CURRICULUM

OF

FRESH WATER BIOLOGY AND FISHERIES

MS

(Revised 2016)
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<tr>
<td>Prof. Dr. Mukhtar Ahmed</td>
<td>Chairman</td>
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<tr>
<td>Mr. Fida Hussain</td>
<td>Director General (Acad)</td>
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<td>Ms. Ghayur Fatima</td>
<td>Director (Curr)</td>
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<tr>
<td>Mr. Muhammad Arif</td>
<td>Deputy Director (Curr)</td>
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<td>Mr. Rizwan Shoukat</td>
<td>Deputy Director (Curr)</td>
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<td>Mr. Abid Wahab</td>
<td>Assistant Director (Curr)</td>
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<td>Mr. Riaz-ul-Haque</td>
<td>Assistant Director (Curr)</td>
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The curriculum, with varying definitions, is a plan of the teaching-learning process that students of an academic programme are required to undergo. It includes objectives and learning outcomes, course contents, scheme of studies, teaching methodologies and methods of assessment of learning. Knowledge in all academic disciplines is expanding and even new disciplines are also emerging, it is imperative that curriculum are developed and revised regularly.

University Grants Commission (UGC) was designated as the competent authority to develop, review and revise curricula beyond Class-XII vide Section 3, Sub-Section 2 (ii), Act of Parliament No. X of 1976 titled “Supervision of Curricula and Textbooks and Maintenance of Standard of Education”. With the repeal of UGC Act, the same function was assigned to the Higher Education Commission (HEC) under its Ordinance of 2002, Section 10, Sub-Section 1 (v).

In compliance with the provisions, the Curriculum Division of HEC undertakes the revision of curricula after every three years through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector universities, R&D organizations, councils, industry and civil society nominated by their organizations.

In order to impart education at par with quality international standards, HEC NCRCs have developed unified templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture and Engineering in 2007 and 2009.

It is hoped that this curriculum document, prepared by the respective NCRC’s, would serve the purpose of meeting our national, social and economic needs, and it would also provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards. The curriculum is also placed on the website of HEC (www.hec.gov.pk).

(Fida Hussain)
Director General (Academics)
CURRICULUM DEVELOPMENT PROCESS

STAGE-I | STAGE-II | STAGE-III | STAGE-IV

CURRI. UNDER CONSIDERATION | CURRI. IN DRAFT STAGE | FINAL STAGE | FOLLOW UP STUDY

COLLECTION OF REC | APPRAISAL OF 1ST DRAFT BY EXP. OF COL./UNIV | PREP. OF FINAL CURRI. | QUESTIONNAIRE

CONS. OF CRC. | FINALIZATION OF DRAFT BY CRC | INCORPORATION OF REC. OF V.C.C. | COMMENTS

PREP. OF DRAFT BY CRC | APPROVAL OF CURRI. BY V.C.C. | PRINTING OF CURRI. | REVIEW

IMPLE. OF CURRI. | BACK TO STAGE-I

ORIENTATION COURSES

Abbreviations Used:
CRC.  Curriculum Revision Committee
VCC.  Vice Chancellor's Committee
EXP.  Experts
COL.  Colleges
UNI.  Universities
PREP.  Preparation
REC.  Recommendations
INTRODUCTION

Final meeting of National Curriculum Revision Committee to review and revise the curriculum for Freshwater Biology and Fisheries at B. Sc, BS (4years) and MS (2 years) degree levels was held at HEC Regional Center, Karachi from April 21-22 2016. The following attended the meeting:

01. Prof. Dr. Naeem Tariq Narejo  
    Convener  
    Professor  
    Department of Freshwater Biology and Fisheries  
    University of Sindh, Jamshoro

02. Prof. Dr. Shahida Husnain  
    Member  
    Vice Chancellor  
    Department of Molecular Biology & Genetics, The Women University Campus, Multan

03. Dr. Muhammad Arshad  
    Member  
    Professor/ Chairman  
    Department of Zoology, University of South Asia 47 Tufail road, Lahore

04. Dr. Muhammad Afzal  
    Member  
    The Principal Scientific Officer  
    Aquaculture & Fisheries Program  
    National Agriculture Research Council  
    Chak Shahzad, Islamabad

