DEPARTMENT OF BIOTECHNOLOGY

ANNA UNIVERSITY, CHENNAI

Vision:

The Department of Biotechnology is committed to evolve as a world class science and technology centre by integrating quality and ethics in teaching and research

Mission:

The mission of the department is

- Empowering students with an unique multidisciplinary learning experience and fostering the young minds to develop as a researcher, entrepreneur, etc.
- Enhancing academic and industrial collaborative research initiatives for the development of biotechnological, food and therapeutic products.
- Emphasizing and equipping the students towards innovative industrial and research developments.
- Serving the society with utmost commitment, integrity, enthusiasm, and dedication.

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M. TECH. COMPUTATIONAL BIOLOGY
REGULATIONS – 2023
CHOICE BASED CREDIT SYSTEM
CURRICULUM AND SYLLABI
FOR I TO IV SEMESTERS

Sl.No.	PROGRAM EDUCATIONAL OBJECTIVES (PEOs)
1.	Graduates shall have proficiency in scientific and technological skills that enables and motivates them to pursue further education, leading to careers in research and other fields related to computational biology.
2.	Graduates shall have leadership ability, Entrepreneurship skills, and excellence in their field of interest.
3.	Graduates shall have competency in handling computational biology related challenges and recent advancements in research.
4.	Graduates will be able to innovate and provide solutions to the practical problems of any organization and serve as valuable consultants for computational biology.
5.	Graduates shall be able to translate the computational biology knowledge for societal purposes and take up active entrepreneurship.

2. PROGRAMME OUTCOMES (POs):

PO	Graduate Attribute
PO1	Ability to independently carry out research/investigation and development work to solve practical problems.
PO2	Ability to write and present a substantial technical report/document.
PO3	Able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor programme.
PO4	Evaluate and Create algorithms, programs, apply software tools, conduct experiments, collect, analyze and interpret the computational biology data
PO5	Apply various software tools and appropriate modern techniques to scientific and research oriented computational biology problems
PO6	Ability to be competent in industries focusing on Systems Biology, Machine learning, Simulations, NGS, Structural biology and other computational biology techniques along with the handling of complex biological data .

3. MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVE WITH PROGRAMME OUTCOMES

	PROGRAMME OUTCOMES					
PROGRAM EDUCATIONAL OBJECTIVES (PEOs)	PO1	PO2	PO3	PO4	PO5	PO6
I	3	3	3	1	3	3
II	2	1	1	2	3	2
III	2	2	2	3	2	2
IV	2	2	2	2	2	2
V	2	2	2	2	2	2

PROGRAM ARTICULATION MATRIX

Average of CO- PO mapping value obtained in each course are to be filled here to arrive the program articulation matrix

		COURSE NAME	PROGRAMME OUTCOMES					
			PO1	PO2	PO3	PO4	PO5	PO6
YEAR I	SEMESTER I	Applied Probability and Statistics						
		Research Methodology and IPR						
		Concepts in Computational Biology	3	2	3	2	3	2
		Python and its applications in Computational Biology	3	2	2	3	3	2
		Algorithms in Computational Biology	3	2	2	3	3	2
		Elective I						
		Elective II						
		Python and its applications in Computational Biology Lab	3	2	2	3	3	2
	SEMESTER II	Machine Learning and Data Mining	3	2	2	3	3	2
		Biomolecular Simulations	3	2	2	2	3	2
		Big Data Analytics and Next Generation Sequencing	3	2	2	3	3	2
		Structural Biology	3	2	3	2	3	2
		Elective III						
		Elective IV						
		Structural Biology and Biomolecular Simulations Lab	3	2	3	2	3	2
		Machine learning and Data mining Lab	3	2	3	2	3	2
YEAR II	SEMESTER III	Analytical Techniques and Methods Lab	3	3	3	2	2	2
		NGS Data Analytics Lab	3	2	3	2	3	2
		Systems Biology Lab	3	2	3	2	3	2
		Project Phase I	3	3	3	3	3	3
	SEMESTER IV	Project Phase II	3	3	3	3	3	3

ANNA UNIVERSITY, CHENNAI
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CHOICE BASED CREDIT SYSTEM
CURRICULUM AND SYLLABI FOR I SEMESTER

SEMESTER I

SI. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA3158	Applied Probability and Statistics	FC	4	0	0	4	4
2.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
3.	BC3101	Concepts in Computational Biology	PCC	3	0	0	3	3
4.	BC3102	Python and its applications in Computational Biology	PCC	3	0	0	3	3
5.	BC3103	Algorithms in Computational Biology	PCC	2	1	0	3	3
6.		Professional Elective I	PCC	3	0	0	3	3
7.		Professional Elective II	PEC	3	0	0	3	3
PRACTICALS								
8.	BC3111	Python and its applications in Computational Biology Laboratory	PCC	0	0	4	4	2
			TOTAL	**20**	**2**	**4**	**26**	**24**

SEMESTER II

SI.NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1	BC3201	Machine Learning and Data Mining	PCC	3	0	0	3	3
2	BC3202	Biomolecular Simulations	PCC	3	0	0	3	3
3	BC3203	Big Data Analytics and Next Generation Sequencing	PCC	3	0	0	3	3
4	BC3251	Structural Biology	PCC	3	0	0	3	3
5		Professional Elective III	PEC	3	0	0	3	3
6		Professional Elective IV	PEC	3	0	0	3	3
PRACTICALS								
7	BC3211	Structural Biology and Biomolecular Simulations Laboratory	PCC	0	0	4	4	2
8	BC3212	Machine Learning and Data Mining Laboratory	PCC	0	0	4	4	2
			TOTAL	**18**	**0**	**8**	**26**	**22**

SEMESTER III

SI. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1	BC3311	Analytical Techniques and Methods Lab	PCC	0	0	6	6	3
2	BC3312	NGS Data Analytics Lab	PCC	0	0	4	4	2
3	BC3313	Systems Biology Lab	PCC	0	0	4	4	2
4	BC3314	Project Phase – I	EEC	0	0	12	12	6
			TOTAL	**0**	**0**	**26**	**26**	**13**

SEMESTER IV

Sl. No.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	BC3411	Project Phase - II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS: 71

PROFESSIONAL ELECTIVES COURSES
ELECTIVE I

Sl. No.	COURSE CODE	COURSE TITLE	CATE GORY	TOTAL CONTACT PERIODS	L	T	P	C
1.	BC3001	Analytical Techniques and Methods	PEC	3	3	0	0	3
2.	BP3151	Molecular Pharmacology	PEC	3	3	0	0	3
3.	BC3002	Foundations of Biology	PEC	3	3	0	0	3
4.	BC3003	Computational Drug Discovery	PEC	3	3	0	0	3
5.	BC3004	Molecular Evolution and Phylogeny	PEC	3	3	0	0	3
6.	BT3053	Enzyme Engineering and Technology	PEC	3	3	0	0	3
7.	BT3055	Metabolic Engineering	PEC	3	3	0	0	3
8.	BT3057	Nanobiotechnology	PEC	3	3	0	0	3
9.	BC3005	Computational Systems Biology	PEC	3	3	0	0	3
10.	BT3051	Applied Genomics and Proteomics	PEC	3	3	0	0	3
11.	BC3006	Signal Processing in Biotechnology	PEC	3	3	0	0	3
12.	BC3007	High Performance Computing	PEC	3	3	0	0	3
13.	BC3051	Synthetic Biology	PEC	3	3	0	0	3
14.	BC3008	Java in Computational Biology	PEC	3	3	0	0	3
15.	BC3009	Natural Language Processing	PEC	3	3	0	0	3
16.	BC3010	Bioimaging Techniques	PEC	3	3	0	0	3

PROFESSSIONAL CORE (PCC)

Sl.No.	CODE NO	COURSE TITLE	L	T	P	CREDITS
1.	MA3158	Applied Probability and Statistics	4	0	0	4
2.	BC3101	Concepts in Computational Biology	3	0	0	3
3.	BC3102	Python and its applications in Computational Biology	3	0	0	3
4.	BC3103	Algorithms in Computational Biology	2	1	0	3
5.	BC3111	Python and its applications in Computational Biology lab	0	0	4	2
6.	BC3201	Machine Learning and Data Mining	3	0	0	3
7.	BC3202	Biomolecular Simulations	3	0	0	3
8.	BC3203	Big Data Analytics and Next Generation Sequencing	3	0	0	3
9.	BC3251	Structural Biology	3	0	0	3
10.	BC3211	Structural Biology and Biomolecular Simulations Lab	0	0	4	2
11.	BC3212	Machine Learning and Data Mining Lab	0	0	4	2
12.	BC3312	NGS Data Analytics Lab	0	0	4	2
13.	BC3313	Systems Biology Lab	0	0	4	2
14.	BC3311	Analytical Techniques and Methods Lab	0	0	6	3

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

Sl. No.	CODE NO.	COURSE TITLE	PERIODS PER			CREDITS
			L	T	P	
1	RM3151	Research Methodology and IPR	2	1	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

Sl. No.	CODE NO	COURSE NAME	L	T	P	CREDITS
1	BC3314	Project Phase – I	12	0	0	6
2	BC3411	Project Phase – II	24	0	0	12

SUMMARY

	SEM 1	SEM 2	SEM 3	SEM 4	Total	Percentage
PCC	15	16	7		38	53.5
PEC	6	6			12	16.9
RMC	3				3	4.2
EEC			6	12	18	25.4
Total Credit	24	22	13	12	**71**	100

MA3158 APPLIED PROBABILITY AND STATISTICS L T P C
4 0 0 4

OBJECTIVES

The Course aims to

- Teach the basics of random variables with emphasis on the standard discrete and continuous distributions.
- Introduce the concepts of sampling distributions and the test statistics.
- Impart knowledge on the statistical methods and concepts by which real life problems are analyzed.
- Teach analyzing of data using statistical techniques.
- Train the students in design experiments and use these concepts for research.

UNIT I PROBABILITY THEORY 12

Random variables – probability density and distribution functions-moment generating and characteristic functions – Binomial, Poisson, Normal distributions and their applications.

UNIT II SAMPLING THEORY 12

Sampling distributions – Standard error – t, F, Chi square distributions – applications.

UNIT III ESTIMATION THEORY 12

Interval estimation for population mean, standard deviation, difference in means, preparation ratio of standard deviations and variances.

UNIT IV TESTING OF HYPOTHESIS AND ANOVA 12

Hypothesis testing – Small samples – Tests concerning proportion, means, standard deviations – Tests based on chi square – and Redistribution test -Design of experiments

UNIT V ANOVA 12

Design of experiments – One, Two factor Models

TOTAL: 60 PERIODS

OUTCOMES:

The students will be able to

CO1 Analyze the performance in terms of probabilities and distributions achieved by the determined solution.

CO2 Evaluating various test statistics for the samples.

CO3 Create an ability to apply statistical tests in experiments as well as to analyze and interpret data.

CO4 Use the statistical tools for their project and future research.

CO5 Explain the concepts in design of experiments in real life problems

REFERENCES:

1. Gupta and Kapoor, “Fundamentals of Applied Statistics”, Sultan Chand and sons, 4th Edition, New Delhi, 2019.
2. Hooda, “Statistics for Business and Economics”, Macmillan, 3rd Edition, India, 2003.
3. John.E.Freunds, “Mathematical statistics with applications”, Pearson Education, 8th Edition, New Delhi, 2013.
4. Levin and Rubin, “Statistics for Management”, Pearson Education India, 7th Edition,
5. New Delhi, 2013.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2

RM3151 RESEARCH METHODOLOGY AND IPR L T P C
2 1 0 3

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis-concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for wring thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.

5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

BC3101 CONCEPTS IN COMPUTATIONAL BIOLOGY L T P C
3 0 0 3

OBJECTIVES

The course aims to

- Teach biological data resources and bioinformatics tools for analysis and to introduce database management system for biological data storage and query.
- Impart knowledge on the techniques for phylogenetic studies, protein modeling, analysis of proteomic, genomic and transcriptomic data.

UNIT I INTRODUCTION TO BIOLOGICAL SEQUENCES AND DATABASES 9

Molecular sequences, Biological databases: Protein, Nucleotide, Genomic, Transcriptomic and other specialized databases, Sequence Alignment, Local and Global Alignment, Basic Local Alignment tool and its applications, Multiple sequence alignment, Profiles and Motifs

UNITII BIGDATAINBIOLOGY,NEXTGENERATIONSEQUENCINGDATA ANALYSIS 9

Introduction to Big Data in Biology, Genome sequencing: pipeline and data, Next generation sequencing data and analysis, Whole genome sequencing, RNA-Sequencing, Exome sequencing, Singlecell sequencing, Methylome sequencing, MiRNA sequencing and CHiP sequencing.

