

ORDINANCES FOR

2- year Post-graduate Course

**M.Sc. Bioinformatics
(under Self Finance Scheme)**

From the session 2016-17

**Ch. Charan Singh University
Meerut**

OVERVIEW

The term 'Data Science' was coined at the beginning of the 21st century, and it is a fairly young field of science and technology. Over the past few decades, data science has increasingly become popular all over the world. It has become the part and parcel of every business model.

Our students have obtained jobs in Biotechnology, Pharmaceutical, and Chemical, industries, Reliance, IBM life sciences, Biomedical Informatics and Silicon Genetics and Tessella, Wipro, Cysco System, Ranbaxy, Himalaya Biotech, Charak Pharmaceuticals, Baxal Pharmaceutical, Panacea Biotech, Adarsh Beverages in Government and Private R&D institutions related to agriculture, medical and environmental studies (DRDO, INMAS, CIMAP, CDRI, AIIMS, NIL, IGIB, IARI, IITs, CDFD, IMTECH, C-DEC *etc.*) in central & state govt. departments, universities & colleges and as Research Scientists/Post Doctoral Fellows/Research students in abroad such as Germany, USA, UK, Canada, Taiwan, China, France, Spain, UAE, etc.

AIMS

We aim to give a significant level of theoretical and practical understanding. It would be good to have Bioinformatics in our University to train students, faculties of affiliated colleges and to understand biological processes at molecular level. It would also be helpful to do Computer Assisted Drug Designing by using this facility.

We have also planned to develop databases of protein sequences of mangrove medicinal plants, gene sequences of endangered species, and medicinal plants. We also plan to do data mining work of various biological databases that are available at NCBI site.

This course would be useful for all the faculties of this university who wish to do computational biology related work. This facility would also be useful to provide advanced training in bioinformatics to students and teachers of our university as well as affiliated colleges. Finally it will be useful to do quality research and get publications in high quality reputed journals. This course will be helpful to students/researchers of all life science subjects.

ORDINANCES

All rules for conduct of examination pattern pass percentage and admissions shall be the same as for other post-graduate courses in the Faculty of Science on the University campus. Internal and external examination shall be as indicated in the given Table. The pattern of internal assessment shall be decided by the Department however, it will mainly include tests, quizzes, seminars, term papers, group discussions and home assignments. A candidate will have to complete a project in the fourth semester for a period 4 to 6 months. The Project may also be completed in Department of Microbiology. One of the supervisors for project work may be opted from outside the University where the candidate shall complete his/her project work. After the completion of Project work the candidate shall submit a detailed project report/thesis and will make an open presentation for 20-30 minutes. He/she will defend his/her experimental design, results and conclusions before the Board of Examiners to be appointed by the competent body/officer of the University who shall normally be the Vice-Chancellor. Besides, the project report, the candidate will also appear in written examination in Bioinformatics. The question paper will be set jointly by the internal and external examiner both who shall also be the examiners of his/her project report. The question paper will consist of short questions including objective type to test thorough knowledge of the candidate in the field of specialization. The answer sheets will be jointly evaluated by the same Board of Examiners who will set the question paper. The Department shall be free to alter the sequence of courses in any semester depending upon the resources available.

Number of seats and fee structure

Initially there should be only 20 seats which may be altered depending upon the facilities available in the Department/College/Institute. Reservation shall apply as per the policy of the University for other Courses in the University. This course is approved under self finance scheme of the University/State Govt. and annual tuition fee shall be decided by the concerned Department/College/Institute depending upon the resources available.

Eligibility for Admission

Minimum eligibility for admission in this two year M.Sc. (Bioinformatics) course shall be undergraduate degree / B.Sc. (Biology group (CBZ) / Bioinformatics / Biotechnology / Microbiology / Computer Science /Mathematics / Statistics / BMLT).

Appointment of Examiners

Course Coordinator is authorized to make a proposal of the examiners (both for theory and practical examination) in consultation with the members of Board of Students either through telephonic conversation or through electronic media. Alternately, a meeting of Board of Studies may be convened.