05. Dr. Punhal Khan Lashari  
    Member  
    Associate Professor  
    Department of Freshwater Biology and Fisheries  
    University of Sindh, Jamshoro

06. Dr. Muhammad Siddique Awan  
    Member  
    Chairman/Associate Professor  
    Department of Zoology, University of Azad Jammu Kashmir Muzaffarabad

07. Dr. Shahid Raza  
    Member  
    Dean/Director  
    Department of Biological Science, University of South Asia, 47 Tufail road, Lahore

08. Dr. Muhammad Shoainb  
    Member  
    Associate Professor, Department of Zoology, University of Karachi

09. Dr. Muhammad Naeem
10. Dr. Adeela Haroon  
   Assistant Professor  
   Department of Botany, The Woman University  
   Multan, Karachi Campus, LMQ, Road Multan, Multan

11. Dr. Khalid Abbas  
   Assistant Professor  
   Department of Zoology, Wildlife & Fisheries,  
   University Agriculture, Faisalabad, Faisalabad

12. Dr. Kifayatullah Khan  
   Assistant Professor  
   Department of Environmental & Conversation  
   Science, Main Campus, University of Sawat,  
   Sawat KPK

13. Dr. Zaigham Hasan  
   Assistant Professor, Department of Zoology,  
   Zoology, University of Peshawar, Peshawar

14. Dr. M. Nasir Khan Khatak  
   Assistant Professor, Department of Zoology,  
   Hazara University, Mansehra

15. Dr. Amina Zubari  
   Secretary/ Member  
   Assistant Professor  
   Department of Animal Science,  
   Quaid e azam University Islamabad

16. Dr. Muhammad Hafiz- Ur-Rehman  
   Assistant Professor, Department of Fisheries  
   and Aquaculture, University of Veterinary &  
   Animal Sciences, Lahore

17. Dr. Rehan Iqbal  
   Assistant Professor, Institute of molecular  
   Biology & Biotechnology, BZU, Multan

18. Dr. Ghulam Abbas  
   Assistant Professor  
   Center of Excellence, in Marine Biology,  
   University of Karachi, Karachi

19. Ghayyur Fatima  
   Member  
   Director (Curriculum) HEC, Islamabad
MS /MPhil (2-YEARS) PROGRAM IN FRESHWATER BIOLOGY AND FISHERIES

The MS in Freshwater Biology and Fisheries will be of two years program with 24 credit hours theory and 6 credit hours thesis research work (Total: 24+6=30 C.H.) The courses will be selected from the following list according to specialty of academic staff and research facilities in the institutions

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<td><strong>Total:</strong></td>
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DETAILS OF COURSES

FISHERIES REGULATIONS AND ADMINISTRATION (4) CH

Learning outcomes
After the completion of this course, the students would be able to:
• Understand the fisheries policies, laws and monitoring systems
• Manage the conservation of aquatic resources
• Familiarize with trade related aspects of intellectual property rights

Introduction to organizations and administration of fisheries at the federal and provincial levels; responsibilities; implications for livelihoods-centered fisheries management; Monitoring, Control, Surveillance; Enforcement and conflict management; Informal, local community rules; Formal, national regulations; The social consequences of implementing laws on mesh sizes of nets; management and conservation of resources; fisheries legislations and regulations; implementation and monitoring systems, accession of exclusive economic zone EEZ; concept and responsibilities; international and regional bodies conventions and legislations (CBD, Ramsar Convention UNCLOS, etc., fish inspection and quality control systems, WTO regime (Sanitary and phytosanitary (SPS) measures, Trade-related aspects of intellectual property rights (TRIPS), Agreement on Technical Barriers to Trade (TBT).

Recommended books

ADVANCES IN AQUACULTURE (4) CH

Learning outcomes
After completion of this course, the students would be able to:
• Describe the aquaculture production system
• Analyze different aquaculture types and practices
• Describe the latest developments in aquaculture in Pakistan with world

An overview of aquaculture production systems: Present status, constraints and future perspectives of aquaculture production systems in Pakistan and the world. Advances in design and construction: Hatcheries;
Earthen ponds; Concrete tanks; Pens and cages; Rafts; Racks. Aquatic plant production systems: Ornamental aquatic plants; microalgae and seaweeds; Long line production system. Aquaculture production management: monitoring of water quality; feeding and monitoring, sampling and harvesting of finfish and shellfish. Advances in farming systems: enhancing carrying capacity; integrated farming systems; semi-intensive and intensive culture systems; Recirculatory aquaculture system; Flow-through system.