UNIT III PHYLOGENETICS 9

Introduction to Phylogenetics, Distance and Character based methods for phylogenetic tree construction: UPGMA, Neighbour joining, Maximum Likelihood Trees, Ultrametric and Min ultrametric trees, Parsimonous trees, Additive trees, Bootstrapping.

UNIT IV INFORMATICS TECHNIQUES FOR ANALYSIS OF OMICS DATA 9

Microarrays and Clustering techniques for microarray data analysis, Informatics in Genomics and Proteomics: Genome alignment tools, Peptide Mass Fingerprinting, Mass spectrometry data and protein identification resources.

UNIT V DBMS AND SQL: APPLICATIONS FOR BIOLOGICAL DATA 9

Database management System Models, Relational Database Management System, Structured Query Language: Data Definition, Data Manipulation and Data Control Language commands in Structured Query Language (SQL), Group functions, Creating database tables with biological data, Joining Tables, Building simple and nested queries for analyzing biological data.

Demos for Biological Databases, Sequence alignment: BLAST family of programs, Clustal Omega for multiple sequence alignment, Phylogenetics software, SQL Language commands, SQL functions and queries.

TOTAL: 45 PERIODS

OUTCOMES:

The students will be able to

CO1 Acquire knowledge of basic concepts in computational biology and its tools
CO2 Explain various omics technologies and data
CO3 Extend the evolutionary relationship using phylogenetic analysis.
CO4 Analyze and interpret data corresponding to experimental techniques
CO5 Infer, relate and build database management system for biological data storage and query

REFERENCES:

1) Dan Gusfield. Algorithms on Strings Trees and Sequences, Cambridge University Press,1999
2) David W. Mount Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory Press. 2004
3) Arthur M. Lesk, Introduction to Bioinformatics by Oxford University Press 2014
4) Andrew R. Leach, Molecular Modeling Principles And Applications, Second Edition, Prentice Hall, 2001
5) Baldi, P., Brunak, S. Bioinformatics: The Machine Learning Approach, East West Press, 2001
6) Durbin, R. Eddy S., Krogh A., Mitchison G. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids. Cambridge University Press.2013
7) Cathy H. Wu, Chuming Chen; Bionformatics for Comparative Proteomics: Humana Press 2010
8) Raghu Ramakrishnan, Johannes Gehrke,;Database Management Systems, McGraw-Hill Publications 2014
9) Essential Bioinformatics by Jin Xiong, 3rd edition 2008, Cambridge University Press

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	2	3	2	3	2
CO2	3	2	3	2	3	2
CO3	3	2	3	2	3	2
CO4	3	2	3	2	3	2
CO5	3	2	3	2	3	2
Overall CO	3	2	3	2	3	2

BC3102 PYTHON AND ITS APPLICATIONS IN COMPUTATIONAL BIOLOGY **L T P C**
3 0 0 3

OBJECTIVES

The course aims to

- Teach the concepts of Linux and Python
- Provide knowledge on basics of Python and Object-Oriented Programming
- Impart skills to solve biologically relevant problems, use python powerful tools

UNIT I INTRODUCTION TO LINUX AND PYTHON 9

Introduction to Linux environment, Linux File System, Basic Linux Commands, Shell Programming -grep, awk, Shell Scripting, Introduction to Python programming, text editors, data types, expression, operators

UNIT II COLLECTIONS AND CONTROL STATEMENT 9

Functions and Parameters, Using Modules, Strings, Tuples, Lists, Mappings-Dictionaries, Sets, Control Statements – Conditional, Loops and Iterations.

UNIT III CLASSES AND FILE HANDLING 9

Introduction to Object oriented programming, Defining Classes, Class and Instance attributes, class and methods relationships, inheritance, Files – Creating file objects, File methods, Exception handling

UNIT IV PATTERN MATCHING AND WEB PROGRAMMING 9

Pattern Matching- Fixed length and Variable length matching, re modules, Web Programming- Manipulating URLs, opening webpages, Submitting queries, Web Clients and Servers, Web programs for python, Python DB-API Specification, Creation, Query

UNIT V BIOPYTHON AND NUMPY 9

Introduction- Biopython Components – Alphabet, Seq, MutableSeq, SeqRecord, Align, ClustalW, SeqIO, AlignIO, Blast, PDB, Basics of NumPy, Pandas, Matplotlib, Processing large data sets.

TOTAL: 45 PERIODS

OUTCOMES:

The students will be able to

CO1 Illustrate basic LINUX commands and shell scripting
CO2 Apply Python language features and develop, write and compile simple programs
CO3 Illustrate object-oriented programming concepts and develop and compile efficient programs in Python using files
CO4 Outline the pattern matching and web programs for python
CO5 Apply, develop and compile programs using Python packages to solve biological related problems

REFERENCES:

1. Mitchell L Model, Bioinformatics Programming Using Python- Practical Programming for Biological Data, O'Reilly Media, 2009
2. Sebastian Bassi, Python for Bioinformatics (Chapman & Hall, CRC Mathematical and Computational Biology), CRC Press, 2017, 2nd Edition
3. Jason Kinser, Python for Bioinformatics, DSc First Edition 2009, Jones and Bartlett Publishers
4. Martin Jone, Createspace, Python for Biologists: A complete programming course for beginners Paperback, 2013, Independent Publishing Platform
5. Martin Jone, Createspace , Advanced Python for Biologists 1st Edition, 2014, Independent Publishing Platform

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	2	2	3	3	2
CO2	3	2	2	3	3	2
CO3	3	2	2	3	3	2
CO4	3	2	2	3	3	2
CO5	3	2	2	3	3	2
Overall CO	3	2	2	3	3	2

BC3103 ALGORITHMS IN COMPUTATIONAL BIOLOGY L T P C
2 1 0 3

OBJECTIVES

The course aims to

- Teach Algorithms in Computational biology, running time and complexity
- Explain protein and nucleotide sequence related algorithms

- Impart knowledge to understand and apply DP and sequence based algorithms

UNIT I INTRODUCTION TO ALGORITHM 9

Algorithms-Complexity of algorithms and running time, Polynomial, NP complete problems, Recursion, Linear, Exhaustive search, Branch and Bound, divide and conquer algorithms, sorting

UNIT II EXACT MATCH AND HIDDEN MARKOV MODELS 9

Knuth-Morris- Pratt and Boyer-Moore algorithm for exact match and graph and maximum likelihood algorithm, Hidden Markov Model: Forward and Backward Algorithms, most probable state path: Viterbi algorithm, Parameter Estimation for HMMs: -Baum-Welch Algorithm, EM Algorithm, Applications of profile HMMs for multiple alignment of proteins and for finding genes in the DNA.

UNIT III DNA AND RNA RELATED ALGORITHMS 9

Finding regulatory motifs in DNA, Genome alignment, Suffix Trees, RNA secondary structure prediction: Base pair maximization and the Nussinov folding algorithm, Energy minimization and the Zuker folding algorithm, Design of covariance models, Application of RNA Fold.

UNIT IV DYNAMIC PROGRAMMING AND SEQUENCE BASED ALGORITHMS 9

Dynamic programming Principles and its uses. Local and Global alignment principles, finding longest common subsequences, Statistical and Similarity based methods for gene prediction, Models of evolution.

UNIT V SEQUENCE ASSEMBLY AND PROTEIN STRUCTURE 9

DNA sequencing, shortest super-string problem, sequencing by Hybridization as a Hamiltonian Path Problem, Consecutive one's problem (CIP) for aligning clones based on STSs, Randomized algorithms: Gibbs Sampling, Protein sequencing and identification, spectral graphs and spectral alignment, Protein structure prediction- Secondary structure prediction algorithms, Threading, Comparative Modeling

Tutorials and Demos will be given for tools that implement protein and nucleotide sequence and structure related algorithms

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course students will be able to,

CO1 Design and implement algorithms used in Computational Biology
CO2 Illustrate DNA and RNA related algorithms
CO3 Apply dynamic programming and sequence based algorithms for structure prediction and sequence alignment.
CO4 Formulate simple algorithms for user defined problems
CO5 Apply the tools based on these algorithms to make meaningful interpretations

REFERENCES:

1) Neil C. Jones and Pavel .A Pevzner An introduction to Bioinformatics Algorthims.(computational Molecular Biology) (2004) MIT press. ISBN-10: 0262101068
2) R. Durbin, S.Eddy, A.Krogh, G.Mitchison Biological sequence analysis : Probabilistic models of Proteins and Nucleic acids (2013) Cambridge University Press 0521540798
3) Michael.S.Waterman Introduction to Computational Biology: Maps, Sequences and Genomes. Waterman. reprint(2018) Chapman and Hall/ CRC Press ISBN: 1439861315
4) Dan GusfieldAlgorthims on Strings, Trees and Sequences: Computer Science and Computational Biology (1997) Cambridge University Press. ISBN-10: 0521585198

5) Horowitz, S. Sahini, and Rajasekharan: Fundamentals of Computer Algorithms (2004) , Galgotia Publications. ISBN-10: 81-7515-257-5.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	2	2	3	3	2
CO2	3	2	2	3	3	2
CO3	3	2	2	3	3	2
CO4	3	2	2	3	3	2
CO5	3	2	2	3	3	2
Overall CO	3	2	2	3	3	2

BC3111 PYTHON AND ITS APPLICATIONS IN COMPUTATIONAL BIOLOGY LAB

L T P C
0 0 4 2

OBJECTIVES

The course aims to

- Provide hands on sessions in Linux and its environment
- Impart knowledge for developing and writing programs in Python
- Provide training to implement Python programs using Biopython and Python packages

LIST OF EXPERIMENTS

1) Linux Environment, How to install software, Basic Linux commands, Text editors
2) Exercises on grep and awk, Shell Scripting
   Programs based on
3) Strings, tuples, list, Dictionaries
4) Conditional, Loops and Iterations
5) Functions and Modules
6) Classes and methods
7) Inheritance, Exception handling
8) File handling and CSV Files
9) Pattern Matching and Regular Expressions
10) Biopython
11) Python Packages such as Numpy
12) Python Packages such as Pandas, Matplotlib
13) Web Programming

TOTAL: 60 PERIODS

OUTCOMES:

At the end of the course students will be able to

CO1 Make use of Linux Environment and apply Linux commands
CO2 Design, develop and compile programs in Python for solving Biological problems
CO3 Develop and compile programs using Biopython, Numpy and Python Packages

Course Articulation Matrix

Course Outcome	Program Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	2	2	3	3	2
CO2	3	2	2	3	3	2

CO3	3	2	2	3	3	2
Overall CO	3	2	2	3	3	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respective

SEMESTER II

BC3201 MACHINE LEARNING AND DATA MINING L T P C
3 0 0 3

OBJECTIVES

The course aims to

- Teach Machine learning techniques like Artificial Neural Networks, Genetic Algorithms, Decision Trees and Support Vector Machines
- Instruct various steps involved in knowledge discovery from data; develop multidimensional data models and perform data mining
- Provide training to familiarize with techniques for association mining and correlation analysis

UNIT I MACHINE LEARNING 9

Machine learning Introduction: goals and applications, Supervised and Unsupervised learning - Inductive Classification concepts and Learning aspects. Clustering: k-means, Outlier analysis, Techniques of machine learning – Artificial Neural Networks: Feed Forward Networks, Error correction and Back propagation algorithm, Genetic algorithms, operators, crossover and mutation rates, fitness functions. Decision trees, Computing average disorder of trees, noisy data and pruning

UNIT II MODELS AND METHODS 9

Bayesian Classification, Bayes theorem, Naive Bayes classification, Support Vector Machines, Concept of Hyperplanes and Support Vectors. Reinforcement Learning, Ensemble Learning - Bagging and Boosting. Graphical models

UNIT III DATA MINING 9

Data Mining Introduction, Relational databases and Data warehouses, Data Mining functionalities, Concept/Class Description, Data mining Task primitives, Data Preprocessing: Descriptive Data Summarization: Statistical measures, measuring central tendency, dispersion of data, box plots. Data cleaning, integration, transformation and reduction

UNIT IV DMQL AND MULTIDIMENSIONAL DATA MODELS 9

Use of Data mining Query Language DMQL, Multidimensional Data Models: Tables, Stars, Snowflakes and Fact Constellations. Data cubes, Curse of dimensionality, Data Warehouse and Online Analytical Processing Technologies: OLAP, Data visualization

UNIT V ASSOCIATION MINING AND CORRELATION ANALYSIS 9

Frequent item sets, Interestingness measures: Support, Confidence. Frequent Item set Mining methods- Apriori algorithm, Frequent Pattern tree algorithm, Association mining-correlation analysis

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course students will be able to

CO1 Apply and experiment with machine learning techniques for training and classification of biological data and prediction
CO2 Choose and Create potential solutions for real time applications using ML techniques
CO3 Examine data, Perform data mining and select suitable methods for data analysis
CO4 Create multidimensional data models and formulate queries
CO5 Identify frequent item set using correlation analysis and do prediction