COURSE STRUCTURE

Following course structure is approved

Applicable from academic session 2016-17

Course No.	Course	Internal Maximum Marks	External Maximum Marks
	Semester I		
BI 101	Basic of Bioinformatics, Computer system and 'C' Programming	50	50
BI 102	Biomathematics	50	50
BI 103	Biological Database System and Data mining	50	50
BI 104	Microbiology & Immunology	50	50
BI 105	Practical (Course BI 101, BI 102, BI 103, BI 104)		100
	Semester II		
BI 201	Operating System through Unix/Linux	50	50
BI 202	Object Oriented Programming with 'C++'	50	50
BI 203	Sequence Analysis	50	50
BI 204	Molecular Biology & Genetic Engineering	50	50
BI 205	Practical (Course BI 201, BI 202, BI 203, BI 204)		100
	Semester III		
BI 301	Statistical Analysis and Optimization	50	50
BI 302	Biocomputing Programming	50	50
BI 303	Structural Biology & Molecular Modeling	50	50
BI 304	Genomics, Proteomics & Systems Biology	50	50
BI 305	Practical (Course BI 301, BI 302, BI 303, BI 304)		100
	Semester IV		
BI 401	Project Report include Viva-voce		400
BI 402	Bioinformatics (short questions including objective type)		100

Course 1, Code BI 101- Basics of Bioinformatics, Computer system and ‘C’ Programming

Unit I- Introduction to Bioinformatics Definition & Concept; Human Genome Project; Role of Bioinformatics, Introduction of Internet in Biology & Objectivity; Services of Internet used for Biological Data (E-Mail, File Transfer Protocol, Usenet, Telnet). Important bioinformatics resources (NCBI, EBI, SIB).

Unit II- Computer System- Definition and characteristics, Components (Input/Output unit, Control Unit, Primary Storage Unit, Arithmetic and Logic Unit), Types of Memory, Communication Pathways (Control Bus, Address Bus, Data Bus), Classification of Computers (according to logic & size), Generation of Computers; Introduction to Software, Classification of Software, Translators (Compiler & Interpreter); Number Systems; Logic Gates.

Unit III- Networking- Definition, Client/Server, Types (LAN, WAN, MAN); Network Connecting Devices; Topologies (Bus Network, Ring Network, Star Network, Mesh Network, Tree Network) and their advantages & disadvantages. Elements of Networking (Network Services such as File Services, Database Services, Print Services, Application Services); Transmission Medias (Coaxial Cable, Fiber Optics, Twisted Pair).

Unit IV- Functional Structure of Programming in C: Concepts of flowcharting and algorithm development; Tokens in C (Constant, Variable & Keywords); Data types; Operators (Arithmetic Operators, Relational Operators, Increment Operators, Decrement Operators, Assignment Operators & Conditional Operators), if statement; if-else statement; switch statement; for statement; while statement; do-while statement; Odd Looping.

Unit V-Arrays in C: One Dimensional Array; Two Dimensional Array; String Handling in Array (Declaration of String Variable, Printing of a string, Concatenation of a String, Comparison of the String). Built-in Functions & User Defined Functions (Definition; syntax; main function; printf function; scanf function; getchar function; getche function; putchar function; strcmp function; strcpy function; strcat function; strlen function; Declaration and definition of User-Defined Function; Call by Value; Call by Reference; Recursion); Pointers in C (Definition; Objectivity; Initialization of Pointers; Pointers & Array; Pointers & Function).

Suggested Readings (Latest Editions):

- *J.B. Dixit. 2009 Computer fundamentals and programming in ‘C’. LP Publication*
- *Guigo R. Ed. & Gusfield. 2014. Algorithm in Bioinformatics. O.Ed. Berlin. Springer-Verlog*
- *Yashavant Kanetkar, 13th Edition, 2016, Let Us C/C++, Paperback.*
- *E. Balaguruswami. 5th Edition . 2008. Programming in ANSI ‘C’. Tata Mac Graw Hill.*
- *Sharma, Munjal and Shankar.2007. A Text book of bioinformatics. Rastogi Publications.*
- *P.K. Sinha. 2016. Fundamental of computers. BPB publication.*

Course 2, Code BI 102- Biomathematics

Unit I: - Matrices: Algebra of matrices, transpose and inverse of a matrix, determinants. Arithmetic and Geometric Series, Binomial Theorem. Permutation and combinations. Introduction to set theory, Functions, Polynomials, limits and continuity.

