

CURRICULUM
OF
FRESH WATER BIOLOGY AND
FISHERIES
BS

(Revised 2016)



HIGHER EDUCATION COMMISSION
ISLAMABAD

CURRICULUM DIVISION, HEC

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PREFACE

The curriculum, with varying definitions, is a plan of the teaching-learning process that students of an academic programme are required to undergo. It includes objectives and learning outcomes, course contents, scheme of studies, teaching methodologies and methods of assessment of learning. Knowledge in all academic disciplines is expanding and even new disciplines are also emerging, it is imperative that curriculum are developed and revised regularly.

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

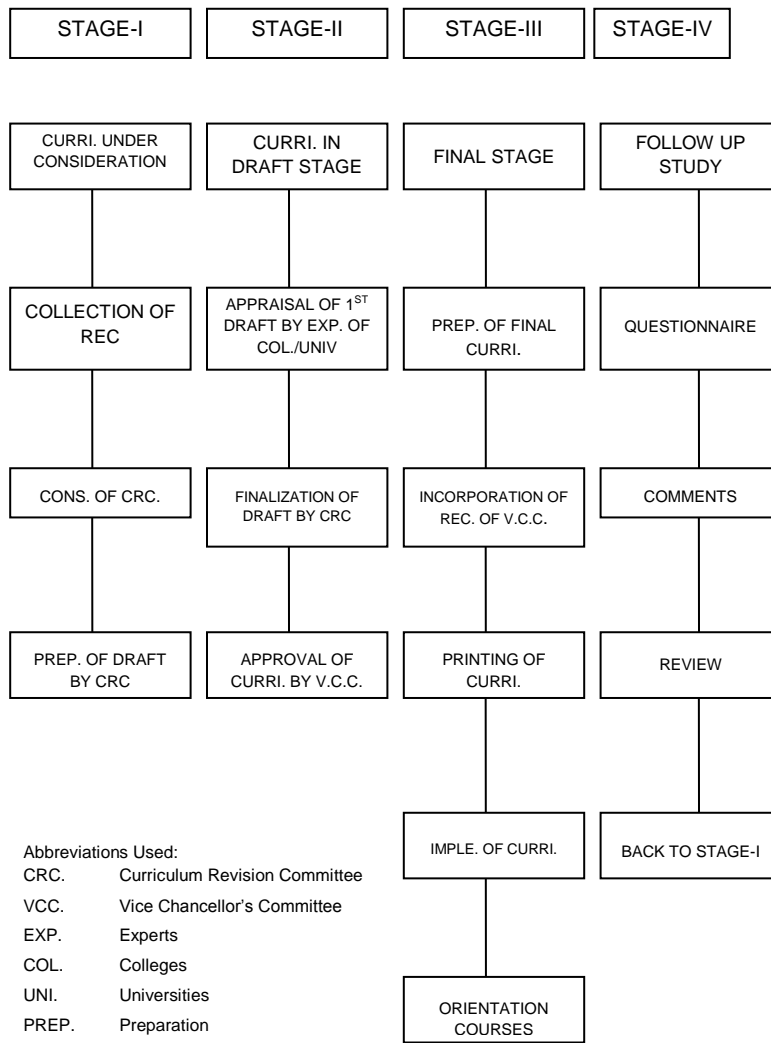
In compliance with the provisions, the Curriculum Division of HEC undertakes the revision of curricula after every three years through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector universities,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

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

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

(Fida Hussain)
Director General (Academics)

CURRICULUM DEVELOPMENT PROCESS



INTRODUCTION

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

- | | | |
|-----|---|----------|
| 01. | Prof. Dr. Naeem Tariq Narejo Professor Department of Freshwater Biology and Fisheries University of Sindh, Jamshoro | Convener |
| 02. | Prof. Dr. Shahida Husnain Vice Chancellor Department of Molecular Biology & Genetics, The Women University Campus, Multan | Member |
| 03. | Dr. Muhammad Arshad Professor/ Chairman Department of Zoology, University of South Asia 47 Tufail road, Lahore | Member |
| 04. | Dr. Muhammad Afzal The Principal Scientific Officer Aquaculture & Fisheries Program National Agriculture Research Council Chak Shahzad, Islamabad | Member |
| 05. | Dr. Punhal Khan Lashari Associate Professor Department of Freshwater Biology and Fisheries University of Sindh, Jamshoro | Member |
| 06. | Dr. Muhammad Siddique Awan Chairman/Associate Professor Department of Zoology, University of Azad Jammu Kashmir Muzaffarabad | Member |
| 07. | Dr. Shahid Raza Dean/Director Department of Biological Science, University of South Asia, 47 Tufail road, Lahore | Member |
| 08. | Dr. Muhammad Shoaib Associate Professor, Department of Zoology, University of Karachi | Member |
| 09. | Dr. Muhammad Naeem | Member |

- Professor, Institute of molecular Biology & Biotechnology, BZU, Multan
10. Dr. Adeela Haroon Member
Assistant Professor
Department of Botany, The Woman University
Multan, Karachi Campus, LMQ, Road Multan, Multan
 11. Dr. Khalid Abbas Member
Assistant Professor
Department of Zoology, Wild life & Fisheries,
University Agriculture, Faisalabad, Faisalabad
 12. Dr. Kifayat ullah Khan Member
Assistant Professor
Department of Environmental & Conversation
Science, Main Campus, University of Sawat,
Sawat KPK
 13. Dr. Zaigham Hasan Member
Assistant Professor, Department of Zoology,
Zoology, University of Peshawar, Peshawar
 14. Dr. M. Nasir Khan Khatak Member
Assistant Professor, Department of Zoology,
Hazara University, Mansehra
 15. Dr. Amina Zubari Secretary/ Member
Assistant Professor
Department of Animal Sicnec,
Quaid e azam University Islamabad
 16. Dr. Muhammad Hafiz- Ur- Rehman Member
Assistant Professor, Department of Fisheries
and Aquaculture, University of Veterinary &
Animal Sciences, Lahore
 17. Dr. Rehan Iqbal Member
Assistant Professor, Institute of molecular
Biology & Biotechnology, BZU, Multan
 18. Dr. Ghulam Abbas Member
Assistant Professor
Center of Excellence, in Marine Biology,
University of Karachi, Karachi
 19. Ghayyur Fatima Member
Director (Curriculum) HEC, Islamabad

BS (4-Years) and MS (2-Years) DEGREES IN FRESHWATER BIOLOGY AND FISHERIES

Freshwater Biology and 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 and 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 systematic, anatomy, physiology, behavior, 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's 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 and Fisheries, the graduates and post-graduates will be able to get jobs in a wide range of professions in various government and nongovernmental 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, practicals, 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 FRESHWATER BIOLOGY AND FISHERIES

Courses of studies in Freshwater Biology and Fisheries

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

Duration 4 years (Eight semesters): 136 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 Freshwater Biology will have to complete following courses:

| Semester/Year | Name of Subject | Credits |
|---------------|--|---------|
| First | COMPULSORY-I (ENGLISH-I) | 3 |
| | COMPULSORY-II ISLAMIC STUDIES / ETHICS | 2 |
| | COMPULSORY-III MATH/STAT-I | 3 |
| | GENERAL-I (ZOOLOGY-I) | 3 |
| | FOUNDATION-I (INTRODUCTORY FRESHWATER BIOLOGY) | 4 |
| | GENERAL-II (PLANT DIVERSITY) | 3 |
| | | 18 |
| Second | COMPULSORY-IV (ENGLISH-II) | 3 |
| | COMPULSORY-V PAKISTAN STUDIES | 2 |
| | COMPULSORY-VI (MATH/STAT-II / UNIV. OPTIONAL) | 3 |
| | FOUNDATION -II BIostatistics, | 3 |
| | FOUNDATION-III (ICHTHYOLOGY) | 4 |
| | GENERAL-III (ZOOLOGY-II) | 3 |
| | | 18 |
| Third | COMPULSORY-VII (ENGLISH-III) | 3 |
| | COMPULSORY-VIII (INTRODUCTION TO COMPUTER) | 3 |
| | FOUNDATION-IV (AQUATIC MICROBIOLOGY) | 3 |
| | GENERAL-IV (BIOCHEMISTRY) | 4 |
| | GENERAL-V (PLANT PHYSIOLOGY) | 3 |
| | | 16 |

| | | |
|----------------|--|----|
| Fourth | COMPULSORY-IX (ENGLISH-IV / UNIV. OPTIONAL) | 3 |
| | FOUNDATION-V (DEVELOPMENTAL BIOLOGY) | 4 |
| | FOUNDATION-VI (INTRODUCTORY FISH CULTURE) | 4 |
| | GENERAL-VI (ANIMAL PHYSIOLOGY) | 3 |
| | GENERAL-VII (ECOLOGY) | 3 |
| | | 17 |
| Fifth | FOUNDATION-VII (LIMNOLOGY) | 4 |
| | FOUNDATION-VIII (CELL AND MOLECULAR BIOLOGY) | 4 |
| | MAJOR-I (FISH AND FISHERIES BIOLOGY) | 4 |
| | MAJOR-II (FISHERY TECHNOLOGY) | 4 |
| | | 16 |
| Sixth | FOUNDATION-IX (PHYCOLOGY) | 4 |
| | FOUNDATION-X (GENETICS) | 4 |
| | MAJOR-III (FRESH WATER INVERTEBRATES) | 4 |
| | MAJOR-IV (AQUATIC MACROPHYTES AND MANAGEMENT) | 4 |
| | | 16 |
| Seventh | MAJOR-V (FISH BREEDING AND CONSERVATION) | 4 |
| | MAJOR-VI (WATER POLLUTION) | 4 |
| | MAJOR- VII RESEARCH PROJECT / INTERNSHIP | 3 |
| | ELECTIVE-I | 3 |
| | ELECTIVE-II | 3 |
| | | 17 |
| Eight | MAJOR-VIII (FISH NUTRITION) | 4 |
| | MAJOR-IX (FISH HYGIENE AND DISEASE MANAGEMENT) | 4 |
| | MAJOR-X (BIOTECHNOLOGY IN AQUACULTURE) | 4 |
| | MAJOR-X1 RESEARCH PROJECT / *SPECIAL PAPER | 3 |
| | ELECTIVE-III | 3 |
| | | 18 |