REFERENCES:

1. Jiawei Han, Micheline Kambler "Data Mining: Concepts and Techniques", Third Edition (2012) Morgan Kaufman Publishers.ISBN-13: 978-0123814791
2. Ian H.Witten Eibe Frank Data Mining : "Practical machine learning tools and Techniques with java implementation" (2016) ISBN 1-55864-552-5
3. Tom Mitchell "Machine Learning" McGraw-Hill (2012).
4. Murphy, K. P. (2012). Machine learning: a probabilistic perspective. Cambridge, MA, MIT Press
5. Bengio, Y.; Goodfellow, I.; Courville, A., Deep Learning; MIT Press: Massachusetts, 2017

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	2	2	3	3	2
CO2	3	2	2	3	3	2
CO3	3	2	2	3	3	2
CO4	3	2	2	3	3	2
CO5	3	2	2	3	3	2
Overall CO	3	2	2	3	3	2

BC3202 BIOMOLECULAR SIMULATIONS

L	**T**	**P**	**C**
3	**0**	**0**	**3**

OBJECTIVES

The course aims to

- Teach the principles and practices on Molecular Modeling, in particular simulation of biological macromolecules
- Provide skills needed to perform MD Simulation
- Impart knowledge to interpret and analyse MD Simulation of biomolecules

UNIT I INTRODUCTION **9**

Introduction-Molecular Modeling, Statistical Mechanics, Thermodynamics Basics, Introduction to Quantum Mechanics- Black body radiation, Harmonic Wave Function, Schrodinger equation, Overview of Biomolecular Structure

UNIT II MOLECULAR MECHANICS **9**

Force Fields, General features of Molecular Mechanics Force Fields, Types of Force Fields, Bond Stretching, Angel bending, Torsional terms, Non bonded interactions- Electrostatic and , van der Waals interactions, Types of Potentials, Lennard-Jones Potential

UNIT III MOLECULAR DYNAMICS SIMULATION METHODS **9**

Molecular Dynamics Simulation-Introduction, Molecular units and timescales, Energies, Equations of motion, trajectories, phase space, Temperature, velocity distributions, elements

of an MD simulation, Setting up and Running a Molecular Dynamics Simulation, Visualization and Analysis

UNIT IV MOLECULAR DYNAMICS SIMULATION PARAMETERS 9

Potential Energy Surface, Energy minimization, constraints, Cutoffs and long-range electrostatics, Integration algorithms, Entropy, Thermodynamic ensembles, Properties of water, Water models, Hydrogen bonds, Periodic boundary conditions, Temperature and pressure control and challenges in molecular dynamics simulations

UNIT V MOLECULAR MODELLING AND HIGH PERFORMANCE COMPUTING 9

Drug discovery process, Methods and Tools in Computer-aided molecular Design, Structure based drug design, Ligand based Drug Design, QSAR, Virtual screening strategies for lead identification, Introduction to Parallel Processing Concepts- task, thread; Models - SIMD, MIMD, Dataflow Models , Architectures- multi-core, multi-threaded, Parallel Computing applications in Bioinformatics and in MD Simulation, Machine learning in MD Simulation

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course students will be able to

CO1 Illustrate Molecular Dynamics Simulation principles

CO2 Build and apply MD Simulations techniques on biomolecules

CO3 Define and construct parameters used for molecular dynamics simulation

CO4 Formulate and compile MD simulation to address biological questions related to biomolecules

CO5 Apply and adapt methods and tools in Computer-aided molecular Design for drug discovery

REFERENCES:

1. Andrew R. Leach Molecular Modeling Principles and Applications (2nd Ed.). Prentice Hall ,2001
2. Ramachandran, Deepa and Namboori Computational Chemistry and Molecular Modeling-Principles and Applications, Springer, 2008
3. Alan Hinchliffe, MolecularModelling for Beginners, (2nd Edition) John Wiley & Sons Ltd. 2008
4. Tamar Schlick Molecular Modeling and Simulation – An interdisciplinary Guide Springer, 2010
5. Patrick Bultinck, Marcel Dekker Computational medicinal chemistry for drug discovery CRC Press 2004
6. J.M. Haile, "MolecularDyanmics Simulation Elementary Methods ", John Wiley and Sons,1997.
7. Georg Hager, Gerhard Wellein, Introduction to High Performance Computing, CRC Press, 2011

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	2	2	2	3	2
CO2	3	2	2	2	3	2
CO3	3	2	2	2	3	2
CO4	3	2	2	2	3	2
CO5	3	2	2	2	3	2
Overall CO	3	2	2	2	3	2

BC3203 BIG DATA ANALYTICS AND NEXT GENERATION SEQUENCING **L T P C**
3 0 0 3

OBJECTIVES

The course aims to

- Teach the emerging area of next generation sequencing
- Deliver knowledge of various NGS platforms, big data analysis
- Train programming skills in R Language and applications of R package

UNIT I INTRODUCTION TO BIG DATA **9**

Evolution of Big data-- Big data characteristics - Volume, Veracity, Velocity, Variety--Big data sources -parallel processing systems – Cloud computing – grid computing -map reduce – enterprise analytic sand box- Analytic methods – analytic tools – Cognos – Microstrategy – Pentaho.

UNIT II BIG DATA FRAMEWORK **9**

IBM for Big Data – Map Reduce Framework - Hadoop – Hive - – Sharding – NoSQL Databases- S3 - Hadoop Distributed file systems – Hbase – Impala – Analyzing big data with twitter – Big data for E-Commerce – Big data for blogs

UNIT III NGS PLATFORMS AND ASSEMBLY **9**

NGS - NGS Platforms – Assembly – Reference Genome Assembly and Denovo assembly Biological application -Whole genome sequencing --Exome Sequencing-- methylome sequencing

UNIT IV R PACKAGE IN NGS ANALYSIS **9**

R – Basic Syntax , Data types, Variables, Operators, Loops, Decision making, Function,Strings ,Vectors, Lists, Matrices, Array,Mean-median-mode, Normal Distribution, Binomial Distribution.

UNIT V NGS TOOLS AND APPLICATIONS **9**

Explore the GALAXY server, Real Time Processing of Proteomics Data Using Hadoop

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course students will be able to

CO1 Illustrate and analyse NGS data
CO2 Explain and apply Bigdata tools and its applications
CO3 Apply and adapt various platform for performing NGS data analysis
CO4 Develop and compile R programs and R package for analysis
CO5 Build and compile programs developed using NGS tools for addressing Biological questions

REFERENCES

1. Stuart M. BrownNext-generation DNA sequencing Informatics Cold Spring Harbor Laboratory 2013 ISBN 1936113872
2. EijaKorpelainen, JarnoTuimala, PanuSomervuo, Mikael Huss, Garry Wong. RNA-seq Data Analysis: A Practical Approach. Chapman & Hall/CRC, 2014.ISBN-13: 978-1466595002
3. Hillman Chris, Ahmad Yasmeen, Whitehorn Mark, and CobleyAndyNear real-time processing of proteomics data using HADOOP Mary annLiebert, Inc- Big Data. 2014 2 (1): BD44- BD49.
4. SoweSulayman K. and Zettsu Koji Curating Big Data Made Simple: Perspectives from Scientific Communities Big Data. 2014 2 (1): 23-33

5. Melanie Swan The quantified self: Fundamental Disruption in Big Data Science and Biological Discovery Mary annLiebert, Inc. Big data ,2013, 1(2): BD85-99
6. Wong Lee-Jun C. (ed.) Next generation sequencing: Translation to Clinical Diagnostics Springer 2013ISBN 978-1-4614-7001-4.
7. Paul Zikopoulos, Chris Eaton, Paul Zikopoulos, "Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data", McGraw Hill, 2017.
8. Paul Zikoopulus, , Krishnan Parasuraman, Thomas Deutsch , James Giles, Dirkde RoosDavid Corrigan, "Harness the Power of Big data – The big data platform", McGraw Hill, 2012.
9. Jiawei Han, Micheline Kamber "Data Mining Concepts and Techniques", Second Edition, Elsevier, Reprinted 2011.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	2	2	3	3	2
CO2	3	2	2	3	3	2
CO3	3	2	2	3	3	2
CO4	3	2	2	3	3	2
CO5	3	2	2	3	3	2
Overall CO	3	2	2	3	3	2

BC3251 STRUCTURAL BIOLOGY

L	**T**	**P**	**C**
3	**0**	**0**	**3**

OBJECTIVES

The course aims to

- Impart knowledge on structural aspects of protein and DNA
- Teach the concepts of computational and biophysical techniques used for structure determination
- Instruct analysis and interpretation of X-Ray Crystallography, NMR and cryoelectron microscopy data

UNIT I STRUCTURE OF MACROMOLECULES – PROTEINS 9

Scope of structural biology – implications, Fundamentals of protein structure, Structural Hierarchy, Motifs and domains: domain structures, Study of prototype protein under each category - alpha, beta, alpha-beta structures, lysozyme, immunoglobulins, thioredoxin, transferases, membrane proteins, structure of viruses

UNIT II STRUCTURE OF MACROMOLECULES – DNA 9

Principles of nucleic acid structure - Watson and Crick's base-pairings and their implications. Non Watson and Crick pairing schemes - base stacking interactions - DNA polymorphism - structure of A-DNA, B-DNA and Z-DNA. Unusual DNA structures - hairpins, bulges, cruciform, triplexes, tetraplexes

UNIT III STRUCTURAL BIOINFORMATICS 9

Methods to secondary structural elements and prediction, Prediction of protein tertiary Structure, Threading, ab initio and Homology Modeling methods, Molecular Docking principles and applications, Protein-protein and Protein-DNA Interactions, Structural genomics

UNIT IV X-RAY CRYSTALLOGRAPHY 9

Elementary crystallography, symmetry in crystals, lattices and unit cells, crystal systems, Bravais lattices, classes of symmetry operations, point groups and space groups, X-ray diffraction - Bragg's law - reciprocal lattice, X-ray scattering: Concept of resolution, Atomic scattering factor - structure factor equation - electron density and Fourier Transform, solving phases, model building and refinement

UNIT V NMR AND CRYO-ELECTRON MICROSCOPY 9

NMR and its application in Structural Biology, Introduction to the principles of cryo-electron microscopy, – Image formation, aberrations, and beam-induced motion, – Classification, refinement, and reconstruction of 3D models, Sample preparation and practical considerations in cryo-EM, Applications of Cryo-EM in biology

TOTAL: 45 PERIODS

OUTCOMES:

The students will be able to

CO1 Define, classify, explain, and interpret and the structural and functional aspects of protein and DNA

CO2 Illustrate, experiment, examine, explain and develop tools for biophysical techniques

CO3 Experiment, interpret, explain and discuss principles of macromolecular structure determination

CO4 Define, demonstrate, develop, discover and determine Molecular Docking principles and applications

CO5 Explain, compare and develop the applications of Cryo-EM and NMR in structural biology

REFERENCES

1. K.P.Murphy. Protein structure, stability and folding (2001) Humana press. ISBN 0-89603682-0
2. Arthur M.Lesk Introduction to protein architecture (2010) Oxford University Press. ISBN 0198504748
3. A.McPherson, Introduction to Macromolecular Crystallography. 2nd edition (2016)., John Wiley Co.
4. Carl Branden and John Tooze and Carl Brandon Introduction to Protein Structure, (1999) John Garland, Publication Inc. ISBN 0815323050
5. George H. Stout, Lyle H. Jensen, X-Ray Structure Determination: A Practical Guide, 2nd Edition.ISBN 0471607118. 2007
6. Ed Donald J Abraham Wiley-Interscience. Burger's Medicinal Chemistry and Drug discovery. Volume 2, Drug Discovery and development.6th Edition (2003). ISBN 0471370282
7. Crystallography Made Crystal Clear: A Guide for Users of Macromolecular Models, 2006 by Gale Rhodes, Academic Press; 3 edition, ISBN-10: 0125870736, ISBN-13: 978-0125870733
8. The Nuclear Overhauser Effect in Structural and Conformational Analysis, by David Neuhaus Wiley-VCH; 2 edition, 2000, ISBN-10: 0471246751, ISBN-13: 978-0471246756
9. Single-particle Cryo-electron Microscopy: The Path Toward Atomic Resolution/ Selected Papers Of Joachim Frank With Commentaries, World Scientific Publishing Co Pte Ltd, 2018

Course Articulation Matrix:

Course Outcome	Programme Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	2	3	2	3	2
CO2	3	2	3	2	3	2

CO3	3	2	3	2	3	2
CO4	3	2	3	2	3	2
CO5	3	2	3	2	3	2
Overall CO	3	2	3	2	3	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BC3211 STRUCTURAL BIOLOGY AND BIOMOLECULAR SIMULATIONS LAB L T P C
0 0 4 2