Unit II: - Differentiation and Integration: Derivative of simple algebraic and trigonometric functions. Maxima and minima. Integration of some standard functions. Integral by parts. Applications of Integral calculus in biology. Definite integral. Ordinary differential equations (first order) - example from biology.

Unit III: - 2D Coordinate Geometry: Equation of a line, circle, ellipse, parabola, and hyperbola. 3D geometry: Equation of sphere, cone.

Unit IV:- Numerical Analysis: Gaussian Elimination and Gauss Jordan Methods for the solution of system of linear equations. Solution of Algebraic and Transcendental Equations by Bisection Method and Newton- Raphson Method.

Unit V: - Interpolation: Newton's formulae, Lagrange's formula. Curve fitting by Method of least squares. Numerical differentiation using Newton formulae. Numerical Integration: Trapezoidal rule, Simpson's 1/3 and 3/8 rules.

Suggested Readings (Latest Editions):

- *J . D. Murray. 2014. Mathematical Biology. Springer Verla.*
- *Segal, L. 2012. Mathematical Models in Molecular and Cellular Biology Cambridge: Cambridge University Press.*
- *Balaguruswamy. 2016. Numerical Methods . TMH.*
- *V Rajaraman. 2007. Computer oriented numerical methods. Printice hall India.*
- *S. C. Gupta. 2009. Fundamental of Methametics . Sutanchand & Sons Publication.*
- *A.R. Vasistha. 2014. Matrices. Krishna Publication.*

Course 3, Code BI 103- Biological Database System

Unit I:- Database System- Definition; Purpose of Database System; Advantages of Database System; Components of Database System (., Hardware, Software & Users), Database Administrator; Data Administrator; Data Models (Relational, Network, Hierarchical); Three Level Architecture for Database System (Internal Level; Conceptual Level; External Level); Data Independence; Data Abstraction; Mapping; Data Definition Language; Data Manipulation Language; Data Sub Language; Role of Schemas in Three Level Architecture; Client/Server architecture; Distributed Processing; Database Technologies (Flat Files, Relational & Object).

Unit II:- Relational Database- Definition; Relational Data Model (Binary, Ternary, Quaternary & n-ary Relation); Important terms in Relational database system (Tuple, Records, Fields, Domain, Degrees, Cardinality); Keys(Primary Key, Candidate Key, Composite Key, Foreign Key& Alternate Key).

Unit III:- Structured Query Language- Creating Table; Applying Column & Table Constraints; Inserting Values in Table; Deletion(of Rows & Table); Updating Values; Altering Table; Retrieving Values from Table; Revoke Command; Drop Command; Grant Command; Commit Command; Rollback Command.

Unit IV:- Biological Database- Primary Database & Secondary Database; Submitting Sequence to the Database and Information Retrieval through LocusLink; Sequence Databases (EMBL, GenBank, DDBJ).

Unit V: - Protein and other databases: SWISS-PROT, PIR, TrEMBL); Protein Family/Domain Databases (PROSITE, Pfam, PRINTS & SMART), cDNA Libraries and ESTs & Structure Database (PDB, CATH, SCOP).

Suggested Readings (Latest Editions):

- *Ivan Bayross. 2010. SQL, PL/SQL the programming language of Oracle., BPB Publication*
- *C.J. Date. 2010. An introduction to database systems. Addison Wesley*
- *Orpipa Bosu and Simminder Kaur, Thukaral. 2009. Bioinformatics: Database, tools and algorithms. Oxford Publications*
- *Hanery Korth and Abraham Silberchaltz. 2013. Database system concepts. Tata Mac Graw Hill*
- *Baxevanis, A.D. and Ouellette. 2004. Bioinformatics: A practical guide to the analysis of the gene and protein b. B.F.F, New York, John Wiley and Sons, Inc Publication*
- *Atwood, T.K. and Aprry-Smith. 2003. Introduction to Bioinformatics. D.J. Delhi, Pearson education (Singapore)*

Course 4, Code BI 104- Microbiology & Immunology

- Unit I :** Discovery of microbial world, controversy over spontaneous generation; origin of life. Microbial evolution and diversity; five kingdom and eight-kingdom classification.
- Unit II :** General account of prokaryotes: structural organization of Eubacteria and Archae (cell membrane, cytoplasmic matrix, inclusion bodies, nucleoid, flagella, pilli and endospore); General characters of eukaryotic microbes, structure and organization of a typical eukaryotic cell, Evolutionary relationship of each group based on modern systems of classification.
- Unit III :** History and discovery of viruses; nature of viruses; General characters of viruses; Nomenclature and Classification of viruses; Bacteriophage: Structure and life cycle pattern of T-even phage; Genome organization of viruses.
- Unit IV :** Introduction to the immune system: Innate immunity; anatomic, physiological, phagocytic & inflammatory barriers. Adaptive immunity; natural & artificial immunity. Cells involved in immune response: lymphoid lineage (producing B & T lymphocytes) & Myeloid lineage (phagocytes: macrophages, neutrophils & eosinophils. And auxillary cells; basophils, mast cells & platelets). Organs involved in immune system: primary & secondary lymphoid organs.
- Unit V :** Types of antigens; Structure & types of Immunoglobulins, genetic diversity of immunoglobulins; Cytokines: B-cell biology: Antigen-Antibody binding, B-cell activation. T-cell biology: major histocompatibility complex molecules; Types of vaccines & their characteristics; Immune disorders; Hybridoma technology, applications of monoclonal antibodies. Antigen-antibody reactions *in vitro*.

Suggested Readings (Latest Editions):

- Prescott - Harley - Klein -2007- Microbiology - IV Edition - International edition - McGraw Hill - ISBN0-07-115830-8.
- D. J. Taylor - N. P. O. Green - G. W. Stout – Biological Sciences - III Edition - Ed. - R. Soper - Cambridge University Press - ISBN0 - 521 - 639239 (Low Price Paperback)
- K. P. Talaro & A. Talaro,. Foundations in Microbiology, HI - International Edition. WCB / McGraw Hill –ISBN0, 697, 35452 . 0
- Guntram Seltmann, Otto Holst Bacterial cell walls. Springer ISBN:3540426086
- Nelson D. L. and Cox M. M. (2005) Lehninger's Principles of Biochemistry, Fourth edition, W. H. Freeman & Co. New York.
- White David Physiology and Biochemistry of Prokaryotes. 2nd Ed. Oxford University Press, New York.
- Berg Jeremy, Tymoczko John, Stryer Lubert Biochemistry 4th Ed, W. H. Freeman, New York.

Course 5, Code BI 105- Practical based on courses taught in first semester

Course 6, Code BI 201: Operating System through Unix/Linux

Unit I- Operating System: Introduction: Windows and Unix/Linux, Definition; Concepts; Function of Operating System; Batch Processing; Multiprogrammed Batch System; Time Sharing System; Parallel System; Distributed System; Real Time System.

Unit II- Process & Memory Management: Process; Process State(New, Running, Waiting, Ready, Termination); Process Control Block; Process Scheduling (Round Robin Scheduling, Priority Scheduling, Multiple Queues, Shortest Job Scheduling); Operations on Process; Basic Management of Memory; Swapping Virtual Memory; Paging.

Unit III- Input/Output Management: I/O Devices; Device Controllers; I/O Software; Device Drivers; Deadlock; Resources; Principles of Dead Lock; Detection and Recovery; Deadlock Prevention; Deadlock Avoidance.

Unit IV- UNIX/LINUX Operating Systems: Introduction; Concepts; Layers of UNIX; Role of System Administrator and Ordinary User; Tree Structure of UNIX; Root File System; /bin Directory; /dev Directory; /bin Directory; /etc Directory; /lib Directory; /proc Directory; /mnt Directory; /root Directory; /sbin Directory; /tmp Directory; /var Directory; Relative Path; Absolute Path; Creation of Directory; Creating file; removing file; Listing Files and Directories copying file; renaming file; Changing File Permission; Changing Directory Permission; Changing Group; Changing Owner; Pipe; Filters; pwd command; date command; head command; tail command less command; more command; grep command; VI Editor (Creating a new File; Inserting Text in File; Deleting Text in File; Copy , Cut & Paste Text; Save File).

Unit V- Shell Programming- Variables(Configuration Variable & Environmental Variable); Operators(Arithmetic Operator, Logical Operator, Relational Operator); Instruction(Sequence Control Instruction, Selection Control Instruction, Repetition or Loop Instruction); echo command; read command; output command.

Suggested Readings (Latest Editions):

- *Ramesh Bangia. 2015. Learning Unix. BPB Publication.*
- *Peter Baer Galvin. 2016. Operating System Concepts. BPB Publication*
- *Stuart E. Madnick. 2001. Operating System. Tata Mac Graw Hill.*
- *Kenneth H. Roshan. 2007. The complete reference Unix Tata Mac Graw Hill..*
- *D. M. Dhamethire. , 2011. System Programming and Operating Systems. Tata Mac Graw Hill.*
- *Kirrgcox. 2001. Red Hat Linux by. Printice Hill India.*
- *Andrew S. Talenbaum. 2008. Modern Operating system. Printice Hill India.*
- *Sumetabha Das. 2013. Unix (Concept and Application). Tata Mac Graw Hill.*

Course 7, Code BI 202- Object Oriented Programming with ‘C++’

UNIT-I: Introduction to Object-oriented programming, Concepts of object oriented programming: Objects, Classes, Data Abstraction, Data encapsulation, Inheritance, Polymorphism, Advantages of OOP, Application of OOP with C++.

UNIT-II: Introduction to C++, Token, Keywords, Identifiers, Data types (User define & Derived Data types), Variables, Declaration of Variables, Operators, Scope resolution operator, Manipulators, Operator Overloading, Operator Precedence, Controlling Structures: Sequence structure, Selection structure(if...else if & switch statement), Loop structure (for loop, while loop & do-while loop).

UNIT-III:Function Prototyping, Call by reference, Friend function, Inline function, Outside function inline, Private Member functions, Public Member functions, Static class members: Static data member, Static member function, Object assignment, Passing objects to function, Objects as function arguments, Function & operator overloading.

UNIT-IV: Array, Array of objects, Arrays within class, Pointers to object, Memory allocation, Initializing allocated memory, Allocating Array, Allocating objects. Constructor & Destructor, Creating string objects, manipulating string objects, relational operators, string characteristics, comparing and swapping.

UNIT-V: Inheritance : Base class Access control, Inheritance & protected members, Derived class, Protected base class inheritance, Single Inheritance, Multilevel Inheritance Inheritance, Multiple Inheritance, Hierarchical Inheritance, Hybrid Inheritance Virtual base classes . Virtual functions & Polymorphism: Virtual function, Constructors in Derived Classes, Formatted & Unformatted I/O operations.

Suggested Readings (Latest Editions):

- E. Balaguruswami, *6th Edition . 2013*, Object Oriented Programming with ‘C++’, *Tata Mac Graw Hill*.
- Yashavant Kanetkar, 13th Edition, 2016, Let Us C/C++, Paperback.
- Robert Lafore, 4th Edition, 2008, Object Oriented Programming in ‘C++’, Paperback.
- Scott Meyers, Latest Edition, Effective Modern C++, Paperback.

Course 8, Code BI 203- Sequence Analysis

- Unit I:** Sequence comparison algorithm, sequence scoring schemes (weight matrix as Identify scoring, genetic code scoring scheme chemical scoring, observed substitution matrix and Gap penalties.)
- Unit II:** Sequence database similarity searching algorithms, local alignment, global alignment, FASTA, BLAST (BLASTP, BLASTN, BLASTX, TBLASTN, TBLASTX) and similarity searching scores and their statistical interpretation.
- Unit III :** Motifs and Domains, algorithm for multiple alignments (CLUSTALx and CLUSTALW) Biological motifs (consensus, regular expression, profiles, PSSMs, HMMs and application for biological sequence similarity searching(PSI- & PHI BLAST, motifs, patterns)).
- Unit IV:** Functional genomics Strategies for generating EST and full length insert, EST clustering and assembly, statistical analysis of EST and EST data, micro array (target selection/design, image analysis, data validation, statistical analysis).
- Unit V:** Phylogenetic prediction: Relationship of phylogenetic analysis to sequence alignment, Genome complexity and phylogenetic analysis, concept of evolutionary trees. Maximum parsimony method, distance method, maximum likelihood method.

Suggested Readings (Latest Editions):

- Heijne, Gunnar Von. *Sequence Analysis in Molecular biology: treasure trove or trivial Pursuit*
- Koski, T. Dordrecht Kluwer. 2013. *Hidden Markov Models for Bioinformatics*. Academic Publishers
- Darbin, R. Eddy, S. Krogh, A. & Mithchison G.. 2010. *Biological Sequence Analysis: Probabilistic models of Proteins and Nucleic acid* Cambridge University Press, Cambridge
- Sharma, Munjal and Shankar. *A Text book of bioinformatics*.2009. Rastogi Publications
- *Advances in Bioinformatics* by M. S. Krishna Kumar

Course 9, Code BI 204- Molecular Biology & Genetic Engineering

Unit I- Nucleic acids as genetic information carriers, DNA structure, types of DNA. DNA replication in prokaryotes & eukaryotes. Structural features of RNA (mRNA, tRNA, rRNA). Transcription in prokaryotes & eukaryotes.

Unit II- Regulation of gene expression. Basic features of the genetic code. Protein synthesis in prokaryotes and eukaryotes. Recombination: general principles. Plasmids (types of plasmids- F plasmids, R plasmids, Col plasmids & Ti plasmid). Gene transfer mechanisms: transformation, transduction, and conjugation.

Unit III- Mutations: spontaneous mutation, Induced mutagenesis- mutagens (physical mutagens: non ionizing & ionizing radiations; chemical mutagens: Base analogues, alkylating agents, deaminating agents, intercalating agents & others), molecular mechanism of mutagenesis. DNA repair mechanism: repair by direct reversal, excision repair, recombinational repair & SOS repair.

Unit IV- Basic steps of r-DNA technology. Restriction endonucleases. Cloning vectors: general properties, plasmids, bacteriophages, cosmids, shuttle vectors, bacterial artificial chromosomes. Eukaryotic cloning vectors for yeast, & animal cells. Gene libraries: genomic library (Shot gun approach), c DNA library (Different methods for synthesizing c DNA molecules).

Unit V- Molecular Techniques; Principles, methods & their applications in medical diagnosis -such as PCR, Southern Blotting, Northern Blotting, RFLP, RAPD, Western Blotting, DNA finger printing and DNA sequencing. Microbial genetic & design of vaccines; for TB & leprosy. DNA vaccines design & advantages. Recombinant vaccines.

Suggested Readings (Latest Editions):

- Maloy. Microbial Genetics. Jones and Bartlett Publishers.
- Dale JW. Molecular Genetics of Bacteria. John Wiley and Sons.
- Streips and Yasbin Modern Microbial Genetics. Niley Ltd.
- Watson, JD, Hopkins NH, Roberts JW, Steitz JA and Weiner AM. Molecular Biology of the Gene. Benjamin / Cummings Publications Co. Inc. California.
- Lewin. Gene VII. Oxford University Press.
- Friedberg, C, Graham C, Walker and Wolfram S. DNA repair and mutagenesis. ASM Publications.
- Larry, Snyder and Wendy. Molecular Genetics of Bacteria. ASM Publications.

Course 10, Code BI 205- Practical based on courses taught in second semester

Course 11, Code BI 301- Statistical Analysis and Optimization Techniques

- Unit I:** Frequency distribution. Measures of central tendency and measures of dispersion. Correlation and regression: Scatter Diagram, Coefficient of Correlation, Rank correlation. Lines of Regression.
- Unit II :** Probability theory: Classical and Statistical definitions, conditional probability, Bayes' Theorem. Random variable, mathematical expectation. Probability Distributions: Binomial, Multinomial, Poisson and Normal Distribution. Introduction and Properties of 't', Chi-square and F distribution.
- Unit III :** Estimation: Population and sample, Different kinds of sampling. Fundamental concepts of estimation, Maximum Likelihood Estimation, Interval Estimation. Hypothesis testing: students t-test, Paired t-test, large sample tests, F-test, Chi-square test, Analysis of variance.
- Unit IV:** Multivariate analysis: Multiple correlation and Regression. Introduction to Principal component analysis, Discriminant analysis and Cluster Analysis. Applications: extracting clusters of functionally related genes from microarray results.
- Unit V:** Dynamic Programming, Gibbs sampling, Markov chains, Hidden Markov Model, Simulated annealing, Genetic algorithm. Applications of these methods in sequence alignments, Protein classification and structure prediction.

Suggested Readings (Latest Editions):

- *Boca Raton, Ayyub B. M. & McCuen, R H. 2003. Probability statistics, and reliability for engineers. CRC Press.*
- *S.C.Gupta & V.K. Kapoor.2004. Fundamentals of Mathematical Statistics. Sultan Chand publication*
- *Ewens, W. J. & Grant, G. R.. 2012. Statistical methods in bioinformatics: an introduction. New York. Springer,.*
- *S.C.Gupta & V.K. Kapoor.2014. Fundamentals of Applied Statistics Sultan Chand publication*
- *Ghosh, Subir.. 2012. Statistical design and analysis of industrial experiments.*
- *David W. Mount, David Mount. 2004. Bioinformatics: Sequence and Genome Analysis.*

Course 12, Code BI 302: Biocomputing Programming

Unit I- Hyper Text Programming Language: Structure of HTML program(<HTML>, <HEAD>, <TITLE>, <BODY>); Titles & Footer; Text Formatting(Paragraph break<P>, line break
); Text Styles(Bold, Italics<I>, Underline<U>); Font Style, Color & Size; Image Tag(); Table (<TABLE>, <TR>, <TH>, <TD>) & Attributes(Border, Width, Align); Frames; Forms (Text Box, Check Box, Command Button, List Box); Anchors.

Unit II- Java Script- Data Types; Literals; Variables; Arrays; Operators (Arithmetic, Comparison, Logical, String, Assignment); Condition Check(if-then-else); looping(for, while); Functions(Built-in, user defined); scope of functions; Dialog Boxes(Alert Dialog Box, Prompt Dialog Box; Confirmed Dialog Box).

Unit III- PERL- Scalar Data; Scalar Variable; List Data & Variable; Operators, <STDIN>; print & printf; Arrays; Assigning values to Array elements, Accessing Array elements; Finding the length of an Array; Hashes; Accessing Hash elements; Deleting Hash elements; Conditionals (if & elseif); while loop(while, until & do); for loop; controlling loop (last, next & redo); Manipulating Lists and Strings (Sorting, Searching, Modifying List Elements such as: push & pop, shift & unshift, splice, reverse, index, substr), Pattern Matching, File Handling.

Unit IV- PHP Basics- PHP Syntax, Variables, Strings, Constants, Operators, Echo / Print, Conditionals (if, if...else, if...elseif); Loops For, Foreach, While, Functions, string functions, user defined functions.

Unit V- PHP Array & MySQL- Get length without using pre-defined functions, Array push and pull, Associative arrays, loop through arrays, Array Sorting without using pre-defined functions, MySQL datatypes, DML and DDL, Aggregate functions, Sub query and join.

Suggested Readings (Latest Editions):

- Dick Oliver. 2014. *HTML 4 in 24 hrs. Techmedia Publication*
- Dick Oliver. 2014. *JavaScript 4 in 24 hrs. Techmedia Publication*
- Ivan Bayross. 2013. *Web Enabled commercial application development using HTML, DHTML, JavaScript and PERL CGI. BPB Publication*
- James Tisdall. 2012. *Beginning perl for Bioinformatics. O-Reilly*
- Cynthia Gibos, Per Jambeck. 2010. *Developing Bioinformatics Computer Skills. O-Reilly*
- Randal L. Schwartz, Tom Phoenix. 2008. *Learning Perl. O-Reilly*
- Techmedia Aldo. 2002. *Perl programming, Wiley Publication.*
- Eric C. Hermamm.2008. *Mastering Perl 5. BPB Publication.*

Course 13, Code BI 303- Structural Biology & Molecular Modeling

Unit I: Macromolecular Structures: Protein - Primary, Secondary, Super secondary, Tertiary and Quaternary structure, Enzymes- Introduction, Michaelis Menton Kinetics, Enzyme regulation; Classification, Structure and function of Carbohydrates and lipids; 3D Viral structures.

Unit II: Methods to study 3D structure, Principles of crystallography, Co-ordinate systems, Fitting and refinement, Validation, Analysis of 3D structures, Methods for 3D structure prediction, Knowledge based & Fold recognition; Principles of protein folding and methods to study protein folding.

Unit III: Basic concept of Bioenergetics; Thermodynamics principle in biology; energy rich bonds, Computational approaches in structural biology; Macromolecular interactions, Protein - Protein, Protein - Nucleic acids, Protein - carbohydrates.

Unit IV: Overview of molecular modelling - Introduction and challenges, Molecular modelling methods, Conformational searching, Potential energy maps, Ramachandran maps, Ab-initio methods, Semi-empirical methods, Empirical methods- Conformational analysis, Introduction and Methods, Molecular fitting, Energy Minimization, Non-derivative and derivative methods.