Recommended books

NEW TRENDS AND TECHNIQUES IN AQUACULTURE (4) CH

Learning outcomes
After completion of this course, the students would be able to:
• well equipped with the latest trends and development in Fisheries and Aquaculture industries

Latest reviews and books published in last five years will be followed to teach recent advancements in different areas of fisheries and aquaculture. Presentations and group discussions of latest, high impact research articles.

ADVANCED ECO-TOXICOLOGY (4) CH

Learning outcome
After completion of this course, the students would be able to:
• understand the key processes involve in fate, behavior and the bioaccumulation of contaminants
• know the uptake and transport of environmental pollutants in ecosystems and on how pollutants can affect organisms, populations, and thus ecosystem processes.
• link the structures and characteristics of compounds with effects
get insight in integrative approaches of ecotoxicology

Fate of contaminants, dynamic interactions with the (a)biotic environment, toxikokinetics; physico-chemical properties, partitioning processes in environmental compartments, partitioning to biota, bioavailability and bioaccumulation concepts, partitioning in biota; Toxicodynamics (effect of contaminants on biota), internal concentrations; dose-response concept, molecular mechanisms of toxic actions – classification, Exercise: databases and estimation of toxicity; Toxic effects: from molecular to ecosystems, complex mechanisms and feedback loops, mixtures and multiple stressors, stress- and adaptive responses, dynamic exposures, confounding factors, food web interactions, Exercise: linking compounds with modes of toxic action; metal ecotoxicology: integrative approaches and case studies, bioassays, systems ecotoxicology, phenotypic anchoring, in vivo versus in vitro biotesting, linking chemical with biological analytics, bioassay-directed fractionation and identification, (inter) national case studies and linkage of learned with approaches in practice

Recommended books

ADVANCED PLANKTOLOGY (4) CH

Learning Outcome
After completion of this course, the students would be able to:

- Comprehend ecological and evolutionary processes
- Understand the spatial and temporal distribution of species and organisms
- Acquire knowledge related to the diversity of the aquatic ecosystem
- Conceptualize the ways and means of conversion of energy and matter in ecosystems, mediated by organisms

Introduction to planktology, taxonomic classification of planktons in freshwater systems, biology, distribution, Plankton diversity and their contribution to freshwater productivity, Primary and secondary production - estimation, significance, factors affecting production-biomass ratio (P/B); Indices of productivity; phytoplankton and zooplankton, Biological interrelationship in running water among phytoplankton, macrophytes,
bacteria, zooplankton, benthic animals, periphyton, fish and birds. Distribution of planktons and their periodicities. Importance in aquatic food chain. Economic importance of diatoms.

**Recommended books**

**LAKE MANAGEMENT (4) CH**

**Learning outcomes:**
After completion of this course, the students would be able to:
- Familiarize with professional approaches of landscape architecture, urban and regional planning
- Contribute in protecting, improving, restoring, and sustaining water resources for humanity and the rest of the biosphere

Lakes origins and evolution, Types, lake basins, biota, biotic and abiotic factors, seasonal cycles, zones, ecosystem processes, land-water subsidies, watershed issues: water levels and erosion, pollution, characterization on the basis of productivity, aquatic weed and management, watershed protection case study, ecosystem services, temporary waters, habitat, conservation and design issues. Science of lake management: economic and the social/regulatory framework, plan organization and development, implementation and evaluation. Lake monitoring: problems and solutions for monitoring inland freshwater lakes. Managing and analyzing physical, chemical and biological parameters.