OBJECTIVES

The course aims to

- Teach and demonstrate Visualisation and Modelling tools
- Train techniques of X-Ray Crystallography
- Instruct interpretation of MD Simulation, and Docking results

LIST OF EXPERIMENTS

1) Biomolecules Visualisation Software
2) Modeling of Protein Structures: Homology modelling
3) Protein-ligand docking
4) Protein-Protein and Protein-DNA docking
5) Molecular Dynamics Simulation of Protein
6) MD Simulation of Protein-Ligand Complex
7) Crystallization of lysozyme -1
8) Crystallization of lysozyme -2
9) Crystallization of Thaumatin-1
10) Crystallization of Thaumatin-2
11) X-ray data processing, model building and refinement
12) Cryo-EM structures and their analysis

TOTAL: 60 PERIODS

OUTCOMES:

At the end of the course students will be able to,

CO1 Demonstrate and interpret MD simulation and docking experiments on biomolecules
CO2 Choose, apply and develop appropriate tools for a given biological problem
CO3 Define, construct and elaborate biological questions related to biomolecules

Course Articulation Matrix

Course Outcome	Program Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	2	3	2	3	2
CO2	3	2	3	2	3	2
CO3	3	2	3	2	3	2
Overall CO	3	2	3	2	3	2

BC3212 MACHINE LEARNING AND DATA MINING LAB L T P C
0 0 4 2

OBJECTIVES

The course aims to

- Teach to perform data mining tasks using data mining tool

- Demonstrate the working of machine learning algorithms
- Give hands on session in make use of Data sets in implementing the machine learning algorithms

LIST OF EXPERIMENTS

1) Introduction to Data Mining Tool, Training data set
2) Implementing Training and Test data Samples using Data mining tool
3) Pre-Processes Techniques on Data Set
4) Generate Association Rules using the Apriori Algorithm
5) Generating association rules using FP Growth algorithm
6) Backpropagation algorithm
7) Decision tree-based algorithm
8) Naïve Bayesian Classifier model
9) KNN algorithm
10) Linear Regression in Machine Learning
11) Case Study using Decision tree
12) Case Study using above algorithms and data sets

TOTAL: 60 PERIODS

OUTCOMES:

At the end of the course students will be able to

CO1 Demonstrate Machine Learning Algorithms and interpret the results

CO2 Build classification and clustering algorithms on data sets and interpret the predictions

CO3 Build and apply data mining techniques for various data sets and interpret the results

Course Articulation Matrix

Course Outcome	Program Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	2	3	2	3	2
CO2	3	2	3	2	3	2
CO3	3	2	3	2	3	2
Overall CO	3	2	3	2	3	2

SEMESTER III

BC3311 ANALYTICAL TECHNIQUES AND METHODS LAB **L T P C**
0 0 6 3

OBJECTIVES

The course aims to

- Teach and Demonstrate relevant preparative techniques required in research and industry
- Teach experiment analytical techniques required in research or Industry
- Train and evaluate spectroscopy, Separation methods and Electrochemistry

LIST OF EXPERIMENTS

1) Preparation of Acetate, Tris and Phosphate Buffer systems and validation of Henderson-Hasselbach equation.
2) Reactions of amino acids – Ninhydrin, Pthaldehyde, Dansyl chloride – measurement using colorimetric and fluorimetric methods.
3) Differential estimations of carbohydrates – reducing vs non-reducing, polymeric vs

oligomeric, hexose vs pentose
4) Estimation of protein concentration using Lowrys' method, Dye-binding method
5) DNA determination by UV-Vis Spectrophotometer – hyperchromic effect Separation of lipids by TLC.
6) Enzyme Kinetics: Direct and indirect assays – determination of Km, Vmax and Kcat, Kcat/ Km
7) Restriction enzyme – Enrichment and unit calculation
8) Ion-exchange Chromatagraphy – Purification of IgG and Albumin
9) Gel filtration – Size based separation of proteins
10) Affinity chromatography – IMAC purification of His-tagged recombinant protein
11) Assessing purity by SDS-PAGE Gel Electrophoresis
12) Chemical modification of proteins – PITC modification of IgG and Protein immobilization

TOTAL: 90 PERIODS

OUTCOMES:

The students will be able to

CO1 Explore and understand techniques required in the quantitation of biomolecules and enzymology

CO2 Analyze and develop skills in downstream processing techniques

CO3 Interpret the chemical modification of proteins

REFERENCES:

1. 1.Alfred Pingoud, Claus Urbanke, Jim Hoggett, Albert Jeltsch, Biochemical Methods: A Concise Guide for Students and Researchers, 2002 John Wiley & Sons Publishers, Inc,
2. Irwin H. Segel ;Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry, 2nd Edition,, 1976 John Wiley & Sons Publishers, Inc,
3. Wilson, K. and Walker, J. Principles and Techniques of Practical Biochemistry-Cambridge Press. 2000

Course Articulation Matrix

Course Outcome	Program Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	3	3	2	2	2
CO2	3	3	3	2	2	2
CO3	3	3	3	2	2	2
Overall CO	3	3	3	2	2	2

BC3312 NGS DATA ANALYTICS LAB

L	**T**	**P**	**C**
0	**0**	**4**	**2**

OBJECTIVES

The course aims to

- Teach and Provide hands on experience in make use of Data sets and OMICS Databases
- Teach Programming with R / Python
- Demonstrate and train NGS techniques

LIST OF EXPERIMENTS

1. OMICS Databases - ENA, SRA
2. Galaxy introduction - Input of Sequence, Analysis of Sequence, Reference Mapping
3. Analysing and improving the quality of Data

4. Counting Exons with highest number of SNPs
5. RNA sequence analysis
6. Gene Expression analysis
7. SNP and CpG island analysis
8. Metabolic Map Development from Whole genome Analysis of E. coli
9. Basics of R Programming exercises
10. Analyse a Data and find the Mean, Median, and Mode, and perform ANNOVA
11. Visualization of Data using R
12. Analyse the Gene expression Omnibus and create the Expression analysis with R-programing.

TOTAL: 60 PERIODS

OUTCOMES:

At the end of the course students will be able to

CO1 Apply and Make use of NGS Tools and Databases

CO2 Design, develop and compile programs using NGS Tools for solving Biological problems

CO3 Develop and compile programs in R to solve biological related queries

Course Articulation Matrix

Course Outcome	Program Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	2	3	2	3	2
CO2	3	2	3	2	3	2
CO3	3	2	3	2	3	2
Overall CO	3	2	3	2	3	2

BC3313 SYSTEMS BIOLOGY LAB

L	**T**	**P**	**C**
0	**0**	**4**	**2**

OBJECTIVES

The course aims to

- Teach and demonstrate Systems Biology data resources and tools
- Illustrate and teach creation of simple kinetic models
- Teach metabolic models for flux balance analysis

LIST OF EXPERIMENTS

1. Tools and Databases for systems biology
2. Network anaysis using Cytoscape
3. RNA-seq data network analysis using cytoscape
4. Differentially Expressed Genes Network Analysis using cytoscape
5. Discrete dynamic modelling
6. Basics of MATLAB and OCTAVE
7. Mathematical problems using MATLAB
8. SBML toolbox, Cobra toolbox in MATLAB
9. Genome Scale Metabolic Model; Model reconstruction and running FBA in ModelSEED
10. Running a FBA by altering the parameters using FAME and MATLAB
11. Kinetic Model building using COPASI
12. Simulating a model using COPASI and changing the parameters of the model

13. Metabolic control analysis
14. Parameter estimation using COPASI

TOTAL: 60 PERIODS

OUTCOMES:

At the end of the course students will be able to

CO1 Identify, analyze and evaluate data and parameters necessary for developing models
CO2 Extend, model and develop kinetic and metabolic models for flux balance analysis
CO3 Demonstrate, analyze and interpret the data that would help in interdisciplinary studies

Course Articulation Matrix

Course Outcome	Program Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	2	3	2	3	2
CO2	3	2	3	2	3	2
CO3	3	2	3	2	3	2
Overall CO	3	2	3	2	3	2

BC3314 **PROJECT PHASE I** **L T P C**
0 0 12 6

OBJECTIVES:

The course aims to enable the students to identify the research problem relevant to their field of interest, search databases to define the problem, design experiment, conduct preliminary study and report the findings.

COURSE CONTENT

Individual students will identify a research problem relevant to his/her field of study with the approval of project review committee. The student will collect, and analyze the literature and design the experiment. The student will carry out preliminary study, collect data, interpret the result, prepare the project report and present before the committee.

TOTAL: 180 PERIODS

OUTCOMES:

At the end of the course the students will be able to

CO1: Identify the research problem
CO2: Collect, analyze the relevant literature and finalize the research problem
CO3: Design the experiment, conduct preliminary experiment, analyse the data and conclude
CO4: Prepare project report and present

Course Articulation Matrix

Course Outcome	Program Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
Overall CO	3	3	3	3	3	3

SEMESTER IV

BC3411 **PROJECT PHASE II** **L T P C**
0 0 24 12

I. Continuation of Project Work I (at Institution/Industry)

OBJECTIVES:
The course aims to enable the students to conduct experiment as per the plan submitted in Project work I to find solution for the research problem identified.

COURSE CONTENT
The student shall continue Project work I as per the formulated methodology and findings of preliminary study. The student shall conduct experiment, collect data, interpret the result and provide solution for the identified research problem. The student shall prepare the project report and present before the committee.

TOTAL: 360 PERIODS

OUTCOMES:
At the end of the course the students will be able to
CO1: Conduct the experiment and collect data
CO2: Analyze the data, interpret the results and conclude
CO3: Prepare project report and present

Course articulation Matrix

Course Outcome	Program Outcome (PO)					
	1	2	3	4	5	6
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
Overall CO	3	3	3	3	3	3

II. Not the continuation of Project Work I (at Industry)

OBJECTIVES:
The course aims to enable the students to identify the research problem at the company, search databases to define the problem, design experiment, and conduct experiment to find the solution.

COURSE CONTENT
Individual students will identify a research problem relevant to his/her field of study at the company and get approval of project review committee. The student will collect, and analyze the literature and design the experiment. The student will carry out the experiment, collect data, interpret the result, prepare the project report and present before the committee.

TOTAL: 360 PERIODS

OUTCOMES:
At the end of the course the students will be able to
CO1: Identify the research problem
CO2: Collect, analyze the relevant literature and finalize the research problem
CO3: Design and conduct the experiment, analyse the data and conclude
CO4: Prepare project report and present

Course Articulation Matrix

Course Outcome	Program Outcome (PO)					
	1	2	3	4	5	6
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3

CO4	3	3	3	3	3	3
Overall CO	3	3	3	3	3	3

ELECTIVES

BC3001 ANALYTICAL TECHNIQUES AND METHODS

L	T	P	C
3	0	0	3

OBJECTIVES

The course aims to

- Teach basic concepts and analytical techniques
- Teach methods in microscopy and provide concepts in spectroscopy
- Impart knowledge in basics of separation methods and Biochemistry

UNIT I MICROSCOPY **9**

Identification of microorganisms using light and compound microscopy, Phase Contrast Microscopy, Fluorescence Microscopy, Confocal Microscopy, Microscopy with Light and Electrons, Electrons and Their Interactions with the Specimen, Electron Diffraction, The Transmission Electron Microscope, The Scanning Electron Microscope, Atomic Force Microscopy.

UNIT II SPECTROSCOPY **9**

Introduction to Spectroscopic Methods, Ultraviolet-Visible Molecular Absorption Spectrometry, Fluorescence Spectrometry, Infrared Spectrometry, Raman Spectroscopy, Nuclear Magnetic Resonance Spectroscopy, Molecular Mass Spectroscopy.

UNIT III SEPARATION METHODS **9**

Introduction to Chromatographic Separation, Column Chromatography, Thin Layer Chromatography, Gas Chromatography, Liquid Chromatography, High Performance Liquid Chromatography.

UNIT IV ELECTROANALYTICAL TECHNIQUES **9**

Fundamentals of Electrochemistry, Electrodes, Potentiometry, Electrolysis, Electrogravimetric Analysis, Coulometry, Voltammetry- Polarography, Faradaic and Charging Currents, Square Wave Voltammetry, Microelectrodes

UNIT V BIOCHEMICAL TECHNIQUES **9**

Estimation of Carbohydrates, Estimation of Lipids, Estimation of Proteins and Nucleic Acids.

