fertilization.	15
V	Hatchery technology for different species: Indian major and minor carps, Exotic carps, Catfishes, Tilapia, Masheer, Trout, etc.	10
Course Outcomes		
CO1	Creation of basic knowledge on the operation of commercial hatcheries.	
CO2	Current methodology and various techniques of commercial seed production.	
CO3	Design, development and operation of carp hatchery including hypophysation.	
CO4	Knowledge on new techniques for seed production like carp.	
CO5	Types of quality assessment methods in hatchery operation.	
Reference Books:	FAO. 1992. *Manual of Seed Production of Carps*. FAO Publ. ICAR. 2006. *Hand Book of Fisheries and Aquaculture*. ICAR. Jhingran VG & Pullin RSV. 1985. *Hatchery Manual for the Common, Chinese and Indian Major Carps*. ICLARM, Philippines. Jhingran VG. 1991. *Fish and Fisheries of India*. Hindustan Publ. Landau M. 1992. *Introduction to Aquaculture*. John Wiley & Sons. Mcvey JP. 1983. *Handbook of Mariculture*. CRC Press. Pillay TVR & Kutty MN. 2005. *Aquaculture- Principles and Practices*. Blackwell. Rath RK. 2000. *Freshwater Aquaculture*. Scientific Publ. Thomas PC, Rath SC & Mohapatra KD. 2003. *Breeding and Seed Production of Finfish and Shellfish*. Daya Publ.	

Practical

COURSE CODE	LAB V	Practicals:120
AC21M407		2

- Assessment of physico-chemical parameter.
- Operation of different type of instruments use in aquaculture and fisheries science.