Grand Total: 136

*Research project is for one year with 6 Credit Hours (CH). In case of internship, the student has to take one extra special course of 3 CH in eight semesters

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

| YEAR | CREDITS | COMPUL-SORY REQUIR E-MENTS (NO CHOICE) | GENERA L SCIENCE REQUIR E-MENTS | DISCIPLI NE SPECIFIC FOUNDATION COURSE S | REQUIR EMENT S TOWAR DS A MAJOR | ELECTI VE WITHIN THE MAJOR |
|----------------|------------|---|---------------------------------|--|---------------------------------|----------------------------|
| Total | 136 | 25 | 22 | 38 | 42 | 9 |
| Year 1 | | | | | | |
| Semeste r I | 18 | 8 | 6 | 4 | - | - |
| Semeste r II | 18 | 8 | 3 | 7 | - | - |
| Year 2 | | | | | | |
| Semeste r III | 16 | 6 | 7 | 3 | - | - |
| Semeste r IV | 17 | 3 | 6 | 8 | - | - |
| Year 3 | | | | | | |
| Semeste r V | 16 | - | - | 8 | 8 | - |
| Semeste r VI | 16 | - | - | 8 | 8 | - |
| Year 4 | | | | | | |
| Semeste r VII | 17 | - | - | - | 11 | 6 |
| Semeste r VIII | 18 | - | - | - | 15 | 3 |

DETAILS OF COURSES

CURRICULUM FOR BS 4 YEARS (8 SEMESTERS)

FRESHWATER BIOLOGY AND FISHERIES

GENERAL COURSES

| S. No. | Course Name | Credit Hours (CH) |
|--------|-------------------|-------------------|
| 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 | 3 (2+1) |

Total: 22 (15+7)

ZOOLOGY-I 3 (2+1) CH

Learning outcomes

After completing this course, students would be able to:

- describe the importance of zoology and its relation with other sciences
- correlate the life with its chemical basis
- draw and explain structure and functions of organelles of cell
- compare activity of different energy producing molecules

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.

Practicals

- 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. Smith, D.G. and Schenk, M.P., 2014. Exploring Zoology in the Laboratory 2nd ed. Morton Publishing Company, USA.
2. Hickman, C.P., Roberts, L.S. and Larson, A., 2013. Integrated Principles of Zoology. 16th ed. (International). McGraw Hill, Singapore.
3. Miller, S.A. and Harley, J.B., 2012. Zoology. 9th ed. (International). McGraw Hill, Singapore.
4. Wallace, R.L. and Taylor, W.K., 2002. Invertebrate Zoology Laboratory Manual. 6th ed. Pearson Education.
5. Miller, S.A., 2002. General Zoology Laboratory Manual. 5th ed. (International). McGraw Hill, Singapore.
6. Campbell, N.A., 2002. Biology. 6th ed. Benjamin/Cummings Publishing Company, Inc. Menlo Park, California.
7. Kent, G.C. and Miller, S., 2001. Comparative Anatomy of Vertebrates. McGraw Hill Company, New York.
8. Pechenik, J.A., 2000. Biology of Invertebrates, 7th ed. (International). McGraw Hill, Singapore.
9. Hickman, C.P. and Kats, H.L., 2000. Laboratory Studies in Integrated Principles of Zoology. McGraw Hill, Singapore.

PLANT DIVERSITY

3 (2+1) CH

Learning outcomes

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

- understand the diversity of plants, their structure and economic significance
- describe, classify and appreciate the biology and evolution of plant architecture
- demonstrate the technical description of plants of the local flora and their identification up to species level with the help of a regional/Flora of Pakistan

Comparative study of life form, structure, reproduction and economic significance of Viruses (RNA and DNA types) with special reference to TMV; Bacteria and Cyanobacteria (*Nostoc*, *Anabaena*, *Oscillatoria*) with specific reference to bio-fertilizers, pathogenicity and industrial importance; Algae (*Chlamydomonas*, *Spirogyra*, *Chara*, *Vaucheria*, *Pinnularia*, *Ectocarpus*, *Polysiphonia*) Fungi (*Mucor*, *Penicillium*, *Phyllactinia*, *Ustilago*, *Puccinia*, *Agaricus*), their implication on crop production and industrial applications. Lichens (*Physcia*) Bryophytes, *Riccia*, *Anthoceros*, *Funaria*, Pteridophytes, Fossils and fossilization, Psilopsida (*Psilotum*), Lycopsida (*Selaginella*), Sphenopsida (*Equisetum*), Pteropsida (*Marsilea*), Seed Habit, Gymnosperms *Cycas*, *Pinus*, *Ephedra*

Practicals

- 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. Gibson, J.P. and Gibson, T.R., 2007. Plant Diversity: The green world. Infobase Publishing, USA.
2. Ingrouille, M. and Eddie, B., 2006. Plants: Diversity and Evolution. Cambridge University Press, UK.
3. Mauseth, J.D., 2003. Botany: An Introduction to Plant Biology. 3rd ed. Jones and Bartlett Publishing, UK.
4. Prescott, L.M., Harley, J.P. and Klein, A.D., 2004. Microbiology, 3rd ed. Wm C. Brown Publishers, Inc. Oxford, UK.
5. Vashishta, B.R., 2011. Botany for degree students. S. Chand publisher, India.

ZOOLOGY-II

3 (2+1) CH

Learning outcomes

After completing this course, students would be able to:

- describe the structure and role of chromosome in heredity
- explain the history of evolution and the role of heredity in evolution
- compare different shades of animal behavior and learning.

Cell Division

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

Inheritance Patterns

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

Chromosomes and Gene Linkage

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

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.

Animal Behavior

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

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.

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., 2013. Integrated Principles of Zoology. 16th ed. (International). McGraw Hill, Singapore.
2. Miller, S.A. and Harley, J.B., 2012. Zoology. 9th ed (International). McGraw Hill, Singapore.
3. Campbell, N.A., 2002. Biology. 6th ed. Benjamin/Cummings Publishing Company, USA.
4. Pechenik, J.A., 2000. Biology of Invertebrates. 4th ed. (International). McGraw Hill, Singapore.
5. Kent, G.C. and Miller, S., 2000. Comparative Anatomy of Vertebrates. McGraw Hill, USA.

Practicals

- 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. Smith, D.G. and Schenk, M.P., 2014. Exploring Zoology in the Laboratory 2nd ed. Morton Publishing Company.
2. Miller, S.A. and Harley, J.B., 2012. Zoology. 9th ed (International). McGraw Hill, Singapore.
3. Miller, S.A., 2002. General Zoology Laboratory Manual. 5th ed. McGraw Hill, Singapore.
4. Hickman, C.P. and Kats, H.L., 2000. Laboratory Studies in Integrated Principles of Zoology. McGraw Hill, Singapore.

BIOCHEMISTRY

4 (3+1) CH

Learning outcomes

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

- gain deep understanding of many of the chemical reactions and structures of biological molecules essential to life on Earth
- explain/describe the synthesis of proteins, lipids, nucleic acids, and carbohydrates and their role in metabolic pathways
- know the Macromolecular separation techniques

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) multi enzyme 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 transamination; 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. Berg, J.M. Tymoczko, J.L. and Stryer, L., 2012. Biochemistry 7th ed. W. H. Freeman and Company, USA.
2. Nelson, D.L. and Cox, M.M., 2012. Lehninger Principles of Biochemistry 6th ed. W.H. Freeman and Company, USA.
3. Voet, D. and Voet, J.G., 2011. Biochemistry. 4th ed. John Wiley and Sons, USA.
4. Nelson, D. L., Cox, M.M. and Lehninger, A.L., 2004. Principles of Biochemistry, 4th ed. McMillan Worth Publishers, USA.
5. McKee, T. and McKee, J.R., 2003. Biochemistry: the Molecular Basis of Life. 3rd ed. McGraw Hill Company, USA.
6. Murray, R.K., Granner, D.K., Mayer, P.A. and Rodwells, V.W., 2000. HARPER'S Biochemistry. 25th ed. McGraw Hill Company, USA.
7. Zubay, G., 1995. Biochemistry. 4th ed. Wm. C. Brown Publishers, Inc., UK.

Practicals

- Preparation of standard curve for glucose by orthotoluidine 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. Joshi, R.A. and Saraswat, M., 2002. A Text Book of Practicals Biochemistry. 1st ed. B. Jain Publishers, India.
2. Wilson, K. and Walker, J., 1994. Practicals Biochemistry: Principles and Techniques. 4th ed. Cambridge University Press, UK.
3. Plummer, D. T., 1990. An Introduction to Practicals Biochemistry. 4th ed. McGraw-Hill Book Company, UK.

ANIMAL PHYSIOLOGY

3 (2+1) CH

Learning outcomes

After completing this course, students would be able to:

- describe working of different body system of living beings
- correlate the physiology of different systems with each other
- to compare different types of homoeostatic activities and evaluate their role and efficiency in general homoeostasis of the body

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; Osmoregulation. Exchange of Gases: Transport of O₂ and CO₂ between respiratory surface and body cells.

Practicals

- 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. 5th ed. W.H. Freeman and Company, USA.
2. Bullock, J., Boyle, J. and Wang, M.B., 2001. Physiology. 4th ed. Lippincott, Williams and Wilkins, Jordan.
3. Levy, M.N., Koeppen, B.M. and Stanton, B.A.. 2005. Principles of Physiology. 4th ed. Mosby, USA.
4. Guyton, A.C. and Hall, J.E., 2010. Textbook of Medical Physiology. 12th ed. W.B. Saunders Company, USA.
5. Schmidt-Nelsen, K., 1997. Animal Physiology, Adaptation and Environment. 5th ed. Cambridge University Press, UK.
6. Withers, P.C, 1992. Comparative Animal Physiology. W.B. Saunders Company, USA.

PLANT PHYSIOLOGY

3 (2+1) CH

Learning outcomes

After studying this course the students would be able to:

- Describe role of water in photosynthesis and other activities of plant life
- Evaluate the importance of photosynthesis for the survival and growth of plants
- Explain the process of growth in plants and the role of photoperiod in growth
- Prove experimentally the impact of photosynthesis and photoperiod on plant growth

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 C₃ and C₄ 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

Practicals

- 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. 3rd ed. *Sinauer Associates, Inc* publisher, USA.
2. Ihsan, I., 1995. Plant Physiology, Biochemical Processes in Plants. UGC Press, Pakistan.
3. Salisbury, F.B. and Ross, C.B., 1992. Plant Physiology. 5th ed. Wadsworth Publishing Company, Canada.
4. Hopkins, W.B., 1999. Introduction to Plant Physiology. 2nd ed. John Wiley and Sons. USA.
5. Hussain, F., 1989. Field and Laboratory Manual of Plant Ecology. National Academy of Higher Education, Islamabad.

ECOLOGY

3 (2+1) CH

Learning outcomes

After completing this course, students would be able to:

- Describe the physical and chemical basis of different types of ecosystem
- Fully grasp different ways and aspects of energy flow in ecosystem

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.

Practicals

- 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. Nicholas, B. D., Krebs, J. R. and West, S.A., 2012. An Introduction to Behavioral Ecology. 4th ed. Wiley-Blackwell Publishing, USA.
2. Thomas, M.S. and Smith, R.L., 2012. Elements of Ecology. 8thed. Benjamin Cummings, USA.
3. Townsend C.R., Begon, M. and Harper, J.L., 2008. Essentials of Ecology. 3rd ed. Blackwell Publishing, UK.
4. Molles, M. C., 2005. Ecology: Concepts and Applications. 6th ed. McGreaw Hill., USA.

FOUNDATION COURSES

| S. No. | COURSE NAME | Credit Hours (CH) |
|---------------|------------------------------------|----------------------|
| 1 | INTRODUCTORY FRESHWATER BIOLOGY | 4(3+1) |
| 2 | BIOSTATISTICS | 3(2+1) |
| 3 | ICHTHYOLOGY | 4(3+1) |
| 4 | AQUATIC MICROBIOLOGY | 3(2+1) |
| 5 | DEVELOPMENTAL BIOLOGY | 4(3+1) |
| 6 | INTODUCTORY FISH CULTURE | 4(3+1) |
| 7 | LIMNOLOGY | 4(3+1) |
| 8 | CELL AND MOLECULAR BIOLOGY | 4(3+1) |
| 9 | PHYCOLOGY | 4(3+1) |
| 10 | GENETICS | 4(3+1) |
| Total: | | 38 (28+10) |

DETAILS OF COURSES

INTRODUCTORY FRESHWATER BIOLOGY

4 (3+1) CH

Learning outcomes

After studying this course the students would be able to:

- name and describe important freshwater resources of Pakistan
- explain the zonation of different aquatic habitats.
- describe the fauna and flora of freshwater bodies

Brief description of freshwater resources of Pakistan, types of freshwater habitats and their zonation. Study of life form, structure, reproduction and economic significance of Bacteria and Cyanobacteria (*Nostoc*, *Anabaena* and *Oscillatoria*) with specific reference to biofertilizers, pathogenicity and industrial importance. Freshwater Algae: Chlorophyta (*Chlamydomonas*, *Spirogyra*, *Volvox*); Charyophyta (*Chara*); Xanthophyta (*Vaucheria*); Bacillariophyta (*Pinnularia*); Phaeophyta (*Ectocarpus*); Rhodophyta (*Batrachospermum*). Study of life form, structure, reproduction and economic significance of Protozoan, Shrimps, Crayfish, Snails, Crustaceans, Molluscs.

Practicals

- Study of various economic common freshwater algae and animal forms given in theory.
- Collection, identification and preservation of different groups of freshwater animals and plants.

Recommended books

1. Moss, B.R., 2010. Ecology of Fresh Waters: A View for the Twenty-First Century. 4th ed. Wiley-Blackwell, USA.
2. Bronmark, C. and Hansson, L., 2005. The Biology of Lakes and Ponds. Oxford University Press, UK.
3. J.G. Needham, J.G., 1962. Guide to the Study of Freshwater Biology 5th ed. McGraw-Hill, USA. Maitland, P.S., 1990. Biology of Fresh Waters. Springer, USA.

BIOSTATISTICS

Cr (2+1) CH

Learning outcomes

After studying this course the students would be able to:

- Apply basic statistical procedures for analysis of data for practical and research.
- Demonstrate statistical reasoning skills correctly and contextually

- Interpret results of commonly used statistical analyses in written summaries.
- Use basic analytical techniques to generate results.

Introduction and scope

use of statistics in biology. Practical examples of using statistics in biological study and research, **Population and sample:** Stages of research, Types of data: methods of data collection. Data arrangement and presentation, formation of tables and charts, **Measures of central tendency:** computation of mean, median and mode from grouped and ungrouped data, **Measures of dispersion:** computation of variance, standard deviation, standard error and their coefficients, **Probability rules:** Binomial, Poisson and normal distributions. Hypothesis testing, Student's t test, Chi square test, **Handling of multiple samples:** Analysis of variance and LSD, **Correlation and regression:** Experimental designing, planning of an experiment, replication and randomization.

Practicals

- To perform a two-sample t-test and interpret the results; calculate a 95% confidence interval for the difference in population means
- To select an appropriate test for comparing two populations on a continuous measure, when the two sample t-test is not appropriate
- To use SPSS/STATA package to
 - Perform two sample comparisons of means and create confidence intervals for the population mean differences
 - Compare proportions amongst two independent populations
 - Interpret output from the statistical software package STATA related to the various estimation and hypothesis testing procedures covered in the course

Recommended books

1. Rosner, B., 2011. Fundamental of Biostatistics. 7th ed. Books/Cole Cengage and Learning, USA.
2. Samuels, M.L., Witmer, J.A. and Schaffner, A., 2011. Statistics for the Life Sciences. 4th ed. Prentice Hall, USA.
3. Zar, J. H., 2010. Biostatistical analysis. 5th ed. Prentice Hall, USA.
4. Forthofer, R. N., Lee, E. S. and Hernandez, M., 2006. Biostatistics: A Guide to Design, Analysis and Discovery. 2nd ed. Academic Press, UK.
5. Quinn, G., P. and Keough, M. J., 2002. Experimental Design and Data Analysis for Biologists. Cambridge University Press. UK.

6. Norman, G. R. and Streiner, D. L., 2007. Biostatistics: The Bare Essentials. 3rd ed. Pmph, USA.
7. Campbell, R. C., 1989. Statistics for Biologists. 3rd ed. Cambridge University Press.UK.

ICHTHYOLOGY

4 (3+1) CH

Learning outcomes

After studying this course the students would be able to:

- Identify and classify the fishes at least up to generic level
- Describe the structure and functions of different body systems of fish
- Assess the age of fish by using different methods
- Evaluate the effects of different environmental factors on different aspects of life of fish

Introduction to Ichthyology, Classification of fish. Biology of commercial food fishes of Pakistan (Morphology, anatomy, ecology and distribution). Scales in fishes (structure, types, importance identification, classification and age determination). Gas bladder, types of fins and their function. Physiology of digestion (food, feeding habits, feeding adaptations), Circulatory system, Nervous system, Respiration (structure and working of gills, aerial respiration) Excretion and Osmoregulation (renal, gills, difference between freshwater and marine fish) Reproduction (sexual dimorphism, maturity, fecundity, breeding habits, parental care), Fish migration and fish ladders, Different environmental factors and their effects on fish behavior.

Practicals

- Identification of commercially important fish of Pakistan.
- Museum survey.
- Study of external features and skeleton of fish.
- Preparation of permanent slide of Fish scales.
- Dissection of fish to expose its internal features, especially digestive, circulatory, respiratory, excretory and reproductive system.

Recommended books

1. Lagler, K.F., Baradach, J.E. and Miller, R.R., 2012. Ichthyology. John Wiley and Sons, Inc., New York.
2. Ali, S.S. and Narejo, N.T., 2009. Fundamentals of Ichthyology. Sindh University Press, Jamshoro.
3. Kapoor, G. B. and Khana, B., 2004. Ichthyology hand book. Springer.

4. Ali, S.S., 1999. Freshwater Fisheries Biology. Naseem Book Depot, Pakistan.

AQUATIC MICROBIOLOGY

3 (2+1) CH

Learning outcomes

After studying this course the students would be able to:

- Describe general morphology and classification of aquatic microbes
- Correlate environmental factors with presence and abundance of aquatic microbes
- Explain the role of microorganism in biogeochemical cycles, bioremediation and biodegradation

Introduction and historical perspective of aquatic microbiology. General classification and characteristics of archaea, bacteria, viruses and fungi. Microbial communities in the aquatic environment: distribution; nutrients, oxygen and pH gradients. Microbial flora of surface and ground waters; Nature of aquatic environment; Extremophiles: halophilic, psychrophilic and barophilic bacteria; nutrient cycling at hydrothermal vents. Role of microbes in biogeochemical cycles. Biodegradation and bioremediation of organic and inorganic pollutants. Metagenomics of the microbes.