TOTAL: 45 PERIODS

OUTCOMES:

The students will be able to

CO1 Explain the principles and working of various analytical techniques
CO2 Examine the application of analytical techniques
CO3 Design their experiments
CO4 Analyse the data and results obtained
CO5 Learn the basics of separation methods

REFERENCES:

1. Skoog, Holler, Crouch, Principles of Instrumental Analysis *2017*
2. Robert D. Braun, Introduction to Instrumental Analysis Pharma Book Syndicate. 2006

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	1	2	3	4	5	6
CO1	3	3	3	2	3	1
CO2	3	3	3	3	3	3
CO3	3	3	2	3	3	3
CO4	3	2	3	2	3	3
CO5	3	3	3	3	3	3
Overall CO	3	3	3	2	3	2

BP3151 MOLECULAR PHARMACOLOGY L T P C
3 0 0 3

OBJECTIVE

The course aims to

- Teach the mechanism of action of drugs at molecular level and different molecular targets.
- Educate advanced knowledge about pharmacology
- Teach concepts of drugs and toxicology

UNIT I OVERVIEW OF DRUGS ACTING ON VARIOUS SYSTEMS 9

Central nervous system, Autonomic nervous system, Autacoids, Analgesic, Antipyretic, and Anti-inflammatory Agents, Renal and cardiovascular system, Anti Infective agents, Hormones, Hematopoietic agents, Immunopharmacology.

UNIT II RECEPTORS AND THEIR MODE OF ACTION 9

Angiotensin receptors Excitatory amino acid receptors Kinin receptor, Adrenoceptors, Low molecular weight heparins and GP IIB/IIIa receptor antagonists, Cholinergic receptors, Dopamine receptors, Serotonin receptors, Hormone receptors, GABA and Benzodiazepine receptors, Opioid receptors, Glutamate receptors.

UNIT III BIOACTIVE MOLECULES 9

Endogenous bioactive molecules: Cytokines, neuropeptides and their modulators, neurosteroids, nitric oxide, phosphodiesterase enzyme and protein kinase C, arachidonic acid metabolites, COX- 2 regulators and their role in inflammation, endothelium derived vascular substances (NO, endothelins) and their modulators. Pharmacology of atrial peptides, reactive oxygen intermediates, antioxidants and their therapeutic implications.

UNIT IV MOLECULAR MECHANISM OF DRUG ACTION 9

Receptor occupancy and cellular signaling systems such as G-proteins, cyclic nucleotides, calcium and calcium binding proteins, phosphatidylinositol. Ion channels and their modulators.: Basic concepts in molecular pharmacology: agonists, antagonists and inverse agonists; potency, intrinsic activity and efficacy; mechanisms of signaling and its inhibition; measurement of binding and response. Preparation, G protein-coupled receptors, G proteins and effectors, Mechanism of G protein-mediated signaling, hedgehog and notch, Intrinsic tyrosine kinases, Biophysical characterization of ion flux, Voltage-gated ion channels.

UNIT V TOXICOLOGY 9

Principles of toxicology, Physicochemical, Biochemical and genetic basis of toxicity, principles of toxicokinetics, mutagenesis and carcinogenesis, Acute, sub-acute and chronic toxicity studies according to guidelines. Guidelines and regulatory agencies – CPCSEA, OECD, FDA, ICH, FHSA, EPA, EEC, WHO etc.,

TOTAL: 45 HOURS

OUTCOME

At the end of the course the student will be able to

CO1 Explain drugs acting on various systems
CO2 Define and classify receptors
CO3 List and describe bioactive molecules
CO4 Classify receptors and explain drug receptor interactions
CO5 Design and carry out toxicity studies as per guidelines

REFERENCES

1) Satoskar, "Pharmacology and Therapeutics", Elsevier India, 25th edition, 2017.
2) Tripathi, K.D."Medical Pharmacology",Jaypee Brothers Medical Publishers,8th ed.2018.
3) Karen Whalen, "Lippincott Illustrated Reviews: Pharmacology", Lippincott Williams and Wilkins, 6th Edition, 2014.
4) Rang, M.P, Dale M.M, Reter J.M, "Pharmacology", Churchill Livingstone, 8th revised edition, 2015.
5) Laurence Brunton , Bjorn Knollmann , RandaHilal-Dandan, "Goodman and Gilman's: The Pharmacological basis of therapeutics", McGraw-Hill Education / Medical, 13th edition, 2017.
6) Kulkarni S.K., "Handbook of Experimental Pharmacology", 2016
7) Katzung, B.G., "Basic and Clinical Pharmacology", 13th Edition, McGraw Hill 2015.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	2	1	2	2	3	2
CO2	2	1	1	1	-	2
CO3	2	1	1	1	-	2
CO4	2	1	2	2	3	2
CO5	2	1	2	2	3	2
Overall CO	2	1	1.6	1.6	3	2

BC3002 FOUNDATIONS OF BIOLOGY

L	**T**	**P**	**C**
3	**0**	**0**	**3**

OBJECTIVES

The course aims to

- Teach general concepts in Biology
- Prepare the students for more advanced topics in Biology
- Instruct general concepts in genetic engineering

UNIT I CELL BIOLOGY **9**

Structural organization of prokaryotic and eukaryotic cells, Cellular Components – Cytoskeleton – components of Cytoskeleton, Microtubules, Intermediate filaments – Microfilaments, Endoplasmic reticulum, Golgi complex, Types of vesicles - transport and their functions, Lysosomes. Cell cycle, Biomembranes- Structural organization- Models of a plasma membrane, Membrane permeability- Transport across cell membranes

UNIT II INTRODUCTION TO BIOMOLECULES **9**

Amino Acids, Nucleic Acids, Covalent Structures of Proteins and Nucleic Acids ,Tertiary and Quaternary structures of Proteins, Introduction to Carbohydrates and Lipids.

UNIT III ENZYMES AND METABOLISM **9**

Introduction to Enzymes.Rates of Enzymatic Reactions.Enzymatic Catalysis. Introduction to Metabolism, Glycolysis, Glycogen Metabolism, Citric Acid Cycle, Electron Transport and Oxidative Phosphorylation, Introduction to Lipid Metabolism, Amino Acid Metabolism and Nucleotide Metabolism.

UNIT IV GENES AND REGULATION 9

Genes and Chromosomes, DNA replication and recombination, transcription, translation, prokaryotic and eukaryotic gene regulation.

UNIT V : GENETIC ENGINEERING 9

Restriction enzymes, DNA modifying enzymes, Gene manipulation, Host cells and vectors, PCR, Applications of Genetic engineering in biotechnology: production of enzymes, therapeutic proteins.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course the student will be able to

CO1 Illustrate the organization of the cell, bio-molecules
CO2 explain basic principles of biochemistry
CO3 Illustrate the basics of molecular biology
CO4 explain fundamentals of genetic engineering
CO5 explain application of genetic engineering in biotechnology.

REFERENCES:

1. Voet and Voet, Biochemistry 3Ed., Wiley 2004 ISBN: 978-0-471-19350-0
2. Nelson and Cox, Lehninger Principles of Biochemistry 5e W H Freeman & Co 2009 ISBN: 978-0-716-77108-1
3. Jocelyn, E. Krebs., Stephen, T. Kilpatrick., Elliott S Goldstein, Lewin's Gene X, 10th Edition 2011, Jones and Bartlett Publishers.
4. An introduction to Genetic engineering, Desmond S.T. Nicholl., Cambridge University Press, 3rd Edition., 2008.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	1	2	3	4	5	6
CO1	3	2	3	2	3	2
CO2	3	2	3	2	3	2
CO3	3	2	3	2	3	2
CO4	3	2	3	2	3	2
CO5	3	2	3	2	3	2
Overall CO	3	2	3	2	3	2

BC3003 COMPUTATIONAL DRUG DISCOVERY

L	T	P	C
3	0	0	3

OBJECTIVES

The course aims to

- Teach the overview of drug discovery pipeline
- Instruct the concepts of high throughput screening.
- Teach the process of testing and Regulatory affairs

UNIT I DRUGS AND THEIR INTERACTIONS 9

Introduction to Drugs: Drug nomenclature, Routes of drug administration and dosage forms, Principles of Pharmacokinetics and Pharmacodynamics: ADME, Bioavailability of drugs - Lipinski's rule; How drugs work - Drug targets, drug-target interaction and dose-response relationships.

UNIT II DRUG DISCOVERY PIPELINE AND CADD 9

New Drug Discovery & Development: Overview of new drug discovery, development, cost and timelines. Target Identification & Validation. Lead Discovery: Rational and irrational approaches - Drug repurposing, Natural products, High-throughput screening (HTS), Combinatorial chemistry and computer aided drug design (CADD).

UNIT III DRUG TOXICITY, ASSAYS AND TESTING 9

Preclinical Testing of New Drugs: Pharmacology - In vitro/in vivo Pharmacokinetics and Pharmacodynamics testing; Toxicology - Acute, chronic, carcinogenicity and reproductive toxicity testing; Drug formulation testing. Clinical Trial Testing of New Drugs: Phase I, Phase II and Phase III testing; Good clinical practice (GCP) guidelines - Investigators brochures, Clinical trial protocols and trial design; Ethical issues in clinical trials - How are patient rights protected?

UNIT IV DRUG REGULATORY AFFAIRS 9

Drug Regulatory Agencies: US Food & Drug Administration (US FDA) and Central Drugs Standard Control Organization (CDSCO), India. Regulatory Applications & New Drug Approval: Investigational new drug (IND) application & New drug application (NDA); Regulatory review and approval process. Regulatory Requirements for Drug Manufacturing: Current Good manufacturing practice (cGMP) and GMP manufacturing facility inspection & approval.

UNIT V INTELLECTUAL PROPERTY RIGHTS AND PATENTS 9

Intellectual Property Rights (IPR): IPR Definition and implications for discovery & development. Forms of IPR Protection - Copyright, Trademark and Patents.International organization and treaties for IPR protection – World Trade Organization (WTO) & Trade Related Aspects of Intellectual Property Rights (TRIPS) Agreements. Importance of IPR in Indian Scenario & Indian laws for IPR protection. Patents: National and international agencies for patenting - US Patent & Trademark office (USPTO), Controller General of Patents, Designs &TradeMarks, India (CGPDTM), World Intellectual Property organization (WIPO)-Patent Cooperation Treaty (PCT); Requirements for patentability, Composition of a patent, How to apply and get patents – US, Indian and PCT. **9**

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course the student will be able to

- **CO1** Illustrate the principles of pharmacokinetics and pharmacodynamics of drug
- **CO2** Explain the process ofDrug Discovery & Development
- **CO3** Explain Clinical trial protocols and trial design
- **CO4** Outline regulatory affairs and IPR
- **CO5** Apply Computational drug Discovery for industrial and academic research

REFERENCES:

1. Rick NG. Wiley Blackwell; Drugs: From discovery to approval 3rd edition (2015)
2. Deborah E. Bouchoux, Intellectual Property Rights. Delmar Cenage Learning. 2005
3. Tripathi Kd. Essentials of Medical Pharmacology, 6the Edition (Hardcover) Publisher: Jaypee Brothers (2018) 8th edition.
4. A. V. Narasimha Rao;Laws of Patents: Concepts and Cases © 2005 The ICFAI University Press
5. PrankrishnaPal; Intellectual Property Rights In India: General Issues And Implications. Publisher: Deep & Deep Publications Pvt.ltd (2008).

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	2	3	2	3	2
CO2	3	2	3	2	3	2
CO3	3	2	3	2	2	2
CO4	3	2	3	2	3	2
CO5	3	2	3	2	3	2
Overall CO	3	2	3	2	3	2

BC3004 MOLECULAR EVOLUTION AND PHYLOGENY

L	T	P	C
3	0	0	3

OBJECTIVES

The course aims to

- Impart knowledge on the Molecular aspects of evolution
- Teach analysis and exploration of the different Models of evolution
- Teach analysis and interpretation of the process of Genome evolution

UNIT I INTRODUCTION TO EVOLUTION 9

History of evolution of life on earth: Chemical basis of evolution, Evolution of DNA, RNA and proteins, origin of the genetic code. Hardy-Weinberg equilibrium; Evolutionary changes by mutation, gene flow, genetic drift and natural selection

UNIT II MOLECULAR EVOLUTION AND INSERTION ELEMENTS 9

The concept of homology in molecular evolution. Role of transitions and transversions; chromosomal deletions and insertions in evolution. Role of repetitive DNA, transposable elements and junk DNA in evolution.

UNIT III MODELS OF EVOLUTION 9

Neutral theory (Kimura) and nearly neutral theory (Ohta) of molecular evolution (Kimura).Phylogenetic tree. Reconstruction of phyogenetic trees using distance matrix methods, the Maximum Parsimony method, Maximum likelihood and Bayesian inference. Selection at the molecular level.