**Recommended books**

RESEARCH METHODOLOGY (4) CH

Learning outcomes
After completion of this course, the students would be able to:

- Understand the basic framework of scientific research process
- Overview various research designs and techniques
- Identify various sources of information for literature review and data collection
- Comprehend the ethical dimensions of conducting applied research

Philosophy of scientific research. Problem identification and defining research questions, formulation of the research hypotheses, Research design – experimental and non-experimental, field research and survey research. Qualitative and quantitative research, choosing research methods: Interviewing (methods of recording, the interview schedule, establishing rapport, asking questions and probing for information), focus groups, questionnaires (constructing questionnaires - deciding which questionnaire to use, wording and structure of questions, length and ordering of questions, piloting the questionnaire) and participant observation, concept of research background, Primary and secondary research. Sampling strategies, Preparation of research proposal: contents of a good proposal, reasons of research proposals failure, Data analysis: qualitative and quantitative data analysis, Presentation of research findings: Technical report writing, journal articles and oral presentations. Ethics in scientific research; overt and covert research, code of ethics

Recommended books
Fish Processing and Quality Assurance 4 (3+1) CH

Learning outcomes
After completion of this course, the students would be able to:

- Familiarize with the advancements in the fields of Fish Processing and Quality Assurance
- Gain the knowledge about freshwater fish processing technology
- Demonstrate various preservation techniques of fish and fisheries products
- Know the importance of an efficient post-harvest and fish marketing chain promotes in accordance with consumer needs.

Biological preservation, fermentation, biochemical dynamics and quality of fresh and frozen fish, Biochemical composition, methods of assessing and selecting for quality, microbiology of products, identifying allergens in fish, rapid detection of sea food toxins, preservation of fish, traditional preservation (curing, drying, salting, smoking etc.), New preservation techniques for finfish and shellfish (chilling, freezing, canning etc.), Special processing procedures, value addition (minced fish, surimi products, gelatin); industrial processing; fish meals, oils, protein concentrate and by-products; concepts of quality and freshness. International standards; food laws; food safety; organization for quality assurance and standards, HACCP, Codex alimentarix, ISO 9002, ISO 14000

Practicals

- Detection of microorganisms
- Biochemical analyses of value added fish products
- Tests for freshness and food safety
- Peroxide value determination,
- pH value determination in meat,
- Near Infra Red (NIR) Analysis.

Recommended books

FISH BREEDING AND CONSERVATION (4) CH
Learning outcomes
After completion of this course, the students would be able to:
• Understand the hatchery infrastructure, components and allied nursery and rearing ponds.
• Enhance skills in induced breeding of fish
• Know about the endangered and threatened species and conservation strategies
• Understand the fish biodiversity and stock replenishment program

Introduction to fish hatchery and its components (broodstock pond, nursery ponds and rearing ponds, glass hatching jars, circular tanks, holding tanks, nursing tanks). Broodstock selection and management, Assessment of male and female ripeness, artificial propagation; Natural and induced spawning, cryopreservation of gametes, gametes quality analysis, Egg fertilization, enumeration, development, and incubation, Rearing techniques (larval, fry and fingerlings). Conservation strategies for threatened and endangered species; sustainable use of fisheries resources; stock replenishment program, management of natural resources (lakes, reservoirs, dams and rivers); habitat management practices and biological conservation policy; national, regional and international conventions; rules and regulations for conservation of natural resources (awareness program and community participation).

Practicals
• Study of gonadal development in carps and other culturable fish species.
• Broodstock selection and identification.
• Induced breeding (striping and fertilization) of fishes through various inducing agents.
• Evaluation of carp milt and egg; estimation of fecundity, fertilization and hatching success.
• Packing and transportation of fish seed.
• Visit to different coldwater and warmwater fish hatcheries.
• Field survey of different natural aquatic habitats.

Recommended books
FISH BIOTECHNOLOGY (4) CH

Learning outcomes

After completion of this course, the students would be able to:

- Understand the basics of biotechnology in relation to fisheries
- Develop a skill into the application of biotechnological advances
- Elucidate different aspects of genetic biotechnology and fish genomics


Recommended books


FISH IMMUNOLOGY (4) CH

Learning outcomes

After completing this course, students would be able to:

- Understand basic knowledge about the structure of the immune system and how it functions
• Know how the immune response is being regulated
• Understand the immunological memory of fishes.
• Know the importance of several factors that affect the immune response.

General concepts in immunology, Fish Leucocytes, monocytes/macrophages, granulocytes, non-specific cytotoxic cells, Nonspecific immunity, physical barriers, non-specific humoral defence, Lymphocytes, Specific defence mechanism in Fish, Humoral antibody system (B-cells), Helper T-cells, B-cell activation, cell mediated immunity (T-cells), lymphoid organs in fish, primary lymphoid organs, secondary lymphoid organs. Antibody function, Monoclonal antibody, polyclonal antibody, Immune response: primary and secondary immune response, Immunological memory, recognition and response. Evolution of immune system, Ontogeny of Fish Immune System (evidence of Ig in the eggs and passive transfer of immunity from mother to young, Ontogeny of T and B Cells in lymphoid organs, Ontogeny of specific, non-specific, innate and adaptive immunity). Invasions of recombination-activation gene transposon (RAG transposon), Whole genome duplication (WGD,s) immunoglobins, Lymphocytes B-cells and T-cells, the life history of T-lymphocytes, Antibody, basic structure and isotypes.

Recommended Books

EXPERIMENTAL BIOSTATISTICS (4 CH)

Learning outcomes
After studying this course the students would be able to
• Identify completely randomized designs, factorial designs, and complete block designs
• Perform correct analysis of experimental data using SAS
• Plan and estimate treatment comparisons using appropriate multiple comparison techniques
• Assess model fit and validity of assumptions
• Suggest remedial measures or alternative analyses when assumptions are not met
• Distinguish fixed and random effects

Introduction to Biostatistics, Sampling – Random and non-random sampling methods – Description, merits and demerits, Data summarization – measures of averages and dispersion, Data
Presentation techniques – Graphical and tabular, Standard error, Confidence interval and sampling distribution – definition, computation, interpretation and applications, Basic principles of testing of hypothesis, Test of significance - t-test, one way ANOVA, Repeated measures ANOVA, Chi square and Non parametric methods, Sample size in health science research – Basic principles and computations. Correlation and Regression, Software packages-SPSS, Research Design Principles, Completely Randomized Designs, Treatment Comparisons–Contrasts and Multiple Comparisons, Checking Assumptions: Diagnostics and Remedial Measures, Power and Sample Size, Factorial Designs, Random Effects Models, Mixed Models, Nested Effects, Complete Block Designs, Analysis of Covariance, Split-Plot Designs, Repeated Measures Designs

Recommended Books

FISH MOLECULAR ECOLOGY (4) CH

Learning outcomes
After studying this course, students would be able to:
- Differentiate the common contemporary molecular markers and analyses used to address ecological questions
- Describe the wide range of research directions that comprise the field of molecular ecology and the common molecular approaches to these research questions
- Analyze and interpret data from common analyses employed in ecological and conservation studies


Recommended Books

MOLECULAR EVOLUTION AND FISH PHYLOGENETICS (4) CH

Learning outcome
After completion of this course, the students would be able to:

- Know the different molecular processes that leads to changes in the genome and the evolutionary consequences
- Gain experience with internet resources on bioinformatics
- Attain experience with statistical analysis of molecular data and interpretations
- Use data to evaluate and defend phylogenetic hypotheses

**Recommended books**


**GLOBAL CLIMATE CHANGES AND IMPACT ON AQUATIC LIFE**

(4) CH

**Learning outcomes**

- Develop an interdisciplinary understanding of social and economic areas
- Develop an awareness of present and future impacts on aquatic life especially on fish
- Equip the stakeholders with fundamental factual elements surrounding climate change in order to facilitate effective participation in the response to realize and predicted climate change

Introduction to Global Warming and Climate Change (history, present status and future predictions); Atmospheric carbon dioxide and climate with special reference to aquatic life; Carbon dioxide budget in aquatic atmosphere; Ocean, freshwater and Land; Diversity of aquatic animals; Catastrophic consequences of climatic changes on the Fish; aquatic production and its impact; aquatic habitat destruction and fragmentation; Ocean acidification, stratification and increasing oceanic dead zones; Climate Change Indicators (air temperature, precipitation); possibility of abrupt climate change and its effects on aquatic life; Attribution of rising
temperature and extinction of fish species; Impact of climate change on economic growth with special reference to Pakistan.

**Recommended Books**

**MOLECULAR SYSTEMATICS OF FISH**

4 (3+1) CH

**Learning outcomes**

After completion of this course, the students would be able to:

- Describe the methods and principle of modern molecular systematics including: parsimony, distance, maximum likelihood, Bayesian analyses
- Relate systematics analysis to the evolution of the taxa under investigation
- Use the major software packages associated with performing molecular systematic

**Introduction and tree thinking, Molecular data and evolution, Taxonomic units, Sequence alignment, Tree Inference /Models of DNA evolution, Clustering methods, Maximum likelihood, Bayesian analysis. Parsimony, Tree confidence and support, Whole genome base phylogenetics, Introduction to the CLI, Data formats and trouble shooting, Obtaining data and sequence alignment, Substitution models, Distance methods, Hypothesis testing and ancestral state reconstruction.**

**Practicals**

Making buffers, DNA extraction from fresh fish tissues and from museum and ancient sources, Gel electrophoresis, The Polymerase Chain Reaction, Primer design, nuclear gene amplification, Amplify nuclear genes on gradient and/or touchdown, Different Methods of Cleaning PCR products and sequencing reactions, Searching gene databases and depositing sequences in Genbank, Look at sequences using Sequencer, making contigs, blasting sequences in Genbank, Cloning DNA, RNA: extraction and what it can be used for, Making Gene Libraries, Making
cDNA library; RT-PCR Reverse Transcriptase (RT)-PCR/Real Time PCR, Gene-specific PCR, Aligning DNA/RNA /protein sequences

**Recommended Books**

**FISH GENOMICS (4) CH**

**Learning outcomes**
After studying this course, students would be able to:
- Describe fundamental concepts in genomics
- Elucidate some of the current genomics technologies and illustrate how these can be used to study gene function.
- Perform a range of practical techniques including DNA sequencing, PCR, genotyping and genotypic molecular data analysis.
- Analyze information and data relating to specific genes using a number of general and fish-specific databases, bioinformatics principles and tools.

Introduction, Genomes and genome sizes. Mutations as the source of genetic variations. Restriction enzymes and their applications, Base pairing: the basis of molecular biology techniques; Hybridization techniques; PCR. DNA fingerprinting techniques – RFLP, SSR, AFLP, SNPs, SSCP (Type II markers). Molecular diagnosis. Comparative gene mapping; Type I molecular markers; Expressed sequence tags (ESTs). Functional genomics, Transcriptome analysis, proteome analysis, microarrays, gene chips, and various methodologies used for the analysis of genome expression. Genetic engineering: gene transfer; regulation and inheritance of transgenes. QTL mapping and marker-assisted selection. Application of genome technologies in aquaculture and fisheries.
Recommended Books

FISH PROTEOMICS (4) CH

Learning outcomes
After completion of this course, the students would be able to:
- Perceive the theoretical and practical knowledge in proteomics
- Know about common workflows for the large-scale analysis of proteins
- Analyze post-translational modifications and protein-protein interactions
- Identify proteins by mass spectrometry and quantification of proteomes through various techniques


Recommended Books

FISHERIES AND AQUACULTURE ECONOMICS (4) CH

Learning outcomes
After completion of this course, the students would be able to:
- Analyze the essential elements of Aquaculture and Fisheries economics
- Apply quality benefit and capital theories to quality relationships
- Evaluate projects on Aquaculture and Fisheries
- Evaluate results from aquaculture and fisheries economic analyses for policy decision making
- Synthesize potential risks involved in resource extraction

Review of the Production Function

Linear Programming
Definition of Linear Programming. Use of LP. Basic Assumptions of LP. Expression of LP (Structure). Existence of optimal solutions

Theory of Demand and Supply

Market Structure, Conduct and Performance
Introduction. Elements of Market Structure. Seller concentration, Product differentiation, Barriers to entry, Barriers to exit, Buyer concentration, Growth rate of market demand. Types of Market system
Perfect/ Pure Competitive Market system
Assumptions for Pure Competitive Market system
Supply Decisions under perfect competition

**Imperfect Competition**

**Time Value of Money**

**Present value**

**Cost Benefit Theory**

**Efficient Market Hypothesis - EMH**

**Welfare Economics**
Introduction to Welfare economics. Approaches to studying welfare economics. Efficiency. Income distribution

**Recommended Books**

APPLICATION OF GIS IN FISHERIES 4 (3+1) CH

Learning outcomes
After completion of this course, the students would be able to:
• Create, devise, restructure and relate various GIS components
• Resolve issues involved in choosing a suitable GIS analysis procedure
• Integrate data, vector and raster models, and convert from one to another
• Delineate temporal and spatial distribution of human resources, economic status, natural resources and hazards in a given geographic region

GIS: fundamental concepts, components, data formats, Subsystems, data models, Spatial and attribute data, Vector, Raster and image, Advantages and disadvantages of vector and raster models. Attribute data models, tabular and relational models (RDBMS), Data sources.
Introduction to remote sensing (orbits, satellites, sensors and platforms), remote sensing as an input to GIS, Use of GPS, Manual digitizing and automatic scanning, Data editing and quality assurance, Map features point, line, polygon, area, Map characteristics, map projection and coordinate system, Creation of thematic layers,

Practicals
Practicing of GIS software (ArcGIS, ERDAS, MATLAB)

Recommended Books

FISHERIES EXTENSION (4) CH

Learning outcomes
After completion of this course, the students would be able to:
• Understand the role of fisheries extension in fisheries development and economy
• Describe different methods of fisheries extension
• Grasp the socio economic problems of fish farmers and suggest possible solutions

Introduction to fisheries extension - concepts, objectives and principles; Fisheries extension methods; Transfer of technology process: models (training sessions, fish festival, role of slogans, handouts, banners, booklets, audio-visual aids etc.). Role of NGOs and CBOs (community based organization) in fisheries. Nature of fisheries extension; Future of fisheries extension and traditional management; Communication and flow of information, Technical and socio-economic problem of fishermen, Role of women in fisheries. Need of technical knowledge to fishermen, community participation.

Recommended Books

RECREATIONAL AND ORNAMENTAL FISHES (4) CH

Learning outcomes
After completion of this course, the students would be able to:
• Realize commercial and aesthetic values of ornamental fish
• Prepare balance feeding and breeding plan
• Design and fabricate the aquaria

Introduction, History of ornamental fish as a pet, commercial importance, benefits, feed and feeding of ornamental fish, culture of live food organisms, preparation of artificial feed, Feed additives, breeding of live bearers, breeding of egg layer, setting up of spawning tank. Common diseases and their control, Genetic improvement, Fabrication of aquaria and its arrangements including aeration filtration, Water quality management and aquarium plants.

Recommended Books
PROJECT MANAGEMENT (4) CH

Learning outcomes
After completion of this course, the students would be able to:
- Plan, execute, control, and close out projects
- Understand the roles and responsibilities of any successful project manager.
- Assess and improve current project management system which can be applied for project management principles

Introduction (Project definition and characteristics with examples, project life cycle), project constraints and risks, project management processes, benefits of structured project, Work Breakdown Structures (WBS), controlling and managing project schedules, converting effort estimates into activity duration, MS Project, Program Evaluation and Review Technique (PERT) and Critical Path Method (CMP) and Gantt charts, developing project estimates and budgets, managing/controlling project budgets, project procurement management, project risk management, identifying risks qualitative and quantitative risk analysis, monitoring and controlling risks, project human resource management, leadership and exercising leadership as a project manager, motivating people, development of project teams and time management, project communications, project monitoring and evaluation, project termination, bottlenecks faced and lessons learned

Recommended Books

Recommendations
Future Proposed Courses
a) Estuarine Fisheries
Recommendations

1. The Committee feels that this curriculum, as proposed is the step forward to the continuation of the process so that an additional list was suggested by the committee to be considered in future development of this discipline.

2. The committee strongly recommends that the discipline of Fresh Water Biology and Fisheries should also be initiated in other Universities of the country to meet the growing demand of experts to cater the needs of the country.

3. Finally, the committee proposes that adequate facilities must be provided to the respective Universities to conduct quality research. Refresher courses in the subject may also be regularly conducted to train teachers/researchers with modern advancement in the field.