Practicals

- Introduction to basic techniques for sterilization/disinfection, isolation, culture, purification and preservation; Dilution plate technique, Mean plate count, Enumeration of coliform bacteria and fungi from water.

Recommended books

1. Maier, F.M., Pepper, I.L. and Gerba, C.P., 2009. Environmental Microbiology. 2nd ed. Academic Press, London, UK.
2. Austin, B. and Austc, D.A., 2007. Bacterial fish pathogens; diseases of farm and wild fish. Springer USA
3. Prescott, L.M., Harley, J.P. and Klein, D.A., 2007. Microbiology, McGraw Hill Inc., USA
4. Duncan, M. and Nigel, H., 2003. The Handbook of water and wastewater Microbiology. Academic Press, UK

DEVELOPMENTAL BIOLOGY

4 (3+1) CH

Learning outcomes

After studying this course the students would be able to:

- describe early cleavage and development of vertebrates

- draw fate maps for different types of egg
- explain the molecular control of development and growth

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.

Practicals

- 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., 2013. Developmental Biology. 10th ed. Sinauer Associates, Sunderland, USA.
2. Balinsky, B.I., 2012. An Introduction to Embryology. 5thed. W.B. Saunders Company, Philadelphia.
3. Oppenheimer, S.S., 2004. Introduction to Embryonic Development. 4th ed. Allen and Bacon, Chicago Press, USA.
4. Saunders, J.W., 2000. Development Biology. McMillan and Co., Inc., London

INTRODUCTORY FISH CULTURE

4 (3+1) CH

Learning outcomes

After studying this course, student would be able to:

- Know the importance of fish in human diet
- familiarize with Culturable fish species of Pakistan

- help fish farmer in designing, constructing and maintaining fish farm
- describe fish handling, processing and preservation techniques

Status of fish in human diet; History of fish culture; Fish culture systems and types; Culturable fishes of Pakistan; Criteria for farm site selection; Designing, construction, liming and fertilization of fish pond; Criteria for selection of fish species for culture; Stocking, feeding and maintenance of fish farms; Ingredients of supplementary fish feed; Introduction to integrated fish farming. Water quality monitoring and management in fish pond; Fish enemies and their control; Methods for handling, processing and preservation of fish (drying, salting, curing, smoking and freezing); Common fish diseases and their control.

Practicals

- Visit of fish processing unit.
- Calculation and use of different organic, inorganic fertilizers and feed in fish ponds.
- Visit to fish farms and hatcheries.
- Quality analysis of pond water.

Recommended books

1. Boyd, C.E. and McNevin, A.A., 2014. Aquaculture, Resource Use, and the Environment. Wiley-Blackwell, USA.
2. Parker, R., 2011. Aquaculture Science. 3rd ed. Delmar Publishing, USA.
3. Sharma, O.P., 2009. Handbook of Fisheries and Aquaculture. Agrotech Publishing Academy, India.
4. Hart, P.J.B. and Reynolds, J.D., 2008. Handbook of Fish Biology and Fisheries. Vol. 2. Blackwell Science Ltd, USA.
5. Pillay, T.V.R. and Kutty, M.N., 2005. Aquaculture: Principle and Practices. Wiley-Blackwell, USA.
6. Horvath, L., Tanes, G. and Seagrave, C., 2002. Carp and Pond Fish Culture. 2nd ed. Fishing News Book, USA
7. Ali, S.S., 1999. Freshwater Fishery Biology. Naseem Book Depot., Pakistan
8. Huet, M., 2010. Text Book of Fish Culture - Breeding and Cultivation of Fish. Fishing News, UK.

LIMNOLOGY

4 (3+1) CH

Learning outcomes

After studying this course the students would be able to:

- describe types, characteristics and classification of different freshwater bodies
- evaluate importance of physical and chemical properties of freshwater
- Correlate the impact of physico-chemical properties of freshwater with survival and distribution of fauna and flora
- analyze the aquatic fauna and flora both in qualitative and quantitative terms
- describe the fauna and flora of freshwater bodies

Introduction, history and scope of limnology. Lotic and lentic waters, lakes and reservoirs, streams and their classification. Zonation, thermal stratification; water movements, eutrophication; physical properties of water (temperature, light, colour, turbidity, electrical conductivity, total suspended and dissolved solids), chemical variables (Oxygen, Carbon Dioxide, hardness, alkalinity, pH, nitrogen, phosphorus, other Nutrients) effect of physico-chemical parameters on aquatic life.. Food-chain dynamics in freshwater bodies. Introduction to wetlands and their importance. Introduction to Planktons, including Zooplankton, Phytoplankton and microplanktons. General characters and species composition of major planktons. Qualitative and quantitative analysis of plankton and their periodicities. Phytoplankton and zooplankton relationship and importance of planktons in food chain of aquatic systems. Economic importance of diatoms.

Practicals

- Survey of lotic and lentic water bodies.
- Water sampling, preservation techniques and determination of physicochemical parameters.
- Sampling, identification and preservation of phytoplankton and zooplankton.
- Study of temporary and permanent mounts of phytoplankton and zooplankton.

Recommended books

1. Dodds, W. K. and Whiles. M. R., 2010. Freshwater Ecology: Concept and Environmental Applications of Limnology. Academic Press, New York, USA.
2. Moss, B. R., 2010. Ecology of Fresh Waters. John Wiley & Sons Inc., New York, USA.
3. Lampert, W. and Sommer. U., 2007. Limnoecology: The Ecology of Lakes and Streams. Oxford University Press, Oxford, UK.

4. Sullivan, P. and Reynolds, C.S., 2004. The Lakes Handbook: Limnology and Limnetic Ecology. Blackwell Science Ltd., Oxford, UK.
5. Wetzel, R.G., 2001. Limnology: Lake and River Ecosystem. 3rd ed. Academic Press, New York, USA.

CELL AND MOLECULAR BIOLOGY

4 (3+1) CH

Learning outcomes

After studying this course, student would be able to:

- describe basic biological concepts and principles
- differentiate between prokaryotes and eukaryotes
- recognize the different levels of biological organization
- gain knowledge about cell cycle, DNA recombinant technology and Animal cloning

Introduction to cell biology, Difference between prokaryotes and eukaryotes, Physico-chemical properties of protoplasm, Ultra-structure, chemical composition and functions of cell wall, cell membrane and cellular organelles, Cytoskeleton, Chemical composition and molecular structure of chromosomes. Cell cycle. Cell reproduction, DNA Replication, genetic code, transcription, translation, regulation of gene expression in prokaryotes and eukaryotes. Principles of DNA recombinant technology. Animal cloning.

Practicals

- Study of different types of Prokaryotic and Eukaryotic cell, and cell organelle. Identification of DNA with staining. Isolation of plant, animal and bacterial DNA. Gel electrophoresis. Study of chromosome morphology and variation in chromosome number.
- Experimental studies integrating genetics and biochemistry in the studies of molecular genetics in prokaryotic and eukaryotic cellular and viral systems.
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Recommended books

1. Karp, G., 2014. Cell and Molecular Biology: Concepts and Experiments, 7th ed. John Wiley and Sons, USA.
2. Alberts, B., 2007. Molecular Biology of the Cell. Taylor and Francis, UK.
3. Lodish, H., Matsudaira, P., Berk, A., Ploegh, H., Scott, M., Kaiser, C. A., Krieger, M. and Bretscher, A., 2007. Molecular Cell Biology. W. H. Freeman and Company, USA.
4. Pollard, T.D., Lippincott-Schwartz, J. and Earnshaw, W.C., 2007. Cell Biology, Saunders W B Co. USA.

5. Alberts, E.A., 2006. Essential Cell Biology. Academic Publisher, USA.
6. Watson, J.D., 2004. Molecular Biology of the Gene. Pearson Education, USA.
7. Gartner, L.P., Hiatt, J.L. and Strum, J.M., 2003. Cell Biology and Histology. Lippincot Williams and Wilkins, USA.
8. De Robertis, E.D.P. and De Robertis, E.M.F., 2001. Cell and Molecular Biology. 8th ed. Lippincot Williams and Wilkins, USA.

PHYCOLOGY

4 (3+1) CH

Learning outcomes

After studying this course, student would be able to:

- Identify and classify Algae and Bryophytes
- know economic importance of Algae and Bryophytes
- Understand the general morphological characteristics of freshwater algae and Bryophytes.

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 products; nucleus; morphological diversity; reproduction (sexual and asexual), life cycle patterns, ecology, evolution and economic importance. Ecology of freshwater 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.

Practicals

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

Recommended books

1. Vashishta, B.R., Singh, V.P. and Sinha, A.K., 2014. Botany for Degree Students. S. Chand and Company, India.
2. Hoek, C.V.D., Mann, D.G. and Jahns, H.M., 2009. Algae: An introduction to Phycology. Cambridge University Press, UK.
3. Linda, E., James, G., Graham, M. and Wilcox, L.W., 2008. Algae. 2nd ed. Benjamin Cummings, USA.
4. John, D.W. and Sheath, R.G., 2003. Fresh Water Algae of North America: Ecology and Classification. Academic Press, USA.

5. John, D.M., Whitton, B.A. and Brook, A.J., 2002. The Freshwater Algal Flora of the British Isles. Cambridge University Press, UK.

GENETICS

4(3+1) CH

Learning outcomes

After studying this course, student would be able to:

- understand the basic principle of inheritance
- know the qualitative and quantitative and sex linkage inheritance
- familiarize with mutations and molecular basis of mutations
- describe the factors responsible for change in gene and genotypic frequency

Introduction to genetics. Heredity and variation, Mendel's laws of inheritance. Gene interaction; Multiple alleles. Linkage and crossing over, gene mapping. Sex linkage and sex determination. Gene and environment: Mutations and molecular basis of mutations. Extra-nuclear inheritance. Qualitative and quantitative inheritance. Chromosomal aberration, Bacterial and viral chromosomes. Mechanisms of genetic exchange among prokaryotes. Genetic code, recombination and regulation of gene expression. Bacteriophages and recombination, transposons and integrons. Introduction to population genetics. Genetic constitution of a population; Hardy-Weinberg (HW) equilibrium. Changes in gene and genotype frequency.

Practicals

- Preparation of culture medium and maintenance of *Drosophila* cultures in lab.
- Problems related to Mendelian inheritance, gene interaction, gene mapping.
- Blood groups-ABO blood groups and Rh factors.
- Problems relating to genetic exchange in bacteria and viruses.
- Problems related to gene frequencies and Hardy Weinberg equilibrium.

Recommended books

1. Klug, W.S., Michael R.C., Charlotte A.S. and Michael, A.P., 2013. Essentials of Genetics. 8th ed. Pearson Education, USA.
2. Strickberger, W. M., 2008. Genetics. 3rd ed. MacMillan Publishing Co., USA.
3. Primrose, S.B. and Twyman, R.M., 2006. Principles of Gene Manipulation and Genomics. Blackwell Scientific Publications, USA.
4. Snustad, D.P. and Simmons, M.J. 2006. Principles of Genetics. 4th ed. John Wiley and Sons, USA.

5. Hedrick, P.W., 2005. Genetics of Populations. Jones and Bartlett, Sudbury, USA.
6. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C., Gelbart, W.M., Suzuki, D.T. and Miller, J.H., 2005. Introduction to Genetic Analysis. W.H. Freeman and Company, USA.
7. Gardner, N.Y., Simmons, E.J. and Snustad, D.P., 2004. Principles of Genetics. 3rd ed. John Wiley and Sons, USA.
8. Klug, W.S. and Cummings, M.R., 2004. Concepts of Genetics. Prentice Hall, USA.
9. Synder, L. and Champness, W., 2004. Molecular Genetics of Bacteria. American Society for Microbiology, USA.
10. Leland, H., Leroy, H., Michael, G.L., Silver, L., Lee M., Veres, R. C. and Ann, R., 2004. Genetics. McGraw-Hill Science, USA.
11. Ringo, J., 2004. Fundamental Genetics. Cambridge University Press, USA.
12. Hartl, D.L. and Jones, E.W., 2002. Essentials of Genetics. 3rd ed. Jones and Bartlett, Sudbury, USA.

MAJOR COURSES

| S.No | Course Name | Credit Hours (CH) |
|------|-------------------------------------|-------------------|
| 1 | FISH AND FISHERIES BIOLOGY | 4(3+1) |
| 2 | FISHERY TECHNOLOGY | 4(3+1) |
| 3 | FRESHWATER INVETEBRATES | 4(3+1) |
| 4 | AQUATIC MACROPHYTES AND MANAGEMENT | 4(3+1) |
| 5 | FISH BREEDING AND CONSERVATION | 4(3+1) |
| 6 | WATER POLLUTION | 4(3+1) |
| 7 | RESEARCH POJECT/INTERENSHIP | 6/3 |
| 8 | FISH NUTRITION | 4(3+1) |
| 9 | FISH HYGIENE AND DISEASE MANAGEMENT | 4(3+1) |
| 10 | BIOTECHNOLOGY IN AQUACULTURE | 4(3+1) |

Total: 42 (30+9)

DETAILS OF COURSES

FISH AND FISHERIES BIOLOGY

4 (3+1) CH

Learning outcomes

After studying this course the students would be able to:

- compare important fish growth models and their efficiency
- calculate fish growth by using different methods
- assess different dynamics of fish life like mortality, natality, fecundity etc

Food and feeding behavior and 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 population estimation, population size and Population dynamics. Mortality rates, natality and mortality, reproduction, behavior and fecundity of fish. Fundamental links in the life cycles of the fish and their migration,

Practicals

- Analyses of gut contents.
- Assessment of age and growth of fish.
- Computation of length-weight relationships and condition factor.
- Population estimation of fish.
- Statistical analysis of different fish variables.
- Estimation of fecundity in fish.

Recommended books

1. Lagler, K.F., Baradach, J.E. and Miller, R.R., 2012. Ichthyology. John Wiley and Sons, Inc., USA.
2. Payne, A., John, A. and Cotter, R., 2008. Advances in Fisheries Science. John Wiley and Sons, USA.
3. Moyle, P.B. and Cech, J.J., 2004. Fishes: An Introduction to Ichthyology. Pearson Prentice Hall, USA.
4. Bone, Q. and Marshall, N.B., 2004. Biology of Fishes. Chapman and Hall Inc. USA.
5. Ricker, W.E., 2002. Methods of Assessment of Freshwater Fish Production. Blackwell Scientific Publications, USA.

FISHERY TECHNOLOGY

4 (3+1) CH

Learning outcomes

After studying this course the students would be able to:

- compare the efficiency, merits and demerits of different methods of fish capture

- describe main features of post harvest /capture technology

Introduction to capture fishery and its role in world food production, reasons of fish decline and development potential, stock assessment techniques, various fishing methods, fishing vessels; river crafts; large fishing boats; fishing gears (nets); harvesting; live hauling; on board handling; initial handling of netted fish; icing procedures; offloading; transportation to fish markets; common fishing gears and crafts with special reference to Pakistan. Methods of fish handling and processing, transportation and preservation, by-products of fish industry, marketing strategies. Processing techniques and fishery by-products.

Practicals

- Fish stock assessment of lakes.
- Study of nets (composition design and operation, methods of gear selectivity and efficiency, visits to fish landing and marketing centers, fish netting.
- Study of fishing gears and crafts.

Recommended books

1. Kumar, P.S., 2009. Fishery Technology APH Publishing, India.
2. Hameed, M.S. and Boopendranath, M .R., 2000.Modern Fishing Gear Technology. Daya Publishing House, India.
3. Ali, S.S., 1999. Freshwater Fishery Biology. Naseem Book Depot, Pakistan.
4. Hall, D.G.M., 1997. Fish Processing and Technology. Springer, USA.

FRESHWATER INVERTEBRATES

4 (3+1) CH

Learning outcomes

After studying this course, student would be able to:

- understand interactions and phylogenetic relationships between freshwater species
- know the economic significance of freshwater invertebrates
- describe the role of environmental factor in the distribution and abundance of benthos

Overview of freshwater habitats, Phylogenetic relationships, Life history, Ecology, Economic significance and distribution of the freshwater invertebrates belonging to: Phyla Porifera, Cnidaria, Platyhelminthes, Gastrotricha, Rotifera, Nematoda, Nematomorpha, Nemertinea, Mollusca, Annelida, Bryozoa, Tardigrada, Arthropoda. Influence of environmental

factors on the abundance and distribution of benthic organisms, Role of macro fauna in the aquatic ecosystem.

Practicals

- Collection and study techniques, sampling, preservation and identification of freshwater invertebrates' fauna from various available and accessible freshwater bodies.
- Examination of prepared slides
- Quantitative and qualitative analyses of benthos

Recommended books

1. Micheael, D., Pawley, D., Fletcher, M. and Powell, A., 2012. Guide to Freshwater Invertebrates. Ambleside, USA.
2. James, H. T. and Christopher. R., 2011. Field Guide to Freshwater Invertebrates of North America. USA.
3. Balian, E.V., 2008. Freshwater animals Diversity assessment. Springer, USA.
4. Reese, V.Jr., 2002. A Guide to Common Freshwater Invertebrates. McDonald and Woodward, USA.
5. Thorp, J.H. and Covich, A.P., 2001. Ecology and Classification of North American Freshwater Invertebrates. 2nd ed. Academic Press, USA.

AQUATIC MACROPHYTES AND MANAGEMENT

4 (3+1) CH

Learning outcomes

After studying this course, student would be able to:

- Identify common aquatic macrophytes through the use of keys
- Understand the role they play in the ecosystem.
- Know the methods of preservation
- Familiar with qualitative and quantitative analyses of macrophytes

Introduction to macrophytes, characteristics, classification of common macrophytes, methods of identification and preservation; qualitative and quantitative analyses (quadrate, 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.

Practicals

- Sampling techniques.
- Identification and preservation of macrophytes.

- Exercise relating to quantitative and qualitative analyses of macrophytes.

Recommended books

1. Capello, R., 2014. Macrophytes: Biodiversity, Role in Aquatic Ecosystems and Management Strategies. Nova Science Publishers.
2. Caffrey, J.M., Dutartre, A., Haury, J., Murphy, K.M. and Wade, P.M., 2010. Macrophytes in Aquatic Ecosystem: From Biology to Management. Springer, Dordrecht, Netherlands.
3. Bornette, G. and Puijalon, S., 2009. Macrophytes: Ecology of Aquatic Plants. In: eLS. John Wiley and Sons, USA.
4. Hill, D., Fasham, M., Tucker, G., Shewry, M. and Shaw, P., 2005. Handbook of Biodiversity Methods; Survey, Evaluation and Monitoring. Cambridge University Press.
5. Naylor, R. E., 2002. Weed Management Handbook. 9th ed. John Wiley and Sons, USA.
6. Peter, T., 2000. Interactions between Fish and Aquatic Macrophytes in Inland waters: A review. FAO. Rome.
7. Naylor, R. E., 2002. Weed Management Handbook. John Wiley and Sons Publishers, USA.

FISH BREEDING AND CONSERVATION

4 (3+1) CH

Learning outcomes

After studying this course the students would be able to:

- Compare the efficiency of different methods of fish breeding in different ecological zones
- Determine the role of hormone in artificial breeding of fish
- Describe/ formulate conservation strategies for fish

Fish reproduction (Neuro-endocrine and environmental control), spawning quality, control of fish sex, sexual determination and differentiation and its importance in aquaculture, Brood stock selection and management, Reproductive technology (Hypophysation and Induced breeding, cryopreservation of gametes and egg quality analysis) selective breeding, hybridization. Rearing techniques of fry and fingerlings. Conservation strategies for threatened and endangered species; sustainable use of fisheries resources; stock replenishment program, management of natural resources (lakes, reservoirs, dams and rivers); habitat management practices and biological conservation policy; national, regional and international conventions; rules and regulations for conservation of natural resources (awareness program and community participation).

Practicals

- Study of gonadal development in carps and other cultivable finfishes.
- Collection and identification of cultivable freshwater finfish seed.
- Packing and transportation of fish seed.
- Induced breeding (striping and fertilization) of fishes through various inducing agents
- Evaluation of carp milt and egg; estimation of fecundity, fertilization and hatching success.
- Preparation of brood and larval feed for different cultivable finfish.
- Visit to different finfish hatcheries.
- Field survey of different natural aquatic habitats.
- Practical methods of conservation of natural resources.

Recommended books

1. Gjedrem, T. and Baranski, M., 2009. Selective breeding in Aquaculture: An Introduction. Springer, USA.
2. Gjedrem, T., 2005. Selection and Breeding Programs in Aquaculture. Springer, Netherland.
3. Rothschild, M. and Scott, N., 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI
4. Thomas, P.C., Rath, S.C. and Mohapatra, K.D., 2003. Breeding and Seed Production of Finfish and Shellfish. Daya Publisher, India

WATER POLLUTION

4 (3+1) CH

Learning outcomes

After studying this course, student would be able to:

- Understand the properties of water that make it unique
- Describe the types of water pollutants, their sources and fates and health risks associated with water supplies.
- Discuss the criteria and methods proposed to improve water quality.

Overview of pollutants. Types and sources of water pollution (domestic, hospital, agricultural and industrial sources. Water quality (Dissolved oxygen - BOD, COD, TOC criteria). Effects of Pollutants on human and other biota; Bio-indicator, Bioaccumulation and bio- magnifications, Pollutants treatment technologies i.e. Primary, secondary and tertiary treatments. Environmental Laws: International Protocols; Case Studies e.g. Characterization of industrial effluents; Examples of treatment systems for selected typical industrial operations i.e. Oil refinery and chemical, food processing, textile plant, tanneries, pulp and paper operations, acid mine drainage and heavy metal problems.

Practicals

- Analysis of water samples from polluted areas for selected parameters
- Study of pollution indicators
- Visit to polluted water bodies
- Visit to bioremediation/treatment plant

Recommended books

1. Patricia, U.O., 2010. Aquatic pollution. LAP Lambert academic Publisher, UK.
2. Goel, O.P.K., 2006. Water pollution and causes, effects and control. New Age International, India
3. Hill, M.K., 2005. Understanding Environmental Pollution, 2nd ed. Cambridge University Press, UK.
4. Peiece, J.J., Weiner, R.F. and Vesilaind, P.A., 1998. Environmental Pollution and Control. 4th ed. Elsevier, USA.

FISH NUTRITION

4(3+1) CH

Learning outcomes

After studying this course the students would be able to:

- Name and describe important types of feeds used in aquaculture
- Formulate different types of feed and evaluate their relative efficiency
- Evaluate fish growth by using different growth methods
- Discuss signs symptoms and treatments for nutritional disorders

Fundamentals of fish nutrition, Description of fish growth and important nutrients required for fish growth, feed types (Wet feeds, moist feeds, mashes, pelleted feeds, floating and sinking pellets), Nutrient requirements of cultivable fish (energy, carbohydrate, protein, fat, vitamin and mineral requirements of fish). Methods of feed formulation and manufacturing. Role of binders, antioxidants, enzymes, pigments growth promoters and feed stimulants as feed additives. Use of non-conventional feed ingredients in fish feed formulation, anti-nutritional factors and their management, digestive enzymes, feed digestibility and factors affecting digestibility. Feed conversion ratio, feed efficiency, net protein utilization and biological value. Nutritional deficiency disorders, symptoms and nutrition related diseases in fishes.

Practicals

- Proximate composition of fish feed ingredients and diets.
- Formulation and preparation of different types of fish feed.
- Methods of feed storage.

Recommended books

1. Halver, J.E., 2013. Fish Nutrition. 4th ed. Academic Press, USA.
2. Obedd, G., 2010. Fish Nutrition. Blackwell Publishing, USA.
3. Parker, R.O., 2004. Aquaculture Science. 4th ed. Delmar Learning, UK.
4. Pillay, T.V.R., 1991. Aquaculture, Fishing News Book, U.K

FISH HYGIENE AND DISEASE MANAGEMENT**4 (3+1)****Learning outcomes**

After studying this course the students would be able to:

- Differentiate between a healthy and diseased fish
- Describe symptoms and treatments for common infectious and non-infectious fish diseases
- Discuss the principals of health management in fish

Signs of healthy fish and prophylactic measures taken for prevention of diseases. General signs of diseased fish. Common infectious diseases of fish: viral, bacterial, fungal and parasitic diseases; clinical signs and symptoms, diagnosis and treatment of disease. Non- infectious fish diseases; thermal stress, stress due to oxygen deficiency and excessive carbon dioxide, gas bubble disease, acidosis, alkalosis and poisoning. Principles of fish health management, Predisposing factors, Environmental stress, Defensive mechanisms in fish to combat stress/ foreign organisms. Host pathogen and environment relationship.

Practicals

- Collection and preservation of fish and crustacean parasites.
- Preparation of parasite slides and their identifications.
- Treatment methods for common diseases of fish.

Recommended books

1. Noga, E. J., 2010. Fish Disease: Diagnosis and Treatment. 2nd ed. Willey Blackwell. USA.
2. Wais, K., 2005. Handbook on Fish and Crustacean Diseases in the SAARC region. SAARC Agricultural Information Center.
3. Pandey, B.N., 2004. Fish Research. APH Publishing Corporation, India.
4. Wedemeyer, G.A., Meyer, F.P. and Smith, L., 1999. Environmental Stress and Fish Diseases. Narendra Publishing House, India.

BIOTECHNOLOGY IN AQUACULTURE

4 (3+1) CH

Learning outcomes

After studying this course, the students would be able to:

- Conceptualize the principal bases of biotechnology and emerging issues in fisheries
- Develop Insight into the application of biotechnological advances in aquaculture and fisheries
- Elucidate different aspects of genetic biotechnology and fish genomics with reference to transgenesis, pathogen detection and broodstock management
- Demonstrate o various techniques of molecular nature applied for fisheries development

History of Biotechnology, Genetics and Selective Breeding in Aquaculture and Fisheries, Phenotypic variation and environmental effects. Qualitative traits and selection for qualitative traits. Strain evaluation, domestication and strain selection. Population size, Inbreeding, Random genetic drift and maintenance of genetic quality. Gynogenesis, Andogenesis, Intraspecific Crossbreeding, Interspecific hybridization, Polyploiday and Xenogenesis, Sex reversal and breeding, Biochemical and molecular markers, Genetic engineering and gene transfer (transgenic fish). Biotechnologies available for fish nutrition, broodstock improvement and disease diagnosis,

Practicals

- DNA isolation from fish.
- Electrophoresis, Agarose and polyacrylamind gel electrophoresis.
- Demonstration of amplification of DNA through PCR.

Recommended books

1. Dunham, R.A., 2011. Aquaculture and Fisheries Biotechnology: Genetic approaches. CABI, UK.
2. Kumar, R., 2010. Biotechnology and Genetics in Fisheries and Aquaculture. Blackwell, USA.
3. Stickney, R.R., 2009. Aquaculture: An introductory Text. CABI Publishing, UK.
4. Sarkar, S.K., 2002. Freshwater Fish Culture. Daya Publishing House, India.

ELECTIVE COURSES FOR BS (4 Years)

| S.No | Course Name | Credit Hours |
|------|------------------------------|--------------|
| 1 | INTEGRATED FISH FARMING | 3(2+1) |
| 2 | AQUATIC TOXICOLOGY | 3(2+1) |
| 3 | INLAND FISHERIES MANAGEMENT | 3(2+1) |
| 4 | FISH BEHAVIOUR | 3(2+1) |
| 5 | FISH POST HARVEST TECHNOLOGY | 3(2+1) |
| 6 | ENDOCRINOLOGY | 3(2+1) |
| 7 | BIOSAFETY AND BIOETHICS | 3(2+1) |
| 8 | FISH IMMUNOLOGY | 3(2+1) |
| 9 | FISH PARASITOLOGY | 3(2+1) |

TOTAL: 27 (18+9)

DETAILS OF COURSES

INTEGRATED FISH FARMING

3 (2+1) CH

Learning outcomes

After studying this course, student would be able to:

- know how to produce fish in combination with other agricultural/livestock farming operations
- utilize the available resources in best suitable way
- demonstrate how waste or byproduct from one system is effectively recycled

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.

Practicals

- 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, India.
2. Sandhu, G.S., 2007. Applied Ichthyology. Dominant Publishers, India.
3. Little, D. and Edwards, P., 2003. Integrated Livestock-fish Farming Systems. Food and Agriculture Organization of the United Nations. USA.

AQUATIC TOXICOLOGY

3 (2+1) CH

Learning outcomes

After studying this course, student would be able to:

- understand the basic concept of aquatic ecotoxicology, including bioaccumulation, trophic transport of contaminants, biomarkers, specific challenges, and *in vitro* toxicology.
- be aware of the behavior of fish in response to toxicants
- know the factors affecting chronic environmental toxicity

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.

Practicals

- Determination of physico-chemical parameters in relation to metal's toxicity.
- Determination of acute (LC₅₀ and lethal concentrations) toxicity of metals by using Probit Curve
- Effects of chronic metals toxicity on fish growth

Recommended books

1. Walker, C.H., Sibly, R.M., Hopkin, S.P. and Peakall, D.B., 2012. Principles of ecotoxicology, 4th ed. CRC Press, USA.
2. Adel, D., 2007. Water Pollution Biology. CRC Press, USA.
3. Schwarzenbach, R.P., Gschwend, P.M. and Imboden, D.M., 2005. Environmental Organic chemistry. 3rd ed. Wiley and Sons, USA.
4. Blaise, C. and Ferard, J.F., 2005. Small Scale Freshwater Toxicity Investigation: Toxicity Test Methods. Springer, USA.
5. Mason, C.F., 2002. Biology of Freshwater Pollution. Prentice Hall, USA.
6. Klaasen, C.D., 2001. Casarett and Doull's Toxicology The basic science of poisons. McGraw-Hill Company, USA.
7. Rand, G.M., 2001. Fundamentals of Aquatic Toxicology, 2nd ed. Taylor and Francis Publisher, USA.

INLAND FISHERIES MANAGEMENT

3 (2+1) CH

Learning outcomes

After studying this course, student would be able to:

- Know the nature of inland water and inland fish population
- Learn fishing techniques, inland fishery resource evaluation and inland fisheries management
- Accustom with biodiversity and conservation issues

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.

Practicals

- 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. Helfman, G., Collette, B.B., Facey, D.E., 2009. Diversity of Fishes: Biology, Evolution, and Ecology . John Wiley & Sons, Singapore.
2. Bone, Q. and Moore, R., 2008 . Biology of Fishes. Garland Science, USA.
3. Moyle, P.B. and Cech, J.J, 2004. Fishes: An Introduction to Ichthyology. 5th ed. Pearson Prentice Hall, USA.
4. Kapoor, B.G. and Khanna, B., 2004. Ichthyology Handbook. Springer Science & Business Media
5. Lagler, K.F., Baradach, J.E. and Miller, R.R., 2003. Ichthyology. John Wiley and Sons, USA.
6. Ostrander, G.K., 2000. The Laboratory Fish. Elsevier, USA.

Fish Behaviour

3(2+1) CH

Learning outcomes

After studying this course, student would be able to:

- Describe the foraging, predatory , antiptdratory, reproductive , migratory behavior of fish
- Know the learning capability of fish
- Know the impact of rearing environment on the behavior of fish
- Recognize the role of fish learning skills in fisheries and aquaculture

Behavioral patterns with respect to Feeding, Reproduction, Parental care, Territory, Navigation, Migration, Attractants, Repellents. Behavior of fish in captive and wild environment. Fish cognition and behavior, learning foraging skill, Learned defenses and counter defenses in predator-prey interaction, social learning, Mimicry, Habituation, chemical alarm cues and the assessment of predation risk by fishes, Learning & Mate Choice, Modulating aggression through experience, Machiavellian intelligence in fishes. Neural mechanisms of learning in teleost fish. The role of fish learning skills in fisheries and aquaculture

Particles

- To compare the boldness, exploratory behavior of wild and captive reared fish
- To study the behavioural changes related to artificial noise exposure
- To determine if a goldfish can be trained to associate the sound of a bell with feeding time
- To determine the motor behavior function of fish in response to toxicant exposure
- To study the learning capability of fish

Recommended books

- Brown, C., Laland, K. N. and Krause, J., 2010. Fish cognition and behavior. Blackwell Science.UK.
- Sloman, K.A., Wilson, R.W. and Balshine, S., 2006. Behaviour and Physiology of Fish. Elsevier, Netherlands.
- Grubb, T.C. J., 2003. The Mind of the Trout. University of Wisconsin Press, Madison.
- Lucas, C.M. and Baras, E., 2002. Migration of Freshwater Fishes. Blackwell Science Ltd. UK.
- Reeb, S., 2001. Fish behavior in the aquarium and in the wild. Cornell University Press, USA.
- Zupanc, G.K.H. 1988. Fish and their Behavior, Tetra Press, Germany.
- Pitcher, T.J., 1993. Behavior of teleost fishes. Chapman & Hall, UK.

FISH POST HARVEST TECHNOLOGY 3(2+1) CH

Learning Outcomes

After studying this course, student would be able to:

- Use fish post harvest technology in fisheries
- Perform the handling, preservation, processing and control of fish quality
- Describe methods of quality control and processing of fish

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; offloading; 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.

Practicals

- 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. Hall, G. M., 2011. Fish Processing: Sustainability and New opportunities. Willey Blackwell, UK
2. Pearson, A.M. and Dutson, T.R., 2004. HACCP in Meat, Poultry and Fish Processing. Kluwer Academic Publishers, India.
3. FDA., 2003. Fish and Fisheries Products Hazards and Control Guidance. US Food and Drug Administration.
4. Lucas, J.S. and Southgate, P.C., 2003. Aquaculture: Farming Aquatic Animals and Plants. Fishing News Books. Blackwell, Australia
5. NIIR., 2003. Hand Book on Fisheries and Aquaculture Technology. Asia Pacific Business Press, India.
6. Bremner, H. A., 2002. Safety and Quality issues in fish processing. Woodhead publishing, UK.
7. Connell, J.J., 2001. Control of Fish Quality. Blackwell, USA.

ENDOCRINOLOGY

3(2+1) CH

Learning outcomes

After studying this course, student would be able to:

- Define the levels of integration among major physiological systems
- Explain the major neuroendocrine axes that modulate growth, reproduction, and stress
- Describe how organisms interact with their environments and how environmental conditions modulate physiological regulatory mechanisms

Fish endocrine system and mechanism; The evolution fish endocrinology; Pituitary gland and its functions; Neurohypophys and its hormones; Adenohypophys and its hormones; Thyroid gland and its functions in fish; The pancreas types in fish, pancreas gland and pancreatic hormones; Gastro-intestinal hormones in fish; Adrenal cortex (interrenal tissue), Chromaffin tissue and Corpuscles Stannius; Gonadal hormones in fish;

Testes and Ovaries (androgenic tissue: structure and chemistry; transport, metabolism and mechanism of action. Ovarian hormones: steroid biochemistry and biosynthesis; transport, metabolism and mechanism of action). Pheromones; Endocrine disrupters chemicals and the effects on fish; the relation between fish hormones and migration; the hormones in aquaculture; Molecular fish endocrinology.

Practicals

1. Demonstration of endocrine glands and associated structures in dissections, transparencies, computer projections etc
2. Histological and ultra structure features of endocrine glands
3. Demonstration of physiological roles of hormones of different endocrine glands
4. Demonstration on functional diversity and endocrine mechanism of hormones in different vertebrates.

Recommended books

1. Melmed, S., Polonsky, K. S., Larsen, P.R. and Kronenberg, H. M., 2016. WILLIAMS textbook of Endocrinology. 13th ed. Elsevier Inc, USA.
2. Norris, D.O. and Carr, J. A., 2013. Vertebrate Endocrinology .5th ed. Elsevier publishing, USA.
3. Papoutsoglou, S.E., 2012. Test book of Fish Endocrinology. Nova Science, USA.
4. Norris, D.O. and Carr, J.A., 2005. Endocrine Disruption. Oxford University Press. USA.
5. Reinecke, M., Zaccone, G., B.G. Kapoor, B.G., 2006. Fish Endocrinology. (2 volume set) 1st ed. CRS Press, USA.
6. Sloman, K.A., Balshine, S. and Wilson, R.W., 2005. Behaviour and Physiology of Fish. Academic Press. UK.

BIOSAFETY AND BIOETHICS

Learning outcomes

After studying this course, students would be able to:

- Demonstrate good laboratory procedures and practices
- Describe the standard operating procedures for biotechnology research and assign Biosafety levels
- Discuss the social and ethical issues related to plant and animal biotechnology
- Discuss the relevance of intellectual property rights to modern biotechnological innovations

Safety and ethical issues: guidelines for research on genetically modified organisms (GMOs), quality control of biological produced by rDNA

technology, safety in the contained use and release of transgenic animals, ecological risk of engineered organisms/plants and remedial measures, ethical issues related to biotechnology products. Biosafety regulations : guidelines for environmental release of GMOs, guidelines for import and shipment of GMOs, mechanism of implementation of biosafety guidelines at Institutional, national and international level, Role of national agencies in regulating GMOs; Acts and treaties related to biosafety of GMOs, Public awareness, perception and acceptance of products of biotechnology. Patent laws: Global scenario of genetically modified organisms, Intellectual Property Rights (IPR), patent laws at institutional, national and international level. Parenting and Procreation, the Ethics of Incentives, Discrimination, Stereotyping and Profiling, Duty to Rescue

Recommended books

- Goel, D. and Parashar, S., 2013. IPR, Biosafety and Bioethics. Kindle Edition. Pearson Education, India.
- Sateesh , M.K., 2010. Biosafety and bioethics. I.K. International Publishing house Pvt. India.
- Joshi, R., 2006. Biosafety and Bioethics. Gyan Publishing House, India.
- Tzotzos, G.T., 1995. Genetically modified organisms-A guide to biosafety, CAB International. UK.

FISH IMMUNOLOGY

3 (2+1) CH

Learning outcomes

After completing this course, students would be able to:

- Know the Specific immune system (cellular defenses, humoral defenses) of fish
- Describe the functions of immune organs
- Understand the ontogeny of immune responses
- Know how the immune response is being regulated
- Know the importance of several factors including environmental factors that affect the immune response

General concepts in immunology, Fish immunology , Cells and Tissues of the immun system of fish, the non-specific immune system(cellular defenses, humoral defenses), specific immun system (cellular defenses, humoral defenses), primary immune response, secondary immune response, difference in primary and secondary immune response, lymphocytes, B-cells and T-cells, ontogeny of immune response, ontogeny of lymphoid organ development, Environmental factors in fish immunology, Immunostimulation , immunosuppression.

Practicals

- To study the innate immune response of fish before and after challenge to pathogens
- To study the immune response of fish after feeding immunostimulant.

Recommended books

1. Secombes, C.J. and Ellis, A.E., 2012. The Immunology of Teleosts: in Fish Pathology. 4th ed. Blackwell, UK.
2. daDouglas P. A., 2003. Textbook of Fish Immunology: Diseases of Fishes. Narendra Publishing, India.

Fish Parasitology

3(2+1) CH

Learning outcomes

After studying this course, students would be able to:

- Have knowledge of important ecto and endo parasites of fish
- Know about life style of parasites and their intermediate hosts
- Describe ecto and endo method for the identification of parasites

Define parasitism, ectoparasite and endoparasite concepts , Life styles of parasites and their intermediate hosts, methods which are used for identification, Effects of parasites on fishes, mechanism of illnesses by parasite on fishes, Methods of parasite identification (ecto and endo methods). Important ecto and endo parasites. Some protozoon parasite species on fishes with parasitic characteristics, the diagnosis, the protection and the importance in terms of human health, Some parasite species belonging to phylum Plathelminthes, Nemathelminthes and Arthropoda on fishes with parasitic characteristics, the diagnosis, the protection and the importance in terms of human health. Individual and evolutive effects of parasitism on fishes. The medically important parasites, Protection and the treatment of fish parasites.

Practicals

- To identify some protozoon parasite species n fish with parasitic characteristics
- To identify some parasite species belonging to phylum Plathelminthes, Nemathelminthes and Arthropoda on fishes with parasitic characteristics
- To study the life style of fish parasites having intermediate hosts

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

Functional English

- a. Grammar
 1. Thomson, A.J. and Martinet, A.V., 1997. Practicals English Grammar, Exercises Third Ed. Oxford University Press. ISBN 0194313492
 2. Thomson, A.J. and Martinet, A.V., Exercises 2. Third Ed. Oxford University Press. ISBN 0194313506
- b. Writing
 1. Boutin, M., Brinand, S. and Grellet, F., 1993. Writing. Intermediate. Oxford Supplementary Skills. Fourth Impression. ISBN 0 19 435405 7 Pages 20-27 and 35-41
- c. Reading/Comprehension
 1. Tomlinson, B. and Ellis, R., 1992. Reading. Upper Intermediate. Oxford Supplementary Skills. Third Impression.

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. Thomson, A.J. and Martinet, A.V., 1986. Practicals English Grammar, Exercises 2. Third Ed. Oxford University Press
- b. Writing
 1. Boutin., Brinand, S. and Grellet, F., 1993. Writing. Intermediate. Oxford Supplementary Skills. Fourth Impression. Pages 45-53 (note taking)
 2. Nolasco, R., 1992. Writing. Upper-Intermediate. Oxford Supplementary Skills. Fourth Impression. (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing)
- c. Reading
 1. Tomlinson, B. and Ellis, R., 1991. Reading. Advanced. Oxford Supplementary Skills. Third Impression. ISBN 0194534030
 2. Langan, J., 2012. Reading and Study Skills.

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.

Essay Writing and Academic Writing:

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

Presentation Skill**Reading**

1. Neulib, J., Cain, K.S., Ruffus, R. and Scharon, M. The Mercury Reader. A Custom Publication. Compiled by northern Illinois University. General Editors: (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 Contents

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.

Recommended books

1. Burki, S.J., 1980. State and Society in Pakistan, The Macmillan Press Ltd
2. Zaidi, A.S., 2000. Issue in Pakistan's Economy. Karachi: Oxford University Press

3. Burke, S.M. and Ziring, L., 1993. Pakistan's Foreign policy: A Historical analysis. Karachi: Oxford University Press
4. Mehmood, S., 1994. Pakistan Political Roots and Development. Lahore
5. Wilcox, W., 1972. The Emergence of Banglades. Washington: American Enterprise, Institute of Public Policy Research
6. Amin, Tahir. Ethno - National Movement in Pakistan, Islamabad: Institute of Policy Studies, Islamabad
7. Ziring, L., 1980. Enigma of Political Development. Kent England: WmDawson and sons Ltd
8. Zahid, A., 1980. History and Culture of Sindh. Karachi: Royal Book Company
9. Rafique, A.M., 1998. Political Parties in Pakistan, (I), (II) and III. Islamabad: National Institute of Historical and cultural Research
10. Sayeed, K., 1967. The Political System of Pakistan. Boston: Houghton Mifflin
11. Aziz, K.K., 1976. Party, Politics in Pakistan, Islamabad: National Commission on Historical and Cultural Research
12. Waseem, M., 1987. Pakistan Under Martial Law, Lahore: Vanguard

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.

Course Contents

Introduction to Quranic Studies

1. Basic Concepts of Quran.
2. History of Quran.
3. Uloom-ul –Quran.

Study of Selected Text of Holy 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 Holy Quran

1. Verses of Surah Al-Ihزاب 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 and Hadith.
6. Legal Position of Sunnah.

Selected Study from Text of Hadith

Introduction to Islamic Law and Jurisprudence

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

Islamic Culture and Civilization

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

Islam and Science

1. Basic Concepts of Islam and Science.
2. Contributions of Muslims in the Development of Science.
3. Quran and 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 and 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.

Recommended books

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

ANNEXURE - D

Note: One course will be selected from the following three 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

Objectives

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 Contents

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

1. Dolciani, M.P., Wooton, W., Beckenback E.F. and Sharron. S., 1978. Algebra 2 and Trigonometry. Houghton and Mifflin

Suggested text

1. Kaufmann, J.E., 1986. College Algebra and Trigonometry: Fundamentals of Algebra and Trigonometry.6th ed. PWS-Kent Company,USA.

2. MATHEMATICS II (CALCULUS)

Prerequisite (s): Mathematics I (Algebra)

Credit Hours: 3

Objectives

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 Contents

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

1. Anton, H., Bevens, I., Davis, S., 2005. Calculus: A New Horizon. 8th ed. John Wiley, USA.
2. Stewart, J., 1995. Calculus. 3rd ed. Brooks/Cole
3. Swokowski, E.W., 1983. Calculus and Analytic Geometry. PWS-Kent Company, USA.
4. Thomas, G.B. and Finney, A.R., 2005. Calculus. 11th ed. Addison-Wesley, Reading, USA.

3. MATHEMATICS III (GEOMETRY)

Prerequisite (s): Mathematics II (Calculus)

Credit Hours: 3

Objectives

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 Contents

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

1. Kaufmann, J.E., 1987. College Algebra and Trigonometry. PWS-Kent Company, USA.
2. Swokowski, E.W., 1997. Fundamentals of Algebra and Trigonometry . 9th ed. PWS-Kent Company, Boston
3. Abraham, S., 1969. Analytic Geometry, Scott, Freshman and Company

INTRODUCTION TO STATISTICS

Credit Hours: 3

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.

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.

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.

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.

Probability and Probability Distributions

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

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.

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.

Testing of Hypothesis- Single Population

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

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.

Testing of Hypothesis-Independence of Attributes:

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

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. Muhammad, F., 2005. Statistical Methods and Data Analysis. Kitab Markaz, Islamabad.
2. Walpole, R. E., 1982. Introduction to Statistics. 3rd ed. Macmillan Publishing, USA.

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.

ANNEXURE - F

Introduction to Information and Communication Technologies

Course Structure: Lectures: 2 Labs: 1 **Credit Hours: 3**
Pre-requisite: None **Semester: 1**

Course Description

This is an introductory course on Information and Communication Technologies. Topics include ICT terminologies, hardware and software components, the internet and World Wide Web, and ICT based applications.

After completing this course, a student will be able to:

- Understand different terms associated with ICT
- Identify various components of a computer system
- Identify the various categories of software and their usage
- Define the basic terms associated with communications and networking
- Understand different terms associated with the Internet and World Wide Web.
- Use various web tools including Web Browsers, E-mail clients and search utilities.
- Use text processing, spreadsheets and presentation tools
- Understand the enabling/pervasive features of ICT

Course Contents

Basic Definitions & Concepts

Hardware: Computer Systems & Components

Storage Devices, Number Systems

Software: Operating Systems, Programming and Application Software

Introduction to Programming, Databases and Information Systems

Networks

Data Communication

The Internet, Browsers and Search Engines

The Internet: Email, Collaborative Computing and Social Networking

The Internet: E-Commerce

IT Security and other issues

Project Week

Review Week

Text Books/Reference Books

1. Introduction to Computers by Peter Norton, 6th International Edition, McGraw-Hill
2. Using Information Technology: A Practical Introduction to Computer & Communications by Williams Sawyer, 6th Edition, McGraw-Hill
3. Computers, Communications & information: A user's introduction by Sarah E. Hutchinson, Stacey C. Swayer
4. Fundamentals of Information Technology by Alexis Leon, Mathews Leon, Leon Press.