UNIT IV MOLECULAR CLOCK, MITOCHONDRIA IN EVOLUTION 9

The concept of the Molecular Clock.Calibration.Limitation of molecular clock models. Human molecular clock: deducing evolutionary histories through mitrochondrial DNA and Ychromosome

UNIT V GENOME EVOLUTION, HUMAN GENOME PROJECT 9

Evolution of the genome:Human Genome Project, ENCODE, Genome 10 K, Genome duplication (Ohno's hypothesis), Gene duplication, Exon Shuffling, Concerted evolution

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course the student will be able to

CO1 Discover, understand, analyze and interpret molecular basis of evolution
CO2 Compare and contrast the processes of phylogeny
CO3 Assess and apply the concept of homology in molecular evolution
CO4 Compare, infer, deduce and compile different models of evolution
CO5 Identify, Compare, interpret and apply molecular clock theory in evolution

REFERENCES:

1. Wen Hsiung-Li; Molecular Evolution, 1997, Sinauer Associates, Sunderland, MA. ISBN 0878934634.
2. Evolution (3rd Edition) by Ridley, M., 2004, Blackwell Science. ISBN 1-4051-0345-0
3. Kitching, I., Forey, P. L., Humphries, C. J. & Williams, D. M. 1998. Cladistics: The Theory and Practice of Parsimony Analysis, 2nd ed. The Systematics Association Publication No. 11. Oxford University Press.
4. Nei, M. & Kumar, S. 2000. Molecular Evolution and Phylogenetics. Oxford University Press

5. Salemi, M. & A.-M. Vandamme, Eds. 2003. The Phylogenetic Handbook: A Practical Approach to DNA and Protein Phylogeny. Cambridge University Press.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	2	3	2	3	2
CO2	3	2	3	2	3	2
CO3	3	2	3	2	3	2
CO4	3	2	3	2	3	2
CO5	3	2	3	2	3	2
Overall CO	3	2	3	2	3	2

BT3053 ENZYME ENGINEERING AND TECHNOLOGY

L	**T**	**P**	**C**
3	**0**	**0**	**3**

OBJECTIVES

The course aims to

- Teach principles of enzyme engineering and enzyme technology.
- Impart knowledge about immobilization techniques and kinetics in enzyme technology.

UNIT I ENZYMES, COENZYMES AND COFACTORS 9

Enzymes: Enzyme as biological catalysts; activation energy, specificity, Enzyme action, active site, enzyme substrate complex, cofactors, Classification, Source of enzymes; production, isolation and purification of enzymes; Characterization in terms of pH, temperature, ionic strength, substrate and product tolerance, effects of metal ions; Coenzymes and cofactors: Coenzymes, classification of vitamins, role and mechanism of action of some important coenzyme (NAD+/NADP+, FAD, lipoic acid, tetrahydrofolate, B12-coenzyme), role of cofactors with specific examples

UNIT II ENZYME KINETICS 9

Methods for investigating the kinetics of Enzyme catalysed reactions – order of reaction, initial velocity studies. Michaelis-Menten equation, Km and Vmax, enzyme inhibition; methods of plotting enzyme kinetics data; Enzyme turnover number, Solution of numerical problems. competitive, non-competitive, uncompetitive, irreversible; order of reaction, methods of plotting enzyme kinetics data; determination of Kcat, Km, Vmax, Ki, Half Life, effect of pH and Temperature on enzyme activity Multi Substrate enzymes and kinetics mechanisms; Enzyme induction, repression, covalent modification, Isoenzymes, allosteric effects

UNIT II ENZYME ENGINEERING 9

Introduction, Random and rational approach of protein engineering; Directed evolution and its application in Biocatalysis; various approaches of creating variant enzyme molecules; Future of Biocatalysis; Ideal biocatalyst.

UNIT IV IMMOBILIZED ENZYME TECHNOLOGY 9

Different techniques of immobilization of enzymes and whole cells; Advantages and disadvantages of immobilization; Cross linked enzymes, enzyme crystals, their use and preparation Kinetics of immobilized enzymes, design and operation of immobilized enzymes

reactors; Type of reactors, classification, retention of enzymes in a reactor, kinetics of enzyme reactors; Reactor performance with inhibition, operation of enzyme reactors; case studies; Application and future of immobilized enzyme technology

UNIT V ENZYMATIC TRANSFORMATION 9

Functional group interconversion using enzymes (hydrolysis reaction, oxidation/reduction reactions, C-C bond formations). Reaction engineering for enzyme-catalyzed biotransformations. Catalytic antibodies. Biocatalysts from extreme Thermophilic and Hyperthermophilic microorganisms (extremozymes). The design and construction of novel enzymes, artificial enzymes, Biotransformation of drugs (hydroxylation of Steroids), Host Guest Complexation chemistry, enzyme design using steroid templates, enzymes for production of drugs, fine chemicals and chiral intermediates.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course the students will be able to

CO1 Understand basics such as enzyme's classification, action and factors affecting its activity.

CO2 Understand and analyze enzyme kinetics and different types of enzyme inhibition.

CO3 Apply the concept of biocatalysts in industrial processes

CO4 Perform and optimize enzyme engineering process and immobilization.

CO5 Design enzymes for industrial applications

REFERENCES:

1. Stryer, L., "Biochemistry" Freeman. New York, 2002
2. Lehninger, A. L., "Principles of Biochemistry, 4th ed., Worth. New York, NY, 2004
3. Voet, D., &Voet, J. G., "Biochemistry", 4th ed., Wiley & Sons. Hoboken, NJ:, 2004
4. Rehm, H. & J. Reed, G., "Enzyme Technology", Volume 7a. John Wiley & Sons, 1986
5. Irwin H. Segel, "Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry", 2nd revised Ed. John Wiley & Sons.1976
6. Biotol, "Bioreactor Design & Product Yield", Butterworth-Heinemann, 1992
7. Wang, D. I. C, Fermentation and Enzyme Technology. Wiley. New York, 1979
8. Trevor Palmer , Enzymes IInd Horwood Publishing Ltd, 2007
9. Faber K ,Biotransformations in Organic Chemistry, IV edition , Springer, 2018

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	3	2	2	-	1
CO2	2	3	2	1	1	2
CO3	-	3	-	2	-	-
CO4	2	3	2	2	2	2
CO5	-	3	-	-	-	-
OVERALL CO	2	3	2	2	2	2

BT3055 **METABOLIC ENGINEERING** **L T P C**
3 0 0 3

OBJECTIVES

The course aims to

- Familiarize the student with quantitative approaches for analyzing cellular metabolism and make the students aware of the use of theoretical and experimental tools that can give insights into the structure and regulation of metabolic networks.
- Make the students identify the optimal strategy for introducing directed genetic changes in the microorganisms with the aim of obtaining better production strains using case studies.

UNIT I METABOLIC FLUX ANALYSIS 9

Introduction to metabolic engineering, comprehensive models of cellular reactions with stoichiometry and reaction rates; metabolic flux analysis of exactly determined systems for lactic acid ,citric acid and systems, Shadow price, sensitivity analysis.

UNIT II TOOLS FOR EXPERIMENTALLY DETERMINING FLUX THROUGH PATHWAYS 9

Monitoring and measuring the metabolome, Methods for the experimental determination of metabolic fluxes by isotope labelling of linear, branched and cyclic pathways using NMR, metabolic fluxes using various separation-analytical techniques. GC-MS for metabolic flux analysis, genome wide technologies: DNA /phenotypic microarrays and proteomics.

UNIT III CONSTRAINT BASED GENOMIC SCALE METABOLIC MODEL 9

Development of Genomic scale metabolic model, Insilico Cells:studying genotype-phenotype relationships using constraint-based models, case studies in *E. coli, S. cerevisiae* metabolic network reconstruction methods, optimization of metabolic network, Identification of targets for metabolic engineering; software and databases for genome scale modeling.

UNIT IV METABOLIC CONTROL ANALYSIS AND KINETIC MODELING 9

Metabolic Control Analysis, control coefficients and the summation theorems, Determination of flux control coefficients. Multi-substrate enzyme kinetics, engineering multifunctional enzyme systems for optimal conversion, and a multi scale approach for the predictive modeling of metabolic regulation.

UNIT V CASE STUDIES IN METABOLIC ENGINEERING 9

Metabolic engineering examples for bio-fuel, bio-plastics and green chemical synthesis. Identification of rational targets by elementary mode analysis and genome scale model in various systems for the production of green chemicals using software tools. Validation of the model with experimental parameters.

TOTAL: 45 PERIODS

OUTCOME

At the end of the course the students will be able to

CO1 Understand and identify the optimal strategy for introducing genetic changes in the microorganisms with the aim of obtaining better production strains.
CO2 Apply knowledge on metabolic flux analysis by NMR and GCMS
CO3 Develop databases for genome scale modelling
CO4 Understand and gain knowledge on metabolic regulation
CO5 Design novel concept of green chemical synthesis

REFERENCES

1. Stephanopoulos, G.N. “Metabolic Engineering: Principles and Methodologies”. Academic Press / Elsevier, 1998.
2. Lee, S.Y. and Papoutsakis, E.T. “Metabolic Engineering”. Marcel Dekker, 1998.
3. Nielsen, J. and Villadsen, J. “Bioreaction Engineering Principles”. Springer, 2007.

4. Smolke, Christiana D., “The Metabolic Pathway Engineering Handbook Fundamentals”, CRC Press Taylor & Francis, 1st edition 2010.
2. Voit, E.O. “Computational Analysis of Biochemical Systems : A Practical Guide for Biochemists and Molecular Biologists”. Cambridge University Press, 1st edition 2000.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	-	2	3
CO2	3	-	3	1	3	3
CO3	3	-	3	1	3	3
CO4	3	-	3	2	3	3
CO5	3	-	2	2	2	1
OVERALL CO	3	2	3	2	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT3057 NANOBIOTECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

The course aims to

- Provide fundamental concepts of nanobiotechnology
- Impart the knowledge for the application of nanobiotechnology including nanomedicine.

UNIT I NANOSCALE PROCESSES AND NANOBIOTECHNOLOGY 9

Introduction to Nanoscience and Nanotechnology; Milestones in Nanotechnology; Overview of Nanobiotechnology and Nanoscale processes; Physicochemical properties of materials in Nanoscales.

UNIT II FABRICATION AND CHARACTERIZATION OF NANOMATERIALS 9

Types of Nanomaterials (Quantum dots, Nanoparticles, Nanocrystals, Dendrimers, Buckyballs, Nanotubes); Gas, liquid, and solid –phase synthesis of nanomaterials; Lithography techniques (Photolithography, Dip-pen and Electron beam lithography); Thin film deposition; Electrospinning. Bio-synthesis of nanomaterials.

UNIT III PROPERTIES AND MEASUREMENT OF NANOMATERIALS 9

Optical Properties: Absorption, Fluorescence, and Resonance; Methods for the measurement of nanomaterials; Microscopy measurements: SEM, TEM, AFM and STM. Confocal and TIRF imaging.

UNIT IV NANOBIOLOGY AND BIOCONJUGATION OF NANOMATERIALS 9

Properties of DNA and motor proteins; Lessons from nature on making nanodevices; Reactive groups on biomolecules (DNA & Proteins); Surface modification and conjugation to nanomaterials. Fabrication and application of DNA nanowires; Nanofluidics to solve biological problems.

UNIT V NANO DRUG DELIVERY AND NANOMEDICINE 9

Properties of nanocarriers; drug delivery systems used in nanomedicine; Enhanced Permeability and Retention effect; Blood-brain barrier; Active and passive targeting of diseased cells; Health and environmental impacts of nanotechnology.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course the students will be able to

CO1 Understand fundamental concepts of nanoscale processes and nanobiotechnology

CO2 Analyse and interpret the fabrication and characterization of nanomaterials in various applications

CO3 Designing novel nanomaterials for appropriate applications

CO4 Apply the knowledge for making of nanodevices and applications

CO5 Design nano-based drug delivery and nanomedicine

REFERENCES:

1. Nanobiotechnology: Concepts, Applications and Perspectives, Christ of M. Niemeyer(Editor), Chad A. Mirkin (Editor) , Wiley-VCH; 1 edition, 2004.
2. Nano Biotechnology: BioInspired Devices and Materials of the Future by Oded Shoseyovand Ilan Levy, Humana Press; 1 edition 2007.
3. NanoBiotechnology Protocols (Methods in Molecular Biology) by Sandra J Rosenthal andDavid W.W right , Humana Press; 1 edition, 2005.
4. Bio-Nanotechnology Concepts and applications. Madhuri Sharon, Maheshwar Sharon,SunilPandey and Goldie Oza, Ane Books Pvt Ltd, 1 edition 2012
5. Microscopy Techniques for Material Science. A. R. Clarke and C. N. Eberhardt (Editors)CRC Press. 1st Edition, 2002.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	-	-	-	-
CO2	-	3	-	1	2	2
CO3	2	3	3	3	3	3
CO4	-	3	3	3	2	3
CO5	-	-	3	-	-	3
OVERALL CO	2	3	3	2.33	2.5	2.75

BC3005 COMPUTATIONAL SYSTEMS BIOLOGY

L	**T**	**P**	**C**
3	**0**	**0**	**3**

OBJECTIVES

The course aims to

- Impart Systems Biology concepts, Graph theory, network models and properties.
- Teach network motifs, SBML and genome scale modeling
- Teach and Elaborate data resources and tools, kinetic modeling and flux balance analysis

UNIT I INTRODUCTION TO NETWORKS 9

Introduction to Systems Biology, Systems level understanding of biological systems. Basic concepts in Systems modeling, Networks and graph theory**:** Basic properties of Network: Degree, average degree and degree distribution. Adjacency matrix, weighted and unweighted networks, Bipartite network, Paths and distances, Random Networks**:**Erdos-Renyi model, Small-world effect,clustering coefficient, Scale-free networks**:**Power laws, Hubs, ultra-small

property, degree exponent, The Barabasi-Albert Model. Degree correlations: assortativity and disassortativity

UNIT II KINETIC MODELING **9**

Kinetic modeling of biochemical reactions, describing dynamics with ODEs, rate equations, deriving a rate equation, incorporating regulation of enzyme activity by effectors, E-cell platform and erythrocyte modeling

UNIT III FLUX BALANCE ANALYSIS **9**

Introduction to Flux balance analysis, Construction of stoichiometric matrices, Constraint based models. Network basics, examples of mathematical reconstruction of transcriptional networks and signal transduction networks.