Unit V: Global optimization (simulated annealing, Tabu search, genetic algorithms), Applications of energy minimization, Molecular Mechanics, Conformations: global vs. local, Force fields: expressions for stretch, bond, torsion, etc., Description of various force fields: MM3, Dreiding, AMBER, CHARMM, Mechanics of Bio-macromolecules, Molecular Dynamics- Newton's equations for many particles, Verlet and related algorithms, Types of dynamics simulations: adiabatic, constant T, annealed, etc., Conformational searching using MD and other methods, Free energy calculations, Dynamics of Bio-macromolecules

Suggested Readings (Latest Editions):

- Philip E. Bourne (Editor), Helge Weissig (Editor). 2003. *Structural Bioinformatics - Methods of biochemical Analysis V. 44.* New Jersey. Wiley-Liss.
- Jan Drenth. 2008. *Principles of protein X-ray Crystallography* Springer-Verlag.
- Branden, Carl & Tooze, John, *Introduction to Protein Structure.* Garland Publishing.
- Friesner, R.A. Ed., Prigogine, L. Ed. & Rice, S.A. New York. John Wiley & sons. 2002. *Computational methods for protein folding : advances in chemical physics vol. 120.* Inc. publication.
- Hans Dieter and Didier Rognan. 2003. *Molecular Modeling: Basic Principles and application.* Wiley VeH GmbH and Co. KGA.
- Heilmeyer, L. & Friedrich, P. Amsterdam . 2001. *Protein modules in cellular signaling* edited. IOS Press.

Course 14, Code BI 304- Genomics, Proteomics & Systems Biology

- Unit I:** Objective and Overview of Genome Comparisons, Genome Alignments, BLAST2, MUMmer, PipMaker, VISTA, Comparison of Gene Order, Comparative Genomics— Viruses, Microbes, Pathogens, Eukaryotes,
- Unit II:** Comparative Genomics Databases- COG, VirGen, CORG, HOBACGEN, Homophila, XREFdb, Gramene, Single Nucleotide Polymorphism, dbSNP and other SNP-related databases; An overview of pharmacogenomics.
- Unit III:** Definition, History and Scope of Proteomics, Experimental Techniques (SDS-PAGE, 2D-PAGE, X-ray crystallography, NMR spectroscopy, isoelectric focusing, mass spectroscopy, (MALDI), differential display, protein chips and antibody microarrays, functional protein microarrays; resolution and identification of proteins), analysis of post translational modifications of proteins; Bioinformatics Approaches, Protein-Protein Interaction Networks, databases and software, DIP (Database of Interacting Proteins).
- Unit IV:** PPI Server, BIND - Biomolecular Interaction Network Database, PIM – Hybrigenics PathCalling Yeast Interaction Database, MINT - a Molecular Interactions Database, GRID - The General Repository for Interaction Datasets, InterPreTS - protein interaction prediction through tertiary structure.
- Unit V: Systems Biology:** Biological Systems--System of Molecular Networks; Ecosystem, Elements of systems modeling, Gene regulatory network and the models; Computational modeling in biology.

Suggested Readings (Latest Editions):

- Hecker, M. & Mullner, S., Berlin. 2003. Proteomics of microorganisms. Springer-Verlag.
- Liebler, D.C. & Yates, J.R. III. 2002. *Introduction to proteomics: tools for the new biologist*. New York. Humana Press.
- Pennington, S. R. & Dunn, M. J. 2002. *Proteomics: from protein sequence to function* New Delhi, Viva Books Private Ltd.
- David Mount. 2004. *Bioinformatics: sequence and genome analysis*. Cold Spring Harbor Press.
- Sankoff, D. & Nadeau, J.H., Netherlands. 2004. *Comparative genomics: empirical and analytical approaches to gene order dynamics, map alignment and the evolution of gene families*. Kluwer Academic Publishers.

Course 15, Code BI 305- Practical based on courses taught in third semester

Course 16, Code BI 401- Project VIVA

400 marks

Course 17, Code BI 402

100 marks

The candidate will appear in a written examination based on short questions including objective type to test his thorough knowledge in the field of Bioinformatics besides his/her project/thesis.

