

**CURRICULUM OF**  
**FRESH WATER BIOLOGY AND FISHERIES**  
**FOR**

**B.Sc.(Pass)**  
**BS & MS**

**(Revised 2011)**



**HIGHER EDUCATION COMMISSION**  
**ISLAMABAD – PAKISTAN**

## **CURRICULUM DIVISION, HEC**

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Composed by: Mr. Zulfiqar Ali, HEC, Islamabad

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# PREFACE

The curriculum of subject is described as a throbbing pulse of a nation. By viewing curriculum one can judge the stage of development and its pace of socio-economic development of a nation. With the advent of new technology, the world has turned into a global village. In view of tremendous research taking place world over new ideas and information pours in like of a stream of fresh water, making it imperative to update the curricula after regular intervals, for introducing latest development and innovation in the relevant field of knowledge.

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

In compliance with the above provisions, the HEC undertakes revamping and refurbishing of curricula after regular intervals in a democratic manner involving universities/DAIs, research and development institutions and local Chamber of Commerce and Industry. The intellectual inputs by expatriate Pakistanis working in universities and R&D institutions of technically advanced countries are also invited to contribute and their views are incorporated where considered appropriate by the National Curriculum Revision Committee (NCRC).

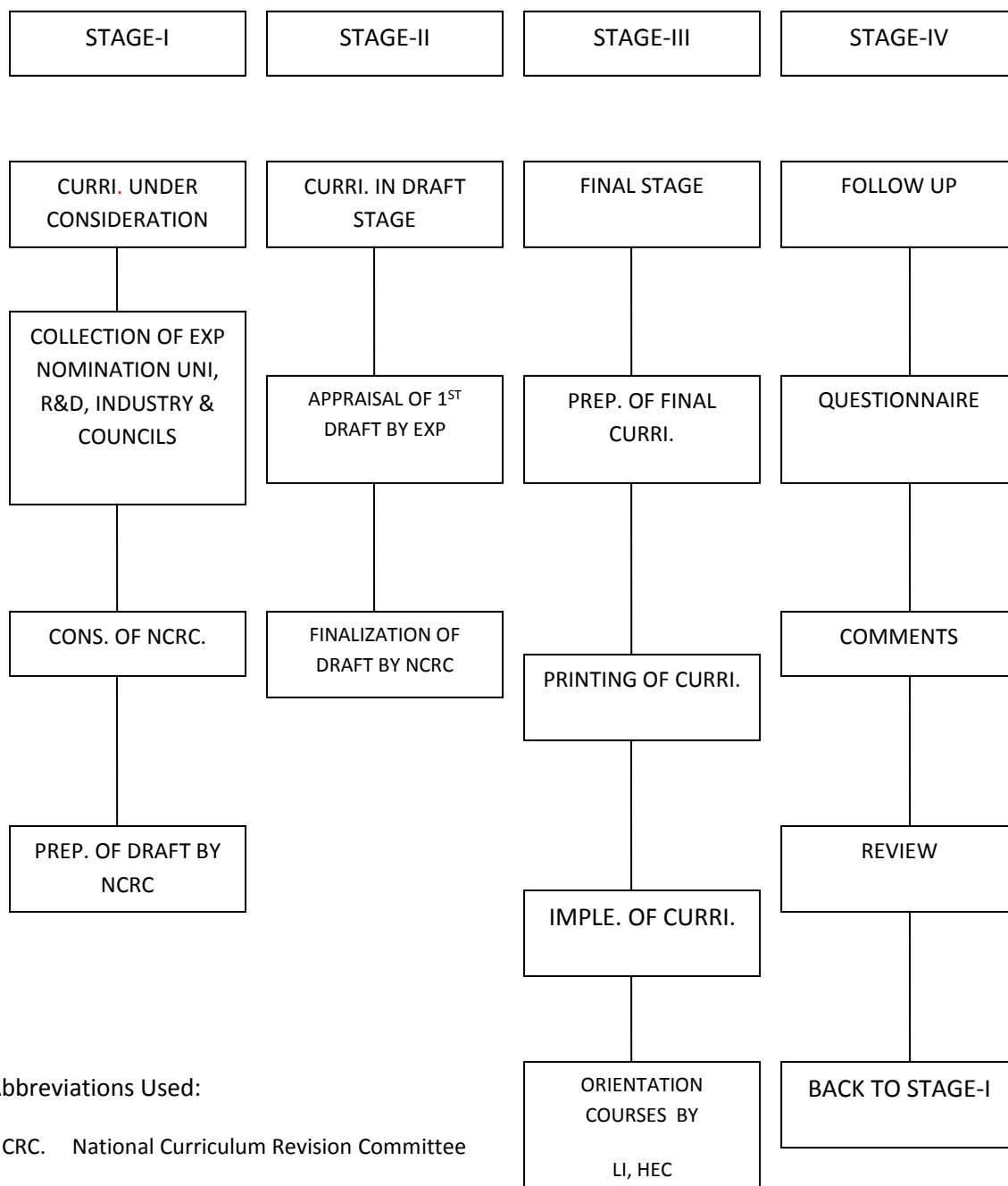
To bring international compatibility to qualifications held from Pakistani universities/DAIs for promotion of students mobility and job seekers around the globe, a Committee comprising of Conveners of the National Curriculum Revision Committee of HEC met in 2009 and developed a unified template for standardized 4-years/8-semester BS degree programs. This unified template was aimed to inculcate broader base of knowledge in the subjects like English, Sociology, Philosophy, Economics etc in addition to major discipline of study. The Bachelor (BS) degree course requires to be completed in 4-years/8-semester, and shall require qualifying of 130-140 credit hours of which 77% of the curriculum will constitute discipline specific and remaining 23% will comprise compulsory and general courses.

In line with above, NCRC comprising senior university faculty and experts from various stakeholders and the respective accreditation councils has finalized the curriculum for B.Sc. (Pass), BS and MS (Fresh Water Biology and Fisheries). The same is being recommended for adoption by the universities/DAIs channelizing through relevant statutory bodies of the universities.

**MUHAMMAD JAVED KHAN**  
Adviser Academics

**June 2011**

# CURRICULUM DEVELOPMENT



**Abbreviations Used:**

NCRC. National Curriculum Revision Committee

VCC. Vice-Chancellor's Committee

EXP. Experts

COL. Colleges

UNI. Universities

PREP. Preparation

# INTRODUCTION

Final meeting of National Curriculum Revision Committee to review and revise the Curriculum for Fresh Water Biology and Fisheries at B.Sc. (Pass), BS (4 Years) and MS (2 Years) degree levels was held at HEC Regional Centre, Karachi from February 28 to March 02, 2011. The following attended the meeting:

Prof. Dr. Naeem Tariq Narejo  
Department of Freshwater Biology & Fisheries,  
University of Sindh,  
Jamshoro

Convener

Prof. Dr. Gulshan Ara Sahito  
Department of Freshwater Biology & Fisheries,  
University of Sindh,  
Jamshoro

Member

Prof. Dr. Aliya Rehman  
Department of Botany,  
University of Karachi,  
Karachi

Member

Dr. Muhammad Afzal  
Principal Scientific Officer,  
Aquaculture & Fisheries Program,  
Animal Sciences Institute,  
NARC, Islamabad

Member

Mr. Tahir Omer  
Associate Professor,  
Department of Zoology,  
Govt. College University,  
Lahore

Member

Mr. Amjad Ali  
Associate Professor,  
Balochistan Agriculture College,  
Quetta

Member

Dr. Amina Zuberi  
Assistant Professor,  
Department of Animal Sciences,  
Quaid-e-Azam University,  
Islamabad

Member

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

Member

Mr. Muhammad Hafeez-ur-Rehman  
Department of Fisheries & Aquaculture,  
University of Veterinary & Animal Science,  
Lahore

Member

Prof. Dr. Muhammad Javed  
Department of Zoology & Fisheries  
University of Agriculture,  
Faisalabad

Secretary/Member

The meeting started with recitation by Dr. Altaf Ali G. Shaikh, Member Academics. He welcomed the participants and informed the members of the committee about procedure for review and revision. He also informed the members of the committee regarding legal obligations as assigned to the Commission under its law and in accordance with the provisions of Act No. XII of 1976 titled Federal Supervision of Curricula & Text Books. He emphasized the need for periodic revision of curriculum in view of the fact lot of knowledge, new techniques and methodologies are evolving the world over dictating the professionals to keep pace with time and adopt these changes for the need of future professionals.

The curriculum to standardize B.Sc. (Pass), BS (4 years) and MS (2 years) degree programs in Freshwater Biology and Fisheries were prepared to bring the national curriculum at par with the international standards and to fulfill the national needs for human resource development. The course contents were reviewed and new courses inducted in the revised curriculum to give a basic broad based knowledge to the student to ensure the quality of education in the country. The committee approved 130 credit hours (flexible from 130 to 136) for BS (4 years) and 30 credit hours for MS (2 years) programs. The curriculum for BS and MS programs were finalized in the light of standard template/framework given by the HEC. The committee unanimously approved the final draft of Curriculum of Freshwater Biology and Fisheries for B.Sc. (Pass), BS (4 years) and MS (2 years) degree programs. The committee also appreciated the efforts made by the officials of HEC for making arrangements to facilitate the committee and comfortable stay of the members at Karachi.

The Meeting adjourned with vote of thanks by the Convener.

# **COURSE OF STUDIES FOR B.Sc. (PASS) IN FRESH WATER BIOLOGY AND FISHERIES TO BE TOUGHT IN COLLEGES**

Candidates having passed H.Sc. Part II examination (Pre-medical) from any recognized board are eligible for admission to this program. Besides compulsory subjects, the candidates seeking admission in B.Sc. program have to take three optional subjects. For those candidates who desire to take Fresh Water Biology and Fisheries as one of the optional subjects shall have to choose two other optional from Group I and the other from Group II as under:

## **Group-I: Botany/Zoology**

## **Group-II: Chemistry/Functional Math/Statistics**

**Following is the breakup of the courses:**

- 1<sup>st</sup> year:** Two theory papers of 100 marks each and two practical of 50 marks each  
**2<sup>nd</sup> year:** Two theory papers of 100 marks each and two practical of 50 marks each

**B.Sc. (Pass) Total Marks: 100+50, 100+50, 100+50, 100+50 =600**

## **B.Sc. (Pass) Part-I (1<sup>st</sup> year)**

### **Paper-I (Theory) Introductory Fresh Water Biology (100 Marks)**

- Brief description of freshwater resources of Pakistan, types of fresh water habitats and their zonation
- Classification of living fish into major sub-divisions, description of important food fish of Pakistan
- Digestive, Respiratory, Circulatory, Excretory and Nervous Systems of fish, Structure of skin, sense organs and skeleton of cartilaginous fish (type: Dogfish) and a bony fish (type; Rahu, *Labeoq, rohita*)
- Differentiation between various Thallaphytes, their occurrence, structure and reproduction of Cyanophyta (type: *Oscillatoria*, occurrence structure and reproduction of Chlorophyta (type: *Chlamydomonas*), general classification of algae and its economic importance.

### **Laboratory-I: Fresh Water Biology and Fisheries (50 Marks)**

- Study of external and internal features of Dogfish and Rahu
- Study of representative freshwater food fish of Pakistan
- Study of various common freshwater algae and aquatic plants



**Paper-II (Theory): Fresh Water Ecology**

**(100 Marks)**

- a. Basic principles of ecology, habitat and ecological niches, ecosystems, food chain, trophic levels, biogeo-chemical cycles
- b. Adaptive features of hydrophytes, account of common aquatic plants, their importance and role in fresh water ecosystem, control of aquatic weeds
- c. Common freshwater zooplankton and phytoplankton, their role in aquatic food chain
- d. Feeding adaptations and feeding habits of local food fish
- e. Migration in fish with special reference to Palla of Indus river
- f. Nature of Lotic and Lentic waters, brief description of physicochemical factors of water, impact of pollution on aquatic life

**Laboratory-II: Fresh Water Ecology**

**(50 Marks)**

- a. Study of freshwater ecosystems
- b. Collection and identification of aquatic plants
- c. Study of common freshwater zoo- and phytoplankton
- d. Analyses of physical and chemical properties of water

**B.Sc. (Pass) Part-II (2<sup>nd</sup> Year)**

**Paper-III Introduction to Fish Culture**

**(100 Marks)**

History of fish culture; fish culture types and methods; criteria for site selection, designing, construction of pond, liming, fertilization, criteria for selection of fish species for culture; stocking, feeding and maintenance of fish ponds; Introduction to integrated fish farming. Common fishing methods practiced in Pakistan. Methods for handling, processing and preservation of fish (drying, salting, curing, smoking and freezing). General account of by-products of fish industry, common diseases of fish in ponds and their control measures

**Laboratory-III Fish Culture**

**(50 Marks)**

- a. Visits to a fish farm and study of its various installations
- b. Study of boats and nets used for fishing in Pakistan
- c. Collection and identification of cultureable species of fish
- d. Study of common fish diseases and parasites
- e. Study of commercially important food fish of Pakistan
- f. Identification of fish with the help of key
- g. Collection of organic, inorganic and composite fertilizers and fish feed ingredients

## **Paper-IV Limnology**

**(100 Marks)**

Introduction and scope of Limnology. Origin of lotic and lentic waters and estuaries, classification of rivers, lakes and reservoirs, zonation, thermal stratification; water movements, eutrophication; physical properties of water (temperature, light, colour, turbidity, conductivity), interrelationships among physico-chemical variables and fish

## **Laboratory-IV Limnology**

**(50 Marks)**

### **Practical:**

- a. Survey of lotic and lentic water bodies
- b. Water sampling and preservation techniques, determination of DO, light penetration, total alkalinity, pH, hardness and chlorides
- c. Survey report

### **Recommended Books**

1. Stickney, R.R. (2009). Aquaculture: An Introductory Text. CABI Publishing, UK.
2. Patrick O. Sullivan and Reywards, C.S. (2008). The Lakes: Hand Book of Limnology and Lentic Ecology. 3<sup>rd</sup> Ed. Springer, USA.
3. Compert, W. and Somm, U. (2007). Aquatic Ecology. Oxford University Press, London.
4. Pillay, T.V.R. and Kutty, M.N. (2005). Aquaculture: Principle and Practices. Wiley-Blackwell, USA.
5. Sarkar, S.K. (2002). Freshwater Fish Culture. Vol. 1. Daya Publishing House, N. Delhi
6. Wetzel, R.G. (2001). Lake and River Ecosystem. Academic Press, London.
7. Wetzel, R.G. (2000) Limnological Analysis. 3<sup>rd</sup> Ed. Springer, USA.
8. Hauer, R. and Gary A. Lamberti, G.A. (2000). Methods in Stream Ecology. 2<sup>nd</sup> Ed. Academic Press, London.
9. Reddy, M.S. and Sambasiva Rao, K.R.S. (1999). A Text Book of Aquaculture, Discovery Pub., New Delhi.
10. Ali, S.S. (1999). Fresh Water Fishery Biology. Naseem Book Depot. Hyderabad, Pakistan.
11. Boyd, C.E., Graig, T. (1998). Pond Aquaculture, Water Quality Management. Kilmer Academic Publisher.
12. Mead, J.W. (1998). Aquaculture Management. Chapman and Hall Inc., New York.
13. Parker, R. (1994). Aquaculture Science. Delmar Pub., New York.
14. Huet, M. and Timmerman, J.A. (1994). Text Book of Fish Culture: Breeding and Cultivation. Fishing News Books, U.K.

## **BS (4-Years) and MS (2-Years) DEGREES IN FRESH WATER BIOLOGY AND FISHERIES**

Freshwater Biology & Fisheries is a multidisciplinary subject of applied nature relating to the study of aquatic organisms including fish, their habitat, food and feeding, their genetics, morphological and physiological attributes and their conservation. Freshwater Biology & Fisheries is playing an important role in alleviation of poverty, human recourse development and sustainable developments of freshwaters in the country.

### **OBJECTIVES AND OUTCOMES**

The goal of the program is to give the students an insight into, and an overview of the discipline of fisheries biology with emphasis on how exploitation and other external factors influence the aquatic living resources. Students who have completed the program shall have a good knowledge of the systematics, anatomy, physiology, behaviour, development, life history and ecology of fish, in addition to aquatic ecosystems. They shall further have a basic understanding of the population structure of fish stocks, the function and selective properties of fishing gears, exploitation strategies of fish populations from selected ecosystems and simple population dynamic models, in addition to the knowledge of how ecological factors in combination with the fishing pressure influence the development of fish stocks. The students will also get practical experience from work in fisheries biology in the laboratory and field.

### **CAREER OPPORTUNITIES**

One common employer of specialists in fisheries biology is fish and game agencies. These government agencies have a dual goal of protecting natural resources and making natural resources available to people and companies which wish to use them. Conservation organizations also use experts in fisheries biology to study fish populations and make policy recommendations.

After obtaining the degree/s in Freshwater Biology & Fisheries, the graduates and post-graduates will be able to get jobs in a wide range of professions in various government and non governmental organizations, teaching and research, administration, management and extension, forestry, pharmaceutical, agriculture, wild life, aquaculture, fisheries and livestock.

### **PEDAGOGY (TEACHING- LEARNING METHODOLOGIES)**

- The courses will be taught through lectures, practical, seminars and field trips.
- The teaching learning material will include text and reference books, journals/periodicals, handouts and internet.

### **ASSESSMENT AND EVALUATION**

**Internal Evaluation: left to the individual Universities**

- Mid term test
- Seminars and Assignments
- Final Examination

# SCHEME OF STUDIES FOR BS (4 YEARS) IN FRESH WATER BIOLOGY AND FISHERIES

## Courses of studies in Fresh Water Biology and Fisheries

The department offers teaching programs leading to the degrees in the subject of Fresh Water Biology and Fisheries leading to BS (4 years) degree program:

### Duration 4 years (Eight semesters): 134 Credit hours

Candidates having passed H.Sc. Part II examination from any recognized Board of Secondary education or equivalent course (Pre-medical) are eligible for admission to this program. Candidate seeking admission in BS (4 years) degree in Fresh Water Biology will have to complete following courses:

Semester/Year	Name of Subject	Credits
<b>First</b>	COMPULSORY-I (ENGLISH-I)	3
	COMPULSORY-II (ENGLISH-I)	2
	COMPULSORY-III MATH/STAT-I	3
	GENERAL-I (ZOOLOGY-I)	3
	FOUNDATION-I (ICHTHYOLOGY)	4
	GENERAL-II (PLANT DIVERSITY)	3
		<b>18</b>
<b>Second</b>	COMPULSORY-IV (ENGLISH-II)	3
	COMPULSORY-V ISLAMIC STUDIES / ETHICS	2
	COMPULSORY-VI (MATH/STAT-II / UNIV. OPTIONAL)	3
	GENERAL-III (ZOOLOGY-II)	3
	FOUNDATION-II (HYDROBIOLOGY)	4
		<b>15</b>
<b>Third</b>	COMPULSORY-VII (ENGLISH-III)	3
	COMPULSORY-VIII (INTRODUCTION TO COMPUTER)	3
	GENERAL-IV (BIOCHEMISTRY)	4
	GENERAL-V (ANIMAL PHYSIOLOGY)	3
	FOUNDATION-III (FISH CULTURE)	3
		<b>16</b>
<b>Fourth</b>	COMPULSORY-IX (ENGLISH-IV / UNIV. OPTIONAL)	3
	GENERAL-VI (PLANT PHYSIOLOGY)	3
	GENERAL-VII (ECOLOGY)	3
	FOUNDATION-IV (DEVELOPMENTAL BIOLOGY)	4
	FOUNDATION-V (COMPARATIVE FISH ANATOMY)	4
		<b>17</b>
<b>Fifth</b>	FOUNDATION-VI (LIMNOLOGY)	3
	FOUNDATION-VII (PLANKTOLOGY)	3
	MAJOR-I (FISH BIOLOGY)	4
	MAJOR-II (FISHERY TECHNOLOGY)	3
	MAJOR-III (PHYCOLOGY)	4
	<b>17</b>	
<b>Sixth</b>	FOUNDATION-VIII (AQUATIC MICROBIOLOGY)	3
	FOUNDATION-IX (AQUATIC ECOLOGY AND CONSERVATION)	3
	MAJOR-IV (FRESH WATER INVERTEBRATES)	4

	MAJOR-V (FISHERIES BIOLOGY)	3
	MAJOR-VI (AQUATIC MACROPHYTES AND MANAGEMENT)	3
		<b>16</b>
<b>Seventh</b>	MAJOR-VII (FISH BREEDING & HEALTH)	4
	MAJOR-VIII (WATER POLLUTION)	3
	MAJOR-IX RESEARCH PROJECT / INTERNSHIP	3
	ELECTIVE-I	3
	ELECTIVE-II	3
		<b>16</b>
<b>Eight</b>	MAJOR-X (FISH NUTRITION)	3
	MAJOR-XI (ETIOLOGY OF FISH DISEASE)	3
	MAJOR-XII (AQUACULTURE)	3
	ELECTIVE-III	3
	ELECTIVE-IV	3
		<b>15</b>

**Grand Total 130**

University can increase the number of courses pertaining to specialization depending upon its requirements and expertise available.

YEAR	CREDITS	COMPULSORY REQUIREMENTS (NO CHOICE)	GENERAL SCIENCE REQUIREMENTS	DISCIPLINE SPECIFIC FOUNDATION COURSES	REQUIREMENTS TOWARDS A MAJOR	ELECTIVE WITHIN THE MAJOR
<b>Total</b>	<b>130</b>	<b>25</b>	<b>22</b>	<b>31</b>	<b>40</b>	<b>12</b>
<b>Year 1</b>						
Semester I	18	8	6	4	-	-
Semester II	15	8	3	4	-	-
<b>Year 2</b>						
Semester III	16	6	7	3	-	-
Semester IV	17	3	6	8	-	-
<b>Year 3</b>						
Semester V	17	-	-	6	11	-
Semester VI	16	-	-	6	10	-
<b>Year 4</b>						
Semester VII	16	-	-	-	10	6
Semester VIII	15	-	-	-	9	6

# DETAILS OF COURSES CURRICULUM FOR BS (4 YEARS)

## (8 SEMESTER) PROGRAM IN FRESH WATER BIOLOGY AND FISHERIES

### GENERAL COURSES:

1. Zoology-I	3 (2+1)
2. Plant Diversity	3 (2+1)
3. Zoology-II	3 (2+1)
4. Biochemistry	4 (3+1)
5. Animal Physiology	3 (2+1)
6. Plant Physiology	3 (2+1)
7. Ecology	<u>4 (3+1)</u>

**Total: 23 (16+7)**

### **Zoology-I      3 (2+1)**

#### **1. Place of Zoology in Science**

A one-world view: genetic unity, the fundamental unit of life, evolutionary oneness and the diversity of life, environment and world resources; what is zoology.

The classification of animals; the scientific method.

#### **2. The Chemical Basis of Animal Life**

Atoms and elements: building blocks of all matter; compounds and molecules: aggregates of atoms; acids, bases, and buffers; the molecules of animals: fractional account of carbohydrates, lipids, proteins, nucleotides and nucleic acids based on their structural aspects.

#### **3. Cells, Tissues, Organs, and Organ System of Animals**

Structure and functions of cell membranes; various movements across membranes; cytoplasm, organelles, and cellular components: functional account of ribosomes, endoplasmic reticulum, golgi apparatus, lysosomes, mitochondria, cytoskeleton, cilia and flagella, centrioles and microtubules, and vacuoles based on their structural aspects. The nucleus: nuclear envelope, chromosomes and nucleolus. Tissues: diversity in epithelial tissue, connective tissue, muscle tissue and nervous tissue to perform various functions. Structural integrations for functions in organs and organ systems.

#### 4. Energy and Enzymes: Life's Driving and Controlling Forces

Energy and the laws of energy transformation; activation energy; enzymes: structure, function and factors affecting their activity; cofactors and coenzymes; ATP: how cells convert energy? An overview.

##### Practical:

- Study of the prepared slides of epithelial tissue (squamous, cuboidal, columnar), connective tissue (adipose, cartilage, bone, blood), nervous tissue and muscle tissue (skeletal, smooth and cardiac).
- Plasmolysis and deplasmolysis in blood.
- Protein digestion by pepsin.

##### Recommended Books

1. Miller, S.A. and Harley, J.B. (2005). Zoology. 6<sup>th</sup> Ed. (International). McGraw Hill, Singapore.
2. Hickman, C.P., Roberts, L.S. and Larson, A. (2004). Integrated Principles of Zoology. 12<sup>th</sup> Ed. (International). McGraw Hill, Singapore.
3. Campbell, N.A. (2002). Biology. 6<sup>th</sup> Ed. Benjamin/Cummings Publishing Company, Inc. Menlo Park, California.
4. Miller, S.A. (2002). General Zoology Laboratory Manual. 5<sup>th</sup> Ed. (International). McGraw Hill, Singapore.
5. Kent, G.C. and Miller, S. (2001). Comparative Anatomy of Vertebrates. McGraw Hill Company, New York.
6. Pechenik, J.A. (2000). Biology of Invertebrates, 5<sup>th</sup> Ed. (International). McGraw Hill., Singapore.
7. Hickman, C.P. and Kats, H.L. (2000). Laboratory Studies in Integrated Principles of Zoology. McGraw Hill, Singapore.

#### Plant Diversity 3 (2+1)

**Comparative study of life form, structure, reproduction and economic significance of:**

- a) Viruses (RNA and DNA types) with special reference to TMV;
- b) Bacteria and Cyanobacteria (*Nostoc*, *Anabaena*, *Oscillatoria*) with specific reference to bio-fertilizers, pathogenicity and industrial importance;
- c) Algae (*Chlamydomonas*, *Spirogyra*, *Chara*, *Vaucheria*, *Pinnularia*, *Ectocarpus*, *Polysiphonia*)
- d) Fungi (*Mucor*, *Penicillium*, *Phyllactinia*, *Ustilago*, *Puccinia*, *Agaricus*), their implication on crop production and industrial applications.
- e) Lichens (*Phycia*)
- f) Bryophytes,
  - i. Riccia
  - ii. Anthoceros
  - iii. Funaria

- g) Pteridophytes
  - i. Fossils and fossilization
  - ii. Psilopsida (*Psilotum*)
  - iii. Lycopsidea (*Selaginella*)
  - iv. Sphenopsida (*Equisetum*)
  - v. Pteropsida (*Marsilea*)
  - vi. Seed Habit

h) Gymnosperms *Cycas*, *Pinus*, *Ephedra*

### **Practical:**

- Maintenance and preservation of microorganisms
- Study of morphology and reproductive structures of the types mentioned in theory
- Collection, identification and preparation of slides

### **Recommended Books**

1. Prescott, L.M., Harley, J.P. and Klein, A.D. (2004). Microbiology, 3<sup>rd</sup> Ed. Wm C. Brown Publishers, Inc. Oxford, England
2. Agrios, G.N. (2004). Plant pathology. 8<sup>th</sup> Ed. Academic press, London.
3. Mauseth, J.D. (2003). Botany: An Introduction to Plant Biology. 3<sup>rd</sup> Ed. Jones and Bartlett Pub. UK
4. Lee, R.E. (1999). Physiology. Cambridge University Press, UK
5. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. (1996). Introductory Mycology. 4<sup>th</sup> Ed. John Wiley and Sons Publishers.
6. Ingrouille, M. (1992). Diversity and Evolution of Land Plants. Chapman and Hall Inc. New York.
7. Vashishta, B.R. (1991). Botany for degree students (all volumes). S. Chand and Company. Ltd. New Delhi.

## **Zoology-II                      3 (2+1)**

### **1. Cell Division**

Mitosis, cytokinesis and the cell cycle: an overview; control of the cell cycle; meiosis: the basis of sexual reproduction; gamete formation.

### **2. Inheritance Patterns**

The birth of modern genetics; Mendelian inheritance patterns; other inheritance patterns; environmental effects and gene expression.

### **3. Chromosomes and Gene Linkage**

Eukaryotic chromosomes; linkage relationships; changes in chromosome number and structure.



#### **4. Molecular Genetics: Ultimate Cellular Control**

DNA: the genetic material; DNA replication in eukaryotes; genes in action; control of gene expression in eukaryotes; mutations; applications of genetic technologies; recombinant DNA.

#### **5. Animal Behavior**

Four approaches to animal behavior; proximate and ultimate causes; anthropomorphism; development of behavior; learning; control of behavior; communication; behavioral ecology; social behavior.

#### **6. Evolution: A Historical Perspective**

Pre-Darwinian theories of change; Lamarck: an early proponent of evolution; early development of Darwin's ideas of evolution and evidences; the theory of evolution by natural selection; evolutionary thought after Darwin; biogeography.

#### **7. Evolution and Gene Frequencies**

The modern synthesis: a closer look; the Hardy-Weinberg theorem; evolutionary mechanisms: population size, genetic drift, natural selection, gene flow, mutation, and balanced polymorphism; species and speciation; rates of evolution; molecular evolution; mosaic evolution.

### **Recommended Books**

1. Hickman, C.P., Roberts, L.S. and Larson, A. (2004). Integrated Principles of Zoology. 11<sup>th</sup> Ed. (International), McGraw Hill, Singapore.
2. Miller, S.A. and Harley, J.B. (2002). Zoology. 5<sup>th</sup> Ed. (International). McGraw Hill, Singapore.
3. Campbell, N.A. (2002). Biology. 6<sup>th</sup> Ed. Benjamin/Cummings Publishing Company, Inc. Menlo Park, California.
4. Pechenik, J.A. (2000). Biology of Invertebrates. 4<sup>th</sup> Ed. (International). McGraw Hill, Singapore.
5. Kent, G.C. and Miller, S. (2000). Comparative Anatomy of Vertebrates. McGraw Hill, New York.

### **Practical:**

- Study of mitosis in onion root tip
- Study of meiosis in grasshopper testis (students should prepare the slide)
- Multiple alleles study in blood groups
- Study of cytochemical detection of DNA in protozoa and avian blood cell.

### **Recommended Books**

1. Miller, S.A. (2002). General Zoology Laboratory Manual. 5<sup>th</sup> Ed. McGraw Hill, Singapore.
2. Hickman, C.P. and Kats, H.L. (2000). Laboratory Studies in Integrated Principles of Zoology. McGraw Hill, Singapore.

**Theory:**

Amino acids, peptides, proteins and their classification; acid/base properties of amino acid; natural modifications of amino acids in proteins; non-standard amino acids, their structure and role; amino acid composition, cytochrome-c; Macromolecular separation techniques in biochemistry; ion exchange chromatography; isoelectric focusing; density gradient centrifugation.

**Enzymes:** introduction; important characteristics of enzymes; immobilized enzymes; how enzymes work; example of enzymatic reaction; enzyme kinetics, enzyme rate of reaction and substrate concentration, how pH and temperature effect on enzyme activity; kinetics of bi-substrate and multi-substrate reactions.

**Carbohydrates:** classification, types, important characteristics and structure of carbohydrates; history of developments in structure of glucose; monosaccharides; cyanohydrin formation; disaccharides their types structure and function; polysaccharides, storage and structural types; structure and major functions of polysaccharides.

**Lipids:** fatty acids, their types and major characteristics; storage lipids, anti-oxidants acylglycerols; waxes; structural lipids in membranes; major functions of lipids; lipoproteins, their types and major functions.

**Vitamins and cofactors:** Classification of vitamins, their occurrence, structure and biochemical function: modes of action

**Bioenergetics:** concept of free energy; standard free energy change: energy rich compounds

**Metabolism:** detailed description of glycolysis and catabolism of other hexoses; regulation and bioenergetics of glycolysis. Anabolic role of glycolysis; fate of pyruvate under aerobic and anaerobic conditions, lactate, acetyl CoA and ethanol formation; alcoholic fermentation; gluconeogenesis, its regulation and significance in the tissues; utilization of other carbohydrates in glycolysis; phosphorolysis of glycogen and starch; regulation of glycogen metabolism; utilization of dietary polysaccharides (starch) and disaccharides (sucrose and galactose). Bio-synthesis of glycogen, starch and sucrose.

**Citric acid (TCA) cycle:** conversion of pyruvate to acetyl CoA, pyruvate dehydrogenase, a multi-enzyme complex; detailed description of citric acid cycle; bioenergetics and conservation of energy produced in the cycle. Anabolic or biosynthetic role of citric acid cycle intermediates; replenishing or anaplerotic reactions and their role; regulation of citric acid cycle.

**Lipid metabolism:** oxidation of fatty acids; digestion, mobilization and transport of fats; biosynthesis of triacylglycerol; utilization of triacylglycerol; activation of fatty acids and their transportation to mitochondria; beta-oxidation; bioenergetics of beta-oxidation; oxidation of unsaturated and odd chain fatty acids; omega oxidation

pathway; biosynthesis of saturated fatty acid, supply of raw material for palmitic acid synthesis; fatty acid synthetase (FAS) multienzyme complex; biosynthesis of unsaturated fatty acids. Ketone bodies their biosynthesis, utilization and role in the tissues; cholesterol metabolism: cholesterol biosynthesis and its regulation; steroid hormones.

**Nitrogen metabolism:** metabolic fate of amino acids; catabolism of amino acids; deamination and trans-amination; nitrogen excretion and urea cycle; regulation of urea cycle; biosynthesis of some amino acids; incorporation of ammonia in glutamate and glutamine; purine and pyrimidine.

### **Recommended Books**

1. Nelson, D. L. and Cox, M.M. Lehninger, A.L. (2004). Principles of Biochemistry, 4<sup>th</sup> Ed. McMillan Worth Publishers, New York.
2. McKee, T. and McKee, J.R. (2003). Biochemistry, the Molecular Basis of Life. 3<sup>rd</sup> Ed. McGraw Hill Company, New York.
3. Murray, R.K., Granner, D.K., Mayer, P.A. and Rodwells, V.W. (2000). HARPER'S Biochemistry. 25<sup>th</sup> Ed. McGraw Hill Company, New York.
4. Voet. D., Voet, J.G. and Pratt, C.W. (1999). Fundamentals of Biochemistry. John Wiley and Sons, Inc., New York.
5. Zubay, G. (1995). Biochemistry. 4<sup>th</sup> Ed. Wm. C. Brown Publishers, Inc., Oxford, England.
6. Lubert, S. (1995). Biochemistry. 4<sup>th</sup> Ed. W.H. Freeman & Company, New York.

### **Practical:**

- Preparation of standard curve for glucose by ortho-toluidine method
- Tests for detection of carbohydrates in alkaline and acidic media
- Tests for detection of disaccharides
- Detection of non-reducing sugars in the presence of reducing sugars
- Demonstration of acid hydrolysis of polysaccharide
- Separation and identification of various types of sugars, fatty acid and amino acid Thin Layer Chromatography (TLC)
- Determination of pKa values of an amino acid by preparation of titration curves
- Biochemical tests for detection of different amino acids
- Separation of various protein fractions by precipitation method
- Demonstration of differential solubility of lipids in various solvents
- Quantitative analysis of phospholipids by estimation of inorganic phosphorous
- Quantitative analysis of Amylase activity from blood serum or liver
- Study on the effect of temperature on the enzymatic rate of reaction

### **Recommended Books**

1. Plummer, D. T. (1990). An Introduction to Practical Biochemistry. 4<sup>th</sup> Ed. McGraw-Hill Book Company, London.
2. Wilson, K. and Walker, J. (1994). Practical Biochemistry: Principles and Techniques. 4<sup>th</sup> Cambridge University Press, Cambridge.

## Animal Physiology 3 (2+1)

### Theory:

Central themes in Physiology: Structure-function relationship, Homeostasis; Transportation: composition of blood cells (Erythrocytes, leukocytes, Platelets and plasma); Fluid-mosaic model of cell membrane, membrane potential; Circulation; Arterial system; Venous system; Capillaries; Transport of food material; lymphatic system. Excretion: Kidneys; Hypo-osmotic urine; Hyper-osmotic urine; Osmo-regulation. Exchange of Gases: Transport of O<sub>2</sub> and CO<sub>2</sub> between respiratory surface and body cells.

### Practical:

- Oxygen consumption in fish
- Analysis of digestive enzymes
- Swimming patterns in fish
- Environmental effects on respiration, excretion and fish tolerance to toxicants

### Recommended Books

1. Randall, D., Burggren, W., French, K. and Fernald, R. (2002). **Eckert** Animal Physiology: Mechanisms and Adaptations. 5<sup>th</sup> Ed. W.H. Freeman and Company, New York.
2. Bullock, J., Boyle, J. and Wang, M.B. (2001). Physiology. 4<sup>th</sup> Ed. Lippincott, Williams and Wilkins, Philadelphia.
3. Bullock, J., Boyle, J. and Wang, M.B. (2001). Physiology, 4<sup>th</sup> Ed. **Lippincott**, Williams and Wilkins, Philadelphia.
4. Berne, R.M. and Levy, M.N. (2000). Principles of Physiology, 3<sup>rd</sup> Ed. **St. Liouis, Mosby**.
5. Guyton, A.C. and Hall, J.E. (2000). Textbook of Medical Physiology, 10<sup>th</sup> Ed. W.B. Saunders Company, Philadelphia.
6. Schmidt-Nelsen, K. (1997). Animal Physiology, Adaptation and Environment, 5<sup>th</sup> Ed. Cambridge University Press, Cambridge.
7. Withers, P.C. (1992). Comparative Animal Physiology. W.B. Saunders Company, Philadelphia.

## Plant Physiology 3 (2+1)

**Water relations:** water, osmotic and pressure potentials. Absorption and translocation of water; Stomatal regulation.

**Mineral nutrition:** Soil as a source of minerals. Passive and active transport of nutrients. Essential mineral elements, role and deficiency symptoms of macronutrients.

**Photosynthesis:** Introduction, Oxygenic and non-oxygenic photosynthesis mechanisms: light reactions (electron transport and photophosphorylation) and dark reactions (Calvin cycle). Differences between C<sub>3</sub> and C<sub>4</sub> plants. Factors affecting photosynthesis, products of photosynthesis.

**Growth:** Definition; role of auxins, gibberellins, cytokinins, abscisic acid and ethylene in controlling growth. Introduction to plant tissue culture.

**Photoperiodism:** Definition, historical background, classification of plants based on photoperiodic response, role of phytochromes, hormones and metabolites in photoperiodism

**Dormancy:** Definition and causes of seed and bud dormancy; methods of breaking seed dormancy, Physiological processes during seed germination

**Practical:**

- Preparation of solutions of specific normality of acids/bases, salts, sugars, molal and molar solutions and their standardization
- Determination of uptake of water by swelling seeds when placed in sodium chloride solution of different concentrations
- Measurement of leaf water potential by the dye method
- Determination of the temperature at which beet root cells lose their permeability
- Determination of the effects of environmental factors on the rate of transpiration of a leafy shoot by means of a porometer/by cobalt chloride paper method.
- Extraction of chlorophyll from the leaves and separation of component pigments on a paper chromatogram
- Estimation of oxygen utilized by a respiring plant by Wrinkler's method
- Measurement of carbon dioxide evolution during respiration of germinating seeds by the titration method.

**Recommended Books**

1. Taiz, L. and Zeiger, E. (2002). Plant Physiology. 3<sup>rd</sup> Ed. Sinauers Publ. Co. Inc., California.
2. Ihsan Illahi (1995). Plant Physiology, Biochemical Processes in Plants, UGC Press, Pakistan.
3. Salisbury F.B. and Ross C.B. 1992. Plant Physiology. 5th Edition. Wadsworth Publishing Company, Belmont CA.
4. Hopkins, W.B. (1999). Introduction to Plant Physiology. 2<sup>nd</sup> Ed. John Wiley and Sons. New York.
5. Hussain, F. (1989). Field and Laboratory Manual of Plan Ecology. National Academy of Higher Education, Islamabad.

**Ecology**

**4 (3+1)**

**Theory:**

Definition and scope of ecology. Terrestrial and aquatic ecosystems, biotic and abiotic factors of ecosystem, food chain and food web, trophic levels. Source and concept of energy flow; law of thermodynamics, concept of limiting factors. Ecological pyramids of numbers, biomass and energy, community ecology, species diversity, diversity indices, succession and ecological niche.

**Practical:**

- Qualitative and quantitative estimation of primary productivity of various aquatic ecosystems
- Food chain studies through analysis of gut contents
- Study of various ecosystems and report writing
- Abundance, frequency and density of animals

**Recommended Books**

1. Wooten R. J. (2008). Fish Ecology. Springer, India.
2. Jeffries M. and Mils, D. (1992). Freshwater Ecology: Principles and Applications, CBS Publishing, New Delhi.
3. Kaul, B.L. (1999). Advances in Fish and Wildlife Ecology and Biology. Daya Publishing, New Delhi.
4. Welch, P.S. (1988). Limnology. 4<sup>th</sup> Ed. McGraw Hill Book Company, New York.

## FOUNDATION COURSES:

1. Ichthyology	4 (3+1)
2. Hydrobiology	4 (3+1)
3. Fish Culture	4 (3+1)
4. Developmental Biology	3 (2+1)
5. Comparative Fish Anatomy	4 (3+1)
6. Limnology	3 (2+1)
7. Planktology	3 (2+1)
8. Aquatic Microbiology	3 (2+1)
9. Aquatic Ecology & Conservation	<u>3 (2+1)</u>
Total:	31 (22+9)

### Course Contents

#### Ichthyology 4 (3+1)

##### Theory:

Introduction to Ichthyology, history of Ichthyology, classification of fish and their diversity, morphology, forms and locomotion, integumentary, skeletal, digestive, circulatory, respiratory, excretory; reproductive, nervous systems and sense organs of fish

##### Practical:

- Museum survey
- Study of external features and skeleton of fish
- Dissection of fish to expose its internal features

##### Recommended Books

1. Ali, S.S. and Narejo, N.T. (2009). Fundamentals of Ichthyology. Sindh University Press, Jamshoro.
2. Kapoor, G. B. and Khana, B. (2004). Ichthyology Hand Book. Springer, India.
3. Lagler, K.F., Baradach, J.E. and Miller, R.R. (2003). Ichthyology. John Wiley and Sons, Inc., New York.
4. Ali, S.S. (1999). Fresh Water Fisheries Biology .Naseem Book Depot Hyderabad, Pakistan.

#### Hydrobiology 4 (3+1)

##### Theory:

Aquatic ecosystems: abiotic and biotic components, habitats and ecological niche, biogeochemical cycles, introduction to physico-chemical properties of water; relationships between abiotic and biotic components of aquatic ecosystems.

##### Practical:

- Survey of aquatic bodies
- Sampling methods and determination of physico-chemical properties of water

## **Recommended Books**

1. Compert, W. and Somm, U. (2007). Aquatic Ecology. Oxford University Press, London.
2. Dodds, W.K. (2002). Fresh Water Ecology Concepts and Environmental Applications. Academic Press, London.
3. Hosetti, B.B. and Kumar, A. (2001). A Textbook of Applied Aquatic Biology. Daya Publishing House, New Delhi.

## **Fish Culture                    4 (3+1)**

### **Theory:**

History of fish culture; fish culture types and methods; criteria for farm site selection, designing, construction, liming, fertilization, criteria for selection of fish species for culture; stocking, feeding and maintenance of fish farms; Introduction to integrated fish farming. Common fishing methods practiced in Pakistan. Methods for handling, processing and preservation of fish (drying, salting, curing, smoking and freezing). Common fish diseases and their control.

### **Practical:**

- Study of commercially important food fish of Pakistan
- Identification of fish with the help of key
- Collection of locally available fish feed ingredients
- Visit to fish farms and hatcheries

## **Recommended Books**

1. Pillay T.V.R. and Kutty, M.N. (2005). Aquaculture: Principle and Practices. Wiley-Blackwell, USA.
2. Reddy, M.S. and Sambasiva, K.R.S. (1999). A Text Book of Aquaculture, Discovery Publisher, New Delhi.
3. Ali, S.S. (1999). Fresh Water Fishery Biology. Naseem Book Depot. Hyderabad, Pakistan.
4. Arrignon, J. (1999). Management of Freshwater Fisheries, Oxford and IBH Publisher, India.
5. Boyd, C.E. and Graig, T. (1998). Pond Aquaculture, Water Quality Management, Kilmer Academic Publisher, Netherlands.
6. Mead, J.W. (1998). Aquaculture Management, Chapman and Hall Inc. New York.
7. Huet, M. and Timmerman, J.A (1994). Text Book of Fish Culture: Breeding and Cultivation. Fishing News Books, U.K.
8. M. Huet, M. and J.A. Timmerman (1994). Text Book of Fish Culture: Breeding and Cultivation. Fishing News Books. U.K.
9. Parker, R. (1994). Aquaculture Science, Delmar Publishing, New York.
10. Talwar, P.K. & A.G. Jhingran (1991). Inland Fishes of India and Adjacent Countries, Vol I & II. Oxford & IBH Publishing Company, New Delhi.



## **Developmental Biology 3 (2+1)**

### **Theory:**

Introduction: Principal features of development, origin of sexual reproduction, developmental patterns; Spermatogenesis; Oogenesis; Fertilization: Recognition of sperm and egg, fusion of gametes, activation of egg metabolism, rearrangement of egg cytoplasm; Cleavage: Patterns of embryonic cleavage, mechanism of cleavage; Gastrulation: Fate maps, gastrulation in sea urchin, amphibians, birds and mammals. Early Vertebrate Development: Neurulation, ectoderm, mesoderm and endoderm. Cellular Basis of Morphogenesis: Differential cell affinity, cell adhesion molecules; Mechanism of Cellular Differentiation: RNA processing, translational regulation of developmental process, cell-fate by progressive determinants, autonomous cell specification by cytoplasmic determinants, establishment of body axes and mechanism of teratogenesis; Secondary Induction; Organogenesis: A brief account; Origin and Migration of Germ Cells in Vertebrates; Factors controlling Growth and Oncogenesis. Hormones as Mediators of Development; Regeneration in Vertebrates.

### **Practical:**

- Study of structure of gametes in some representative fish species
- Study of cleavage and subsequent development from prepared slides and/or whole mounts
- Study of fertilization, early development of fish through induced spawning under laboratory conditions

### **Recommended Books**

1. Gilbert, S.F. (2004). *Developmental Biology*. Sinauer Associates, Sunderland, USA.
2. Saunders, J. W. (2000). *Development Biology*. McMillan and Co., Inc., London.
3. Ham, R.G. and Veomett, M.J. (1990). *Mechanism of Development*. C.V. Mosby Co., London.
4. Balinsky, B. I. (1985). *An Introduction to Embryology*. W.B. Saunders Company, Philadelphia.
5. Oppenheimer, S.S. (1984). *Introduction to Embryonic Development*. Allen and Bacon, Chicago Press, USA.

## **Comparative Fish Anatomy 4 (3+1)**

### **Theory:**

Comparative anatomy of fish with special reference to integumentation, digestive tube, respiratory system, gas bladder, accessory breathing organs, circulatory system (composition of fish blood), fish heart, excretory system; osmoregulation, reproductive system, nervous system and sense organs.

### **Practical:**

- Dissection of various fish species (catfish / carps / tilapia / snow trout / dogfish) as to study various anatomical organs and systems

- Permanent mounts of various fish scales

### **Recommended Books**

1. Frederic P., Agres, M., Vandome, F. and McBrewster, J. (2010). Fish Anatomy. VDM Publishing House, USA.
2. Lagler, K.F., Bardach, J.E. and Miller, R.R. (2003). Ichthyology. John Wiley and Sons, Inc., New York.
3. Moyle, P.B. and Cech, J.J. (2003). Fishes: An Introduction to Ichthyology. 5<sup>th</sup> Ed. Prentice Hall, New Jersey.
4. Laurence, M.A., Chiasson, R.B. (1988). Laboratory Anatomy of the Shark and Perch. Wm. C. Brown Publishers, Inc., Oxford, England.

### **Limnology      3 (2+1)**

#### **Theory:**

Introduction and scope of limnology. Origin of lotic and lentic waters and estuaries, classification of rivers, lakes and reservoirs, zonation, thermal stratification; water movements, eutrophication; physical properties of water (temperature, light, colour, turbidity, conductivity), interrelationships among physico-chemical variables and fish.

#### **Practical:**

- Survey of lotic and lentic water bodies
- Water sampling and preservation techniques, determination of DO, light penetration, total alkalinity, pH, hardness and chlorides
- Survey report

### **Recommended Books**

1. Sullivan, P.O. and Reayards, C. S. (2008). The Lakes Hand Book of Limnology and Lentic Ecology. 3<sup>rd</sup> Ed. Springer, USA.
2. Compert, W. and Somm, U. (2007). Aquatic Ecology. Oxford University, Press London.
3. Wetzel, R.G. (2001). Lake and River Ecosystem. Academic Press, London.
4. Wetzel, R.G. (2000). Limnological Analysis. 3<sup>rd</sup> Ed. Springer, USA.
5. Hauer, R. and Lamberti, G.A. (2000). Methods in Stream Ecology. 2<sup>nd</sup> Ed. Academic Press, London, UK.

### **Planktology      3 (2+1)**

#### **Theory:**

Introduction to Plankton (Zooplankton, Phytoplankton and Microplankton). Taxonomic classification of plankton in freshwater systems. General characters and species composition of major plankton. Qualitative and quantitative analyses of plankton and their periodicities. Phyto- and zooplankton relationships; importance of plankton in food chain of aquatic systems. Interactions of plankton with other organisms. Economic importance of diatoms.

**Practical:**

- Sampling, identification and preservation of phyto- , zooplankton and microplankton
- Quantitative and qualitative estimation of phyto- and zooplankton
- Study of temporary and permanent mounts of phyto-, zooplankton and microplankton

**Recommended Books**

1. Lambert, M.S., Mirium T.T. and Marseken, S.F. (2010). Phytoplankton. VDM Verlog & Co, USA.
2. Soothers, M. and Rissik, D. (2009). Phytoplankton; A Guide of their Ecology and Monitoring for Water Quality. CSIRO Publishing House, U.K.
3. Harris, G. (1986). Phytoplankton Ecology: Structure, Function and Fluctuation. Chapman & Hall, USA.

**Aquatic Microbiology****3 (2+1)****Theory:**

Introduction to aquatic bacteria and fungi, general characteristics and classification of freshwater bacteria and fungi; type study of a bacteria (*Aeromonas*) and a fungi (*Saprolegina*), isolation and culture techniques, economic importance of bacteria and fungi and their role in fresh water ecosystems

**Practical:**

- Isolation and preparation of permanent slides of bacteria and fungi
- Culture and isolation of pathogenic bacteria

**Recommended Books**

1. Austin, B. and Austin, D.A. (2007). Bacterial fish pathogens: Disease of Farmed and Wild Fish. Springer, USA.
2. Alaxopouls, C.J., Muns, C.W. and Black, M. (1996). Introductory Mycology, 4<sup>th</sup> Ed. McGraw Hill, New York.
3. Pelczer, M.J. (1993). Microbiology: Application Based Approach. McGraw Hill, New York.

**Aquatic Ecology and Conservation****3 (2+1)****Theory:**

Basic principles related to the structure and functioning of marine, brackish and freshwater ecosystems, Environmental degradation and habitat destruction. Effects of toxic gases, heavy metals, organic pollutants and therapeutic compounds on fish, measurements of toxicity, bioaccumulation and biotransformation of toxicants in fish .Impact of fishing and aquaculture on environment and fish biodiversity, Concept of minimum viable population size, Current practices employed in the conservation and management of aquatic habitats and inhabitants, Endangered species and restoration ecology.

**Practical:**

- Studies on endemic and threatened species of Pakistan
- Case study of various fish species

**Recommended Books**

1. Dyke, F. V. (2008). Conservation Biology: Foundation, Concept and Application. Springer, USA.
2. Pullin, A. S. (2002). Conservation Biology. Cambridge University Press, UK.

## MAJOR COURSES:

1. Fish Biology	4 (3+1)
2. Fishery Technology	3 (2+1)
3. Phycology	4 (3+1)
4. Freshwater Invertebrates	4 (3+1)
5. Fisheries Biology	3 (2+1)
6. Aquatic Macrophytes	3 (2+1)
7. Fish Breeding & Health	4 (3+1)
8. Water Pollution	3 (2+1)
9. Major Research Project/Internship	3 (0+3)
10. Fish Nutrition	3 (2+1)
11. Etiology of Fish Diseases	3 (2+1)
12. Aquaculture	<u>3 (2+1)</u>
<b>Total:</b>	<b>40 (26+14)</b>

## COURSE CONTENTS

### Fish Biology 4 (3+1)

#### Theory:

Food and feeding habits of fish; methods of qualitative and quantitative analyses of food; Age and growth studies in fish, growth models, Length-weight relationship and condition factor; Recruitments, marking and tagging of fish, methods of fish population estimation, population size, mortality rates.

#### Practical:

- Fish measurements
- Analyses of gut contents
- Assessment of age and growth of fish
- Computation of length-weight relationships and condition factor

### Recommended Books

1. Lagler, K.F. Baradach, J.E. and Miller, R.R. (2003). Ichthyology. John Wiley and Sons, Inc., New York.
2. Ricker, W.E. (2002). Methods of Assessment of Freshwater Fish Production. Blackwell Scientific Publications, USA.
3. Payne, A., John, A. and Cotter, R. (2008). Advances in Fisheries Science. John Wiley & Sons, USA.

### Fishery Technology 3 (2+1)

#### Theory:

Fishing methods, gears and crafts, processing vessels; fish handling, transportation, processing techniques and fishery by-products.

**Practical:**

- Study of fishing gears and crafts
- Visit to fish landing centers and processing plants
- Submission of report

**Recommended Books**

1. Kumar P.S. (2009). Fishery Technology. APH Publishing, India
2. Hall D.G.M. (1997). Fish Processing Technology. Springer, USA.
3. Ali, S.S. (1999). Freshwater Fishery Biology. Naseem Book Depot, Hyderabad.
4. Regenstein, T.M. and Regenstein, C.E. (1991). Introduction to Fish Technology. CBS Pub. New Delhi, India.

**Phycology****4 (3+1)****Theory:**

Introduction to the science of Phycology: General account of algae based on criteria for classification; pigment pattern; plastids; flagellation and movement pattern; cell wall structure; storage product; nucleus; morphological diversity; reproduction (sexual and asexual), life cycle patterns, ecology, evolution and economic importance. Ecology of fresh water algae, their flora and communities: Springs, streams, rivers, ponds and lakes; the soil, snow and ice flora, aerial epiphytic and epilithic algae, epipelagic, endophytic, endozoic, epizoic algae. Algal blooms. Systematic accounts of the phylum, structure and reproduction of genera belonging to fresh water algae.

**Practical:**

- Collection of fresh water benthic algae from ponds, pools, ditches, water reservoirs, lakes, rivers and soil surfaces
- Identification of algae up to species level
- Preparation of temporary / permanent slides of various algae

**Recommended Books**

1. John D.W. and Sheath R.G. (2003). Fresh Water Algae of North America, Ecology and Classification. Academic Press, USA.
2. John, D.M., Whitton, B.A and Brook, A.J. (2002). The Freshwater Algal Flora of the British Isles. Cambridge University Press, UK.
3. Lee, R.E. (1999). Phycology. Cambridge University Press, UK.
4. Hoek, C. V.D., Mann, D. G. and Jahns, H. M. (1995). Algae: An introduction to Phycology. Cambridge University Press, UK.
5. Bold, H. C. and Wynne, M. J. (1985). Introduction to the Algae: Structure and Reproduction. Prentice Hall Inc. Englewood Cliffs.

## **Freshwater Invertebrates**      4 (3+1)

### **Theory:**

Classification and species composition of various freshwater invertebrates, influence of environmental factors on the abundance and distribution of benthic organisms, role of macro fauna in the aquatic ecosystem.

### **Practical**

- Collection and study techniques, sampling, preservation and identification of benthos and nektonic fauna.
- Quantitative and qualitative analyses of benthos
- Collection and study of freshwater invertebrate fauna from various fresh water habitats.

### **Recommended Books**

1. Balian E.V. (2008). Freshwater Animal Diversity Assessment. Springer, USA.
2. Nybakken J. W. (1996). Diversity of the Invertebrates. Wm C. Brown Publisher, USA.
3. Pennak R.W. (1989). Freshwater Invertebrates of United States: Protozoa to Mollusca. Chapman and Hall Inc. New York.

## **Fisheries Biology**      3 (2+1)

### **Theory:**

Population dynamics: recruitment, natality and mortality, food and feeding behavior, reproduction, fecundity and reproductive behavior of fish, fundamental links in the life cycles of the fish and their migration, fisheries statistics.

### **Practical:**

- Analyses of fish gut contents
- Population estimation of fish
- Determination of fecundity in fish

### **Recommended Books**

1. Moyle, P.B. and Cech, J.J. (2004). Fishes: An Introduction to Ichthyology. Pearson Prentice Hall, New Jersey, USA.
2. Bone, Q. and Marshall, N.B. (2004). Biology of Fishes. Chapman and Hall Inc. New York.
3. Lagler, K.F. Baradach, J.E. and Miller, R.R. (2003). Ichthyology. John Wiley and Sons, Inc., New York.

## **Aquatic Macrophytes**

**3 (2+1)**

### **Theory:**

Introduction to macrophytes, characteristics, classification of common macrophytes, methods of identification and preservation; qualitative and quantitative analyses (quadrant, plotless and Bitterlich); concept of cover, abundance and productivity; influence of vegetation on aquatic biota; brief account of vegetation of saline and marshy areas; economic importance of macrophytes, control measures of aquatic weeds in ponds, lakes and reservoirs.

### **Practical:**

- Sampling techniques
- Identification and preservation of macrophytes
- Exercise relating to quantitative and qualitative analyses of macrophytes

### **Recommended Books**

1. Caffrey J.M. and Dutartre, A. (2006). Macrophytes in Aquatic Ecosystem: from Biology to Management. Springer, USA.
2. Naylor R. E. (2002). Weed Management Handbook. John Wiley and Sons Publishers, USA
3. Cook, C.D.K. (1996). Aquatic and Wetland Plants of India. William Dawson and sons, London.

## **Fish Breeding and Health**

**4 (3+1)**

### **Theory:**

**Reproduction:** Fish gonads: Testes and ovaries, Maturation, Reproductive cells (egg and sperm), Artificial fertilization of sex cells.

**Breeding:** Natural (seasonal) and Artificial: Hormonal induced breeding, role of temperature & photoperiod in induced breeding

**Fish health:** Water quality criteria for fish health and breeding, Hygiene of fish culture facilities, Hygiene of equipment used in fish culture.

### **Practical:**

- Visit to various fish seed hatcheries during breeding seasons
- Study the effects of reproductive various hormone on fish maturation

### **Recommended Books**

1. M. Huet, M. (2003). Text Book of Fish Culture: Breeding and Cultivation. Fishing News Books. U.K.
2. Parker R. O. (2002). Aquaculture Science. 3<sup>rd</sup> Ed. Delmar Learning, London.
3. Meske, C. 1998. Fish Aquaculture: Technology and Experiments (2nd ed.). Pergamon Press, Oxford.



4. Landau, M. (1991). Introduction to Aquaculture. John Wiley & Son Publishers, New York.

## **Water Pollution** **3 (2+1)**

### **Theory:**

Introduction to pollutants. Type of water pollution, toxicology in relation to aquatic organisms, bio-indicators, bio-magnification, bio-remediation, bio-degradation and bio-fouling. Impact of pollution on environment. Effects of heavy metals and pesticides, effect of water pollution on human health, methods for improvement of aquatic environment.

### **Practical:**

- Analyses of water samples from polluted areas for selected parameters (BOD & COD)
- Study of pollution indicators
- Visits to polluted water bodies

### **Recommended Books**

1. Patricia, U. O. (2010). Aquatic Pollution. LAP Lambert Academic Publisher, UK.
2. Tripathi, A.K. and Pandey, S.N. (2009). Water Pollution. APH Publishing, India.
3. Goel, O.P.K. (2006). Water Pollution-Causes, Effects and Control. New Age International, India.
4. Agarwal, S.K. (2005). Water Pollution. APH Publishing, India.

## **Fish Nutrition** **3 (2+1)**

### **Theory:**

Nutrition of fish, digestion and absorption of nutrients, feeding types, energy requirements, energy partitioning. Carbohydrate, protein, fat, vitamin and mineral requirements of fish. Other dietary components viz. fiber, hormones, antibiotics, antioxidants, pigments, binders, feeding stimulants, anti-nutrients and toxins. Diet formulation and processing: low-cost feed formulation. Fish feeding relating to species, age and size. Feeders, feeding rates, feeding practices, special purpose feeding, feeding in cage culture, time of first feeding.

### **Practical:**

- Proximate composition of fish feed ingredients
- Estimation of gross energy of feed
- Formulation of fish feed by using statistical packages
- Preparation of fish feed and methods of feed storage

## **Recommended Books**

1. Godwin O. (2010). Fish Nutrition. Blackwell Publishing Ltd., USA.
2. Parker, R. O. (2004). Aquaculture Science. 4<sup>th</sup> Ed. Delmar Learning, London.
3. Halver, J.E., Ronald, W.H. and Daniel, M.H. (2004). Fish Nutrition. 4<sup>th</sup> Ed. Academic Press, New York, USA.
5. Parker, R. (1994). Aquaculture Science, Delmar Publishing, Washington D.C.
6. N.R.C. (1993). Nutrient Requirements of Fish, National Academy of Sciences.

## **Etiology of Fish Diseases**

**3 (2+1)**

### **Theory:**

General etiology of fish diseases. Prophylaxis and therapy reaction of fish. Non-pathogenic fish diseases; thermal stress, stress due to oxygen deficiency and excessive carbon dioxide, gas bubble disease, white spot disease, acidosis and alkalosis, yolk sac dropsy, poisoning, inflammation of stomach and intestine, formation of tumors. Pathogenic fish diseases: lymphocytosis, pox disease of fish, cauliflower disease, swim bladder inflammation, infectious abdominal dropsy, bacterial fin rot, bacterial gill disease, crustacean parasitic diseases.

### **Practical:**

- Collection and preservation of fish and crustacean parasites
- Preparation of parasite slides and their identifications.

## **Recommended Books**

1. Kabir, W. (2005). Handbook on Fish and Crustacean Diseases in the SAARC Region. SAARC Agricultural Information Center.
2. Pandey B.N.(2004). Fish Research. APH Publishing, India.
3. Wedemeyer, G.A., Meyer, F.P. and Smith, L. (1999). Environmental Stress and Fish Diseases. Narendra Publishing House, New Delhi.
4. Schaperclaus, W. (1991). Fish Diseases. Oxonian Press Pvt. Ltd., New Delhi.

## **Aquaculture**

**3 (2+1)**

### **Theory:**

Comparative account of basis of farming and underlying principles in various aquaculture ( open and closed) sub systems such as ponds, man made reservoirs, raceways, cages and rafts. Extensive-intensive levels of farming. Carrying capacity and means of increasing carrying capacity. Polyculture vs monoculture and sustainability issues in various farming scenarios. Water budgeting in pond and raceways. Recent trends in shell fish culture, cyprinid, cichlids, salmonids farming technology. Advancements in seed production technology. Use of biotechnology in aquaculture.

### **Practical:**

- Visits to extensive ,semi extensive, intensive and integrated fish farming systems

- Visits to ponds, reservoirs and raceways
- Report writing

### **Recommended Books**

1. VanDer Z., A.J., J., Verreth J.A.J., Tri, L., Mensvoort V., M.E.F., Bosma R.H. and Beveridge M.C.M. (2008). Fish ponds in farming systems. Wageningen Academic Publishers.
2. Stickney, R.R. (2005). Aquaculture: An introductory Text. CABI publishing, UK.
3. Parker, R. O.(2004). Aquaculture Science. 4<sup>th</sup> Ed. Delmar Learning, London.
4. Meske, C. (2000). Fish Aquaculture: Technology and Experiments. 3<sup>rd</sup> Ed. Pergamon Press, Oxford.
5. Landau, M. (1991). Introduction to Aquaculture. John Wiley and Sons Publishers, New York.

## ELECTIVE COURSES FOR BS (4 Years)

1. Integrated Fish Farming	3 (2+1)
2. Aquatic Toxicology	3 (2+1)
3. Inland Fisheries Management	3 (2+1)
4. Biotechnology in Aquaculture	3 (2+1)
5. Fish Post Harvest Technology	3 (2+1)
6. Fish Health Management	3 (2+1)
7. Water Quality Management	<u>3 (2+1)</u>
	21 (14+7)

## COURSE CONTENTS

### Integrated Fish Farming 3 (2+1)

#### Theory:

The biology of major freshwater-cultivated fishes in Pakistan, artificial propagation of major carp, grass carp, silver carp and bighead, pond fertilization and fish feeds, rearing of fry and fingerlings, pond culture of food fish. Introduction to Chinese integrated fish farming and its major models, The statistical methods of planning and management of integrated fish farms. Fish cum poultry cum livestock cum agriculture integration. Designing and construction of an integrated fish farm.

#### Practical:

- Visits of fish cum poultry cum livestock cum agriculture integrated farms
- Report writing

#### Recommended Books

1. Pandey, N. (2008). Integrated Fish Farming. Daya Publishing House, New Delhi.
2. Sandhu, G.S. (2007). Applied Ichthyology. Dominant Publishers and Distributors, New Delhi.

### Aquatic Toxicology 3 (2+1)

#### Theory:

Introduction and background of aquatic toxicology, Definitions, sources of contamination: water pollution, General concepts in toxicology. Transport of pollutants, Factor affecting distribution and fate, bioavailability and bioaccumulation, biotransformation, metabolism and de-toxication, Heavy metals, organics. Behavioral responses of fish to toxicants. Toxicity assessments and environmental regulations. Factors affecting the chronic environmental toxicity, Ecotoxicity.

### **Practical:**

- Determination of physico-chemical parameters in relation to metal's toxicity.
- Determination of acute (LC<sub>50</sub> and lethal concentrations) toxicity of metals by using Probit Curve
- Effects of chronic metals toxicity on fish growth

### **Recommended Books**

1. Blaise, C. and Ferard, J.F. (2005). Small Scale Freshwater Toxicity Investigation: Toxicity Test Methods. Springer, USA.
2. Klaasen, C.D. (2001). Casarett and Doull's Toxicology The basic science of poisons. McGraw-Hill Company, New York, USA.
3. Gary M. Rand, (2001). Fundamentals of Aquatic Toxicology, 2<sup>nd</sup> Ed. Taylor & Francis Publisher, New York.

## **Inland Fisheries Management**

**3 (2+1)**

### **Theory:**

The nature of inland waters (lakes, reservoirs, rivers, flood-plains, swamps, marshes, rice fields, lagoons), nature of inland fish populations, fisheries and fishing communities, fishing techniques, inland fishery resource evaluation, inland fisheries management, habitat management, inland fisheries enhancement, mitigation and rehabilitation of inland fisheries, biodiversity and conservation issues. Management of fish feeding. Nutritional fish diseases. Factors affecting fecundity, ecological conditions for the gonad development. Aquatic insect and their control; common freshwater aquatic weeds and their control.

### **Practical:**

- Assessment of age and growth with the help of fish scale, operculum and otolith
- Computation of length-weight relationship and condition factor
- Techniques of fish tagging and recovery
- Fish stock assessment and report writing

### **Recommended Books**

1. Lagler, K.F. Baradach, J.E. and Miller, R.R. (2003). Ichthyology. John Wiley and Sons Publishers, New York.
2. Welcome, R.L. (2002). Inland Fisheries: Ecology and Management & Hospital Industry Publication Service.
3. Rath, R.K. (2002). Freshwater Aquaculture. Scientific Publishers, Jodhpur, india.
4. APO. (2002). Coastal Fisheries Management. Asian Productivity Organization.
5. Arrignon, J. (1999). Management of Freshwater Fisheries. Oxford IBH Publishing Company, New Delhi.

## **Biotechnology in Aquaculture**

**2 (2+1)**

### **Theory:**

Principles of fish genetics, genetic basis of improvement of fish stocks, inbreeding, heterosis, designing and conducting a genetic improvement program, genetic markers, Genetic engineering and gene transfer (transgenic fish). Biotechnologies available for fish nutrition, broodstock improvement, Chromosome set manipulation, polyploidy, gynogenesis, androgenesis, Sex determination and sex control (monosex culture), Cross breeding and hybridization, Disease diagnosis using biotechnology, specific pathogen resistant stocks.

### **Practical:**

- Study of fish endocrine and reproductive organs
- Study of various stages of fish maturation
- Visit to fish hatchery

### **Recommended Books**

1. Kumar, R. (2010). Biotechnology and genetics in fisheries and aquaculture. Blackwell Publishing.
2. Stickney, R.R. (2009). Aquaculture: An introductory Text. CABI publishing, UK.
3. Dunham, R.A. (2004). Aquaculture and Fisheries Biotechnology: Genetic approaches. CABI publishing, UK.
3. Sarkar, S.K. (2002). Freshwater fish culture.Vol.1. Daya Publishing House
4. Gratzek, J.B., Loiselle, P.V. and Norton, J. (1993). Fish Breeding and Genetics. Tetra Press, Melle, Germany.

## **Fish Post Harvest Technology**

**3 (2+1)**

### **Theory:**

Nutritive value of fish, Concept of freshness, Concept of quality, Hygiene and sanitation, Fish spoilage, Traditional and modern methods of fish preservation, (drying, salting, fermentation, smoking, canning, ice-storage, cold-storage, freezing), Convenient fish food, quality control of fish and fishery products, food Safety management System, quality control of fishery products. Fish icing procedures; off loading; on shore handling; transportation to fish markets; various ways of fish disposal; effects of feed on the product: flavor and taints; texture; fish preservation and processing methods; chilled storage life; freezing and frozen storage; chemistry of freezing; pickling; packaging; fish filleting and packing; shelf life of fish food products; packaging; assessment of fish quantity; fish pastes; special processing procedures (minced fish, surimi products, gelation International standards; food laws; food safety and value addition.

### **Practical:**

- Preparation of a brief report on the quality of fish collected from the market
- Methods of fish preservation ,
- Proximate composition of fish and shellfish

## Recommended Books

1. Pearson, A.M. and Dutson, T.R.(2004) HACCP in Meat, Poultry & Fish Processing. Kluwer Academic Publishers.
2. Lucas, J.S. and Southgate, P.C. (2003). Aquaculture: Farming Aquatic Animals and Plants. Fishing News Books, Blackwell Publishing, Australia.
3. NIIR (2003). Hand Book on Fisheries & Aquaculture Technology. Asia Pacific Business Press Inc., New Delhi.
4. Regestein, J.M. and Regestein, C.E. (1997). Introduction to fish Technology. CBS Publishers & Distributors, New Delhi.
5. Breamner, H. A. Safety & Quality Issues in Fish Processing. Wood Head Publishing Ltd.
6. Hall, G. M. (1996). Fish Processing Technology. Kluwer Academic Publishers.

## Fish Health Management 3 (2+1)

### Theory:

Significance of fish health and disease implications in aquaculture. Health vulnerability under various levels of farming systems. Symptoms and disease diagnostics. Environment-disease relationship. Stress and Nutrition-related disease. Pathogenicity and disease prognosis in culture able fishes. An account of viral, bacterial, fungal and algal diseases. Parasites and vector-borne organisms and allied health problems. Fish immunology. Fish health management through physical, biological and chemical instruments/means.

### Practical:

- Diagnostic evaluation of skin, gills, fins and viscera
- Pathological examination of fish
- Isolation, collection and identification of fish pathogens

## Recommended Books

1. Stickney, R.R. (2009). Aquaculture: An introductory Text. CABI publishing.
2. Pillay, T.V.R., Kutty, M.N. (2005). Aquaculture: principles and practices. Blackwell publishing.
3. Sarkar, S.K. (2002). Freshwater fish culture. Vol.1. Daya Publishing House.
4. Noga, E.J. (2000). Fish Disease: Diagnosis and Treatment. Blackwell Publishing Professional implication.
5. Mirza, M.R. and Bhatti, M.N. (1993). Pakistan Ki Machlian aur Mahi Parwari Part-II. Ferozesons (Pvt.) Ltd., Lahore, Pakistan.

## Water Quality Management 3 (2+1)

### Theory:

Introduction to water quality concepts. Physico-chemical characters of lakes. Lake communities: plankton, (phytoplankton and zooplankton). Collection and preservation of samples, Impact of water quality on plankton, (phytoplankton and zooplankton). Impact of water quality on major carps (i.e. *Labeo rohita*, *Catla catla*,

*Cirrhinus, mrigala and Cyprinus carpio*). Impact of water quality on cat fishes (i.e. *Wallago attu, Mystus cavasius, Rita rita, Bagarius bagarius* and *Ompok pabda*). Fate and dynamics of metal pollution in water. Adverse effects of toxic metals on plankton. Adverse effects of toxic metals on major carps and catfish.

**Practical:**

- Analyses of physico-chemical characteristics of water
- Collection & preservation of samples, identification of nekton and plankton

**Recommended Books**

1. Pillay, T.V.R. and Kutty, M.N. (2005). Aquaculture: Principle and practices. Wiley-Blackwell, USA.
2. Boyd, C.E., Graig, T. (1998). Pond Aquaculture, Water Quality Management. Kilmer Academic Publisher.
3. Huet, M.and Timmerman, J.A. (1994). Text Book of Fish Culture: Breeding and Cultivation. Fishing News Books, U.K.
4. Rath, R.H. (1993). Freshwater Aquaculture. Scientific Publishers, India.
5. Boyd, C.E. (1981). Water quality in warm water fish ponds, Craftmaster printers Inc. Opelika, Alabama.



# MS (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:

1. Fisheries Regulations and Administration	4 (4+0)
2. Advances in Aquaculture–I	4 (3+1)
3. Advances in Aquaculture–II	4 (3+1)
4. Advanced Eco-toxicology	4 (3+1)
5. Advanced Phytoplanktology	4 (3+1)
6. Lake Management	4 (3+1)
7. Research Methodology	4 (0+4)
8. Fish Processing and Quality Assurance	4 (3+1)
9. Fish Breeding and Hatchery Management	4 (3+1)
	<b>36 (25+11)</b>

## COURSE CONTENTS:

### Fisheries Regulations and Administration 4 (4+0)

#### Theory:

Introduction to organizations and administration of fisheries at the federal and provincial levels; responsibilities; 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 & legislations (CBD, Ramsar Convention UNCLOS, etc., fish inspection and quality control systems, WTO regime (SPS, AOA, TBT, TRIP).

#### Recommended Books

1. American and International Aquaculture Law. (2000). Henry D McCoy II Blackwell Publications, USA.
2. Alternative Management Systems for Fisheries (1999). David Symes, Blackwell Publications.
3. The WTO Agreement on Sanitary and Phytosanitary Measures: A Commentary (Oxford Commentaries Gatt/WTO Agreements) Joanne Scott, 2007. Oxford University Press, London.

### Advances in Aquaculture-I 4 (3+1)

#### Theory:

History of aquaculture development in the world. Advances in pond, pen, cage, raceway and close-water systems. Feed formulation, preparation and processing for culture able species. Selection of feed ingredients and preparation of pelleted

feed. Techniques and methodologies for fish feeding experiments in control and field conditions. Economics of supplemental and complete feeding. Culture and rearing techniques of high value fish species in Pakistan.

**Practical:**

- Collection of conventional and non-conventional feed stuffs, grinding and sieving of feed ingredients, market survey for the indigenous (low-cost) feed ingredients. Preparation of pellet feed for the rearing of carp and snakeheads.

**Recommended Books**

1. Pillay, T.V.R. and Kutty, M.N. (2005). Aquaculture: Principle and practices. Wiley-Blackwell, USA.
2. Ali, S. S. (1999). Fresh Water Fishery Biology. Naseem Book Depot, Hyderabad, Pakistan.

**Advances in Aquaculture –II**

**4 (3+1)**

**Theory:**

Principles of modern aquaculture: water quality management, biological and mechanical filtration, disinfection, toxicity and disease prevention, species selection, seed production and culture of fresh water prawn, crabs and mussel. Grow out, feeding harvesting, marketing and economics shellfish culture. Rotifer and brine shrimp culture and their uses as live food for fish and shell fish.

**Practical:**

- Identification of male and female shellfish crabs and prawns
- Rotifer and brine shrimp culture
- Visit to fish and prawn hatcheries

**Recommended Books**

1. Chakraborty C. and Sadhu, A.K. (2003). Biology, Hatchery, Culture Technology of Tiger Prawn and Giant Freshwater Prawn. Daya Publishing House, New Delhi.
2. Thomas R. and Mahapatra (2003). Breeding and Seed Production of Finfish and shellfish. Daya Publishing House New Delhi, India.
3. Ali, S.S. (1999). Fresh Water Fishery Biology. Naseem Book Depot, Hyderabad, Pakistan.

**Advanced Eco-toxicology**

**4 (3+1)**

**Theory:**

Classification of pollutants, environmental pollution, their origin and effects on aquatic animals. Evaluation of the effects of toxic compounds on aquatic organisms, Acute and chronic responses of fish to aquatic toxicants. Interactions

among ecosystem components for the uptake and flow of toxicants in water bodies. Biological effects of toxic substances on fish: cellular and tissues targets.

**Practical:**

- Preparation of different stock solutions of toxicants
- Toxicity testing (LC<sub>50</sub>, LD<sub>50</sub> and lethal concentration)
- Observation of acute and lethal effects on fish

**Recommended Books**

1. Adel, D. (2007). Water Pollution Biology. CRC Press, USA.
2. Mason, C.F. (2002). Biology of Freshwater Pollution. Prentice Hall, USA.
3. Coler, R.A. and Rockwood, J. (1989). Water Pollution Biology. Technomic Publishing Company, USA.

**Advanced Phytoplanktology**

**(3+1)**

**Theory:**

Seasonal succession and community structure of phytoplankton, environmental variability and algal blooms, phytoplankton communities, toxic effects of algae on drinking water. Medicinal aspects of phytoplankton. The use of phytoplankton in modern aquaculture. Human intoxication due to algal toxicity, respiratory and gastrointestinal disorders.

**Practical:**

- Preparation of media for algal culture, sampling, collection and identification of algal bloom farming species.
- Phytoplankton culture

**Recommended Books**

1. Ali S.S. and Narejo, N.T. (2009). Fundamentals of Ichthyology. Sindh University Press, Jamshoro.
2. Kapoor, G. B. and Khana, B. (2004). Ichthyology hand book. Springer, India.
3. Lagler, K.F., Baradach, J.E. and Miller, R.R. (2003). Ichthyology. John Wiley and Sons, Inc., New York.
4. Ali S.S. (1999). Fresh Water Fisheries Biology. Naseem Book Depot Hyderabad, Pakistan.

**Lake Management**

**(3+1)**

**Theory:**

Origin and classification of lakes. Properties of lake water, running and stagnant waters, lake communities and succession, saline and alkaline/sodic lakes of Sindh. Species selection, fisher folk communities, their socio-economic problems, lake recreation, conservation and uses.

**Practical:**

- Water sampling techniques
- Techniques for plankton sampling
- Techniques for the estimation of planktonic productivity

**Recommended Books**

1. Jorgenson, S. E., Loffler, H., Rast, W. and Straskraba, M. (2005). Lake and Reservoir Management. Elsevier Publications.
2. Steve, M. C. (2003). Lake and Pond Management. Guide Book. Taylor and Francis Ltd.
3. Stephen, T. T. (2000). Water Quality Processes and Policy. John Wiley and Sons Publishers, New York.
4. Lorna, F. (2000). Water Quality Guidelines, standard and Health, World Health Organization, Geneva.

**Research Methodology****(0+4)****Theory:**

Collection, preservation and transportation of samples (fish, water, prawn, crab) for laboratory studies/analyses. Use of computer packages for research studies, scientific report writing, synopsis, manuscript and thesis writing, paper and poster presentation.

**Fish Processing and Quality Assurance****4 (3+1)****Theory:**

Biological preservation, fermentation, biochemical dynamics and quality of fresh and frozen fish, the role of body constituents in governing fish quality, methods of assessing and selecting for quality microbiology of products, identifying allergens in fish, identification of heavy metals in fish, rapid detection of sea food toxins, preservation of fish, traditional preservation (curing, drying, salting, smoking), new preservation techniques, shrimp products, fish mince, chilling and freezing of fish, canning fish and fish products, concepts of quality and freshness in fish.

**Practical:**

- Detection of microorganisms
- Techniques for microbial studie
- Biochemical analyses of fish products
- Tests for freshness and food safety

**Recommended Books**

1. FDA. (2003). Fish and Fisheries Products Hazards and Control Guidance. US Food and Drug Administration.
2. Bremner, H. A. (2002). Safety and Quality issues in fish processing. Woodhead publishing Limited, Cambridge, England.

3. Connell, J.J. (2001). Control of Fish Quality. Blackwell Science
4. Hall, G.M. (1996). Fish Processing Technology. Kluwer Academic Publishers.
5. Regestein, J.M. and Regestein, C.E. (1997). Introduction to fish Technology. CBS Publishers & Distributors, New Delhi.
6. Martin, R.E., Collette, R.L. and Slavin, J. 1997. Fish Inspection, Quality Control, and HACCP, A Global Focus. Technomic Publishing Co. Inc.

## **Fish Breeding and Hatchery Management      4 (3+1)**

### **Theory:**

Fish Hatchery, Types of ponds on Hatchery: Nursery ponds, rearing ponds, Brood fish ponds/ Stocking Ponds. Hatchery Building and its requirements, Glass Jar Hatchery, Grow-out ponds, Brood stock management and conditioning, identifying the sexes, Assessment of male and female ripeness, Spawning methods, Egg stripping, gamete quality, Egg fertilization, Egg enumeration, Egg development, Egg incubation, Egg care, larval rearing of finfish/shellfish, Fish seed rearing techniques.

### **Practical:**

- Visit to fish hatchery
- Feasibility report of fish hatchery
- Induced spawning techniques, striping and fertilization
- Estimation of egg and fry numbers
- Fish seed packing and transport

### **Recommended Books**

1. Stickney, R.R. (2005). Aquaculture: An Introductory Text. CABI Publishing, UK.
2. Pillay, T.V.R. and Kutty, M.N. (2005). Aquaculture: Principle and Practices. Wiley-Blackwell, USA.
3. Boyd, C.E., Graig, T. (1998). Pond Aquaculture, Water Quality Management. Kilmer Academic Publisher
4. Huet, M. and Timmerman, J.A. (1994). Text Book of Fish Culture: Breeding and Cultivation. Fishing News Books, U.K.
5. Rath, R.H. (1993). Freshwater Aquaculture. Scientific Publishers, India.

# RECOMMENDATIONS

## Future Proposed Courses

- a) Fish Genetics
- b) Endocrinology
- c) Fish microbiology/Immunology
- d) 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.

**COMPULSORY COURSES IN ENGLISH FOR  
BS 4-YEAR**

**English I (Functional English)**

**Objectives:** To enhance language skills and develop critical thinking.

**Course Contents**

Basics of Grammar  
Parts of speech and use of articles  
Sentence structure, active and passive voice  
Practice in unified sentence  
Analysis of phrase, clause and sentence structure  
Transitive and intransitive verbs  
Punctuation and spelling

**Comprehension**

Answers to questions on a given text

**Discussion**

General topics and every-day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students)

**Listening**

To be improved by showing documentaries/films carefully selected by subject teachers

**Translation skills**

Urdu to English

**Paragraph writing**

Topics to be chosen at the discretion of the teacher

**Presentation skills**

Introduction

**Note:** *Extensive reading is required for vocabulary building*

**Recommended books:**

1. **Functional English**
  - a) Grammar
    1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 1. Third edition. Oxford University Press. 1997. ISBN 0194313492
    2. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press. 1997. ISBN 0194313506
  - b) Writing
    1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Françoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.
  - c) Reading/Comprehension
    1. Reading. Upper Intermediate. Brain Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0194534022.

- d) Speaking

## **English II (Communication Skills)**

**Objectives:** To enable the students to meet their real life communication needs.

### **Course Contents**

#### **Paragraph writing**

Practice in writing a good, unified and coherent paragraph

#### **Essay writing**

Introduction

#### **CV and job application**

Translation skills

Urdu to English

#### **Study skills**

Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension

#### **Academic skills**

Letter/memo writing, minutes of meetings, use of library and internet

#### **Presentation skills**

Personality development (emphasis on content, style and pronunciation)

**Note:** *documentaries to be shown for discussion and review*

### **Recommended books**

#### **Communication Skills**

a) Grammar

1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 019 431350 6.

b) Writing

1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Françoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0194354057 Pages 45-53 (note taking).
2. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0194354065 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).



- c) Reading
1. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0194534030.
  2. Reading and Study Skills by John Langan
  3. Study Skills by Riachard Yorkey.

## **English III (Technical Writing and Presentation Skills)**

**Objectives:** To enhance language skills and develop critical thinking

### **Course Contents**

#### **Presentation skills**

#### **Essay writing**

Descriptive, narrative, discursive, argumentative

#### **Academic writing**

How to write a proposal for research paper/term paper

How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency)

#### **Technical Report writing**

#### **Progress report writing**

*Note: Extensive reading is required for vocabulary building*

### **Recommended Books**

#### Technical Writing and Presentation Skills

- a) Essay Writing and Academic Writing
1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).
  2. College Writing Skills by John Langan. Mc-Graw-Hill Higher Education. 2004.
  3. Patterns of College Writing (4<sup>th</sup> edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.

b) Presentation Skills

c) Reading

The Mercury Reader. A Custom Publication. Compiled by northern Illinois University. General Editors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharon. (A reader which will give students exposure to the best of twentieth century literature, without taxing the taste of engineering students).

## Pakistan Studies (Compulsory)

### Introduction/Objectives

- Develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan.
- Study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

### Course Outline

#### 1. Historical Perspective

- a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-Azam Muhammad Ali Jinnah.
- b. Factors leading to Muslim separatism
- c. People and Land
  - i. Indus Civilization
  - ii. Muslim advent
  - iii. Location and geo-physical features.

#### 2. Government and Politics in Pakistan

Political and constitutional phases:

- a. 1947-58
- b. 1958-71
- c. 1971-77
- d. 1977-88
- e. 1988-99
- f. 1999 onward

#### 3. Contemporary Pakistan

- a. Economic institutions and issues
- b. Society and social structure
- c. Ethnicity
- d. Foreign policy of Pakistan and challenges
- e. Futuristic outlook of Pakistan

### Books Recommended

1. Burki, Shahid Javed. *State & Society in Pakistan*, The Macmillan Press Ltd 1980.
2. Akbar, S. Zaidi. *Issue in Pakistan's Economy*. Karachi: Oxford University Press, 2000.
3. S.M. Burke and Lawrence Ziring. *Pakistan's Foreign policy: An Historical analysis*. Karachi: Oxford University Press, 1993.
4. Mehmood, Safdar. *Pakistan Political Roots & Development*. Lahore, 1994.
5. Wilcox, Wayne. *The Emergence of Banglades.*, Washington: American Enterprise, Institute of Public Policy Research, 1972.

6. Mehmood, Safdar. *Pakistan Kayyun Toota*, Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.
7. Amin, Tahir. *Ethno - National Movement in Pakistan*, Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development*. Kent England: WmDawson & sons Ltd, 1980.
9. Zahid, Ansar. *History & Culture of Sindh*. Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. *Political Parties in Pakistan*, Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
11. Sayeed, Khalid Bin. *The Political System of Pakistan*. Boston: Houghton Mifflin, 1967.
12. Aziz, K.K. *Party, Politics in Pakistan*, Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, *Pakistan Under Martial Law*, Lahore: Vanguard, 1987.
14. Haq, Noor ul. *Making of Pakistan: The Military Perspective*. Islamabad: National Commission on Historical and Cultural Research, 1993.

## ISLAMIC STUDIES (Compulsory)

### Objectives:

This course is aimed at:

- 1 To provide Basic information about Islamic Studies
- 2 To enhance understanding of the students regarding Islamic Civilization
- 3 To improve Students skill to perform prayers and other worships
- 4 To enhance the skill of the students for understanding of issues related to faith and religious life.

### Detail of Courses

#### Introduction to Quranic Studies

- 1) Basic Concepts of Quran
- 2) History of Quran
- 3) Uloom-ul -Quran

#### Study of Selected Text of Holly Quran

- 1) Verses of Surah Al-Baqra Related to Faith (Verse No-284-286)
- 2) Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
- 3) Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
- 4) Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
- 5) Verses of Surah Al-Inam Related to Ihkam (Verse No-152-154)

#### Study of Selected Text of Holly Quran

- 1) Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No. 6,21,40,56,57,58.)
- 2) Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
- 3) Verses of Surah Al-Saf Related to Tafakar,Tadabar (Verse No-1,14)

#### Seerat of Holy Prophet (S.A.W) I

- 1) Life of Muhammad Bin Abdullah ( Before Prophet Hood)
- 2) Life of Holy Prophet (S.A.W) in Makkah
- 3) Important Lessons Derived from the life of Holy Prophet in Makkah

#### Seerat of Holy Prophet (S.A.W) II

- 1) Life of Holy Prophet (S.A.W) in Madina
- 2) Important Events of Life of Holy Prophet in Madina
- 3) Important Lessons Derived from the life of Holy Prophet in Madina

#### Introduction to Sunnah

- 1) Basic Concepts of Hadith

- 2) History of Hadith
- 3) Kinds of Hadith
- 4) Uloom –ul-Hadith
- 5) Sunnah & Hadith
- 6) Legal Position of Sunnah

## **Selected Study from Text of Hadith**

### **Introduction To Islamic Law & Jurisprudence**

- 1) Basic Concepts of Islamic Law & Jurisprudence
- 2) History & Importance of Islamic Law & Jurisprudence
- 3) Sources of Islamic Law & Jurisprudence
- 4) Nature of Differences in Islamic Law
- 5) Islam and Sectarianism

### **Islamic Culture & Civilization**

- 1) Basic Concepts of Islamic Culture & Civilization
- 2) Historical Development of Islamic Culture & Civilization
- 3) Characteristics of Islamic Culture & Civilization
- 4) Islamic Culture & Civilization and Contemporary Issues

### **Islam & Science**

- 1) Basic Concepts of Islam & Science
- 2) Contributions of Muslims in the Development of Science
- 3) Quran & Science

### **Islamic Economic System**

- 1) Basic Concepts of Islamic Economic System
- 2) Means of Distribution of wealth in Islamic Economics
- 3) Islamic Concept of Riba
- 4) Islamic Ways of Trade & Commerce

### **Political System of Islam**

- 1) Basic Concepts of Islamic Political System
- 2) Islamic Concept of Sovereignty
- 3) Basic Institutions of Govt. in Islam

### **Islamic History**

- 1) Period of Khlaft-E-Rashida
- 2) Period of Ummayyads
- 3) Period of Abbasids

### **Social System of Islam**

- 1) Basic Concepts of Social System of Islam
- 2) Elements of Family
- 3) Ethical Values of Islam

### **Reference Books**

- 1) Hameed ullah Muhammad, "Emergence of Islam" , IRI, Islamabad

- 2) Hameed ullah Muhammad, "Muslim Conduct of State"
- 3) Hameed ullah Muhammad, 'Introduction to Islam
- 4) Mulana Muhammad Yousaf Islahi,"
- 5) Hussain Hamid Hassan, "An Introduction to the Study of Islamic Law" leaf Publication, Islamabad, Pakistan.
- 6) Ahmad Hasan, "Principles of Islamic Jurisprudence" Islamic Research Institute, International Islamic University, Islamabad (1993)
- 7) Mir Waliullah, "Muslim Jurisprudence and the Quranic Law of Crimes" Islamic Book Service (1982).
- 8) H.S. Bhatia, "Studies in Islamic Law, Religion and Society" Deep & Deep Publications New Delhi (1989).
- 9) Dr. Muhammad Zia-ul-Haq, "Introduction to Al Sharia Al Islamia" Allama Iqbal Open University, Islamabad (2001).

Note: One course will be selected from the following six courses of Mathematics.

**COMPULSORY MATHEMATICS  
COURSES FOR BS (4-YEAR)**

**(FOR STUDENTS NOT MAJORING IN  
MATHEMATICS)**

**1. MATHEMATICS I (ALGEBRA)**

**Prerequisite (s):** Mathematics at secondary level

**Credit Hours:** 3 + 0

**Specific Objectives of the Course:** To prepare the students, not majoring in mathematics, with the essential tools of algebra to apply the concepts and the techniques in their respective disciplines.

**Course Outline:**

*Preliminaries:* Real-number system, complex numbers, introduction to sets, set operations, functions, types of functions.

*Matrices:* Introduction to matrices, types, matrix inverse, determinants, system of linear equations, Cramer’s rule.

*Quadratic Equations:* Solution of quadratic equations, qualitative analysis of roots of a quadratic equations, equations reducible to quadratic equations, cube roots of unity, relation between roots and coefficients of quadratic equations.

*Sequences and Series:* Arithmetic progression, geometric progression, harmonic progression.

*Binomial Theorem:* Introduction to mathematical induction, binomial theorem with rational and irrational indices.

*Trigonometry:* Fundamentals of trigonometry, trigonometric identities.

**Recommended Books**

Dolciani MP, Wooton W, Beckenback EF, Sharron S, *Algebra 2 and Trigonometry*, 1978, Houghton & Mifflin,

**Boston (suggested text)**

Kaufmann JE, *College Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston



Swokowski EW, *Fundamentals of Algebra and Trigonometry* (6<sup>th</sup> edition), 1986, PWS-Kent Company, Boston

## 2. MATHEMATICS II (CALCULUS)

**Prerequisite (s):** Mathematics I (Algebra)

**Credit Hours:** 3 + 0

**Specific Objectives of the Course:** To prepare the students, not majoring in mathematics, with the essential tools of calculus to apply the concepts and the techniques in their respective disciplines.

### Course Outline:

*Preliminaries:* Real-number line, functions and their graphs, solution of equations involving absolute values, inequalities.

*Limits and Continuity:* Limit of a function, left-hand and right-hand limits, continuity, continuous functions.

*Derivatives and their Applications:* Differentiable functions, differentiation of polynomial, rational and transcendental functions, derivatives.

*Integration and Definite Integrals:* Techniques of evaluating indefinite integrals, integration by substitution, integration by parts, change of variables in indefinite integrals.

### Recommended Books

Anton H, Bevens I, Davis S, *Calculus: A New Horizon* (8<sup>th</sup> edition), 2005, John Wiley, New York

Stewart J, *Calculus* (3<sup>rd</sup> edition), 1995, Brooks/Cole (suggested text)

Swokowski EW, *Calculus and Analytic Geometry*, 1983, PWS-Kent Company, Boston

Thomas GB, Finney AR, *Calculus* (11<sup>th</sup> edition), 2005, Addison-Wesley, Reading, Ma, USA

## 3. MATHEMATICS III (GEOMETRY)

**Prerequisite (s):** Mathematics II (Calculus)

**Credit Hours:** 3 + 0

**Specific Objectives of the Course:** To prepare the students, not majoring in mathematics, with the essential tools of geometry to apply the concepts and the techniques in their respective disciplines.

## **Course Outline:**

*Geometry in Two Dimensions:* Cartesian-coördinate mesh, slope of a line, equation of a line, parallel and perpendicular lines, various forms of equation of a line, intersection of two lines, angle between two lines, distance between two points, distance between a point and a line.

*Circle:* Equation of a circle, circles determined by various conditions, intersection of lines and circles, locus of a point in various conditions.

*Conic Sections:* Parabola, ellipse, hyperbola, the general-second-degree equation

## **Recommended Books:**

Abraham S, *Analytic Geometry*, Scott, Freshman and Company, 1969

Kaufmann JE, *College Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston

Swokowski EW, *Fundamentals of Algebra and Trigonometry* (6<sup>th</sup> edition), 1986, PWS-Kent Company, Boston

## **INTRODUCTION TO STATISTICS**

Credit hrs: 3(3-0)

### **Unit 1. What is Statistics?**

Definition of Statistics, Population, sample Descriptive and inferential Statistics, Observations, Data, Discrete and continuous variables, Errors of measurement, Significant digits, Rounding of a Number, Collection of primary and secondary data, Sources, Editing of Data. Exercises.

### **Unit 2. Presentation of Data**

Introduction, basic principles of classification and Tabulation, Constructing of a frequency distribution, Relative and Cumulative frequency distribution, Diagrams, Graphs and their Construction, Bar charts, Pie chart, Histogram, Frequency polygon and Frequency curve, Cumulative Frequency Polygon or Ogive, Histogram, Ogive for Discrete Variable. Types of frequency curves. Exercises.

### **Unit 3. Measures of Central Tendency**

Introduction, Different types of Averages, Quantiles, The Mode, Empirical Relation between Mean, Median and mode, Relative Merits and Demerits of various Averages. properties of Good Average, Box and Whisker Plot, Stem and Leaf Display, definition of outliers and their detection. Exercises.

### **Unit 4. Measures of Dispersion**

Introduction, Absolute and relative measures, Range, The semi-Inter-quartile Range, The Mean Deviation, The Variance and standard deviation, Change of origin and scale, Interpretation of the standard Deviation, Coefficient of variation, Properties of variance and standard Deviation, Standardized variables, Moments and Moments ratios. Exercises.

### **Unit 5. Probability and Probability Distributions**

Discrete and continuous distributions: Binomial, Poisson and Normal Distribution. Exercises

### **Unit 6. Sampling and Sampling Distributions**

Introduction, sample design and sampling frame, bias, sampling and non sampling errors, sampling with and without replacement, probability and non-probability sampling, Sampling distributions for single mean and proportion, Difference of means and proportions. Exercises.

### **Unit 7. Hypothesis Testing**

Introduction, Statistical problem, null and alternative hypothesis, Type-I and Type-II errors, level of significance, Test statistics, acceptance and rejection regions, general procedure for testing of hypothesis. Exercises.

### **Unit 8. Testing of Hypothesis- Single Population**

Introduction, Testing of hypothesis and confidence interval about the population mean and proportion for small and large samples, Exercises

### Unit 9. **Testing of Hypotheses-Two or more Populations**

Introduction, Testing of hypothesis and confidence intervals about the difference of population means and proportions for small and large samples, Analysis of Variance and ANOVA Table. Exercises

### Unit 10. **Testing of Hypothesis-Independence of Attributes**

Introduction, Contingency Tables, Testing of hypothesis about the Independence of attributes. Exercises.

### Unit 11. **Regression and Correlation**

Introduction, cause and effect relationships, examples, simple linear regression, estimation of parameters and their interpretation.  $r$  and  $R^2$ . Correlation. Coefficient of linear correlation, its estimation and interpretation. Multiple regression and interpretation of its parameters. Examples

### **Recommended Books**

- 1 Walpole, R. E. 1982. "Introduction to Statistics", 3<sup>rd</sup> Ed., Macmillan Publishing Co., Inc. New York.
- 2 Muhammad, F. 2005. "Statistical Methods and Data Analysis", Kitab Markaz, Bhawana Bazar Faisalabad.

#### *Note: **General Courses from other Departments***

Details of courses may be developed by the concerned universities according to their Selection of Courses as recommended by their Board of Studies.