UNIT IV NETWORK MOTIFS AND MODELS **9**

Network motifs, Feed forward loop network motif. Gene circuits, robustness of models, Chemotaxis model, Integration of data from multiple sources: Building genome scale models.

UNIT V RESOURCES AND SBML **9**

Tools and databases for modeling: Pathway databases KEGG, EMP, Metacyc, Enzyme kinetics database BRENDA, Gene expression databases, Biomodels database, Basics of Systems Biology Markup Language (SBML), SBML editors

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course the students will be able to

CO1 Identify, explore, analyze and compare Systems Biology concepts, network models and properties from biological networks' perspective

CO2 Evaluate and design kinetic models, flux balance analysis and interpret results

CO3 Identify and demonstrate the steps involved in genome scale modeling

CO4 Apply the knowledge on FBA and construct transcriptional networks

CO5 Identify, apply, compare and explain about the tools and databases for modelling

REFERENCES:

1. EddaKlipp, Wolfram Liebermeister, ChristophWierling, Axel Kowald, “Systems Biology a Textbook”, Wiley-VCH, 2nd Edition, 2016

2. Uri Alon, “An introduction to Systems Biology: Design Principles of Biological Circuits”, Chapman and Hall / CRC, 2006

3. EddaKlipp, Ralf Herwig, Axel kowald, ChristophWierling, Hans Lehrach, “Systems Biology in Practice : concepts, implementation and application”, Wiley-VCH, 2005

4. Hiroaki Kitano, “Foundations of Systems Biology”, MIT Press, 2001

5. Lilia Albhergina, Hans V Westerhoff “Systems Biology: Definitions and perspectives”, Springer Publications, 2008

Course Articulation Matrix:

Course Outcome	Programme Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	3	3	3	3	2
CO2	3	2	3	2	3	3
CO3	3	3	3	3	3	2
CO4	3	3	3	2	3	3
CO5	3	2	3	3	3	2
Overall CO	3	2	3	2	3	2

BT3051	APPLIED GENOMICS AND PROTEOMICS	L	T	P	C
		3	0	0	3

OBJECTIVES

The course aims to

- provide advanced theoretical knowledge on the organization and function of genomes and functional genomics
- impart knowledge on the advanced methods and approaches in proteomics.

UNIT I ARCHITECTURE OF GENES AND GENOMES 9

Genomic architecture of eukaryotes and prokaryotes. Genomes of organelles (chloroplast, mitochondrion); Characterization of genomes through genetic and physical mapping methods; Fluorescence In-Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH); Whole genome shot-gun sequencing and its applications.

UNIT II LARGE SCALE GENOMICS AND FUNCTIONAL GENOMICS ANALYSES 9

Single nucleotide polymorphism (SNPs) and Genome-wide association (GWA) analysis; Gene expression analysis by cDNA and oligonucleotide arrays; Micro array experimental analysis and data analysis. Methylome analysis using microarray; ChIP-on-Chip analysis. Next Generation Sequencing (NGS) based sequencing of DNA and RNA.

UNIT III ISOLATION AND SEPARATION OF PROTEOME SAMPLES 9

Over-view of strategies used for the identification and analysis of proteins; Protein extraction from biological samples (Mammalian Cells and Tissues, Yeast, Bacteria, and Plant specimen); Two-dimensional Gel-electrophoresis of proteins (2DE) and Difference Gel Electrophoresis (DIGE); Liquid chromatography separations in proteomics (Affinity, Ion Exchange, Reversed-phase, and size exclusion).

UNIT IV MASS SPECTROMETRY IN PROTEOMICS 9

Introduction to Mass spectrometry; Common ionization methods used for proteomics; Enzymatic cleavage of proteins. Structure and function of MALDI-TOF mass-spectrometry, LC-MS analysis of proteome samples. Protein identification using peptide mass-finger printing and MS/MS strategies.

UNIT V PROTEOMICS THROUGH LARGE-SCALE PROFILING 9

In-vitro and In-vivo labeling of proteins (ICAT and SILAC) followed be mass-spectrometry profiling. Analysis of posttranslational modification (PTM) of proteins; Characterization of protein-protein interactions using yeast two-hybrid system, Protein microarrays and its applications; Proteomics informatics and analysis of protein functions.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course the students will able to,

CO1: Understand advanced theoretical knowledge on the organization and function ofgenomes

CO2: Perform functional genomic analyses

CO3: Decide appropriate methods for isolation and separation of proteomes

CO4: Interpret and analyze the proteins by mass-spectrometers

CO5: Design the schemes for different proteomics approaches involving large-scale protein profiling

REFERENCES:

1. S.P. Hunt and F. J. Livesey, (2000) Functional Genomics, Oxford University press
2. N. K. Spur, B. D. Young, and S. P. Bryant (1998) ICRF Handbook of GenomeAnalysis Volume 1 & 2, Black well publishers

3. G. Gibson and S. V. Muse, 3rd ed., (2009) A primer ofGenome Science, SinauerAssociates, Inc. Publishers
4. R. J. Reece (2004) Analysis of Genes and Genomes, John Wiley & SonsLtd
5. Rinaldis E. D. and Lahm A (2007) DNA Microarrays. Horizon bioscience.
6. Simpson R. J."Proteins and Proteomics - A Laboratory Manual".Cold SpringHarbour Laboratory Press, 2002.
7. Twyman R. M. "Principles of Proteomics". Taylor & Francis. 2004
8. O'Connor C. D. and Hames B. D. "Proteomics". Scion, 2008.
9. Schena M. "Protein Microarrays". Jones and Bartlett, 2005.
10. Smejkal G. B. and Lazarev A. V. "Separation methods in Proteomics". CRC Press,2006.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	3	1	2	3	-
CO2	3	3	2	1	3	2
CO3	3	2	1	3	2	2
CO4	2	2	1	2	3	3
CO5	2	2	1	2	2	3
OVERALL CO	2	2	1	2	3	3

BC3006 SIGNAL PROCESSING IN BIOTECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES

The course aims to

- Teach the Concepts of Signal Processing
- Train the students with Signals and Transforms
- Instruct Detection Theory and Estimation Theory

UNIT I SIGNALS AND SYSTEMS **9**

Signals and Systems -Example Signals: Sinusoids, complex exponentials, impulse and step signals, - LTI Systems and properties: impulse response, convolution, Eigenfunctions of LTI systems-Example: Biological time series signals from gene expression microarrays

UNIT II TRANSFORMS **9**

Transforms-Discrete time fourier transform-Fast fourier transform-Sampling theorems-Biological example: Fourier transform of DNA sequences reveal inherent periodicities

UNIT III DETECTION THEORY (NON-BAYESIAN) **9**

Detection theory (Non-Bayesian)-Hypothesis testing-Neyman-Pearson lemma-Likelihood ratio test-Matched filter-Metrics: ROC curve, area-under-the-ROC curve, sensitivity, specificity

UNIT IV ESTIMATION THEORY (NON-BAYESIAN) **9**

Estimation theory (Non-Bayesian)-Sufficient statistic-Bias and Minimum Variance unbiased estimators-Maximum likelihood estimators-Efficient estimation

UNIT V BAYESIAN DETECTION AND ESTIMATION **9**

Bayesian Detection and Estimation-Bayesian statistics: Incorporating prior knowledge-Minimum mean square error -Linear MMSE estimator-Maximum A Posteriori Probability detection

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course the students will be able to

CO1 Explore and understand the concepts of Signal Processing

CO2 Identify, examine and apply knowledge of signals, Transforms and Detection Theory

CO3 Discover, demonstrate and evaluate applications of signal processing in biotechnology

CO4 Explore and evaluate the estimation theory

CO5 Analyze, explore and develop tools on bayesian detection and estimation methods

REFERENCES:

1. Oppenheim and A. Willsky, “Signals and Systems,” 2nd edition, Prentice Hall, 2015.
2. S. M. Kay, "Fundamentals of Statistical Signal Processing: Estimation Theory", Prentice Hall PTR, 1993.
3. S. M. Kay, "Fundamentals of Statistical Signal Processing: Detection Theory", Prentice Hall PTR, 1998
4. Digital Signal Processing: Principles, Algorithms, and Applications by J. G. Proakis and D. G. Manolakis.

Course Articulation Matrix:

Course Outcome	Programme Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	3	3	3	3	2
CO2	3	2	3	2	3	3
CO3	3	3	3	3	3	2
CO4	3	3	3	2	3	3
CO5	3	2	3	3	3	2
Overall CO	3	2	3	2	3	2

BC3007 HIGH PERFORMANCE COMPUTING

L	**T**	**P**	**C**
3	**0**	**0**	**3**

OBJECTIVES

The course aims to

- Impart knowledge on Parallel processing concepts
- Train and demonstrate Parallel programming languages and GPU
- Teach applications of parallel programming concepts in Bio-informatics and Computational Biology.

UNIT I PARALLEL PROCESSING FUNDAMENTALS **9**

Parallel Processing Concepts - Levels of parallelism - task, thread, memory, function; Models (SIMD, MIMD, Dataflow Models etc), Architectures- multi-core, multi-threaded.

UNIT II PARALLEL PROGRAMMING MODELS **9**

Parallel Programming and Multiprogramming, Programming Models in high performance computing architectures – Shared memory and Message passing paradigms - Fundamental Design Issues in Parallel Computing – Synchronization - Interconnect, Communication, Memory Organization Memory hierarchy and transaction specific memory design - Thread Organization.

UNIT III PARALLEL PROGRAMMING LANGUAGES **9**

Parallel Programming Languages – Overview, OpenMP, History of GPUs leading to their use and design for HPC, Introduction to the GPU programming model and CUDA, host and

device memories, Basic CUDA program structure, kernel calls, threads, blocks, grid, thread addressing, predefined variables

UNIT IV CUDA 9

CUDA - example code: vector and matrix addition, matrix multiplication, Using Windows and Linux environments to compile and execute simple CUDA programs, Linux make files, Timing execution time, CUDA events, Host synchronization

UNIT V BIOINFORMATICS AND PARALLEL COMPUTING 9

Bioinformatics and Parallel Computing- Bioinformatics Applications, Recent developments in Computational Biology and Nanotechnology and its impact on HPC.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course the students will be able to

CO1 Explain Parallel Computing concepts and GPU
CO2 Apply Parallel programming mode
CO3 Examine and develop Parallel Programming Language
CO4 Discover and interpret about the CUDA software for parallel programming.
CO5 Develop Parallel Computing concepts to solve Computational Biology Problems

REFERENCES: :

1. George S. Almasi and Alan Gottlieb; Highly Parallel Computing", Benjamin-Cummings Publishing Company; (1993)
2. Kai Hwang, McGraw Hill; Advanced Computer Architecture: Parallelism, Scalability, Programmability, 1993
3. Jason Sanders and Edwards Addison-Wesley, Kandrot CUDA by Example- An Introduction to General-Purpose GPU Programming 2011.
4. David Culler Jaswinder Pal Singh, Morgan Kaufmann, "Parallel Computer Architecture: A hardware/Software Approach", 1999.
5. Jeffrey S. Vetter (Editor), Contemporary High Performance Computing: From Petascale toward Exascale (Chapman & Hall/CRC Computational Science) CRC Press, 2013
6. Georg Hager, Gerhard Wellein, Introduction to High Performance Computing, CRC Press, 2011
7. Wagner, S., Steinmetz, M., Bode, A., Müller, M.M. (Eds.),, High Performance Computing in Science and Engineering, Garching/Munich, Springer Verlog, 2010

Course Articulation Matrix:

Course Outcome	Programme Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	2	3	3	3	2
CO2	3	2	3	2	3	3
CO3	3	2	3	3	3	2
CO4	3	2	3	2	3	3
CO5	3	2	3	3	3	2
Overall CO	3	2	3	2	3	2

BC3051 SYNTHETIC BIOLOGY L T P C
3 0 0 3

OBJECTIVES

The course aims to

- Teach the concepts of modern DNA assembly techniques

- Train the students to build biological circuits
- Instruct the principles of designing biological circuits with control levels.

