CURRICULUM

OF

BIO INFORMATICS

BS/MS

(Revised 2015)

HIGHER EDUCATION COMMISSION
ISLAMABAD

CURRICULUM DIVISION, HEC

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Composed by: Mr. Tanveer Ali, HEC

CONTENTS

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).

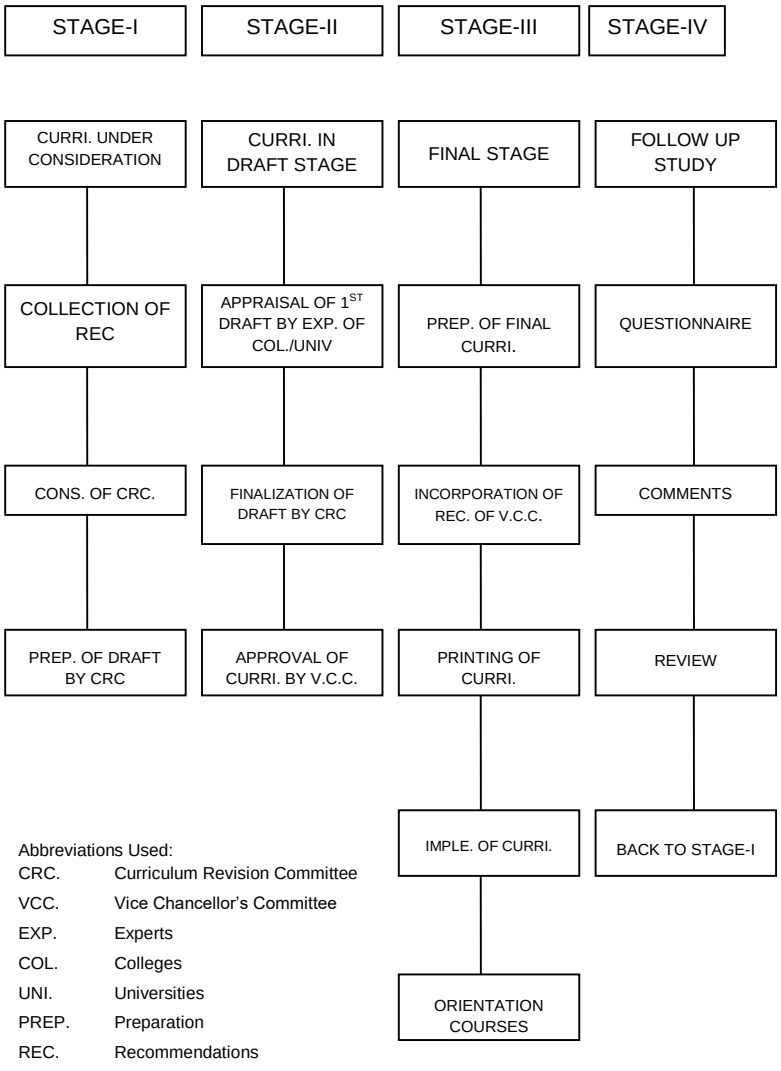
In compliance with the provisions, the Curriculum Division of HEC undertakes the revision of curricula after every three years through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector universities, 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



Abbreviations Used:

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

INTRODUCTION

The final meeting of the National Curriculum Revision Committee in Bioinformatics was held on May 17-19, 2014 at HEC, Regional Centre, Karachi to review and finalize the curriculum for BS (4-years) and MS (2-years) degree programs in Bioinformatics. Following members and experts attended the meeting:

1. Dr. Nazeer Ahmed — Convener
Professor / Chairman,
Department of Biotechnology & Informatics,
Balochistan University of Information Technology,
Engineering & Management Sciences,
Takatoo Campus, Airport Road, Quetta

2. Dr. Muhammad Ayub — Member
Assistant Professor,
Department of Biochemistry,
University of Balochistan, Seriab Road, Quetta

3. Dr. Syed M. Jahangir Matti — Member
CEO (Matti-K-Jahangir, Pvt Ltd.)
Family Suit # 8, Old MNA Hostel,
Sector G-5/1, Islamabad

4. Dr. Isharat Jabeen — Member
Assistant Professor,
Department of Bioinformatics,
National University of Science & Technology,
Research Centre for Modeling & Simulation (RCMS),
H-12, Islamabad

5. Dr. Faisal F. Khan — Member
Assistant Professor / Director,
Institute of Integrative Biosciences,
CECOS University of IT & Emerging Sciences,
Phase-VI, Hayatabad,Peshawar

6. Dr. Muhammad Inam ul Haq — Member
Assistant Professor,
Department of Computer Sciences,
Khushal Khan Khattak University, Karak, KPK

7. Dr. Aftab Ali Shah — Member
Assistant Professor,
Department of Biotechnology,
University of Malakand, KPK.

8. Dr. Shahida Hasnain — Member
Professor / Vice Chancellor,
Department of Microbiology & Molecular Genetics,
The Women University, Katchery Road, Multan

9. Dr. Mehboob Ahmed — Member
Assistant Professor,
Department of Microbiology & Molecular Genetics,
University of the Punjab,
New Campus, Lahore

10. Dr. Muhammad Wasim — Member
Associate Professor,
Institute of Biochemistry & Biotechnology,
University of Veterinary & Animal Sciences, Lahore

11. Dr. Masroor Ellahi Babar — Member
Professor,
Department of Bioinformatics,
Virtual University of Pakistan,
MA Jinnah Campus, Defence Road, Lahore

12. Dr. Samreen Amir — Member
Associate Professor,
Hamdard Institute of Engineering & Technology,
Hamdard University,Madinat-al-Hikmah,
Shahrah-e-Madinat-al-Hikmah, Muhammad Bin
Qasim Avenue, Karachi-74600

13. Dr. Muhammad Arif — Member
Assistant Professor,
Department of Biomedical Engineering,
Mehran University of Engineering & Technology,
Jamshoro, Sindh

14. Dr. Farhat Naureen Memon — Member
Assistant Professor,
Institute of Mathematics & Computer Science,
University of Sindh, Jamshoro

15. Dr. Aziz Mithani — Member
Assistant Professor,
Department of Biology,
Syed Babar Ali School of Science & Engineering,
Lahore University of Management Sciences,
Sector U, DHA, Lahore Cantt. 54792

16. Dr. Muhammad Nauman Aftab — Member
Assistant Professor,
(Secretary NCRC 2011),
Institute of Industrial Biotechnology,
Government College University, Lahore

17. Ms. Iffat Farzana Anjum — Member
Lecturer,
Department of Bioinformatics & Biotechnology,
Room # 11, Maryam Block,
International Islamic University, Islamabad

18. Mr. Rizwan Shaukat — Member
Deputy Director (Curriculum Division)
Higher Education Commission,
Sector H-9,
Islamabad

19. Dr. Sajid Rashid — Secretary
Assistant Professor,
National Centre for Bioinformatics,
Quaid-i-Azam University, Islamabad

Mission Statement

To train the next generation professionals and researchers to gain advanced knowledge in the interdisciplinary field of Bioinformatics that is required to design and implement novel methods and tools to provide a better understanding of biological systems.

Program Objectives

At the end of four years BS program, the graduates should have strong understanding of:

1. Various aspects of biological systems.
2. Different areas of computer science including programming languages.
3. Existing bioinformatics tools and databases.
4. Computational applications related to biological systems.
5. Analysis and interpretation of biological data.

Learning outcomes

At the completion of this program, students are expected to know the relationship between genes and proteins and use of computer to handle biological data. Students should have a deeper insight into various tools and techniques commonly used in bioinformatics. Students should be able to appreciate diversified areas and applications like genomics, drug designing, agri- and health informatics, biotechnology, systems biology and others.

Admission Requirements

Eligibility

Higher Secondary School certificate or equivalent (2nd division with at least 50% marks) in pre-engineering/pre-medical/Intermediate in computer sciences/relevant subjects

Duration

Four years program spread over 8 semesters, two semesters per year.

Course and Credit Requirements

A total of 124-136 credit hours are required to complete BS in Bioinformatics.

STANDARDIZED FORMAT/SCHEME OF STUDIES FOR FOUR-YEAR INTEGRATED CURRICULA FOR BACHELOR DEGREE IN BIOINFORMATICS

STRUCTURE

Sr.	Categories	No. of Courses Min – Max	Credit Hours Min – Max
1.	Compulsory Requirement (No Choice)	9 – 9	25 – 25
2.	General Courses to be chosen from other departments	7 – 8	21 – 24
3.	Discipline Specific Foundation Courses	9 – 10	30 – 33
4.	Major Courses including research project/Internship	11 – 13	36 – 42
5.	Electives within the major	4 – 4	12 – 12
	Total	**40 – 44**	**124 – 136**

Total numbers of Credit hours	124-136
Duration	4 years
Semester duration	16-18 weeks
Semesters	8
Course Load per Semester	15-18 credit hours
Number of courses per semester	4-6 (not more than 3 lab/ practical courses)

LAYOUT

Compulsory Requirements (student has no choice)		**General Courses to be chosen from other departments**		**Discipline Specific Foundation Courses**	
9 courses		**7-8 courses**		**9-10 courses**	
25 Credit hours		**21-24 Credit hours**		**30-33 Credit hours**	
Subject	**Cr. hr.**	**Subject**	**Cr. hr.**	**Subject**	**Cr. hr.**
1. English I 2. English II 3. English III 4. Pak Studies 5. Islamic Studies/ethics 6. Basic Calculus 7. Computer Fundamentals 8. Basic Biology/ Basic Mathematics 9. Chemistry	3 3 3 2 2 3 3 3 3	1. Data Structure and Algorithms 2. Object oriented programming 3. Programming Fundamentals 4. Discrete Structures 5. Database Management Systems 6. Social sciences subject 7. Ethical and legal issues in Bioinformatics	4 4 4 3 4 3 2	1. Linear Algebra and Differential Equations 2. Essentials of Genetics 3. Cell Biology 4. Bioinformatics I 5. Bioinformatics II 6. Biochemistry I 7. Biochemistry II 8. Molecular Biology 9. Recombinant DNA technology	3 4 4 3 4 4 3 4 3
	25		**24**		**32**

Major courses including research project/internship		**Elective Courses within the major**	
11-13 courses		**4 courses**	
36-42 Credit hours		**12 Credit Hours**	
Subject	**Cr. hr.**	**Subject**	**Cr. hr.**
1.Bioinformatics Computing I 2.Genomics 3.Proteomics 4.Graphics and Visualization 5.Bioinformatics Computing II 6.Artificial Intelligence 7.Bioinformatics software Engineering 8.Special topics in Bioinformatics 9.Research Project 10.Systems Biology 11.Modeling and Simulation 12. Probability and Biostatistics	4 3 3 4 3 3 3 3 6 3 3 4	**Elective I** **Elective II** **Elective III** **Elective IV**	3 3 3 3
	42		**12**

Scheme of Studies for BS (Bioinformatics)

Course Code	Semester 1	Credit hours	
	Courses	**Lectures**	**Lab**
Hum-101	English Comprehension	3	0
Hum-105	Pakistan Studies	2	0
Hum-***	Islamic Studies/Ethics	2	0
Bio-101 OR MTH-101	Basic Biology* OR Basic Mathematics*	2 3	1 0
Bio-102	Chemistry	2	1
CS-101	Computer Fundamentals	2	1
	*Deficiency courses		
Total Credit Hours		**13 OR 14**	**3 2**

Course Code	Semester 2	Credit hours	
	Courses	**Lectures**	**Lab**
Bio-203	Probability and Biostatistics	3	1
Bio-103	Basic Cell Biology	3	1
CS-102	Programming Fundamentals	3	1
BSI-191	Basic Calculus	3	0
Bio-104	Biochemistry I	3	1
Total Credit Hours		**15**	**4**

Course Code	Semester 3	Credit hours	
	Courses	**Lectures**	**Lab**
Hum-201	Technical Report Writing	3	0
MTH-201	Linear Algebra and Differential Equations	3	0
Bio-201	Essentials of Genetics	3	1
Hum-103	Communication skills	3	0
CS-201	Data Structure and Algorithms	3	1
Total Credit Hours		**15**	**2**

Course Code	Semester 4	Credit hours	
	Courses	**Lectures**	**Lab**
BI-201	Bioinformatics I	2	1
Bio-204	Biochemistry II	3	0
Bio-202	Molecular Biology	3	1
CS-202	Object Oriented Programming	3	1
SS-***	Social sciences subject	3	0
Total Credit Hours		**14**	**3**

Course Code	Semester 5	Credit hours	
	Courses	**Lectures**	**Lab**
CS-301	Discrete Structures	3	0
GEN-***	Recombinant DNA technology	2	1
CS-302	Database Management Systems	3	1

BI-202	Ethical and Legal Issues in Bioinformatics	2	0
BI-301	Bioinformatics II	3	1
Bio-302	Genomics	3	0
Total Credit Hours		**16**	**3**

Course Code	**Semester 6**	**Credit hours**	
	Courses	**Lectures**	**Lab**
BI-302	Bioinformatics Computing I	3	1
CS-303	Modeling and Simulation	2	1
Bio-303	Proteomics	3	0
CS-304	Graphics and Visualization	3	1
Bio-304	Systems Biology	3	0
Total Credit Hours		**14**	**3**

Course Code	**Semester 7**	**Credit hours**	
	Courses	**Lectures**	**Lab**
CS-401	Artificial Intelligence	3	0
BI-402	Bioinformatics Software Engineering	2	1
***	Elective I	3	0
***	Elective II	3	0
BI-403	Special Topics in Bioinformatics	3	0
	Research Project	0	3
Total Credit Hours		**14**	**4**

Course Code	Semester 8	Credit hours	
	Courses	**Lectures**	**Lab**
BI-401	Bioinformatics Computing II	3	0
***	Elective III	3	0
***	Elective IV	3	0
	Research Project	0	3
Total Credit Hours		**9**	**3**

Total Credit Hours	**110**	**26**

DETAIL OF COURSES

Semester-I

Hum-101	**English Comprehension**	**3+0**	**Annexure - A**
Hum-105	**Pakistan Studies**	**2+0**	**Annexure - B**
Hum-***	**Islamic Studies/Ethics**	**2+0**	**Annexure - C**
Bio-101	**Basic Biology**		**2+1**

Prerequisite: None
Specific objectives of the course:
To provide students with a biological foundation on which they can build a graduate degree in natural and physical science.

Course Outline
Basic concepts of life science: origin of life; biological time scales, branches of biology, prokaryotic and eukaryotic cells, viruses, structure of viruses and bacteriophages, bacteria, bacterial structure and classification; algae, fungi. Introduction to plant and animal biology, role of biology in medicine.

Lab Outline
Study of plant and animal cell structure using compound microscope, culture and staining of microorganisms, study of mitosis and meiosis, study of flowers.

Recommended Books
Latest editions of following books
1. Campbell and Mitchell, "Biology: Concepts and connections", Wesley Longman Inc. New York.
2. Star C., "Biology Concepts and Applications", Thomson.
3. Fogiel M., "The Biology Problem Solver", Research & Education Association.

MTH-101	**Basic Mathematics**	**3+0**

Prerequisite: None

Specific objectives of the course
This is a deficiency course for students who have not studied mathematics at the intermediate level. The basic concepts of trigonometry, linear algebra and vectors are introduced in this course.

Course Outline
Basic concepts of Linear Algebra, Introduction of Trigonometry, Using graphs, Graph transforms, Combination and Permutations, Introductory concepts in Integration and Derivatives, Exponentials, Logarithms, Basic concepts related to Complex Numbers, Basic probability, Introduction to Linear Equations and Algebraic Functions, Sequence and series, Introductory concepts of Vectors and various applications of Vector calculus.

Recommended Books
Latest editions of following books
1. Hebeorn and Littlewood, "Modular Math", Heinemann,
2. Keith Pledger, "Core Mathematics", Edexcel.

Bio-102 Chemistry 2+1

Prerequisite: None

Specific objectives of the course
This course will familiarize students with basic principles, concepts and theories in chemistry.

Course Outline
Periodic table, nature of chemical bonding, state of matter, properties of solutions; properties of liquid vapor pressure, surface tension viscosity, optical activity, refractometry, liquid properties of water as solvent structure and interaction, chemical reactivity, acid, bases, oxidation-reduction reactions, chemical kinetics, first, second, and third order reactions, influence of temperature on reaction rates, polymers and colloids, introduction to organic chemistry.

Lab Outline
Preparation of molar and normal solutions, use of pH meter to determine pH of various solutions, acid base titration, use of spectrophotometer to determine the absorbance, determination of melting point and boiling point.

Recommended Books
Latest editions of following books
1. Brown *et al*., "Chemistry: The central Science", Pearson Printing Hall.
2. Raymond Chang, "Chemistry", McGraw Hill.
3. Christopher J. Crammer, "Computational Chemistry: Theories and Models", John Willey & Sons.

4. Philips / Mathews, “Advanced Chemistry: Physical and Industrial”, Cambridge University Press.

CS-101 Computer Fundamentals 2+1

Prerequisite: None

Specific objectives of the course
This course focuses on introducing computing environments, general application software, basic computing hardware, operating systems, desktop publishing, Internet, software applications and tools and computer usage concepts.

Course Outline
History, classification, computer and society, overview of numbering system with various Boolean functions, flow chart techniques, storage, programs & software, system software, application software, operating systems, office automation tools: word processing, graphics packages, databases and spreadsheets, various operating systems, current trends and research prospects. Legal and moral aspects of computing.

Lab Outline
Computation of Number system, Implementation of Boolean Functions, Basic machines organization including motherboard, memory, I/O cards, Networking devices, Use of flow charts, Introduction to office tools, overview of different browsers including open source browsers, Introduction to various operating systems.

Recommended Books
Latest editions of following books
1. P.K Sinha, “Introduction to Computer Science”,
2. Glenn Brookshear, “Computer Science- An Overview”, Prentice Hall.

Semester-II

Bio-203 Probability and Biostatistics 3+1

Prerequisite: None

Specific objectives of the course
This course introduces the concepts of statistical methods used in analyzing biological data.

Course Outline

Frequency distribution and probabilities, measure of central tendencies and dispersion, Elementary probability theory, Laws of Probability, Conditional Probability, Introduction to Bayes Theorem Introduction to Random Variable and Probability Distributions, Binomial Distribution, Properties of binomial distribution, Poisson distribution, Normal distribution area under the normal curves, Introduction to sampling and various sampling design, Applications of Normal distributions and tests of significance,. Test of independence or association, method related to one and two means, variance and covariance, heritability and its uses, analysis of variance (ANOVA), regression analysis, Pedcheck and merlin for LOD score calculation.

Lab Outline

Collection of data, acquisition of random samples, graphical/tabular representation of data, MS-Excel, SPSS/R, problems related to combining probabilities, central tendencies and dispersion, problems related to chi-square, problems of goodness of fit and independent events, verification of genetic ratios and test of association.

Recommended Books

Latest editions of following books

1. Gravetter Frederick J., “Statistics for Behavioral Sciences”, Wadsworth publishing.
2. Mead R Curnow R. N., “Statistical Methods in Agriculture and Experimental Biology”. Chairman and Hall.
3. Mathews and Farewell, “Using and understanding Medical Statistics”, Krager New York.
4. Ross, S., “Introduction to Probability Models”, Elsevier.
5. Bernard Rosner, “Fundamentals of Biostatistics”, Cengage Learning.
6. Wayne W. Daniel, “Biostatistics: A Foundation for Analysis in the Health Sciences”, Wiley.
7. Ronald E. Walpole, “Probability and Statistics for Engineering and the Sciences”, Pearson.
8. Steel and Torrie, “Principles and procedures of Statistics: a biometrical approach”, McGraw-Hill.

Bio-103 Basic Cell Biology 3+1

Prerequisite: None

Specific objectives of the course

This course provides the basic concepts of life science, with emphasis on diversity of life, physical and chemical nature of living matter, the form and function of the cell and organisms.

Course Outline
An introduction to cell biology, differences between prokaryotes and eukaryotes, physio-chemical properties of protoplasm, cell wall, cell membrane, structure and transport properties, fluid mosaic model, organelles: mitochondria, endoplasmic reticulum, golgi bodies, plastids, lysosomes, peroxisomes, cell internal structure, cytoskeleton, microtubules, microfilaments, intermediate filaments, structure of chromosomes, cell division and cell cycle.

Lab Outline
Study of cell structure using compound microscope and elucidation of ultra-structure from electron microphotographs, measurement of cell size, study of mitosis and meiosis by smear/squash method and from prepared slides, study of chromosome morphology and variation in chromosome number.

Recommended Books
Latest editions of following books

1. David M. P., "Methods in Cell Biology", Academic Press London.
2. Lowery Sekivetz. "Cell Structure and Function", John Willey and Sons Publication.
3. Gerald Karp. "Cell Biology", Wiley.
4. Lodish H. "Molecular Cell Biology", Media Connected
5. Lewin B. "Genes X", Pearson/Prentice Hall.
6. De Robertis, "Cell and Molecular Biology", Lippincott Williams & Wikins.
7. Sadava D. et al., "Life, The Science of Biology", WH Freeman.
8. Bruce Alberts et al., "Molecular Biology of Cell", Garland Science.

CS-102 Programming Fundamentals 3+1

Prerequisite: Basic Math

Specific objectives of the course
The course is designed to familiarize students with the basic programming skills. It emphasizes upon problem analysis, algorithm designing, program development and testing.

Course Outline
Overview of programming, overview of computer languages and translators, basics of structured and modular programming, basics of

algorithms and problem solving logics, fundamentals of programming constructs, translation of algorithms to programs, data types, control structures, functions, arrays, records, files, pointers, program development.

Lab Outline
Introduction to various programming paradigms, coding, executing and debugging simple programs, implementation of simple control structures, implementation of functions, arrays, records, file input / output techniques implementation of pointers and memory allocation/deallocation.

Recommended Books
Latest editions of following books

1. R. P. Halpern, "C for Yourself – Learning C Using Experiments", Oxford University Press.
2. Yashwant Kanetkar, "Let us C", Jones & Bartlett Learning.
3. Robert Lafore, "Turbo C. Programming for PC", Prentice Hall.

BS-191 Basic Calculus 3+0

Prerequisite: None

This course will familiarize students with the basic principles of calculus and their application to problem solving.

Course Outline
Introduction to Functions: Mathematical and physical meaning of functions, graphs of various functions, Introduction to Limits: Theorems of limits and their applications to functions. Derivatives: Introduction to derivatives, Partial derivatives and their geometrical significance Application problems (rate of change, marginal analysis) Higher derivatives: Mean value theorem. Applications of derivatives: curvature and radius of curvature, maxima and minima of a function Applications of Partial Derivatives: Integral calculus: Methods of integration by substitutions and by parts, reduction formulae, Applications of integral calculus: Vector algebra: Introduction to vectors, Vector calculus: Vector differentiation, vector integration and their applications.

Recommended Books
Latest editions of following books

1. Thomas Finney, "Calculus", Penguin.
2. Doniel D. Benice, "Brief Calculus and its applications", Houghton Mifflin College Division.
3. Raymond A. Barnett, "Applied Calculus", Prentice Hall.

4. Gerald L. Bradley, “Calculus”, Hoffman, McGraw Hill.
5. SM Yousaf, “Calculus with analytical geometry”, Ilmi Kitab Khana.

Bio-104 Biochemistry I 3+1

Prerequisite: None

Specific objectives of the course
The course will provide fundamental knowledge about chemistry of biomolecules.

Course Outline
Water, pH and buffer systems, molecules of life: structure, function and classification, nucleic acids as genetic material, lipids, bilayers and membranes, saccharide chemistry, mono, di and polysaccharides, amino acids the building block of proteins, levels of protein structures, protein structure and folding, physiological role of proteins, role in catalysis and signaling

Lab Outline
Hydrolysis of a protein and qualitative tests for amino acids; paper chromatography of amino acids; estimation of proteins by Lowry’s, dye-binding, titration curves of amino acids. Distinction between pentoses and hexoses, reducing and non-reducing sugars, acid value, saponification and iodine values of fat.

Recommended Books

Latest editions of the following books

1. Nelson and Michel, “Lehninger: Principles of Biochemistry”, Freeman and Company.
2. Conn and Stumpf, “Outlines of Biochemistry”, John Willey and Sons.
3. Devlin and Thomas, “Text book of Biochemistry with Clinical Correlations”, John Willey and Sons.
4. Campbell M. and Shawn F, “Biochemistry”, Cengage Learning.
5. Voet and Voet, “Biochemistry”, John Wiley and Sons.
6. Jeremy M. Berg, John L., T, STRYER L, “Biochemistry”, WH Freeman & Co.

Semester-III

Hum-201 Technical Report Writing 3+0 ANNEXURE - A

Hum-103 Communication Skills 3+0 ANNEXURE - A

MTH-201 Linear Algebra and Differential Equations 3+0

Prerequisite: None

Specific objectives of the course
This course introduces matrices, determinants and differential equations for solving linear equations.

Course Outline
Introduction to matrices, elementary row operations and vector spaces: Brief introduction to matrices, system of linear equations, system of non-homogeneous and homogeneous linear equation, introduction to determinants, properties of determinants of order, axiomatic definition of a determinant, multiple integrals, double integrals, differential equations of first order, initial and boundary conditions, methods of solution of differential equation of first order and first-degree, separable equation, homogeneous equations, linear equations, Bernoulli equations, applications of first order differential equations, Higher order linear differential equations, homogeneous linear equations, solution of higher order differential equations.

Recommended Books

Latest editions of following books
1. David C. Lay*, "*Linear Algebra and its applications"*,* Pearson Addison Wesley.
2. Michael Greenberg, "Advanced Engineering Mathematics"*,* Pearson.
3. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons.

Bio-201 Essentials of Genetics 3+1

Prerequisite: Biochemistry 1

Specific objectives of the course
This course provides the basic principles of inheritance and students will gain experience in variety of techniques used in gene analysis.

Course Outline
Introduction, heredity and variations, Mendelian and non-Mendelian inheritance, chromosomal structure, chromosomal theory of heredity, multiple allelic, linkage and gene mapping, polygenic inheritance, epitasis, epigenetics, penetrance and expressivity, Sex-linked inheritance, chromosomal aberrations, gene mutation, genetic disorders; DNA polymorphism, cytoplasmic inheritance, population genetics [Hardy-Weinberg equilibrium, selection, inbreeding and heterosis]

Lab Contents
Chromosome staining, Problems solving related to topics covered – ABO blood grouping,

Recommended Books

Latest editions of following books
1. Strickburger, “Genetics”, Mac Millan.
2. Gardner, “Principles of Genetics”, John Wiley and Sons.
3. Griffith et al., “An Introduction to Genetics analysis”, W. H. Freeman.
4. William S. Klug, Michael Cummings, “Essentials of Genetics”, Pearson/Prentice Hall.
5. Ricky Lewis, “Human Genetics”, McGraw Hill.

CS-201 Data Structure and Algorithms 3+1

Prerequisite: Programming Fundamentals

Specific objectives of the course
It describes data structures and explains some common data structures and their implementation.

Course Outline
Introduction to data structures and algorithms, array based algorithms: storage, retrieval and search, computational complexity, uses of arrays, concept of binary and linear search, Stacks and queues, priority queues, store, retrieve and search functionalities in stacks and queues, linked list, double ended links, linked list efficiency, sorted list. Recursion application, Triangular Numbers, Factorials, Trees, heaps, graphs and their algorithms, sorting techniques: selection sort, insertion sort, bubble sort, merge sort and quick sort. Comparison of sorting techniques and their applications.

Lab Outline
Implementation of arrays, storing and searching data in arrays, implementation of Linear Search, implementation of Binary Search in Arrays, Using different sorting techniques on sample data, implementing Stacks, Queues and priority queues , implementation of different types of Linked Lists , tree and graph algorithms.

Recommended Books

Latest editions of following books
1. Neil C. Jones, Pavel Pevzner, “An introduction to Bioinformatics Algorithms”, The MIT Press
2. Gary Benson and Roderic Page, “Algorithms in Bioinformatics”.
3. R. Sedgewick, “Algorithms in C”, Addison-Wesley.
4. S. Lipschutz, “Data structures with C”, Schaum Series.

Semester-IV

SS-***	**Social sciences subject**	**3+0**
BI-201	**Bioinformatics-I**	**2+1**

Prerequisite: Computer science 101

Specific objectives of the course
This course presents the basic principles and concepts in exploring sequence storage, retrieval and analysis.

Course Outline
Introduction, history, timeline, databases, sequence storage, retrieval and analysis, similarity and homology, creating alignments, local and global alignment, pairwise and multiple sequence alignments, phylogenetic analysis, dot matrix plots, dynamic programming algorithm, word (k-tuple) methods, substitution matrices PAM and BLOSUM, scoring algorithms, gap penalties, online tools BLAST, BLAT and FASTA, PDB file structure.

Lab Outline
Accessing NCBI, ENSEMBL, UniProt , Genbank, EMBL, SWISS-PROT, Accessing structural databases including PDB, SCOP and CATH, EXPASY and FASTA using tools for pairwise and multiple sequence alignment, Phylogenetic analysis, Bioedit.

Recommended Books
Latest editions of following books

1. Arthur M. Lesk, “Introduction to Bioinformatics”, Oxford University Press.
2. Ignacimuthu SJ, “Basic Bioinformatics”, Narosa Publishing House.
3. Yadav Neelam, “A Hand Book of Bioinformatics”, Anmal Publications Pvt.Ltd.
4. Krawetz. Stephen A., “Introduction to Bioinformatics: A Theoretical and Practical Approach”, Humana Press.

Bio-204	**Biochemistry II**	**3+0**

Prerequisite: Biochemistry I

Specific objectives of the course
This course focuses on macromolecules and their metabolisms with emphasis on various cellular pathways.

Course Outline
Study of bioenergetics, introduction to metabolic pathways, metabolism of carbohydrates, Glycolysis, Citric acid cycle, Pentose pathway, electron

transport chain, and oxidative phosphorylation, lipid metabolism, β-oxidation, ketone bodies formation and biosynthesis of triglyceride, protein metabolism, oxidative deamination and decarboxylation, transamination, amino acids metabolism, urea cycle, nucleic acid metabolism, break down and synthesis of purine and pyramidine bases

Recommended Books

Latest editions of following books

1. Nelson and Michel, "Lehinger Principles of Biochemistry", Freedman and Company.
2. Conn and Stumpf, "Outlines of Biochemistry", John Willey and Sons.
3. Devlin and Thomas, "Text book of Biochemistry with Clinical Correlations", Wiley.
4. Campbell M and Shawn F, "Biochemistry", Thomas Book Pub.
5. Voet and Voet, "Biochemistry", John Wiley and Sons.
6. Jeremy M Berg, John L T, Stryer L, "Biochemistry", MacMillan.

Bio-202 Molecular Biology 3+1

Prerequisite: Biochemistry 1

Specific objectives of the course

This course is designed to teach the students about organization of genetic material, regulation of gene expression and translation.

Course Outline

Basic concepts about DNA, RNA and proteins with special emphasis on nature of genetic material and its organization in viruses, prokaryotes and eukaryotes, DNA replication, recombination, mutations and repair, Gene structure, transcription, regulatory elements, regulation of gene expression. RNA processing, splicing and editing, translation and post-translational modifications, control of gene expression in prokaryotes and eukaryotes. Introduction to plasmids and vectors.

Lab Outline

Isolation of plasmid and genomic DNA from eukaryotes and prokaryotes, Primer designing, PCR, gel electrophoresis and its interpretation.

Recommended Books

Latest editions of following books

1. Robert Weaver, "Molecular Biology", McGraw Hill.
2. Benjamin Lewin, "Genes XI", Pearson/Prentice Hall.
3. Gerald Karp, "Cell and Molecular Biology concepts and Experiments", John Willey and Sons.
4. Brown T. A., "Molecular Biology Lab .FEX", Academic Press Publication.

5. Lodish H. et al., “Molecular Cell Biology”, W.H. Freeman.
6. Bruce Alberts et al., “Molecular Biology of Cell”, Garland Science.
7. Reece et al., “Campbell Biology”, Pearson.
8. David Clark, “Molecular Biology”, Elsevier.

CS-202 Object Oriented Programming 3+1

Prerequisite (s): Programming Fundamentals

Specific objectives of the course

The course focuses on object-oriented concepts, analysis and software development.

Course Outline

Concept of object oriented programming (OOP), characteristics of OOP, simple programs, dynamic initializing, scope and lifetime of variables, type conversion and casting, the type promotion rules, arrays, string data type, operator and its types. Introducing classes, declaring objects, object reference, control access, specified, public, private, static, data member and methods. Creating packages, constructors, function overloading, constructor overloading, reference, members, inheritance, polymorphism, dynamic method binding, inner class definitions, Friend function, virtual functions, inline functions, Abstract classes, Interfaces, exception handling.

Lab Outline: Programs formulation according to the Course outlines.

Recommended Book

Latest editions of following books

1. Ivor Horton, “Beginning Java”, Wrox.
2. Herbert Schildt, “Java: The Complete Reference”, Mcgraw-Hill Osborne Media.
3. Robert Lafore, “Object Oriented Programming in C++”, Sams Publishing.
4. Deitel & Deitel, “JAVA: How to Program”, Prentice Hall.

Semester V

CS-301 Discrete Structures 3+0

Prerequisite: Basic Calculus

Specific objectives of the course

Introduces the fundamentals of discrete mathematics as they apply to Computer Science, focusing on providing a solid theoretical foundation

Course Outline

Logic and proofs, direct proofs, proof by contradiction, Sets, combinatorics, sequences, formal logic, prepositional and predicate calculus, methods of proof, mathematical induction and recursion, loop invariants, relations and functions, Pigeonhole principle, trees and graphs, elementary number theory, optimization and matching, Fundamental structures, functions, relations (more specifically recursions), cardinality and countability, probabilistic methods.

Recommended Books

Latest editions of following books

1. Kenneth H. Rosen, “Discrete Mathematics and Its Applications”, McGraw Hill Book Co.
2. Richard Johnsonbaugh, “Discrete Mathematics”, Prentice Hall Publishers.
3. Kolman, Busby and Ross, “Discrete Mathematical Structures”, Prentice-Hall Publishers.
4. Ralph P. Grimaldi, “Discrete and Combinatorial Mathematics: An Applied Introduction”, Pearson.
5. Prather R, “Elements of Discrete mathematics”, Houghton Mifflin.

GEN-507 Recombinant DNA technology 2+1

Prerequisite: None

Specific objectives of the course

The course objectives are to provide information on techniques used to manipulate genetic materials; and to discuss applications of recombinant DNA technology in medicine, agriculture and environment.

Course Outline

Basic concepts in recombinant DNA technology, Gel electrophoresis, hybridization, PCR and gene transformation, Restriction and modification system: types, enzymes, classifications, nomenclature and application: isolation and purification of DNA, cutting of DNA molecules, ligation of DNA molecules, blunt ends and cohesive termini, homopolymer tailing, Cloning vectors: plasmids (bacteria and yeast), viruses (CMV, SV40, BPV, Lamda, Mu, M13), Cosmids and Phosmids, YAC’s, BACs and PACs. Cloning strategies (Prokaryotic and Eukaryotic); selection and characterizations of recombinant molecules, verifications and amplifications of desired genes, Construction and analysis of DNA

libraries, Maximizing the cloned expression, site directed mutagenesis, DNA sequencing techniques, Applications of genetic engineering in medicine, agriculture and environment.

Lab Contents
Isolation of plasmid and chromosomal DNA from bacteria and yeast, Screening of bacteria from plasmid by electrophoresis of total cell lysate, Gel electrophoresis of plasmid DNA (supercoiled, linear and digested with restriction enzyme) and chromosomal DNA, Plasmid transformation of *E. coli*, comparing plasmids of different molecular weights using molecular weight markers, DNA amplification by PCR, Numerical problems related to recombinant DNA.

Recommended Books
Latest editions of following books

1. Brown T. A, "Gene Cloning and DNA analysis: An introduction", Wiley-Blackwell.
2. Desmond S.T. Nicholl, "An Introduction to genetic engineering", Cambridge University Press.
3. Hodge R and N Rosenthal, "Genetic Engineering: Manipulating the mechanism of life (Genetics and Evolution)" Facts on File.
4. Old R. W. and S. B. Primrose, "Principles of Gene manipulation, an introduction to Genetics engineering", Blackwell Scientific Publications.

CS-302 Database Management Systems 3+1

Prerequisite: None

Specific objectives of the course
The course aims to introduce basic database concepts, different data models, storage and retrieval techniques, database design techniques.

Course Outline
Basic database concepts, conceptual modeling, hierarchical, network and relational data models, relational theory and languages, databases design, database security and integrity, query languages, relational calculus, relational algebra, SQL, query processing and optimization, normalization, concurrency and recovery, front-end and back-end databases.

Lab Outline
Structured query language commands, creating and populating tables, design of simple databases, database normalization techniques, query optimization, indexing techniques, partial and full recovery techniques,

developing GUI techniques, implementation of database security mechanisms, MySQL.

Recommended Books

Latest editions of following books

1. Thomas Connolly and Steven Morris, “Database Systems: Design, Implementation & Management”, Cengage Learning.
2. Jeffrey A. Hoffer, Ramesh Venkataraman and Heikki Topi, “Modern database management”, Prentice Hall.
3. Abraham Silberschatz, Henry Korth and S. Sudarshan, “Database system concepts”, McGraw-Hill Science.
4. Jeffrey A. Hoffer, Ramesh Venkataraman and Heikki Topi, “Modern database management”, Prentice Hall.

BI-202 Ethical & Legal Issues in Bioinformatics 2+0

Prerequisite (s): None

Specific objectives of the course

This course introduces the ethical and legal aspects related to bioinformatics practices and products.

Course Outline

Social context of computing and biology, Intellectual property, Privacy and civil liberties, Economic issues in bioinformatics, monopolies and their economic implications, effect of skilled labor supply and demand on the quality of bioinformatics products, pricing strategies in the bioinformatics domain, differences in access to bioinformatics resources and the possible effects thereof. Health, psychological and legal issues in GMOs, biosafety and bio-security issues

Recommended Book

Latest editions of following books

1. Katina Strauch and Bruce Strauch, “Legal and Ethical Issues in Acquisitions”, Routledge.
2. Tom Forester and Perry Morrison, “Computer Ethics: Cautionary Tales and Ethical Dilemmas in Computing”, The MIT Press.
3. Bruce A Rocheleau, “Public Management Information Systems”, Idea Group Publishing.
4. Charles P. Pfleeger, Shari Lawrence Pfleeger and Jonathan Margulies, “Security in Computing”, Prentice Hall.

BI-301 Bioinformatics II 3+1

Prerequisite (s): Bioinformatics I

Specific objectives of the course
This course is designed to develop understanding of gene and protein at structural level using computational tools.

Course Outline
Introduction to genome, gene prediction in prokaryotes and eukaryotes, ORF, TFBS, codon usage table, EST and SNP databases, primer designing, restriction enzyme databases, RNA structure prediction, computational secondary and tertiary protein structure prediction methods, structure optimization and refinement methods, hydrogen bonding, PTMs of proteins, Chou Fasman, PHD and PSIPred, neural network, X-ray crystallography, NMR, *ab initio*, threading and homology modeling methods, protein fold identification using Pfam (A & B) and other tools.

Lab Contents
Online tools: Gene finder, ORF finder, EST database, SNP data, Primer 3, protein structure prediction using online server, protein structure visualizing using visualization programs, Secondary structure prediction, using pfam database.

Recommended Books
Latest editions of following books
1. David Mount, “Bioinformatics: Sequence and Genome analysis”, Cold Spring Harbour Laboratories.
2. P. Rastogi and N. Mendiritta, “Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery”, Prentice-Hall of India Pvt.Ltd.
3. Richard S. Larson, “Bioinformatics and drug discovery”, Humana Press.

Bio-302 Genomics 3+0

Prerequisite: Biochemistry I/Molecular Biology

Specific objectives of the course

Students will be trained to grasp knowledge about structural and functional genomics and their applications.

Course Outline

Introduction , types of genome, genome evolution, genome organization and structure , global expression profiling, microarray data analysis, genome mapping, DNA markers, linkage analysis, genome-wide screening, mutation, type of mutations, mutation identification, DNA repeats, QTL, Human Genome Project, Genevestigator, Non-coding RNAs and their regulation, siRNA, completed genomes, applications of genome analysis, Next generation sequencing.

Recommended Books

Latest editions of following books

1. David Mount, “Bioinformatics: Sequence and Genome analysis”, Cold Spring Harbour Laboratories.
2. Mount, “Bioinformatics: Sequence and Genome: Analysis”, CBS publisher & distributors New Delhi Bangalore by Spring Harbour laboratory press.
3. Tom Strachan and Andrew Read, “Human Molecular Genetics”, Garland Science.
4. T.A. Brown, “Genome”, Garland Science.
5. Arthur M. Lesk, “Introduction to Genomics”, Oxford University Press
6. Lewin, “Gene”, Jones & Bartlett Learning.

Semester-VI

BI-302 Bioinformatics Computing-I 3+1

Prerequisite: Programming Fundamentals

Specific objectives of the course

This course aims to introduce the concepts of data representation, searching, security and ownership. Develop techniques for pattern matching, recognition and their applications in bioinformatics.

Course Outline

Databases: Data management, networks, geographical scope, communications models, transmissions technology, protocols, bandwidth, topology, hardware, contents, security, ownership, implementation, Search engines. search process, search engine technology, searching and information theory, computational methods, knowledge management, sequence and structure visualization, data mining methods and technology, pattern recognition and discovery, pattern matching, dot matrix analysis, substitution matrices, dynamic programming, Scripting

Lab Outline
Simulation of various bioinformatics entities, application of various bioinformatics methods, scripting languages Python, Perl and PHP, and their applications in Bioinformatics

Recommended Books
Latest editions of following books
1. Bryan Borgeron, “Bioinformatics Computing”, Prentice Hall.
2. Vyas S.P. and Kohli D.V, “Methods in Biotechnology and Bioengineering”, CBS Publisher.

CS-303 Modeling & Simulation 2+1

Prerequisite: Programming Fundamentals, Probability and Biostatistics

Specific objectives of the course
This course emphasizes the development of modeling and simulation concepts and analytical skills necessary to design, program and implement various biological models. .

Course Outline
Performance modeling and evaluation, bench marking, performance evaluation of high parallel systems architecture, application of performance evaluation, measurement techniques, hardware monitoring, software monitoring, hybrid monitoring, fundamentals of queuing models, structure and performance parameters, operational analysis of queuing models, general features of queuing models, birth and death processes, m/m/i and m/g/1 systems, dependability modeling, analysis of reliable, available and high assurance systems, fault-tolerant techniques, software reliability modeling, adaptive modeling, agent based modeling, Types of simulations, applications of simulations

Lab Outline
Introduction to modeling techniques using simulation tools like MATLAB toolbox for various performance modeling and evaluation of high parallel systems.

Recommended Books
Latest editions of following books
1. Willem van Meurs, “Modeling and Simulation in Biomedical Engineering: Applications in Cardiorespiratory Physiology”, The McGraw-Hill Companies.
2. John A. Sokolowski, “Principles of Modeling and Simulation: A Multidisciplinary Approach”, John Wiley 7 Sons.
3. Jerry Banks, “Discrete-Event System Simulation”, Prentice Hall.

4. Frank C. Hoppensteadt, “Modeling and Simulation in Medicine and the Life Sciences”, Springer.
5. John A. Sokolowski, “Modeling and Simulation in the Medical and Health Sciences”, John Wiley & Sons.

Bio-303 Proteomics 3+0

Prerequisite: Biochemistry I/Molecular Biology

Specific objectives of the course
This course intends to provide basic concepts regarding proteome and protein chemistry with special focus on protein identification techniques.

Course Outline
Introduction, techniques in proteomics, amino acids structures, properties and function, one dimensional and two dimensional PAGE and analysis, Mass spectrometry and its types. Protein-protein interaction, Bioinformatics tools for analysis of proteomics data, proteomics databases, MS data analysis, peptide mass and fragment fingerprinting, protein identification, post-translational modification, applications of proteomics, protein microarrays.

Recommended Books
Latest editions of following books
1. Richard T., “Principles of Proteomics”, Garland Science.
2. Rigden D. J., “From protein structure to function with bioinformatics”, Springer.
3. Hubbard S. J., “Proteome Bioinformatics”, Humana Press.
4. Rastogi *et al.*, “Bioinformatics methods and applications. Genomics, Proteomics and Drug discovery”, Prentice Hall of India Pvt. Limited.
5. Richerd Simpson J., “Purifying Proteins for Proteomics (a laboratory manual)”, Cord Spring Harbor Laboratory Press.

CS-304 Graphics and Visualization 3+1

Prerequisite: Programming Fundamentals

Specific objectives of the course
This course introduces algorithms and tools for data visualization and its applications to data manipulation.

Course Outline
Introduction, Graphics hardware, fundamental algorithms, applications of graphics, interactive graphics programming, graph plotting, windows, clipping and segmentation, programming raster display systems, panning

and zooming, raster algorithms and software, scan-converting lines, characters and circles, region filling, two and three dimensional imaging geometry and transformations, curve and surface design, rendering, shading, colour and animation.

Lab Outline
Line drawing techniques, clipping effects, 2D and 3D representations and transformations using open GL, development of graphical user interface with various blocks and modules, elliptical and curve creation exercises.

Recommended Books
Latest editions of following books
1. Donald Hearn, "Computer Graphics, C Version", Prentice Hall.
2. F. S. Hill and Stephen M. Kelly, "Computer graphics: Using Open GL", Pearson Prentice Hall.
3. T. Theoharis et al., "Graphics and Visualization-principles and algorithms", CRC Press.

BIO-304 Systems Biology 3+0

Prerequisite
Probability & Statistics, Linear Algebra & Differential Equations, Genomics

Specific objectives of the course
The purpose of the course is to introduce the students to the field of systems biology and to provide an understanding of the cell at systems level.

Course Outline
Introduction to systems biology; modeling of biochemical systems; kinetic modeling of enzymatic reactions; law of mass action; Michaelis-Menten Kinetics; rate equation; model systems: lac operon, phages, plasmids and chemotaxis; analysis of high throughput data; gene expression models; stochastic modeling of biological systems; chemical master equation. stochastic simulation, fluctuations in gene expression; biological networks; network structure, network dynamics and function; network motifs, network modularity

Recommended Books
Latest editions of following books
1. Klipp, E., Wolfram L., Christoph W., Axel K., Hans L., and Ralf H., "Systems biology", Wiley.
2. Ullah, M., and Olaf W., "Stochastic approaches in systems biology", Springer.
3. Newman M., "Networks: An Introduction", Oxford University Press, USA.

4. Alon U., “An introduction to systems biology: design principles of biological circuits. Boca Raton”, Chapman & Hall/CRC.

Semester-VII

CS-402 Artificial Intelligence 3+0

Prerequisite
Programming Fundamentals, Data Structures and Algorithms

Course objectives
Presentation of artificial intelligence as a coherent body of ideas and methods to acquaint the student with basic programs in the field and their underlying theory.

Course Contents
Basic definition of AI and its potential applications, different types of AI agents, Searching as a problem-solving technique: Heuristic functions and their effect on performance of search algorithms, Introduction to genetic algorithms. Knowledge-based agents and logical problem solving, Knowledge engineering: Building knowledge bases and automated theorems, Production systems as an example of logical problem solving, Introduction to truth-maintenance systems and default reasoning. Planning agents: representation of states, goals and actions, Decision trees and the ID3 algorithm, Neural Network concepts: Introduction & Simple neuron model, Type of Learning Methods: Back propagation, Least Square, Steepest descent, Type of Neural Network: Perceptron, Linear networks, Multi layer perceptron, Self-organizing maps, Introduction to Fuzzy Sets.

Recommended Books
Latest editions of following books

1. Stuard Russell and Peter Norvig, “Artificial Intelligence: A Modern Approach”, Prentice Hall Inc.
2. George F. Luger, and William A. Stubblefield, “Artificial Intelligence: Structures and Strategies for Complex Problem Solving”, Addison - Wesley.
3. Edward A. Bender, “Mathematical Methods in Artificial Intelligence”, Wiley IEEE Computer Society Press.
4. David W. Rolston, “Principals of Artificial Intelligence and Expert Systems Development”, Mcgraw Hill.
5. Robin R. Murphy, “Introduction to AI and Robotics”, A Bradford Book.
6. Winston and Horn, “LISP”, Addison Wesley.

Bio-406 Bioinformatics Software Engineering 2+1

Prerequisite

Specific objectives of the course

This course introduces the software engineering principles and methodologies with the goal of developing bioinformatics applications.

Course Outline

System analysis and design, UML, software development methodology, waterfall model, iterative model, rapid application development, prototyping, software life cycle, development of software projects for bioinformatics problems, overview of software architecture, web-based applications, architecture, developing front end applications, database connectivity, software testing and validation, software robustness, software quality assurance.

Lab Outline

Introduction to software development techniques, developing use cases, implementation of various software models using simple case studies, introduction to HTML, XML, use of front end application tool. Designing database driven applications

Recommended Books

Latest editions of following books

1. Pressman R. S., “Software engineering: A practitioner’s approach”, McGraw Hill.
2. Sommerville, “Software Engineering”, Addison Wesley.
3. Larman C., “Applying UML and patterns”, Prentice Hall.
4. Weston P., “Bioinformatics Software Engineering: Delivering effective applications”, Wiley.

BI-407 Special Topics in Bioinformatics 3+0

Prerequisite: Bioinformatics-I

Specific objectives of the course

This course intends to introduce recent advances in bioinformatics.

Course Outline

The course will review the major advances in bioinformatics and the topics will be selected by the faculty members / Coordinator conducting Bioinformatics Program.

***** Elective-I 3+0**

Prerequisite: None

Course Outline
To be chosen from the list of electives

***** Elective-II 3+0**
Prerequisite: None

Course Outline
To be chosen from the list of electives

***** Research Project 0+3**

Prerequisite: None

Course Outline
An independent research project and directed by the student and directed by a full time faculty member of the department.

Semester-VIII

BI-401 Bioinformatics Computing-II 3+0

Prerequisite: Bioinformatics Computing- I

Specific objectives of the course
This course introduces advanced concepts of neural networks and pattern recognition for solving bioinformatics problems.

Course Outline
This course is emphasized on cellular, tissue, organ and system modeling, simulation, analysis, Bio-inspired computation, evolutionary algorithms, Swarm Intelligence, neural networks, application of neural networks to Bioinformatics, neural computation, approximate matching algorithm and their applications for DNA Matching.

Lab Outline
Simulation and application of neural network related techniques for bioinformatics, implementation of approximate matching algorithms, DNA matching algorithms and applications.

Recommended Books
Latest editions of following books
1. SC Rastogi, Namita M, P Rastogi, “Bioinformatics: Concepts, Skills and Applications”, CSB Publishers.

2. Lacroix Zor, Terence Critchlow, “Bioinformatics: Managing Scientific Data”, Morgan Kaufmann.

***** Elective-III 3+0**

Prerequisite: None

Course Outline
To be chosen from the list of electives.

***** Elective-IV 3+0**

Prerequisite: None

Course Outline
To be chosen from the list of electives.

***** Research Project 0+3**

Prerequisite: None

Course Outline
An independent research project and directed by a full time faculty member of the department.

List of Electives

1. Enzyme Kinetics
2. Functional genomics
3. Human Computer Interaction
4. Nanotechnology
5. Environmental Biotechnology
6. Special Topics in Biochemistry
7. Immuno-Informatics
8. Microbial genomics and proteomics
9. Network Biology
10. Biophysics
11. Modern programming languages
12. Methods in protein modeling
13. Pharmacoinformatics
14. Statistical methods in bioinformatics
15. Design and analysis of algorithms
16. Epigenetics and gene regulation
17. Protein chemistry
18. Microbial genetics
19. Molecular oncology
20. Immunology

Note
In addition to the above, the universities can offer any elective which they feel necessary subject to the availability of resources.

RECOMMENDED BOOKS
The latest editions of

Cell and Molecular Biology: Concepts and Experiments
Gerald Karp
John Wiley and Sons

Introduction to Computational Molecular Biology
Setubal, Meidanis
Brooks/Cole

Principles and Techniques of Biochemistry and Molecular Biology
Keith Wilson, John Walker
Cambridge University Press

Instant Notes: Biochemistry
B D Hames
Viva Books Pvt. Ltd.

Basics of Theoretical and Computational Chemistry
BM Rode
John Willey and Sons

Instant Notes: Genetics
P C Winter
Viva Books Pvt. Ltd.

Instant Notes: Molecular Biology
P C Turner
Viva Books Pvt. Ltd.

Molecular Cloning: A laboratory manual
Sambrook
Cold Spring Harbor, Laboratory Press.

Instant Notes: Bioinformatics
David R. Westhead, J. Howard Parish and Richard M. Twyman
Viva Books Pvt. Ltd.

Bioinformatics for Dummies
Jean-Michel Claverie,Cedric Notredame
Wiley Publishing, Inc.

Essential Bioinformatics
Jin Xiong
Cambridge University Press.

Bioinformatics
Bal
Tata McGraw-Hill.

Bioinformatics
Andrzej Polański, Marek Kimmel
Springer.

Bioinformatics: An Introduction
Jeremy Ramsden
Springer.

Bioinformatics: A Concept-based Introduction
Venkatarajan Subramanian Mathura, Pandjassarame Kangueane
Springer.

Bioinformatics: Tools and Applications
David Edwards, Jason Eric Stajich, David Hansen
Springer.

Bioinformatics: Principles and Basic Internet Applications
Hassan A. Sadek
Trafford Publishing, Canada.

Bioinformatics: Applications in Life and Environmental Sciences
M. H. Fulekar
Springer.

Bioinformatics: A Practical Approach
Shui Qing Ye
Chapman & Hall / CRC.

Applied Bioinformatics: An Introduction
Paul M. Selzer, Richard J. Marhöfer, Andreas Rohwer
Springer.

Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins
Andreas D. Baxevanis, B. F. Francis Ouellette
John Wiley and Sons, USA.

Bioinformatics: a Swiss perspective
Ron D. Appel, Ernest Feytmans
World Scientific, Singapore.

Bioinformatics: Genomics and Post-genomics
Frédéric Dardel, François Képès, Translated by Noah Hardy
John Wiley and Sons, France.

Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery
S. C. Rastogi, Namita Mendiratta, Parag Rastogi
PHI Learning Pvt. Ltd.

Bioinformatics and drug discovery
Richard S. Larson
Humana Press.

Computational molecular biology: an algorithmic approach
Pavel Pevzner
MIT Press.

Bioinformatics algorithms: techniques and applications
Ion Măndoiu, Alexander Zelikovsky
Wiley-Interscience.

Bioinformatics: problem solving paradigms
Volker Sperschneider, Jana Sperschneider, Lena Scheubert
Springer.

Parallel computing for bioinformatics and computational biology
Zomaya A. Y.
John Wiley & Sons, Inc.

Research and trends in data mining technologies and applications
David Taniar
Idea Group Inc (IGI).

Machine learning in bioinformatics
Yan-Qing Zhang, Jagath Chandana Rajapakse
John Wiley and Sons.

Computational Intelligence in Bioinformatics
Árpád Kelemen, Ajith Abraham, Yuehui Chen
Springer.

Bioinformatics and the Cell: Modern Computational Approaches in Genomics, Proteomics and Transcriptomics
Xuhua Xia
Springer.

Bioinformatics for Dummies
Jean-Michel Claverie and Cerdric Notredame

Bioinformatics-Sequence and Genome Analysis
David W. Mount.

Introduction to Bioinformatics
T K Attwood and D J Parry-Smith.

Bioinformatics-Gene, Proteins and Computers
C. A. Orengo, D. T. Jones and J. M. Thornton.

MASTER OF SCIENCE (MS) in Bioinformatics

Introduction

The purpose of MS degree program in bioinformatics is to provide the students with an advanced knowledge and practices that will train them to decipher the biological processes with the help of computational tools and to prepare them for further research and/or industry.

Program objectives

At the end of MS program, the graduates should be able to:

1. Develop innovative computer applications to solve biological problems
2. Facilitate other researchers using bioinformatics tools and databases
3. Undertake problem-based research
4. Tackle research based problems in various industries such as pharmaceutical, biotechnology, software industry etc

Learning Outcomes

After completion of MS program in bioinformatics, the graduates will be able to:

- Answer questions about molecular evolution, biological functions and control of biological systems
- Use bioinformatics skills to predict functions from structures, networks, complexes, transcriptome and proteome data
- Develop advanced computational applications related to bioinformatics

Admission Requirements

Eligibility

1. BS in Bioinformatics/Biological Sciences/Computer Sciences/ Biotechnology or equivalent in relevant disciplines (deficiency courses to be completed if needed).
2. Any other criteria set by the University.

Duration

2 years (course work may be completed in two semesters and one year for research work).

Total Credit Hrs

30 (24 credit hours course work + 6 credit hours thesis)

Scheme of Studies for MS Program in Bioinformatics

Semester I and II

Note:
Students coming from computer and physical sciences background must take 1-2 courses from group A and may take at most one course from group B. Similarly, students coming from biological sciences background must take 1-2 courses from group B and may take at most one course from group A.

Students coming from bioinformatics background may take at most 1 course each from groups A and B.

Remaining credit hours for all students must be completed from group C.

Group A- Biological Sciences

1. Molecular Biology
2. Cell Biology
3. Genomics
4. Proteomics
5. Metabolomics
6. Microbial Genetics
7. Biochemistry
8. Gene Manipulation
9. Enzymology
10. Epigenetics
11. Biotechnology
12. Immunology
13. Biostatistics

Group B- Computer Sciences

1. Fundamentals of Programming
2. Object Oriented Programming
3. Data structure
4. Algorithm development
5. Database design
6. Software engineering
7. Graphics and visualization
8. Probability

Group C- Bioinformatics

1. Genome Informatics/Computational Genomics

2. Advanced Bioinformatics/Computational Biology
3. Systems Biology
4. Protein Informatics/Computational Proteomics
5. Computational Drug Design
6. Computational Molecular Evolution
7. Biophysics
8. Molecular Modelling and Simulation
9. Mathematical Models in Biology
10. Machine Learning
11. Metagenomics
12. Data Mining
13. Stochastic Processes
14. Computational Neuroscience
15. Synthetic Biology
16. Functional genomics
17. Cheminformatics
18. Health informatics
19. Big data analysis and management

Note
In addition to the above, the universities can offer any other course in the respective groups according to their specialization.

Semester III and IV

Research Thesis (6 Credit Hours)

Research Project
1. Duration of the research project will be at least two regular semesters. An independent research topic chosen by the student and supervised by a full-time faculty member of the department is required for all students in M.S Bioinformatics.
2. The research work of each student will be reviewed periodically by the supervisor/head of department to ensure the objectives laid down for study are being met.
3. All students must present and defend their research work before the panel of examiners as per the rules of the university.

Recommended Textbooks for MS Bioinformatics Program
DW Mount, Bioinformatics: Sequence and Genome Analysis
1. AD Baxevnis & BF Francis Ouellet, Bioinformatics: A practice Guide to Analysis of Gene and Proteins, Wiley
2. C Gibas & P Jambeck, Developing Bioinformatics Computer Skills, O'Reilly Media
3. AM Campbell & LJ Heyer, Discovering Genomics, Proteins and Bioinformatics, Benjamin Cummings

4. D Stekel, Microarray Bioinformatics, Cambridge University Press
5. AM Lesk, Introduction to Bioinformatics, Oxford University Press
6. BP Bergeron, Bioinformatics Computing, Prentice Hall
7. G Gibson, A Primer of Genome Science, Sinauer Associates
8. HJ Parish, Instant Notes on Bioinformatics
9. D Marshall & J Persner, Bioinformatics and functional Genomics
10. P Baldi and S Brunak, Bioinformatics: The Machine Learning Approach, A Bradford Book
11. NC Jones & PA Persner, An Introduction to Bioinformatics Algorithms
12. CW Sensen, Essentials of Genomics and Bioinformatics
13. M Moorhouse & P Berry, Bioinformatics, Biocomputing and Perl: An introduction to Bioinformatics Computing Skills and Practice, Wiley
14. W Ewens & G Grant, Statistical Methods in Bioinformatics
15. IS Kohane, A Kho & AJ Butte, Microarrays for An Integrative Genomics
16. D Higgins & W Taylor, Bioinformatics; Sequence and Databanks: A Practical Approach
17. RA Dwyer, Genomic Perl: From Bioinformatics Basic To Working Code
18. T Lengauer, Bioinformatics: From Genomes To Drugs, Wiley
19. T Atwood and D Perry-Smith, Introduction To Bioinformatics, Benjamin Cummings
20. P Bourne and H Weissig, Structured Bioinformatics
21. S Misener and S Krawetz, Bioinformatics Methods and Protocols
22. A Tozeren and SW Byers, New Biology for Engineers and scientists
23. P Clote & R Backofen, Computational Molecular Biology: An Introduction
24. J Augen, Bioinformatics in Post-Genomic Era: Genomic Transcription, Proteome and Information Based Medicine
25. U Seiffert, LC Jain & Pschwetzer, Bioinformatics: Using Computational Intelligence Paradigms
26. S Krawetz & D Womble, Introduction To Bioinformatics: a theoretical and Practical Approach
27. MR Barens & IC Gray, Bioinformatics for Geneticists
28. LO Nielsen, Immunological Bioinformatics
29. H Rashidi, Lukas Buehler, Bioinformatics Basics.
30. C Orengo, D Jones & J Thornton, Bioinformatics: Genes, Proteins and Computers.
31. PG Higgs, Bioinformatics and Molecular Evolution
32. A Umar, I Kapetanovic & J Khan, The Application of Bioinformatics in Cancer Detection
33. R Hofestadt, Bioinformatics

34. AF Batiza, B Schacter & K Mullis, Bioinformatics, Genomics and Proteomics: Getting the Big Picture
35. I Jerisca, Dennis Wigle, Knowledge Discovery in Proteomics
36. G Waksman, Proteomics and Protein-Protein Introductions: Biology, Chemistry, Bioinformatics and Drug Design
37. J Ramsden, An introduction to Bioinformatics
38. H Rashidi & L Buehler, Bioinformatics Basics: Application in Biological Science and Medicine
39. LB Jorde, JC Carey, M Bamshad & RL White, Medical Genetics
40. WS Klug & MR Cummings, Essential of Genetics
41. RI Nussbaum, RR Mclnnes & HF Willard, Genetics in Medicine, Thompson & Thompson
42. PA Hoffe, Medical Molecular Genetics
43. SB Primrose & R Twyman, Principles of Gene Manipulation and Genomics
44. A Emery & R Mueller, Essential of Medical Genetics.
45. B Lewin, Gene X
46. G Acquaah, Understanding Biotechnology
47. W Klug, Michael Cumming and Charlotte Spencer, Concept of Genetics
48. B Lewin, Essential Genes
49. G Karp, Cell and Molecular Biology: Concepts and Experiments, Wiley
50. E Nester, Denise Anderson, C. Evans Robert Jr., Microbiology; A Human Perspective
51. BA Pierce, Genetics
52. J Hanford, Ethics from a Faith Perspective
53. J Burrley & J Harris, A companion to Genetics
54. D Mathews, Vernon Farewell, Understanding Medical Statistics
55. R Weaver, Molecular Biology
56. PC Champe, RA Harvey and DR Ferrier, Lippincott's Biochemistry
57. M Grammer and M Rodwell, Harper's Biochemistry
58. Nelson & Cox, Lehninger; Principles of Biochemistry
59. D Voet, Biochemistry
60. R Schalkoff, Pattern Recognition, Statistical, Structural & Neural Approached
61. AS Pandya & RB Macy, Pattern Recognition with Neural Networks in C++
62. Duda, Hart & Stork, Pattern Classification
63. M Pavel, Fundamentals of Pattern Recognition
64. MK Pietikainen, Texture Analysis in Machine Vision
65. SK Pal & PP Wang, Genetic Algorithms for Pattern Recognition
66. RC Gonzales, Digital Image Processing
67. RC Gonzales, Digital Image Processing using Matlab
68. JC Russ, Hand Book of Image Processing
69. JR Parker, Algorithms for Image Processing & Computer Vision

ANNEXURE - A

English I (Functional English)

Objectives: Enhance language skills and develop critical thinking.

Course Contents

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

Comprehension
Answers to questions on a given text

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

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

Translation skills

Urdu to English

Paragraph writing
Topics to be chosen at the discretion of the teacher

Presentation skills
Introduction

Note: Extensive reading is required for vocabulary building

Recommended Books
1. **Functional English**
a) Grammar

1. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 1. Third edition. Oxford University Press. 1997. ISBN 0194313492
2. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. Third edition. Oxford University Press. 1997. ISBN 0194313506

b) Writing

1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.

c) Reading/Comprehension

1. Reading. Upper Intermediate. Brain Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 453402 2.

d) Speaking

English II (Communication Skills)

Objectives: Enable the students to meet their real life communication needs.

Course Contents:

Paragraph writing
Practice in writing a good, unified and coherent paragraph

Essay writing
Introduction

CV and job application

Translation skills
Urdu to English

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

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

Presentation skills
Personality development (emphasis on content, style and pronunciation)

Note: documentaries to be shown for discussion and review
Recommended Books
Communication Skills

a) Grammar
   1. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.

b) Writing
   1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
   2. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).

c) Reading
   1. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.
   2. Reading and Study Skills by John Langan
   3. Study Skills by Richard York.

English III (Technical Writing and Presentation Skills)

Objectives: Enhance language skills and develop critical thinking

Course Contents

Presentation skills

Essay writing
Descriptive, narrative, discursive, argumentative

Academic writing
How to write a proposal for research paper/term paper

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

Technical Report writing

Progress report writing

Note: Extensive reading is required for vocabulary building

Recommended Books

Technical Writing and Presentation Skills

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

b) Presentation Skills

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

ANNEXURE - B

Pakistan Studies (Compulsory)

Introduction/Objectives

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

Course Outline

1. **Historical Perspective**

   a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-Azam Muhammad Ali Jinnah.

   b. Factors leading to Muslim separatism

   c. People and Land
      i. Indus Civilization
      ii. Muslim advent
      iii. Location and geo-physical features.

2. **Government and Politics in Pakistan**

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

3. **Contemporary Pakistan**

   a. Economic institutions and issues

   b. Society and social structure

   c. Ethnicity

   d. Foreign policy of Pakistan and challenges

   e. Futuristic outlook of Pakistan

Recommended Books

1. Burki, Shahid Javed. *State & Society in Pakistan,* The MacMillan Press Ltd 1980.

2. Akbar, S. Zaidi. *Issue in Pakistan's Economy.* Karachi: Oxford University Press, 2000.
3. S. M. Burke and Lawrence Ziring. Pakistan's Foreign policy: An Historical analysis. Karachi: Oxford University Press, 1993.
4. Mehmood, Safdar. *Pakistan Political Roots & Development.* Lahore, 1994.
5. Wilcox, Wayne. *The Emergence of Bangladesh,* Washington: American Enterprise, Institute of Public Policy Research, 1972.
6. Mehmood, Safdar. *Pakistan Kayyun Toota,* Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.
7. Amin, Tahir. *Ethno - National Movement in Pakistan,* Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development.* Kent England: Wm Dawson & sons Ltd, 1980.
9. Zahid, Ansar. *History & Culture of Sindh.* Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. *Political Parties in Pakistan,* Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
11. Sayeed, Khalid Bin. *The Political System of Pakistan.* Boston: Houghton Mifflin, 1967.
12. Aziz, K. K. *Party, Politics in Pakistan,* Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, Pakistan Under Martial Law, Lahore: Vanguard, 1987.
14. Haq, Noor ul. *Making of Pakistan: The Military Perspective.* Islamabad: National Commission on Historical and Cultural Research, 1993.

ANNEXURE - C

ISLAMIC STUDIES
(Compulsory)

Objectives

This course is aimed at:

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

Detail of Courses

Introduction to Quranic Studies

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

Study of Selected Text of Holly Quran

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

Study of Selected Text of Holly Quran

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

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

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

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

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

Introduction to Sunnah

1. Basic Concepts of Hadith
2. History of Hadith
3. Kinds of Hadith
4. Uloom –ul-Hadith
5. Sunnah & Hadith
6. Legal Position of Sunnah

Selected Study from Text of Hadith

Introduction to Islamic Law & Jurisprudence

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

Islamic Culture & Civilization

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

Islam & Science

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

Islamic Economic System

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

Political System of Islam

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

Islamic History

1. Period of Khlaft-E-Rashida
2. Period of Ummayyads

3. Period of Abbasids

Social System of Islam

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

Reference Books

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

Annexure - D

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

COMPULSORY MATHEMATICS COURSES FOR BS (4 YEAR)

(FOR STUDENTS NOT MAJORING IN MATHEMATICS)

1. MATHEMATICS I (ALGEBRA)

Prerequisite(s): Mathematics at secondary level

Credit Hours: 3 + 0

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

Course Outline:

Preliminaries: Real-number system, complex numbers, introduction to sets, set operations, functions, types of functions. *Matrices:* Introduction to matrices, types, matrix inverse, determinants, system of linear equations, Cramer's rule.

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

Sequences and Series: Arithmetic progression, geometric progression, harmonic progression. *Binomial Theorem:* Introduction to mathematical induction, binomial theorem with rational and irrational indices. *Trigonometry:* Fundamentals of trigonometry, trigonometric identities.

Recommended Books

1. Dolciani MP, Wooton W, Beckenback EF, Sharron S, *Algebra 2 and Trigonometry*, 1978, Houghton & Mifflin, Boston (suggested text)

2. Kaufmann JE, College *Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston
3. Swokowski EW, *Fundamentals of Algebra and Trigonometry* (6th edition), 1986, PWS-Kent Company, Boston

2. MATHEMATICS II (CALCULUS)

Prerequisite(s): Mathematics I (Algebra)
Credit Hours: 3 + 0

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

Course Outline:

Preliminaries: Real-number line, functions and their graphs, solution of equations involving absolute values, inequalities. *Limits and Continuity:* Limit of a function, left-hand and right-hand limits, continuity, continuous functions.

Derivatives and their Applications: Differentiable functions, differentiation of polynomial, rational and transcendental functions, derivatives.
Integration and Definite Integrals: Techniques of evaluating indefinite integrals, integration by substitution, integration by parts, change of variables in indefinite integrals.

Recommended Books

1. Anton H, Bevens I, Davis S, *Calculus: A New Horizon* (8th edition), 2005, John Wiley, New York
2. Stewart J, *Calculus* (3rd edition), 1995, Brooks/Cole (suggested text)
3. Swokowski EW, *Calculus and Analytic Geometry*, 1983, PWS-Kent Company, Boston
4. Thomas GB, Finney AR, *Calculus* (11th edition), 2005, Addison-Wesley, Reading, Ma, USA

3. MATHEMATICS III (GEOMETRY)

Prerequisite(s): Mathematics II (Calculus)
Credit Hours: 3 + 0

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

Course Outline

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

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

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

Recommended Books

1. Abraham S, Analytic Geometry, Scott, Freshman and Company, 1969
2. Kaufmann JE, College *Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston
3. Swokowski EW, *Fundamentals of Algebra and Trigonometry* (6th edition), 1986, PWS-Kent Company, Boston

4. COURSE FOR NON-MATHEMATICS MAJORS IN SOCIAL SCIENCES

Title of subject:		MATHEMATICS
Discipline	:	BS (Social Sciences).
Pre-requisites	:	SSC (Metric) level Mathematics
Credit Hours	:	03 + 00
Minimum Contact Hours:		40
Assessment	:	written examination;
Effective	:	2008 and onward

Aims : To give the basic knowledge of Mathematics and prepare the students not majoring in mathematics.

Objectives : After completion of this course the student should be able to:

- Understand the use of the essential tools of basic mathematics;
- Apply the concepts and the techniques in their respective disciplines;
- Model the effects non-isothermal problems through different domains;

Contents :

1. *Algebra*

Preliminaries: Real and complex numbers, Introduction to sets, set operations, functions, types of functions. *Matrices:* Introduction to matrices, types of matrices, inverse of matrices, determinants, system of linear equations, Cramer's rule. *Quadratic equations:* Solution of quadratic equations, nature of roots of quadratic equations, equations reducible to quadratic equations. *Sequence and Series:* Arithmetic, geometric and harmonic progressions. *Permutation and combinations*: Introduction to permutation and combinations, *Binomial Theorem:* Introduction to binomial theorem. *Trigonometry:* Fundamentals of trigonometry, trigonometric identities. *Graphs:* Graph of straight line, circle and trigonometric functions.

2. *Statistics*

Introduction: Meaning and definition of statistics, relationship of statistics with social science, characteristics of statistics, limitations of statistics and main division of statistics. *Frequency distribution*: Organisation of data, array, ungrouped and grouped data, types of frequency series, individual, discrete and continuous series, tally sheet method, graphic presentation of the frequency distribution, bar frequency diagram histogram, frequency polygon, cumulative frequency curve. *Measures of central tendency*: Mean medium and modes, quartiles, deciles and percentiles. *Measures of dispersion*: Range, inter quartile deviation mean deviation, standard deviation, variance, moments, skewness and kurtosis.

Recommended Books

1. Swokowski. E. W., '*Fundamentals of Algebra and Trigonometry*', Latest Edition.
2. Kaufmann. J. E., '*College Algebra and Trigonometry*', PWS-Kent Company, Boston, Latest Edition.
3. Walpole, R. E., '*Introduction of Statistics*', Prentice Hall, Latest Edition.
4. Wilcox, R. R., '*Statistics for The Social Sciences'*,

5. MATHEMATICS FOR CHEMISTRY

Credit Hours: 3

Prerequisites: Mathematics at Secondary level

Specific Objectives of Course:

To prepare the students not majoring in mathematics with the essential tools of Calculus to apply the concepts and the techniques in their respective disciplines.

Course Outline

Preliminaries: Real Numbers and the Real Line, *Functions and their graphs*: Polynomial Functions, Rational Functions, Trigonometric Functions, and Transcendental Functions. Slope of a Line, Equation of a Line, 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 its Applications:* Differentiation of Polynomial, Rational and Transcendental Functions, Extreme Values of Functions. *Integration and Indefinite Integrals:* Integration by Substitution, Integration by Parts, Change of Variables in Indefinite Integrals. Least-Squares Line.

Recommended Books

1. Thomas, Calculus, 11th Edition. Addison Wesley publishing company, 2005.
2. H. Anton, I. Bevens, S. Davis, Calculus, 8th edition, John Willey & Sons, Inc. 2005.
3. Hughes-Hallett, Gleason, McCallum, et al, Calculus Single and Multivariable, 3rd Edition. John Wiley & Sons, Inc. 2002.
4. Frank A. Jr, Elliott Mendelsohn, Calculus, Schaum's Outline Series, 4th edition, 1999.
5. E. W. Swokowski, Calculus and Analytic Geometry PWS Publishers, Boston, 1983.
6. John H. Mathews, Numerical Methods for Mathematics Science and Engineering, Prentice-Hall, Second Edition 1992.

6. MATHEMATICS FOR PHYSICS

Contents

1. **Preliminary calculus.**

- Differentiation
  Differentiation from first principles; products; the chain rule; quotients; implicit differentiation; logarithmic differentiation; Leibnitz' theorem; special points of a function; theorems of differentiation.
- Integration

Integration from first principles; the inverse of differentiation; integration by inspection; sinusoidal function; logarithmic integration; integration using partial fractions; substitution method; integration by parts; reduction formulae; infinite and improper integrals; plane polar coordinates; integral inequalities; applications of integration.

2. Complex numbers and hyperbolic functions

- The need for complex numbers
- Manipulation of complex numbers
  Additions and subtraction; modulus and argument; multiplication; complex conjugate; division
- Polar representation of complex numbers Multiplication and division in polar form
- de Moivre's theorem
  Trigonometrical identities; finding the nth roots of unity; solving polynomial equations
- Complex logarithms and complex powers
- Applications to differentiation and integration
- Hyperbolic functions
  Definitions; hyperbolic-trigonometric analogies; identities of hyperbolic functions; solving hyperbolic equations; inverses of hyperbolic functions; calculus of hyperbolic functions

3. Series and limits

- Series
- Summation of series
  Arithmetic series; geometric series; arithmetico-geometric series; the difference method; series involving natural numbers; transformation of series
- Convergence of infinite series
  Absolute and conditional convergence; convergence of a series containing only real positive terms; alternating series test
- Operations with series
- Power series
  Convergence of power series; operations with power series
- Taylor series
  Taylor's theorem; approximation errors in Taylor series; standard McLaurin series
- Evaluation of limits

4. Partial differentiation

- Definition of the partial derivative
- The total differential and total derivative
- Exact and inexact differentials
- Useful theorems of partial differentiation
- The chain rule
- Change of variables
- Taylor's theorem for many-variable functions
- Stationary values of many-variable functions
- Stationary values under constraints

5. Multiple integrals

- Double integrals
- Triple integrals
- Applications of multiple integrals
  Areas and volumes; masses, centers of mass and centroids; Pappus' theorems; moments of inertia; mean values of functions
- Change of variables in multiple integrals
  Change of variables in double integrals;

6. Vector algebra

- Scalars and vectors
- Addition and subtraction of vectors
- Multiplication by a scalar
- Basis vectors and components
- Magnitude of a vectors
- Multiplication of vectors
  Scalar product; vector product; scalar triple product; vector triple product
- Equations of lines and planes
  Equation of a line; equation of a plane
- Using vectors to find distances
  Point to line; point to plane; line to line; line to plane
- Reciprocal vectors

7. Matrices and vector spaces

- Vectors spaces Basic vectors; the inner product; some useful inequalities
- Matrices
- The complex and Hermitian conjugates of a matrix
- The determinant of a matrix

Properties of determinants

- The inverse of a matrix
- The rank of a matrix
- Simultaneous linear equations
  N simultaneous linear equations in N unknowns
- Special square matrices
  Diagonal; symmetric and antisymmetric; orthogonal; Hermitian; unitary normal
- Eigen vectors and eigen values
  Of a normal matrix; of Hermitian and anti-Hermitian matrices; of a unitary matrix; of a general square matrix
- Determination of eigen values and eigen vectors Degenerate eigen values

8. Vector calculus

- Differentiation of vectors Composite vector expressions; differential of a vector
- Integration of vectors
- Space curves
- Vector functions of several arguments
- Surfaces
- Scalar and vector fields
- Vector operators
- Gradient of a scalar field; divergence of a vector field; curl of a vector field
- Vector operator formulae
- Vector operators acting on sums and products; combinations of grad, div and curl
- Cylindrical and spherical polar coordinates
- Cylindrical polar coordinates; spherical polar coordinates.

Annexure - E

Statistics-I **Credit 3 (2-1)**

Definition and importance of Statistics in Agriculture, Data Different types of data and variables

Classification and Tabulation of data, Frequency distribution, stem-and-Leaf diagram, Graphical representation of data Histogram, frequency polygon, frequency curve.

Measure of Central tendency, Definition and calculation of Arithmetic mean, Geometric mean, Harmonic mean, Median quantiles and Mode in grouped and un-grouped data.

Measure of Dispersion, Definition and Calculation of Range, quartile deviation, Mean deviation, Standard deviation and variance, coefficient of variation.

Practical

a. Frequency Distribution
b. Stem-and-Leaf diagram
c. Various types of Graphs
d. Mean, Geometric mean Harmonic Mean,
e. Median, Quartiles Deviation, mean Deviation.
f. Standard Deviation, Variance, Coefficient of variation,
g. Skewness and kenosis

Recommended Books

1. Introduction to Statistical Theory Part- I by Sher Muhammad and Dr. Shahid Kamal (Latest Edition)
2. Statistical Methods and Data Analysis by Dr. Faquir Muhammad
3. A. Concise Course in A. Level Statistic with world examples by J. Crashaw and J. Chambers (1994)
4. Basic Statistics an Inferential Approach 2nd Ed. (1986) Fran II. Dietrich-II and Thomas J. Keans

Statistics-II **Credit 3 (2-1)**

Sampling Probability and non-Probability Sampling, Simple random sampling stratified random sampling Systematic sampling error, Sampling

distribution of mean and difference between two means. Interference Theory: Estimation and testing of hypothesis, Type—I and type-II error, Testing of hypothesis about mean and difference between two means using Z-test and t-test, Paired t-test, Test of association of attributes using X2 (chi-square) Testing hypothesis about variance.

Practical

a. Sampling random sampling
b. Stratified random sampling.
c. Sampling distribution of mean
d. Testing of hypotheses regarding population mean
e. Testing of hypotheses about the difference between population means
f. Chi-square test
g. Testing of Correlation Coefficient
h. Fitting of simple linear regression
i. One-way ANOVA
j. Two-way ANOVA

Recommended Books

1. Introduction to Statistical Theory Part-II by Sher Muhammad and Dr. Shahid Kamal (Latest Edition)
2. Statistical Methods and Data Analysis by Dr. Faquir Muhammad
3. Principles and Procedures of Statistics A Bio-material approach, 2nd Edition, 1980 by R. G. D Steal and James H. Tarric
4. Statistical Procedures for Agricultural Research 2nd Edition (1980) by K. A. Gomez and A. A. Gomez

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.

RECOMMENDATIONS

1. There is a need to encourage public and private universities/institutes to develop expertise in bioinformatics at their respective campuses.
2. HEC should provide sufficient funds and grants on priority basis in this field. More emphasis should be given to universities/institutes located in developing areas of Pakistan.
3. Both undergraduate and postgraduate courses in bioinformatics should be included in teaching curriculum of relevant disciplines of public and private sector universities and degree awarding institutes.
4. Future emphasis should be on graduate degree program in bioinformatics instead of undergraduate.
5. The option for computer sciences and biology should not be there at matric level. Instead both subjects should be compulsory for science students.
6. At intermediate level, the distinction between pre-medical and pre-engineering groups should be strongly discouraged.
7. HEC should facilitate a survey to identify the opportunities available to and challenges faced by bioinformatics graduates.
8. To promote awareness among students, scientific community and industry, series of seminars and workshops should be organized on regular basis.
9. There should be a strong link between academia and industry for the absorption of bioinformatics graduates.