CURRICULUM
OF
BIOINFORMATICS
BS
MS
(Revised 2011)

HIGHER EDUCATION COMMISSION
ISLAMABAD
CURRICULUM DIVISION, HEC

Prof. Dr. Syed Sohail H. Naqvi Executive Director
Prof. Dr. Altaf Ali G. Shaikh Member (Acad)
Mr. Muhammad Javed Khan Adviser (Academic)
Mr. Malik Arshad Mahmood Director (Curri)
Dr. M. Tahir Ali Shah Deputy Director (Curri)
Mr. Abdul Fatah Bhatti Asstt. Director (Curri)

Composed by: Mr. Zulfiqar Ali, HEC, Islamabad
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PREFACE

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

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

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

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

In line with above, NCRC comprising senior university faculty and experts from various stakeholders and the respective accreditation councils has finalized the curriculum for B.S 4-years and M.S 2-years in Bioinformatics. The same is being recommended for adoption by the universities/DAIs channelizing through relevant statutory bodies of the universities.

MUHAMMAD JAVED KHAN
Adviser (Academics)

June, 2011
Abbreviations Used:

NCRC. National Curriculum Revision Committee
VCC. Vice-Chancellor’s Committee
EXP. Experts
COL. Colleges
UNI. Universities
PREP. Preparation
REC. Recommendations
LI Learning Innovation
R&D Research & Development Organization
HEC Higher Education Commission
INTRODUCTION

The final meeting of the National Curriculum Revision Committee in Bioinformatics was held on May 17-19, 2011 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. Prof. Dr. Gulzar Ahmed Niazi  
   Convener  
   HEC Foreign Professor,  
   Centre of Excellence in Molecular Biology,  
   78 West Canal Bank Road,  
   Thokar Niazbaig,  
   Lahore

2. Prof. Dr. Masroor Ellahi Babar  
   Member  
   Director,  
   Institute of Biochemistry and Biotechnology  
   University of Veterinary and Animal Sciences,  
   Lahore.

3. Prof. Dr. Mohammad Inayatullah Khan Babar  
   Member  
   Professor, Electrical Engineering and  
   Chairman, Computer Science and IT Department,  
   University of Engineering and Technology,  
   Peshawar.

4. Prof. Dr. Shamshad Zarina  
   Member  
   Director,  
   National Center for Proteomics,  
   University of Karachi,  
   Karachi.

5. Prof. Dr. Ahmad Saeed  
   Member  
   Dean,  
   Faculty of Biological Sciences,  
   University of Science and Technology,  
   Bannu.

6. Prof. Dr. Fida Mohammad  
   Member  
   Chairman,  
   Department of Plant Breeding and Genetics,  
   University of Agricultural,  
   Peshawar, Khyber Pakhtunkhwa
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<tr>
<th></th>
<th>Name</th>
<th>Title</th>
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<tbody>
<tr>
<td>7</td>
<td>Dr. Rani Faryal</td>
<td>Member</td>
<td>Associate Professor, Department of Biosciences, COMSATS Institute of Information Technology (CIIT), Islamabad.</td>
</tr>
<tr>
<td>8</td>
<td>Dr. Imran Sajid</td>
<td>Member</td>
<td>Assistant Professor, Department of Microbiology and Molecular Genetics, University of the Punjab, Lahore.</td>
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<tr>
<td>9</td>
<td>Dr. Nazeer Ahmed</td>
<td>Member</td>
<td>Assistant Professor, Faculty of Life Sciences &amp; Informatics, Balochistan University of Information Technology, Engineering and Management Sciences, Quetta</td>
</tr>
<tr>
<td>10</td>
<td>Dr. Muhammad Asif</td>
<td>Member</td>
<td>Senior Scientist, National Institute for Biotechnology and Genetic Engineering, Faisalabad.</td>
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<tr>
<td>11</td>
<td>Mrs. Afshan Kaleem</td>
<td>Member</td>
<td>Lecturer, Department of Zoology, Lahore College for Women University (LCWU), Lahore.</td>
</tr>
<tr>
<td>12</td>
<td>Prof. Dr. Syed Afaq Hussain</td>
<td>Member</td>
<td>Faculty of Engineering and Applied Sciences, Ripah International University, Islamabad.</td>
</tr>
<tr>
<td>13</td>
<td>Prof. Dr. Zubair A. Shaikh</td>
<td>Member</td>
<td>Associate Dean, Faculty of Computer Science, National University of Computer and Emerging Sciences, Karachi.</td>
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<tr>
<td>14</td>
<td>Dr. Syed Sikander Azam</td>
<td>Member</td>
<td>Assistant Professor, Department of Biotechnology and Bioinformatics, Quaid-i-Azam University, Islamabad</td>
</tr>
</tbody>
</table>
Mission Statement:

To train the next generation professionals to gain advanced knowledge in Bioinformatics that is required to design and implement novel methods which can be useful to define and solve problems with emphasis on acquisition, representation, retrieval, visualization and analysis of biological data.

Programme Objectives:

At the end of four years BS programme, the graduates should be able to understand:

1. Gene and protein sequence acquisition, storage, retrieval and analysis
2. Protein structure and function relationship using computational tools
3. Development of computational applications for processing of biological data
4. Modeling and simulation of biological systems.

Learning outcomes:

At the completion of this programme, students are expected to know the relationship between genes and proteins and use of computers in handling flood of biological data which started with the completion of Human Genome project. Bioinformatics is now an established discipline in the main stream of Biology and is a key to unlock the information coded in genome, transcriptome and proteome. Being a multidisciplinary field, it has diversified applications in domains like drug designing, agriculture biotechnology and system biology.

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 programme spread over 8 semesters, two semesters per year.

**Course and Credit Requirements:**
A total of 124-136 credit hours are required to complete Bachelor of Science in Bioinformatics.

**Evaluation:**
For uniformity in the evaluation system, NCRC recommends that the minimum CGPA required for award of degree is 2.5 out of 4.0 at undergraduate level subject to meet all requirements of the university.
### STANDARDIZED FORMAT / SCHEME OF STUDIES FOR FOUR-YEAR INTEGRATED CURRICULA FOR BACHELOR DEGREE IN BIOINFORMATICS

**STRUCTURE**

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Categories</th>
<th>No. of courses (Min – Max)</th>
<th>Credit Hours (Min – Max)</th>
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<tr>
<td>2.</td>
<td>General Courses to be chosen from other departments</td>
<td>7 – 8</td>
<td>21 – 24</td>
</tr>
<tr>
<td>3.</td>
<td>Discipline Specific Foundation Courses</td>
<td>9 – 10</td>
<td>30 – 33</td>
</tr>
<tr>
<td>4.</td>
<td>Major Courses including research project / Internship</td>
<td>11 – 13</td>
<td>36 – 42</td>
</tr>
<tr>
<td>5.</td>
<td>Electives within the major</td>
<td>4 – 4</td>
<td>12 – 12</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>40 – 44</strong></td>
<td><strong>124 – 136</strong></td>
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</table>

- 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)
## Compulsory Requirements (the student has no choice)

<table>
<thead>
<tr>
<th>Subject</th>
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<th>Subject</th>
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<th>Subject</th>
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<tr>
<td>English Comprehension</td>
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<td>Programming Fundamentals</td>
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<td>Linear Algebra and Differential Equations</td>
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<td>Islamic Studies and Pak Studies</td>
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<td>Data Structure and Algorithms</td>
<td>4</td>
<td>Essentials of Genetics</td>
<td>3</td>
</tr>
<tr>
<td>Basic I (Biology/Mathematics)</td>
<td>4</td>
<td>Object oriented programming</td>
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<td>Biostatistics</td>
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<tr>
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<td>Ethical and legal issues in Bioinformatics</td>
<td>2</td>
<td>Bioinformatics I</td>
<td>3</td>
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<tr>
<td>Communication Skills</td>
<td>3</td>
<td>Discrete Structures</td>
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<td>Bioinformatics II</td>
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<tr>
<td>Basic Cell Biology</td>
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<td>Database System</td>
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<td>Biochemistry I</td>
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<td>Basic Calculus</td>
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<td>Modeling and Simulation</td>
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**Total Credit Hours:** 25

## General Courses to be chosen from other departments

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<td>Research Methodology</td>
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**Total Credit Hours:** 27

## Discipline Specific Foundation Courses

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<td>Basic II (Chemistry/Computer fundamentals)</td>
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<td>Basic Cell Biology</td>
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<td>Modeling and Simulation</td>
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<td>Basic Calculus</td>
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**Total Credit Hours:** 30

## Major courses including research project/internship

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<td>Proteomics</td>
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<td>Elective IV</td>
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<td>Bioinformatics Computing II</td>
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**Total Credit Hours:** 32

## Elective Courses within the major

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# Scheme of Studies for BS (Bioinformatics)

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<tr>
<td>Bio-101/MTH-101</td>
<td>Basic I (Biology/Mathematics)*</td>
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<td>Bio-102/CS101</td>
<td>Basic II (Chemistry/ Computer fundamentals)*</td>
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<td>Bio-103</td>
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<td>Bio-202</td>
<td>Molecular Biology</td>
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<td>Data Structure and Algorithms</td>
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<td>Biochemistry II</td>
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<td>Ethical and Legal Issues in Bioinformatics</td>
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<td>Object Oriented Programming</td>
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<td>CS-302</td>
<td>Database Management Systems</td>
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<td>Special Topics in Bioinformatics</td>
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|             | Grand Total Credit Hours | 103 | 26 |            |
## DETAIL OF COURSES
### Semester-I

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<td>Hum-102</td>
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<td>MTH-101</td>
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<td>Prerequisite:</td>
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### 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
2. “Core Mathematics” by Keith Pledger.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bio-101</td>
<td>Basic Biology</td>
<td>3+1</td>
</tr>
<tr>
<td>Prerequisite:</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

### 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 times scale, 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
2. Star C. Biology Concepts and Applications

Bio-102 Chemistry 3+1
Prerequisite: None
Specific objectives of the course:
This is a deficiency course and 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
CS101  Computer Fundamentals  3+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 browser including open source browsers, Introduction to various operating systems.

Recommended Books:
Latest editions of following books
1. “Introduction to Computer Science”, P.K Sinha

Semester-II

Hum-103  Communication Skills  3+0

ANNEXURE - A

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 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
3. Lodish H. Molecular Cell Biology. Media Connected
4. Lewin B. Genes VIII. Pearson/Prentice Hall.
5. Robertes, Cell and Molecular Biology.

**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 computers and programming, overview of language for e.g. C language, basics of structured and modular programming, basic algorithms and problem solving, development of basic algorithms, analyzing problem, designing solution, testing designed solution, fundamental programming constructs, translation of algorithms to programs, data types, control structures, functions, arrays, records, files, testing programs.

**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.
Recommended Books:
Latest editions of following books

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:

Recommended Books:
Latest editions of following books
2. Brief Calculus and its applications by Doniel D. Benice.
3. Applied Calculus by Raymond A. Barnett.

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, nucleic acid 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

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**Semester-III**

**Hum-201**  Technical Report Writing  3+0

**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, determinants, 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 equations, homogeneous equations, equations linear equations, Bernoulli equations, applications of first order differential equations, Higher order linear differential equations, homogeneous linear equations, solution of higher order differential equation.
Recommended Books:
Latest editions of following books
1. Linear Algebra, David C. Lay, Pearson Addison Wesley.

Bio-201 Essentials of Genetics  2+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 molecular techniques used in gene analysis.

Course Outline:
Genetics 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, chromosomal aberrations, gene mutation, genetic disorders; DNA polymorphism.

Lab Contents:
Chromosome staining, Problems solving related to Mendelian inheritance – DNA extraction; PCR, Southern blotting techniques etc.

Recommended Books:
Latest editions of following books
2. Gardner, Principles of Genetics, UHR.

Bio-202 Molecular Biology  3+1
Prerequisite: Biochemistry 1
Specific objectives of the course:
This course is to teach the students about organization of genetic material, and its role in gene expression.

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, 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 about plasmids and vectors.

**Lab Outline:**
Isolation of plasmid and chromosomal DNA from bacteria and yeast. PCR, gel electrophoresis, comparing plasmids of different molecular weights using molecular weight markers, transformation in *E. coli*.

**Recommended Books:**
Latest editions of following books

**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, definitions, overview of algorithms, basics of array data structure, basic data structure functions, store, retrieve and search, idea of big O notation, uses of arrays, concept of binary search and linear search, simple sorting techniques. Stacks and queues, overview of stacks, queues, sorting techniques, selection sort, insertion sort and bubble sort. Comparison of sorting techniques and their applications, 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. Merge Sort.

**Lab Outline:**
Implementation of Basic Arrays, storing and Searching data in Arrays, implementation of Linear Search, implementation of Binary Search in Arrays, Using Bubble Sort, Selection Sort and Insertion on sample data, comparison study of simple sorting techniques, implementing Stacks and Queues, using priority queues for special cases, implementation of different types of Linked Lists for various applications.
**Recommended Books:**
Latest editions of following books
1. Data Structures and Algorithms By Robert Lafore,

**Semester-IV**

**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, significance of scoring, gap penalties, online tools BLAST, BLAT and FASTA.

**Lab Outline:**
Accessing ncbi databases, sequence databases, Genbank, EMBL, SWISS-PROT Accessing structure database PDB, SCOP and CATH, Expasy server, using online alignment tools for pair wise and multiple sequence alignment, phylogenetic analysis by ClustalW, using BLAST and FASTA.

**Recommended Books:**
Latest editions of following books
Bio-203  Bio-statistics  2+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, standard distributions and tests of significance. Test of independence or association, method related to one and two means, variance and covariance, heritability and its uses, Bayesian statistics, analysis of variance (ANOVA), and regression analysis, use of basic software.

Lab Outline:
Collection of data, acquisition of random samples, graphical/tabular representation of data, MS-Excel, SPSS, 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
2. Mead R Curnow R. N. Statistical Methods in Agriculture and Experimental Biology, Chairman and Hall.

Bio-204  Biochemistry II  3+1

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,
urea cycle and amino acids metabolism, nucleic acid metabolism, breakdown and synthesis of pure and pyrimidine bases.

**Lab Outline:**
Estimation of normal and abnormal constituents in urine including glucose, albumin, uric acid, chloride and phosphate, Kidney Function test, Liver function test.

**Recommended Books:**
Latest editions of following books

**BI-202 Ethical & Legal Issues in Bioinformatics 3+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
2. Computer Ethics: Cautionary Tales and Ethical Dilemmas in Computing By Tom Forester, Perry Morrison.
5. Computer Ethics: Cautionary Tales and Ethical Dilemmas in Computing By Tom Forester, Perry Morrison.
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, polymorphism, encapsulation, data hiding. Java introduction, byte code, architectural neutral language, simple programs, compiling and execution, dynamic initializing, scope and lifetime of variables, type conversion and casting, the type promotion rules, arrays, string data type, arithmetic operators, Bit wise operators, relational operators, boolean logical operators. 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, concatenating strings, string constructors, string comparing, string methods, string concatenating, string classes, string methods, Friend function, virtual functions, inline functions, Abstract classes, Interfaces.

Lab Outline:
Programs formulation according to the Course outlines.

Recommended Book:
Latest editions of following books
1. Complete Reference Java by “Herbert Schildt”.
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:

Bio-301 Research Methodology 2+0

Prerequisite: Biochemistry 101

Specific Objectives of course:
The basic concept of this course is to provide knowledge about how to design a research project and present it a professional manner.

Course Outline:
The main objectives of this course are: to understand the concepts of basic and applied research and their usefulness, formulation of research objectives, literature search, study designing, collection & compilation of research data, biostatistical methods used in data analysis, development of writing skills, use of reference manager software (Endnote).

Recommended Books:
Latest texts related to research methodology.
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, introduction to query processing and optimization, introduction to concurrency and recovery, front-end and back-end databases.

Lab Outline:
Structures 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.

Recommended Books:
Latest editions of following books
1. Data Structures and Algorithms By Robert Lafore,

BL-301 Bioinformatics-II 3+1

Prerequisite: 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, hydrogen bonding, PTMs of proteins, Chou Fasman, PHD and PSIPred, neural network, X-ray crystallography, NMR, ab initio, threading and homology modeling, structure prediction evaluation, 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.

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 to genomics, genome anatomy, gene expression, genome evolution, genome mapping, DNA markers, linkage analysis. QTL, mutations, Human Genome Project, Microarray, Genevestigator, Non-coding RNAs and their regulation, siRNA.

Recommended Books:
Latest editions of following books
1. David Mount Bioinformatics Sequences and Genome Analysis. CSB publishers and distributors.
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, data, 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

CS-303  Modeling & Simulation  2+1

Prerequisite: Programming Fundamentals

Specific objectives of the course:
This course emphasizes the development of modeling and simulation concepts and analysis skills necessary to design, program, implement, and use computers.

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.

**Lab Outline:**
Introduction to modeling techniques using simulation tools like MATLAB toolbox for various performance modeling and evaluation of high parallel systems. Using toolbox for analysis and study various faulty tolerant techniques, study queuing techniques.

**Recommended Books:**
Latest editions of following books
1. Complete Reference Java 2 by “Herbert Schildt”.

**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 to proteomics and protein chemistry, techniques in proteomics, iso-electric focusing, one dimensional and two dimensional electrophoresis and analysis, Mass spectrometry, bioinformatics tools for analysis of proteomics data, proteomics databases, MS data analysis, peptide mass and fragment fingerprinting, protein identification, post-translational modification, protein-protein interaction, applications of proteomics.

**Recommended Books:**
Latest editions of following books
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:
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

Elective-I  3+0

Prerequisite:  None

Course Outline:
To be chosen from the list of electives.
Semester-VII

BI-401  Bioinformatics Computing-II  3+1

Prerequisite:  Bioinformatics Computing- I

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

Course Outline:
This course emphasized on cellular, tissue, organ and system modeling, simulation, analysis using an object oriented programming languages, 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

CS402  Artificial Intelligence  3+0

Prerequisite:  Programming Fundamentals

Specific objectives of the course:
This course introduces the techniques of artificial intelligence for solving advanced problems using computers.

Course Outline:
Introduction to artificial intelligence, applications, problem solving, classical approach, generate and test, problem presentation, searching, tree and graph terminology, searching, branch and bound, improvements in branch and bound, common lisp. AI classical systems: general problem solver, rules, simple search, means-ends analysis. ELIZA, pattern matching, rule based translators, Knowledge Representation: natural language, rules, productions, predicate logic, semantic networks, frames, objects, scripts, hill climbing, min-max search, A* search, symbolic mathematics, solving
algebra problems, Logic Programming: Resolution, unification, horn-clause logic, prolog.

**Recommended Books:**
1. “Artificial Intelligence” by Ela Kumar, IK International.

**Elective-II**

**Prerequisite:** None

**Course Outline:**
To be chosen from the list of electives

**Elective-III**

**Prerequisite:** None

**Course Outline:**
To be chosen from the list of electives

**Research Project**

**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**

**Bio-406  Bioinformatics Software Engineering**

**Prerequisite:**

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

**Course Outline:**
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.
Lab Outline:
Introduction to software development techniques, implementation of various software models using simple case studies, introduction to HTML, XML, use of front end application tool.

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. Students are required to make presentation of the selected topics as determined by the faculty members / Coordinator conducting Bioinformatics Programme.

Recommended Books:
Latest editions of following books
1. Namita M. Bioinformatics concepts, skills and applications, CSB publishers and distributors.
2. Lacroix Zor. Bioinformatics managing scientific data, Morgan Kaufmann publishers.

Elective-IV 3+1

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. Microarray Data Analysis
3. Human Computer Interaction
4. Nanotechnology
5. Environmental Biotechnology
6. Special Topics in Biochemistry
7. Immuno-Informatics
8. Microbial genomics and proteomics
9. Protein-protein interaction
10. Digital Image Processing
11. Gene Mining
12. Pattern recognition and matching
13. Biophysics
14. Modern programming languages
15. Medical Image processing

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 2nd Edition
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
MASTER OF SCIENCE (MS) IN BIOINFORMATICS

Introduction:
The purpose of MS degree programme 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. Exponential growth and complexity of biological data can be translated effectively into knowledge by the use of computer based approaches.

General objectives
The enormous influx of biological data can only be handled with better and faster computational approaches together with advanced knowledge in functional genomics and proteomics. Advanced concepts, structures, algorithms and tools are required for effective processing and analysis. Specialized courses in molecular biology, bioinformatics and computation are needed to achieve these objectives.

Learning Outcomes
After completion of MS program in bioinformatics, the graduates will be able to
- answer fundamental questions about molecular evolution, biological functions and control of biological systems.
- use bioinformatics skills predicting functions from structures, networks, complexes, transcriptome and proteome data.
- design novel genes/proteins and small molecules with specific functions.
- 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. 2nd Division or GPA 2.50 or above.
3. Subject GRE/NTS or in-house written test.
4. Interview.

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 Programme in Bioinformatics

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Semester 1 (Credit hours)</th>
<th>Course Code</th>
<th>Semester 2 (Credit hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Courses</td>
<td>Credit hours</td>
<td>Course</td>
</tr>
<tr>
<td>BI-601</td>
<td>Advanced Bioinformatics</td>
<td>3</td>
<td>Elective I</td>
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<tr>
<td>Bio-601</td>
<td>Advanced Molecular Biology</td>
<td>3</td>
<td>Elective II</td>
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<tr>
<td>CS-601</td>
<td>Information Processing</td>
<td>3</td>
<td>Elective III</td>
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<td>BI-602</td>
<td>Advanced Computing Approaches</td>
<td>3</td>
<td>Elective IV</td>
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<td><strong>Total Credit Hours</strong></td>
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<th>Semester 3 &amp; 4 (Credit hours)</th>
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<tr>
<td>Research/Thesis</td>
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<td><strong>Grand Total Credit Hours</strong></td>
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BI-601 Advanced Bioinformatics 3

Prerequisite: None

Specific objectives of the course:
The objective of this course is to train students to develop methods and understanding for integration and analysis of biological data.

Course Outline:
Functional genomics, comparative genomics, DNA microarray, computer aided drug designing (ligand and receptor based), molecular docking, protein-protein interaction network and databases, molecular dynamics simulation, biological networks, transcriptome, metabolomics

Recommended Books:
Latest editions of following books

Bio-601 Advanced Molecular Biology 3

Prerequisite: None

Specific objectives of the course:
The students will learn most recent advances in molecular biology and molecular cloning techniques.

Course outline: Molecular nature of gene’ methods of molecular biology; transcription in prokaryotes and eukaryotes; post transcriptional events; translation; DNA replication, recombination and transposition; homologous; homologous recombination. Genomics and proteomics etc.

Recommended Books:
Latest editions of following books
2. Benjamin Lewin: GENES. Pearson/Prentice Hall.
CS-601 Information Processing

Prerequisite: None

Specific objectives of the course:
To introduce the principles of data analysis, association, classification, matching and their applications to bioinformatics.

Course Outline:
Classification, Bayesian networks, nearest neighbour and k-means clustering, decision tree learning, clustering and data/dimensionality reduction, sampling, feature selection and feature transformation approaches, machine learning for user modeling, data warehousing, advanced query processing, data mining, association analysis, sequence mining, introduction to web mining, content, structure and usage mining.

Recommended Books:
Latest editions of following books
1. Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze.

BI-602 Advanced Computing Approaches

Prerequisite: None

Specific objectives of the course:
This course provides knowledge on advanced principles and applications of biological data analysis and processing.

Course Outline:
Introduction to microarray experiments: principles and experimental design, biomedical image analysis (2D gel, DNA and protein chips), advanced analysis of microarray data, exploratory data analysis and visualization, cluster analysis: hierarchical clustering, k-means, gene shaving, correspondence analysis, multi-dimensional scaling, neural networks, unsupervised and supervised learning: discriminant analysis, error-rate concepts, tree-based methods, genetic algorithms, applications to genetic networks, genetic modeling.

Recommended Books:
Latest editions of following books
1. Image processing using Matlab, RC Gonzales.
2. Pattern classification by Huda & Hart.
SEMESTER-II

In Semester-II, four subjects will be selected from the following list of elective subjects:

LIST OF ELECTIVES

1. Computer aided drug designing
2. Advanced biotechnology
3. System biology
4. Programming for Bioinformatics
5. Data warehousing and data mining
6. Molecular dynamics simulation
7. Intelligent systems
8. DNA microarrays and integrative genetics
9. Functional genomics
10. Epidemiology
11. Advance topics in information systems
12. Neural Computing
13. Research Method in Biological Sciences
14. Advanced Algorithms
15. Current trends in bioinformatics
16. Gene regulation and expression
17. Principles and application of proteomics
18. Medical genetics
19. Epigenetics

Note: In addition to the above the universities can offer any elective course subject to the availability of resources

SEMESTER-III and IV

Research Thesis (6 Credit Hours):
Research Project:
1. Duration of the research project will be at least one full year. 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 Text Books For MS Bioinformatics Programme

1. Bioinformatics: sequence and Genome Analysis, David W. Mount.
3. Developing Bioinformatics Computer Skills, Cynthia Gibbs, Per Jambeck.
4. Discovering Genomics, Proteins and Bioinformatics, A. Makom Cambell, Laurie J. Heyer.
8. A Primer of Genome Sequencing, Greg Gibson.
16. Microarray for An Integrative Genomics S. Isaac, J-Atul, Alvin Khd
18. Genomic Perl: From Basic To Working Code Rex A.Dwyer
20. Biotechnology, Genomics and Bioinformatics Teresa Atwood, David Perry-Smith
21. Introduction To Bioinformatics Teresa Atwood, David Perry-Smith
22. Structured Bioinformatics Philip Bourne, Helge Weissig
27. Bioinformatics: Using Computational Intelligence Paradims U. Seiffert, L.C.Jain, Pschwetzer
28. Introduction To Bioinformatics: a theoretical and Practical Approach
Stephen Krawetz, David D.Womble.
30. Immunological Bioinformatics, Lund Ole Nielsen.
32. Bioinformatics: Genes, Proteins and Computers C.Orengo, D.Jones,
J.Thornton.
33. Bioinformatics and Molecular EvolutionPaul G. Higgs.
34. The Application of Bioinformatics in Cancer Detection Asad Umar
35. Bioinformatics, Ralf Hofestadt.
36. Bioinformatics, Genomics and Proteomics: Getting the Bio PictureAnn
Batiza, Bernice Schacter
37. Knowledge Discovery in Proteomics Igor Jerisca, Dennis Wigle
38. Proteomics and Protein-Protein Introductions:
Biology, Chemistry, Bioinformatics and Drug Design, Gabreil Waksman
40. Bioinformatics Basics: Application in Biological Science and Medicine
Hookman Rashidi, Lukas Buehler.
41. Medical Genetics Lynn B.Jorde, Jhon C.Carey, Micheal .Bamshad,
Raymond L. White
42. Essential of Genetics, William S.Klug, Michel R.Cummings.
43. Thompson & Thompson Genetics in Medicine Robert I.Nussbaum,
44. Medical Molecular Genetics, Patrick A.Hoffe.
45. Genomics, Sandy Primose, Richard Twyman
46. Essential of Medical Genetics Alan Emery, Robert Mueller.
47. Gene VIII Benjamin Lewin.
48. Understanding Biotechnology,George Acquaah.
49. Concept of Genetics, William Klug, Michael Cumming
Charlotte Spencer
50. Essential Genes, Benjamin Lewin.
51. Cell and Molecular Gerald Karp
52. Microbiology; A Human Perspective Eugene Nester, Denise
53. Genetics, Benjamin A. Pierce.
54. Ethics from a Faith Perspective, Jack Hanford.
55. A companion to Genetics Justine Burrley, John Harris
56. Understanding Medical Statistics David Mathews, Vernon Farewell
57. Molecular Biology, Robert Weaver.
58. Lipincot’s Biochemistry Champe; Harvey; Ferrier.
59. Harper’s; Biochemistry, Murray. Grammer, Mayes, Rodwell
60 Lehniger; Principles of Biochemistry Nelson , Cox.
61 Biochemistry Donlad Voet
62 Pattern Recognition, Statistical, Structural & Neural ApproachedRobert
Schalkoff
63 Pattern Recognition with neural networks in C++ Pandya/Macy
64 Pattern Classification Duda, Hart and Stork.
65 Fundamentals of Pattern Recognition, Monique Pavel.
68 Digital Image Processing R.C. Gonzales
69 Digital Image Processing using Matlab R.C. Gonzales
70 Hand Book of Image Processing John C.Russ
**COMPULSORY COURSES IN ENGLISH FOR BS (4-YEAR) IN BASIC & SOCIAL SCIENCES**

**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**
b) Writing

c) Reading/Comprehension

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

b) Writing
good for writing memos, introduction to presentations, descriptive and argumentative writing).

c) Reading
2. Reading and Study Skills by John Langan.

**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

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
   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
   - Economic institutions and issues
   - Society and social structure
   - Ethnicity
   - Foreign policy of Pakistan and challenges
   - Futuristic outlook of Pakistan

Recommended Books:


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

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

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

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

Introduction To Sunnah
1) Basic Concepts of Hadith
2) History of Hadith
3) Kinds of Hadith
4) Uloom-ul-Hadith
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) Quranic & 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,”
6) Ahmad Hasan, “Principles of Islamic Jurisprudence” Islamic Research
9) Dr. Muhammad Zia-ul-Haq, “Introduction to Al Sharia Al Islamia” Allama Iqbal Open University, Islamabad (2001)
RECOMMENDATIONS

1. Only limited numbers of universities are offering under- and post graduate courses in bioinformatics. There is a need to encourage other public and private universities/institutes to develop expertise in bioinformatics at their respective campuses.

2. HEC should allocate sufficient funds and grants on priority basis for faculty development in this newly emerging field, especially for universities/institutes, located in developing areas of Pakistan by sending their faculty members for the short and long-term training courses. This will help in elimination of shortage of specialized manpower in bioinformatics especially at the university level.

3. HEC should facilitate and provide funds for infrastructure and equipments for strengthening the existing program and initiating new programs in bioinformatics.

4. HEC should implement a strict policy of monitoring and evaluation of universities/institutes (both in public and private sectors) offering degree courses in bioinformatics and enroll students giving them false/deceptive information about the faculty, programs and facilities. In this regard a special committee should be constituted comprising of five members (02 biological sciences, 02 computational sciences, 01 HEC, taking at least one member preferably from a developing province).

5. Both under- and post graduate courses in bioinformatics should be included in teaching curriculum of the public and private sector of the universities and degree awarding institutes.

6. A comprehensive course in bioinformatics should be developed for students of other relevant disciplines.

7. To promote public awareness series of seminars and workshops should be organized on regular basis.

8. There should be a strong link between academia and industry for the absorption of bioinformatics graduates. This will encourage other students to take programs in bioinformatics.