UNIT I SYNTHETIC BIOLOGY – BIOLOGICAL COMPONENTS/CIRCUITS 10

Definition and scope, applications of Synthetic biology and milestones in development, principles of artificial gene synthesis, promoters, ribosomal binding sites (RBS), coding sequences and terminators, Logical operators – Repressilator, Toggle-switch, Mammalian tunable synthetic oscillator, Coupled bacterial oscillator , Bacterial tunable synthetic oscillator, Globally coupled bacterial oscillator

UNIT II NUMERICAL METHODS FOR SYSTEMS ANALYSIS AND DESIGN 8

Fundamental on the theoretical and computational modelling of replicating systems, Bioinformatic analysis and characterisation of genes and biomolecules, Mathematical model of processes for metabolic pathways and genetic regulatory circuits, Parameter estimation in biochemical pathways, optimal experimental design, dynamic optimization of biosystems.

UNIT III METABOLISM OF NUCLEIC ACIDS AND LIPIDS 9

Biosynthesis of nucleotides, *de novo* and salvage pathways for purines and pyrimidines, regulatory mechanisms: Degradation of nucleic acid by exo and endo nucleases. Triacylglycerol and phospholipid biosynthesis and degradation; Cholesterol biosynthesis and regulation and targets and action of cholesterol lowering drugs, statins.

UNIT IV FABRICATION OF GENETIC SYSTEMS 9

Introduction to BioBricks and standardization, assembly methods, induction and addition of measurable element, (Eg.GFP) to an existing natural biological circuit, overview and scope of GenoCAD, Clotho framework.

UNIT V CASE STUDIES IN ENGINEERED SYSTEMS 9

RNA-based regulatory system for independent control of transcription activities of multiple targets, Applications of Engineered Synthetic Ecosystems, pT181 antisense-RNA-mediated transcription attenuation mechanism and applications, Ethics and patentability,.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course the students will be able to

CO1 Explain the regulation of the genes and properties of gene products can be altered with synthetic biology methods.

CO2 Apply the scientific approach to the discovering, examining and developing biological systems

CO3 Examine the knowledge of numerical methods for system analysis and design.

CO4 Explain the fabrication of genetic systems

CO5 Criticize the results and generate testable hypotheses for synthetic biology experiments.

REFERENCES: :

1. Synthetic Biology: Tools and Applications by Huimin Zhao, Academic Press; 1 edition (2013), ISBN-10: 0123944309, ISBN-13: 978-0123944306
2. Bioengineering: A Conceptual Approach by MirjanaPavlovic, Springer; 2015 edition, ISBN-10: 3319107976, ISBN-13: 978-3319107974
3. Biological Modeling and Simulation: A Survey of Practical Models, Algorithms, and Numerical Methods (Computational Molecular Biology) by Russell Schwartz, The MIT Press; 1 edition (2008).

Course Articulation Matrix:

Course Outcome	Programme Outcome (PO)					
	1	2	3	4	5	6
CO1	3	2	3	3	3	2
CO2	3	2	3	2	3	3
CO3	3	2	3	3	3	2
CO4	3	2	3	2	3	3
CO5	3	2	3	3	3	2
Overall CO	3	2	3	2	3	2

BC3008 JAVA IN COMPUTATIONAL BIOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES

The course aims to

- Teach the basics of Java programming language,
- Instruct Applets and Java Networking and BioJava
- Train the students to solve biological relevant problems using Java

UNIT I INTRODUCTION TO JAVA **9**

Introduction to Java: Compilation of java programs – Java Development Kit – Java Data Types – Operators – Operator precedence Keywords, Constants, Variables, Operators, Expressions, Decision Making, Branching and Looping

UNIT II JAVA CLASSES **9**

Working with java classes: Declaring classes – super and sub classes – Objects – Methods, Arrays, Strings and Vectors, Constructors – Inheritance – Overloading – Exception handling – InputStream and OutputStream classes - Managing Inputs/Output Files in Java

UNIT III MULTI-THREAD PROGRAMMING **9**

Multi-thread programming: Life cycle of a thread – Creating a thread– Thread priorities – Synchronization – Deadlock, Event handling mechanisms

UNIT IV JAVA APPLETS **9**

Graphics - Applet basics – passing parameters to applets – applet display methods – drawing lines, ovals, rectangles and polygons – Threads and Animation

UNIT V JAVA NETWORKING BASICS AND BIOJAVA **9**

Basic concepts of networking- Working with URLs, Concepts of URLs, Sockets, Database connectivity with JDBC, Introduction to BioJava, Installing BioJava, Basic Sequence Manipulation, Translation, Proteomics, Sequence I/O

TOTAL: 45 PERIODS

OUTCOMES:

The students will be able to

CO1 Develop and test the Java Programs
CO2 Explain Java Applets and Java Networks
CO3 Interpret the concepts of BioJava
CO4 Explain Multi-thread programming
CO5 Apply Java programming language to computational biology problems

REFERENCES:

1. HerbertSchildt, Java:The complete Reference. (11th Ed.) by McGraw-Hill, 2018
2. E. Balagurusamy, Programming with Java: A Primer, McGraw-Hill Education, 2014

3. Cay S. Horstmann, Core Java Volume I - Fundamentals (9th Edition), Prentice Hall, 2013.
4. Yakov Fain. 2015, Java Programming: 24 Hour Trainer, 2nd Edition, Wiley publication.
5. Barry Burd. 2014. Java FOR Dummies. 6th Edition, Wiley & Sons.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	3	3	3	3	2
CO2	3	2	3	2	3	3
CO3	3	3	3	3	3	2
CO4	3	3	3	2	3	3
CO5	3	2	3	3	3	2
Overall CO	3	2	3	2	3	2

BC3009 NATURAL LANGUAGE PROCESSING

L	T	P	C
3	0	0	3

OBJECTIVES

The course aims to

- Teach the fundamentals of natural language processing
- Impart the knowledge of CFG, PCFG, semantics of sentences
- Teach pragmatics in NLP and to apply the NLP techniques to IR applications.

UNIT I INTRODUCTION TO NATURAL LANGUAGE PROCESSING 9

Natural Language Processing – Components - Basics of Linguistics and Probability and Statistics – Language Modeling - Grammar-based LM, Statistical LM - Regular Expressions, Finite-State Automata – English Morphology, Transducers for lexicon and rules, Tokenization, Detecting and Correcting Spelling Errors, Minimum Edit Distance.

UNIT II WORD LEVEL ANALYSIS 9

Unsmoothed N-grams, Evaluating N-grams, Smoothing, Interpolation and Backoff – Word Classes, Part-of-Speech Tagging, Rule-based, Stochastic and Transformation-based tagging, Issues in PoS tagging – Hidden Markov and Maximum Entropy models.

UNIT III SYNTACTIC ANALYSIS 9

Context-Free Grammars, Grammar rules for English, Treebanks, Normal Forms for grammar – Dependency Grammar – Syntactic Parsing, Ambiguity, Dynamic Programming parsing – Shallow parsing – Probabilistic CFG, Probabilistic CYK, Probabilistic Lexicalized CFGs - Feature structures, Unification of feature structures.

UNIT IV SEMANTICS AND PRAGMATICS 9

Requirements for representation, First-Order Logic, Description Logics – Syntax-Driven Semantic analysis, Semantic attachments – Word Senses, Relations between Senses, Thematic Roles, selectional restrictions – Word Sense Disambiguation, WSD using Supervised, Dictionary & Thesaurus, Bootstrapping methods – Word Similarity using Thesaurus and Distributional methods.

UNIT V DISCOURSE ANALYSIS AND LEXICAL RESOURCES 9

Discourse segmentation, Coherence – Reference Phenomena, Anaphora Resolution using Hobbs and Centering Algorithm – Coreference Resolution – Resources: Porter Stemmer, Lemmatizer, Penn Treebank, Brill's Tagger, WordNet, PropBank, FrameNet, Brown Corpus, British National Corpus (BNC).

TOTAL: 45 PERIODS

OUTCOMES:

The students will be able to

CO1 Explain basic Language features

CO2 Apply and design an innovative application using NLP components

CO3 Develop and implement a rule based system to tackle morphology/syntax of a language.

CO4 Design a tag set to be used for statistical processing for real-time applications

CO5 Compare and evaluate the use of various statistical approaches for different types of NLP applications.

REFERENCES:

1. Daniel Jurafsky, James H. Martin, Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech, Pearson Publication, 2014.
2. Steven Bird, Ewan Klein and Edward Loper, Natural Language Processing with Pythonǁ, First Edition, O'Reilly Media, 2009.
3. Breck Baldwin, Language Processing with Java and LingPipe Cookbook, Atlantic Publisher, 2015.
4. Richard M Reese, Natural Language Processing with Javaǁ, O'Reilly Media, 2015.
5. Nitin Indurkhya and Fred J. Damerau, Handbook of Natural Language Processing, Second Edition, Chapman and Hall/CRC Press, 2010.
6. Tanveer Siddiqui, U.S. Tiwary, "Natural Language Processing and Information Retrieval", Oxford University Press, 2008.

Course Articulation Matrix:

Course Outcome	Programme Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	2	3	3	3	2
CO2	3	2	3	2	3	3
CO3	3	2	3	3	3	2
CO4	3	2	3	2	3	3
CO5	3	2	3	3	3	2
Overall CO	3	2	3	2	3	2

BC3010 BIOIMAGING TECHNIQUES

L	**T**	**P**	**C**
3	**0**	**0**	**3**

OBJECTIVES

The course aims to

- Teach the fundamentals of Bioimaging Techniques
- Impart the knowledge of Biomedical image analysis
- Instruct the Image enhancement techniques and Bioimaging applications

UNIT I INTRODUCTION TO IMAGE PROCESSING 9

Imaging System Theory - Linear Systems, Fourier Transformation, Digitization and Sampling, Convolution and Correlation, Projections, Basic Optics - Geometrical Optics, Reflection /Refraction, Interference, Diffraction, Optical Resolution

UNIT II MICROSCOPY TECHNIQUES 9

Fluorescence Microscopy - Optical Microscopy, Fluorescence Labeling and Imaging, Confocal Microscopy, Super Resolution Microscopy, Electron Microscopy, Processing and Analyzing of Microscopic Images.

UNIT III BIOMEDICAL IMAGE ANALYSIS 9

Objectives of biomedical image analysis – Computer aided diagnosis – Nature of medical images: X-ray imaging – Tomography – Ultrasonography – Magnetic resonance imaging. Removal of artifacts – Space domain filters – Frequency domain filters – Optimal filtering – Adaptive filters.

UNIT IV IMAGE ENHANCEMENT TECHNIQUES 9

Image enhancement – Gray level transforms – Histogram transformation – Convolution mask operators – Contrast enhancement. Detection of regions of interest – Thresholding and binarization – Detection of isolated lines and points – Edge detection – Region growing.

UNIT V APPLICATIONS OF BIOIMAGING TECHNIQUES 9

Analysis of shape and texture – Representation of shapes and contours – Shape factors – Models for generation of texture – Measures of diagnostic accuracy – Applications: Contrast enhancement of mammograms – Detection of calcifications by region growing – Shape and texture analysis of tumours.

TOTAL: 45 PERIODS

OUTCOMES:

The students will be able to

CO1 Illustrate and understand Image Processing Techniques
CO2 Explain and apply MicroscopyTechniques
CO3 Apply and adapt biomedical image analysis
CO4 Explain and apply Image enhancement Techniques
CO5 Illustrate**,** Apply and adapt Bioimaging Techniques

REFERENCES:

1. Douglas B. Murphy, Michael W. Davidson, Fundamentals of Light Microscopy and Electronic Imaging, Wiley-Blackwell, 2013
2. Simon R. Cherry, Ramsey D. Badawi, Jinyi Qi, Essentials of In Vivo Biomedical Imaging, CRC Press, 2015
3. Sinha G. R, Patel, B. C., “Medical Image Processing: Concepts And Applications”, Prentice Hall, 2014.
4. Gonzalez R C, Woods R E, “Digital Image Processing”, Third Edition, Prentice Hall, 2007.

Course Articulation Matrix

Course Outcome	Programme Outcome (PO)					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	2	3	2	3	2
CO2	3	3	2	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	2	3	3	3
CO5	3	3	3	3	3	2
Overall CO	3	3	2	3	3	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively