DEPARTMENT OF BIOTECHNOLOGY

ANNA UNIVERSITY, CHENNAI

Vision:

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

Mission:

The mission of the department is

- To provide students a unique and multidisciplinary learning experience that will foster the young minds to develop as a researcher, entrepreneur etc.
- To enhance academic and industrial collaborative research initiatives for the development of biotechnological, food and therapeutic products.
- To emphasise and equip the students towards innovative industrial and research updates.
- To serve the society with utmost commitment, integrity, enthusiasm, and dedication

ANNA UNIVERSITY, CHENNAI 600 025
UNIVERSITY DEPARTMENTS
M. TECH. COMPUTATIONAL BIOLOGY
REGULATIONS – 2019
CHOICE BASED CREDIT SYSTEM

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

1. Find gainful employment in academia and industry pertinent to Computational Biology
2. Get elevated to managerial position and lead the organization competitively.
3. Enter into higher studies leading to research degrees at International and National Institutions and Universities
4. Become consultant and provide solutions to the practical problems of any organization.
5. Become an entrepreneur in Computational Biology and Bioinformatics field

2. PROGRAMME OUTCOMES (POs):

After going through the two years of study, our Computational Biology Post Graduates will exhibit ability to

PO	Post Graduate Attribute	Program Outcome
1.	Engineering Knowledge	Apply the knowledge of mathematics, science, engineering fundamentals, and Computational Biology to the solution of complex problems
2.	Problem Analysis	Identify, formulate and solve problems to arrive at substantiated conclusions
3.	Design/development of solutions	Design real time research oriented problem to improve its performance and develop solutions for it
4.	Conduct investigations of complex Problems	Develop algorithms, programs, apply software tools, conduct experiments, collect, analyze and interpret the data
5.	Modern tool usage	Apply various software tools and appropriate modern techniques to scientific and research oriented computational biology problems

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6.	The engineer and society	Conduct themselves to uphold the professional and social obligations
7.	Environment and sustainability	Design the system with environmental consciousness and sustainable development.
8.	Ethics	Interact in industry, business and society in a professional and ethical manner
9.	Individual and team work	Function in a multidisciplinary team
10.	Communication	Proficiency in oral and written Communication
11.	Project management and finance	Implement cost effective and improved system
12.	Life-long learning	Continue professional development and learning as a life-long activity

3. MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVE WITH PROGRAMME OUTCOMES

PROGRAM EDUCATIONAL OBJECTIVES (PEOS)	PROGRAMME OUTCOMES											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1.	✔	✔						✔				
2.								✔	✔	✔	✔	
3.		✔	✔	✔	✔		✔	✔				
4.				✔	✔					✔	✔	✔
5.			✔						✔	✔	✔	✔

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4. MAPPING OF COURSE OUTCOMES AND PROGRAMME OUTCOMES

		COURSE NAME	PROGRAMME OUTCOMES											
			PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
YEAR I	SEMESTER I	Concepts in Computational Biology	3	3	3	2	3							
		Python and its applications in Computational Biology	3	3	3	2	3							
		Algorithms in Computational Biology	3	3	3	3	3							
		Professional Elective I												
		Professional Elective II												
		Professional Elective III												
		Research Methodology and IPR	3	3			3	2		3				2
		Audit Course I												
		Python and its applications in Computational Biology Lab	2	3	3	3	3							
	SEMESTER II	Machine Learning and Data Mining	3	3	3	2	3							
		Biomolecular Simulations	3	3	3	2	3							
		Big Data Analytics and Next Generation Sequencing	3	3	3	2	3							
		Professional Elective IV												
		Professional Elective V												
		Open Elective												
		Audit Course II												
		Biomolecular Simulations Lab	2	3	3	2	3							
		Mini Project with Seminar	3	3	3	2	3	2	2	3	1	3	2	1

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YEAR II	SEMESTER III	Analytical Techniques and Methods Lab	2	3	3	2	3							
		Big Data Analytics and Next Generation Sequencing Lab	2	3	3	3	3							
		Systems Biology Lab	3	3	3	2	3							
		Project Phase I	3	3	3	3	3	2	2	3	1	3	2	1
	SEMESTER IV	Project Phase II	3	3	3	3	3	2	2	3	1	3	2	1

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

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UNIVERSITY DEPARTMENTS
M. TECH. COMPUTATIONAL BIOLOGY
REGULATIONS – 2019
CHOICE BASED CREDIT SYSTEM CURRICULUM AND SYLLABI FOR I TO IV SEMESTERS

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1	BC5101	Concepts in Computational Biology	PCC	3	0	0	3	3
2	BC5102	Python and its applications in Computational Biology	PCC	3	0	0	3	3
3	BC5103	Algorithms in Computational Biology	PCC	2	0	2	4	3
4		Professional Elective I	PEC	3	0	0	3	3
5		Professional Elective II	PEC	3	0	0	3	3
6		Professional Elective III	PEC	3	0	0	3	3
7	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2
8		Audit Course I*	AC	2	0	0	2	0
PRACTICALS								
9	BC5111	Python and its applications in Computational Biology Lab	PCC	0	0	4	4	2
			TOTAL	**21**	**0**	**6**	**27**	**22**

*Audit Course is Optional

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SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1	BC5201	Machine Learning and Data Mining	PCC	2	0	2	4	3
2	BC5202	Biomolecular Simulations	PCC	3	0	0	3	3
3	BC5203	Big Data Analytics and Next Generation Sequencing	PCC	3	0	0	3	3
4		Professional Elective IV	PEC	3	0	0	3	3
5		Professional Elective V	PEC	3	0	0	3	3
6		Open Elective	OEC	3	0	0	3	3
7		Audit Course II*	AC	2	0	0	2	0
PRACTICALS								
8	BC5211	Biomolecular Simulations Lab	PCC	0	0	4	4	2
9	BC5212	Mini Project with Seminar	EEC	0	1	2	3	2
			TOTAL	**19**	**1**	**8**	**28**	**22**

*Audit Course is Optional

SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1	BC5311	Analytical Techniques and Methods Lab	PCC	0	0	6	6	3
2	BC5312	Big Data Analytics and Next Generation Sequencing Lab	PCC	0	0	4	4	2
3	BC5313	Systems Biology Lab	PCC	1	0	4	5	3
4	BC5314	Project Phase - I	EEC	0	0	12	12	6
			TOTAL	**1**	**0**	**26**	**27**	**14**

SEMESTER IV

S. No.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	BC5411	Project Phase - II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS: 70

PROFESSSIONAL CORE (PCC)

S. No.	CODE NO	COURSE TITLE	L	T	P	CREDITS	SEMESTER
1.	BC5101	Concepts in Computational Biology	3	0	0	3	I
2.	BC5102	Python and its applications in Computational Biology	3	0	0	3	I
3.	BC5103	Algorithms in Computational Biology	2	0	2	3	I
4.	BC5111	Python and its applications in Computational Biology Lab	0	0	4	2	I
5.	BC5201	Machine Learning and Data Mining	2	0	2	3	II
6.	BC5202	Biomolecular Simulations	3	0	0	3	II
7.	BC5203	Big Data Analytics and Next Generation Sequencing	3	0	0	3	II
8.	BC5211	Biomolecular Simulations Lab	0	0	4	2	II
9	BC5311	Analytical Techniques and Methods Lab	0	0	6	3	III
10	BC5312	Big Data Analytics and Next Generation Sequencing Lab	0	0	4	2	III
11	BC5313	Systems Biology Lab	1	0	4	3	III

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PROFESSIONAL ELECTIVES (PEC)

S.No.	COURSE CODE	COURSE TITLE	CATE GORY	TOTAL CONTACT PERIODS	L	T	P	C
1.	BC5001	Analytical Techniques and Methods	PEC	3	3	0	0	3
2.	BC5002	Foundations of Biology	PEC	3	3	0	0	3
3.	BC5003	Computational Drug Discovery	PEC	3	3	0	0	3
4.	BC5004	Molecular Evolution and Phylogeny	PEC	3	3	0	0	3
5.	BC5005	Java in Computational Biology	PEC	3	3	0	0	3
6.	BT5252	Applied Genomics and Proteomics	PEC	3	3	0	0	3
7.	BT5072	Enzyme Engineering and Technology	PEC	3	3	0	0	3
8.	BT5153	Metabolic Engineering	PEC	3	3	0	0	3
9.	BT5073	Nano biotechnology	PEC	3	3	0	0	3
10.	BT5071	Applied Statistics for Biologists	PEC	3	2	1	0	3
11.	BP5071	Advances in Pharmacogenomics	PEC	3	3	0	0	3
12.	BC5071	Structural Biology	PEC	4	2	0	2	3
13.	BC5006	Computational Systems Biology	PEC	3	3	0	0	3
14.	BC5007	Signal Processing in Biotechnology	PEC	3	3	0	0	3
15.	BC5008	High Performance Computing	PEC	3	3	0	0	3
16.	BC5072	Synthetic Biology	PEC	3	3	0	0	3

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RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. No.	CODE NO.	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1	RM5151	Research Methodology and IPR	2	0	0	2	1

OPEN ELECTIVE COURSES [OEC]*

*(Out of 6 Courses one Course must be selected)

S.NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	OE5091	Business Data Analytics	3	0	0	3	3
2.	OE5092	Industrial Safety	3	0	0	3	3
3.	OE5093	Operations Research	3	0	0	3	3
4.	OE5094	Cost Management of Engineering Projects	3	0	0	3	3
5.	OE5095	Composite Materials	3	0	0	3	3
6.	OE5096	Waste to Energy	3	0	0	3	3

AUDIT COURSES (AC)

Registration for any of these courses is optional to students

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	AX5091	English for Research Paper Writing	2	0	0	0	1/2
2.	AX5092	Disaster Management	2	0	0	0	
3.	AX5093	Sanskrit for Technical Knowledge	2	0	0	0	
4.	AX5094	Value Education	2	0	0	0	
5.	AX5095	Constitution of India	2	0	0	0	
6.	AX5096	Pedagogy Studies	2	0	0	0	
7.	AX5097	Stress Management by Yoga	2	0	0	0	
8.	AX5098	Personality Development Through Life Enlightenment Skills	2	0	0	0	
9.	AX5099	Unnat Bharat Abhiyan	2	0	0	0	

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EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No.	CODE NO.	COURSE NAME	L	T	P	CREDITS	SEMESTER
1	BC5212	Mini project with seminar	0	1	2	2	II
2	BC5314	Project Phase – I	12	0	0	6	III
3	BC5411	Project Phase – II	24	0	0	12	IV

SUMMARY

CATGEORY	SEM 1	SEM 2	SEM 3	SEM 4	Total
PCC	11	11	8		30
PEC	9	6			15
RMC	2				2
AC (Non Credit)	0	0			0
OEC		3			3
EEC		2	6	12	20
Total Credit	22	22	14	12	**70**

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SYLLABI

SEMESTER I

BC5101	CONCEPTS IN COMPUTATIONAL BIOLOGY	L T P C
		3 0 0 3

OBJECTIVES

The course aims to,

- Introduce biological data resources and bioinformatics tools for analysis
- Acquaint the student with techniques for phylogenetic studies, protein modeling, analysis of proteomic, genomic and transcriptomic data
- Introduce database management system for biological data storage and query

UNIT I INTRODUCTION TO BIOLOGICAL SEQUENCES AND DATABASES 9

Molecular sequences, Genome sequencing: pipeline and data, Next generation sequencing data, Biological databases: Protein, Nucleotide, Genomic, Transcriptomic and other specialized databases, Sequence Alignment, Local and Global Alignment, Basic Local Alignment tool and its applications, Functional Annotation, Multiple sequence alignment, Profiles and Motifs.

UNIT II 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 III PROTEIN STRUCTURE, MODELLING AND DOCKING 9

Protein Structure Basics, Visualization, Prediction of Secondary Structure and Tertiary Structure, Homology Modeling, Comparison of protein structures, Molecular Docking principles, tools and applications.

UNIT IV INFORMATICS TECHNIQUES FOR ANALYSIS OF GENOMICS, PROTEOMICS AND TRANSCRIPTOMICS DATA 9

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

UNIT V DATABASE MANAGEMENT SYSTEM 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, Phylogeneticssoftware, Homology Modeling and Model evaluation, AutoDock, SQL Language commands, SQL functions and queries.

TOTAL:45 PERIODS

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OUTCOMES:

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

CO1 Acquire knowledge of basic bioinformatics and computational biology concepts and tools

CO2 Perform analysis of biological data including proteomic, genomic and transcriptomic data and provide meaningful interpretation of the results

CO3 Get acquainted with biological data storage using a database management system and run queries using SQL

TEXTBOOKS AND 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

Course Articulation Matrix

Course Outcome Statements		Program Outcome (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	Acquire knowledge of basic bioinformatics and computational biology concepts and tools	3	3	3	2	3	–	–	–	–	–	–	–
CO2	Perform analysis of biological data including proteomic, genomic and transcriptomic data and provide meaningful interpretation of the results	3	3	3	2	3	–	–	–	–	–	–	–
CO3	Get acquainted with biological data storage using a database management system and run queries using SQL	3	3	3	2	3	–	–	–	–	–	–	–
Overall CO		3	3	3	2	3	–	–	–	–	–	–	–

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

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BC5102 **PYTHON AND ITS APPLICATIONS IN COMPUTATIONAL BIOLOGY** **L T P C**
3 0 0 3

OBJECTIVES

The course aims to,

- Introduce Linux and Python to the students
- Provide basics of Python and Object Oriented Programming
- Help the students to solve biological relevant problems, to use python powerful tools and to learn Biopython and Numpy.

UNIT I INTRODUCTION TO LINUX AND PYTHON 9

Introduction to Linux environment, Linux File System, Basic Linux Commands, Shell Programming -grep, awk, Introduction to Python programmimg, 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, CGI in Python, Web programs for python

UNIT V BIOPYTHON AND NUMPY 9

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

TOTAL :45 PERIODS

OUTCOMES:

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

CO1 Understand object oriented programming concepts
CO2 Write efficient programs in Python
CO3 Apply Biopython and Numpy to solve biological related problems

TEXTBOOKS AND 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 Statements		Program Outcome (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	Understand object oriented programming concepts	3	3	3	2	3	–	–	–	–	–	–	–
CO2	Write efficient programs in Python	3	3	3	2	3	–	–	–	–	–	–	–
CO3	Apply Biopython and Numpy to solve biological related problems	3	3	3	2	3	–	–	–	–	–	–	–
Overall CO		3	3	3	2	3	–	–	–	–	–	–	–

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

BC5103 ALGORITHMS IN COMPUTATIONAL BIOLOGY L T P C
2 0 2 3

OBJECTIVES

The course aims to,

- Introduce the student to algorithms, running time and complexity
- Understand exact and heuristic protein and nucleotide sequence related algorithms
- Understand DNA sequence assembly related algorithms

UNIT I INTRODUCTION TO ALGORITHM 12

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 12

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 12

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.

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UNIT IV DYNAMIC PROGRAMMING AND SEQUENCE BASED ALGORITHMS 12

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 12

DNA sequencing, shortest super-string problem, Sequencing by Hybridization as a Hamiltonian Path Problem, Consecutive ones 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.

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

TOTAL:60 PERIODS

OUTCOMES:

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

CO1 Appreciate the design and implementation of algorithms used in Computational Biology
CO2 Make meaningful interpretations and effective choices while using tools based on these algorithms
CO3 Formulate simple algorithms for user defined problems

TEXTBOOKS AND 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.

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Course Articulation Matrix

Course Outcome Statements		Program Outcome (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	Appreciate the design and implementation of algorithms used in Computational Biology	3	3	3	3	3	–	–	–	–	–	–	–
CO2	Make meaningful interpretations and effective choices while using tools based on these algorithms	3	3	3	3	3	–	–	–	–	–	–	–
CO3	Formulate simple algorithms for user defined problems	3	3	3	3	3	–	–	–	–	–	–	–
Overall CO		3	3	3	3	3	–	–	–	–	–	–	–

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

RM5151 RESEARCH METHODOLOGY AND IPR LT P C 2 0 0 2

COURSE OBJECTIVES:

To impart knowledge and skills required for research and IPR:

- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

UNIT I RESEARCH PROBLEM FORMULATION 6

Meaning of research problem- Sources of research problem, criteria characteristics of a good research problem, errors in selecting a research problem, scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations

UNIT II LITERATURE REVIEW 6

Effective literature studies approaches, analysis, plagiarism, and research ethics.

UNIT III TECHNICALWRITING /PRESENTATION 6

Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal, a presentation and assessment by a review committee.

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UNIT IV INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc.

Traditional knowledge Case Studies, IPR and IITs.

TOTAL: 30 PERIODS

COURCE OUTCOMES:

1. Ability to formulate research problem
2. Ability to carry out research analysis
3. Ability to follow research ethics
4. Ability to understand that today' s world is controlled by Computer, Information
   Technology, but tomorrow world will be ruled by ideas, concept, and creativity
5. Ability to understand about IPR and filing patents in R & D.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2	✓											
CO3	✓							✓				
CO4	✓				✓							
CO5	✓					✓						✓

REFERENCES:

1. Asimov, " Introduction to Design" , Prentice Hall, 1962.
2. Halbert, " Resisting Intellectual Property" , Taylor & Francis Ltd ,2007.
3. Mayall, " Industrial Design" , McGraw Hill, 1992.
4. Niebel, " Product Design" , McGraw Hill, 1974.
5. Ranjit Kumar, 2nd Edition, " Research Methodology: A Step by Step Guide for beginners" 2010

BC5111 **PYTHON AND ITS APPLICATIONS IN COMPUTATIONAL BIOLOGY LAB** **L T P C**
0 0 4 2

OBJECTIVES

The course aims to,

- Familiarize themselves in Linux
- Do programs in Python
- Train in Biopython and Numpy

LIST OF EXPERIMENTS

1) Linux Environment, How to install software, Basic Linux commands, Text editors
2) Exercises on grep and awk,
   Programs based on
3) Functions and Modules
4) Strings, tuples, list, Dictionaries,
5) Conditional, Loops and Iterations.
6) Classes and methods,
7) Inheritance, Exception handling
8) File handling and Exception Handling
9) Pattern Matching
10) Web Programming -1
11) Web Programming -2
12) Biopython – 1
13) Biopython-2

TOTAL :60 PERIODS

OUTCOMES:

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

CO1 Work in Linux Environment and use Linux commands
CO2 Do programs in Python for Biological problems
CO3 Do programs using Biopython and Numpy

Course Articulation Matrix

Course Outcome Statements		Program Outcome (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	Work in Linux Environment and use Linux commands	2	3	3	3	3	–	–	–	–	–	–	–
CO2	Do programs in Python for Biological problems	2	3	3	3	3	–	–	–	–	–	–	–
CO3	Do programs using Biopython and Numpy	2	3	3	3	3	–	–	–	–	–	–	–
Overall CO		2	3	3	3	3	–	–	–	–	–	–	–

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

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SEMESTER II

BC5201	MACHINE LEARNING AND DATA MINING	L T P C 2 0 2 3

OBJECTIVES

The course aims to,

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

UNIT I MACHINE LEARNING 12

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 12

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 12

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 12

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 12

Frequent itemsets, Interestingness measures: Support, Confidence. Frequent Itemset Mining methods- Apriori algorithm, Frequent Pattern tree algorithm, Association mining-correlation analysis.

TOTAL :60 PERIODS

OUTCOMES:

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

CO1 Understand the concepts and utilize machine learning techniques for training and classification of biological data and prediction

CO2 Design multidimensional data models and formulate queries with Data Mining Query Language

CO3 Perform data mining and extract interesting patterns and rules

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TEXT BOOKS AND REFERENCES

1. Jiawei Han, MichelineKambler "Data Mining: Concepts and Techniques", Third Edition (2012) Morgan Kaufman Publishers.ISBN-13: 978-0123814791
2. Ian H.WittenEibe 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)

Course Articulation Matrix

Course Outcome Statements		Program Outcome (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	Understand the concepts and utilize machine learning techniques for training and classification of biological data and prediction	3	3	3	2	3	–	–	–	–	–	–	–
CO2	Design multidimensional data models and formulate queries with Data Mining Query Language	3	3	3	2	3	–	–	–	–	–	–	–
CO3	Perform data mining and extract interesting patterns and rules	3	3	3	2	3	–	–	–	–	–	–	–
Overall CO		3	3	3	2	3	–	–	–	–	–	–	–

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

Attested

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BC5202 **BIOMOLECULAR SIMULATIONS** **L T P C**
3 0 0 3

OBJECTIVES

The course aims to,

- Introduce the principles and practices on Molecular Modeling, in particular simulation of biological macromolecules
- Provide skills needed to perform MD Simulation
- Aid the students to do Docking 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

Introduction - Homology Modeling, Drug discovery process, Methods and Tools in Computer-aided molecular Design, Docking, De Novo Drug Design, Virtual screening, Introduction to Parallel Processing Concepts- task, thread; Models - SIMD, MIMD, Dataflow Models , Architectures- multi-core, multi-threaded, Parallel Computing and MD Simulation

TOTAL:45 PERIODS

OUTCOMES

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

CO1 Learn Molecular Dynamics Simulation and Docking principles

CO2 Perform docking of biomolecules and ligands and interpret the results

CO3 Carry out and interpret MD simulation to address biological questions related to biomolecules

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TEXT BOOKS AND 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 Statements		Program Outcome (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	Learn Molecular Dynamics Simulation and Docking principles	3	3	3	2	3	–	–	–	–	–	–	–
CO2	Perform docking of biomolecules and ligands and interpret the results	3	3	3	2	3	–	–	–	–	–	–	–
CO3	Carry out and interpret MD simulation to address biological questions related to biomolecules	3	3	3	2	3	–	–	–	–	–	–	–
Overall CO		3	3	3	2	3	–	–	–	–	–	–	–

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

BC5203 **BIG DATA ANALYTICS AND NEXT GENERATION SEQUENCING** **L T P C**
3 0 0 3

OBJECTIVES

The course aims to,

- Know the emerging area of next generation sequencing
- Familiarize them with NGS platforms, big data analysis
- Familiarize them with 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 understand NGS data

CO2 Familiarize with Big data tools and its applications

CO3 understand the usage of R package for analysis

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TEXTBOOKS AND 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 Roos David 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 Statements		Program Outcome (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	understand NGS data	3	3	3	2	3	–	–	–	–	–	–	–
CO2	Familiarize with Big data tools and its applications	3	3	3	2	3	–	–	–	–	–	–	–
CO3	understand the usage of R package for analysis	3	3	3	2	3	–	–	–	–	–	–	–
Overall CO		3	3	3	2	3	–	–	–	–	–	–	–

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

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BD5211 **BIOMOLECULAR SIMULATIONS LAB** **L T P C**
0 0 4 2

OBJECTIVES

The course aims to,

- Learn Visualisation and Modelling tools
- Learn MD Simulation, and Docking Tools
- Analyse and interpret the results of the MD Simulation and Docking experiments

LIST OF EXPERIMENTS

1) Visualisation of Biomolecules using Visualisation Software - PyMol
2) PDB file analysis using Visualisation Tools such as PyMol
3) Modeling of Protein Structures
4) GROMACS Introduction and Installation
5) Setting up Molecular Dynamics Simulation of a Protein
6) Running and analysing Molecular Dynamics Simulation of Protein
7) Docking of Protein – Ligand
8) Docking of Protein – Ligand with different Parameters
9) MD Simulation of Protein-Ligand Complex
10) Analysis of Simulation of Protein-Ligand Complex
11) MD Simulation and Parallel Computing
12) Case Studies of MD Simulation

TOTAL :60 PERIODS

OUTCOMES:

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

CO1 Perform and interpret MD simulation and docking experiments on biomolecules
CO2 Choose and use appropriate tools for a given biological problem
CO3 Address biological questions related to biomolecules

Course Articulation Matrix

Course Outcome Statements		Program Outcome (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	Perform and interpret MD simulation and docking experiments on biomolecules	2	3	3	2	3	–	–	–	–	–	–	–
CO2	Choose and use appropriate tools for a given biological problem	2	3	3	2	3	–	–	–	–	–	–	–
CO3	Address biological questions related to biomolecules	2	3	3	2	3	–	–	–	–	–	–	–
Overall CO		2	3	3	2	3	–	–	–	–	–	–	–

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

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BC5212 **MINI PROJECT WITH SEMINAR** **L T P C**
0 1 2 2

OBJECTIVES

The course aims to

- encourage the students to get connected with relevant industries/laboratory/research institutes
- acquire knowledge on solving practical problems, gaining work experience and skills
- learn the basics of research methodologies in academic/industrial/research environment

The students individually undergo training in reputed companies/research institutes/ organizations for the specified duration

OUTCOMES:

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

CO 1 learn methods and procedures from industrial/academic/research institute
CO2 gain experience to work as an member in industrial or research team for
CO 3 acquire practical knowledge and enhance skills

Course Articulation Matrix

Course outcome Statements		Programme outcomes (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	learn to work in an industrial/academic/research institute	1	3	2	3	3	3	2	3	2	3	2	3
CO2	gain experience to work as an individual as well as a member of a team	1	3	2	3	3	3	2	3	2	3	2	3
CO3	acquire practical knowledge and enhance skills	1	3	2	3	3	3	2	3	2	3	2	3
Overall CO		1	3	2	3	3	3	2	3	2	3	2	3

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

(Students are expected to do mini project and present seminars along with report on mini project.)

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SEMESTER III

BC5311	ANALYTICAL TECHNIQUES AND METHODS LAB	L T PC 0 0 6 3

OBJECTIVES

The course aims to,

- Relevant preparative techniques required in research and industry
- Analytical techniques required in research or Industry
- Spectroscopy, Separation methods and Electrochemistry

which will prepare him/her for a career in research or employment in the biotech Industry.

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 vsoligomeric, 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:

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

CO1 Become capable in enzymology, techniques required in the quantitation of biomolecules
CO2 Develop skills in downstream processing techniques
CO3 Be familiarized with the chemical modification of proteins

TEXTBOOKS AND REFERENCES

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

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Course Articulation Matrix

Course Outcome Statements		Program Outcome (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	Become capable in enzymology, techniques required in the quantitation of biomolecules	2	3	3	2	3	–	–	–	–	–	–	–
CO2	Develop skills in downstream processing techniques	2	3	3	2	3	–	–	–	–	–	–	–
CO3	Be familiarized with the chemical modification of proteins	2	3	3	2	3	–	–	–	–	–	–	–
Overall CO		2	3	3	2	3	–	–	–	–	–	–	–

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

BC5312 BIG DATA ANALYTICS AND NEXT GENERATION SEQUENCING LAB

L T P C
0 0 4 2

OBJECTIVES

The course aims to,

- Give hands on session in SQL, Hadoop
- Give hands on session in big Data Analytics techniques
- Give hands on session in NGS techniques and Programming with R

LIST OF EXPERIMENTS

1. SQL :- Create a table, Input Data, Retrieve data, Delete data, Run basic Queries,
2. (i)Perform setting up and Installing Hadoop in its two operating modes:
   a) Pseudo distributed,
   b) Fully distributed.
   (ii) Use web based tools to monitor your Hadoop setup.
3. (i) Implement the following file management tasks in Hadoop:
   a) Adding files and directories
   b) Retrieving files
   c) Deleting files
   ii) Benchmark and stress test an Apache Hadoop cluster
4. Run a basic Word Count Map Reduce program to understand Map Reduce Paradigm.
   a) Find the number of occurrence of each word appearing in the input file(s)

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b) Performing a MapReduce Job for word search count (look for specific keywords in a file)

5. Amazon Web Service (AWS) introduction and basic handling.
6. Galaxy introduction
    a. Input of Sequence
    b. Analysis of Sequence
    c. Reference Mapping
7. RNA sequence analysis and Gene Expression
8. CpG island analysis
9. Metabolic Map Development from Whole genome Analysis of E.coli
10. Programming with R
    a. Analyse a Data and find the Mean, Median, and Mode.
    b. Draw Bar Chart for the data and perform ANNOVA
11. 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 Understand and utilize Big Data Tools

CO2 Understand and utilize NGS data

CO3 Implement programs using R

Course Articulation Matrix

Course Outcome Statements		Program Outcome (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	Understand and utilize Big Data Tools	2	3	3	3	3	–	–	–	–	–	–	–
CO2	Understand and utilize NGS data	2	3	3	3	3	–	–	–	–	–	–	–
CO3	Implement programs using R	2	3	3	3	3	–	–	–	–	–	–	–
Overall CO		2	3	3	3	3	–	–	–	–	–	–	–

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

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BC5313	SYSTEMS BIOLOGY LAB	L T P C
		1 0 4 3

OBJECTIVES:

The course aims to,

- introduce the student to Systems Biology data resources and tools
- help build simple kinetic models
- help build metabolic models for flux balance analysis

LIST OF EXPERIMENTS

1. Databases and Data Retrieval
2. SBML Basics
3. SBML editors and SBML code for a pathway
4. Matlab basics
5. Systems Biology toolbox in Matlab
6. Extracting kinetic constants from databases and literature
7. Building a kinetic model for a pathway
8. Running the simulation and altering parameters of the kinetic model for optimization
9. Metabolic reconstruction tools and resources for flux balance analysis
10. Building stoichiometric matrices for metabolic models in flux balance analysis
11. Setting objective functions for flux balance analysis
12. Building and analyzing a simple model for flux balance analysis

TOTAL :75 PERIODS

OUTCOMES:

At the end of the course students will be able,

CO1 To retrieve data and parameters necessary for developing models

CO2 To build kinetic models and metabolic models for flux balance analysis using Systems Biology tools

CO3 Run simulations, analyze and interpret the data that would help in interdisciplinary studies.

TEXTBOOKS AND 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, Christoph Wierling, Hans Lehrach, " Systems Biology in Practice : concepts, implementation and application" , Wiley-VCH, 2005

Course Articulation Matrix

Course Outcome Statements		Program Outcome (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	To retrieve data and parameters necessary for developing models	3	3	3	2	3	–	–	–	–	–	–	–
CO2	To build kinetic models and metabolic models for flux balance analysis using Systems Biology tools	3	3	3	2	3	–	–	–	–	–	–	–
CO3	Run simulations, analyze and interpret the data that would help in interdisciplinary studies	3	3	3	2	3	–	–	–	–	–	–	–
Overall CO		3	3	3	2	3	–	–	–	–	–	–	–

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

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BC5314 **PROJECT PHASE - I** **L T P C**
0 0 12 6

OBJECTIVES

The course aims to

- To train the students to identify and formulate a research / industry oriented problem relevant to their area of interest in Computational Biology
- To equip them with necessary skills to carry out the research / industry oriented problem

OUTCOMES:

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

CO 1 identify and formulate a research problem

CO 2 carry out the research problem and come up with a logical solution

Course Articulation Matrix

Course outcome Statements		Programme outcomes (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	identify and formulate a research problem	2	3	2	2	1	2	-	2	2	1	1	2
CO2	carry out the research problem and come up with a logical solution	2	3	2	2	1	2	-	2	2	1	1	2
Overall CO		2	3	2	2	1	2	-	2	2	1	1	2

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

SEMESTER IV

BC5411 **PROJECT PHASE - II** **L T P C**
0 0 24 12

OBJECTIVES

The course aims to

- Train students to address a research / industry oriented problem and come up with innovative solutions

- Help the students to develop novel algorithms / programs / apply software tools / conduct experiments and collect, analyze and interpret the data

OUTCOMES:

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

CO 1 Use an interdisciplinary approach to research / industry oriented problems

CO 2 Come up with innovative solutions to problems

CO 3 Analyze and interpret the data and develop novel algorithms / provide experimental leads to research / industry oriented problems

Course Articulation Matrix

Course outcome Statements		Programme outcomes (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO 1	Use an interdisciplinary approach to research / industry oriented problems	2	3	3	3	3	2	-	2	2	2	1	2
CO 2	come up with innovative solutions to problems	2	3	3	3	3	2	-	2	2	2	1	2
CO 3	analyze and interpret the data and develop novel algorithms / provide experimental leads to research / industry oriented problems	2	3	3	3	3	2	-	2	2	2	1	2
Overall CO		2	3	3	3	3	2	-	2	2	2	1	2

Attested

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

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ELECTIVES

BC5001 ANALYTICAL TECHNIQUES AND METHODS L T P C
3 0 0 3

OBJECTIVES

The course aims to,

- Introduce basic concepts and analytical techniques and methods in microscopy
- Provide concepts in spectroscopy
- Introduce basics of separation methods, electrochemistry 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

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

CO1 Gain knowledge in the working and principles of various analytical techniques

CO2 design their experiments

CO3 analyse the data and results obtained

TEXTBOOKS AND 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 Statements		Program Outcome (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	Gain knowledge in the working and principles of various analytical techniques	2	3	3	2	3	–	–	–	–	–	–	–
CO2	Able to design their experiments	2	3	3	2	3	–	–	–	–	–	–	–
CO3	Able to analyze the data and results obtained	2	3	3	2	3	–	–	–	–	–	–	–
Overall CO		2	3	3	2	3	–	–	–	–	–	–	–

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

BC5002 FOUNDATIONS OF BIOLOGY L T P C
3 0 0 3

OBJECTIVES

The course aims to,

- Introduce general concepts in Biology
- Serve as a primer to the more advanced courses in Biology
- Introduce 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

Attested

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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 Familiar with organization of the cell, bio-molecules

CO2 understand basic principles of biochemistry

CO3 understand the basics of molecular biology

TEXTBOOKS AND 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 Statements		Program Outcome (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	Familiar with organization of the cell, bio-molecules	2	3	3	1	1	–	–	–	–	–	–	–
CO2	understand basic principles of biochemistry	2	3	3	1	1	–	–	–	–	–	–	–
CO3	understand the basics of molecular biology	2	3	3	1	1	–	–	–	–	–	–	–
Overall CO		2	3	3	1	1	–	–	–	–	–	–	–

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

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BC5003 **COMPUTATIONAL DRUG DISCOVERY** **L T P C**
3 0 0 3

OBJECTIVES

This course aims to,

- Learn the overview of drug discovery pipeline
- Learn the concepts of high throughput screening
- Understand 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.

TOTAL :45 PERIODS

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OUTCOMES:

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

CO1 Gain knowledge on different aspects of drug discovery process

CO2 learn regulatory affairs and IPR

CO3 apply Computational drug Discovery for industrial and academic research

TEXTBOOKS AND 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 Statements		Program Outcome (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	Gain knowledge on different aspects of drug discovery process	2	3	3	1	2	–	–	–	–	–	–	–
CO2	learn regulatory affairs and IPR	2	3	3	1	2	–	–	–	–	–	–	–
CO3	apply Computational drug Discovery for industrial and academic research	2	3	3	1	2	–	–	–	–	–	–	–
Overall CO		2	3	3	1	2	–	–	–	–	–	–	–

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

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BC5004 MOLECULAR EVOLUTION AND PHYLOGENY L T P C
3 0 0 3

OBJECTIVES

The course aims to,

- Understand the Molecular aspects of evolution
- Explore the different Models of evolution
- Understand 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.

UNITII 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. Humanmolecular 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 students will be able to,

CO1 Understand molecular basis of evolution

CO2 Learn phylogeny

CO3 Understand different models of evolution

TEXTBOOKS AND 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

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Course Articulation Matrix

Course Outcome Statements		Program Outcome (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	Understand the molecular basis of evolution	2	3	2	1	2	–	–	–	–	–	–	–
CO2	Learn phylogeny	2	3	2	1	2	–	–	–	–	–	–	–
CO3	Understand different models of evolution	2	3	2	1	2	–	–	–	–	–	–	–
Overall CO		2	3	2	1	2	–	–	–	–	–	–	–

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

BC5005 JAVA IN COMPUTATIONAL BIOLOGY L T P C
3 0 0 3

OBJECTIVES

The course aims to,

- Introduce Java programming language basics to the students
- Provide basics of Applets and Java Networking and BioJava
- Help 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:

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

CO1 Understand and do the Java Programs

CO2 Do programs using Java Applets and Java Networks

CO3 Apply Java programming language to computational biology problems

TEXTBOOKS AND 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.

Course Articulation Matrix

Course Outcome Statements		Program Outcome (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	Understand and do the Java Programs	2	3	3	2	3	–	–	–	–	–	–	–
CO2	Do programs using Java Applets and Java Networks	2	3	3	2	3	–	–	–	–	–	–	–
CO3	Apply Java programming language to computational biology problems	2	3	3	2	3	–	–	–	–	–	–	–
Overall CO		2	3	3	2	3	–	–	–	–	–	–	–

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

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BT5252 APPLIED GENOMICS AND PROTEOMICS LT PC 3 0 0 3

OBJECTIVES

The course aims to,

- provide advanced theoretical knowledge on the organization and function of genomes,
- functional genomic analyses, and advanced methods and approaches in proteomics.

UNIT I STRUCTURE OF GENOMES, MAPPING AND SEQUENCING 9

Organization and structure of genomes in prokaryotes, eukaryotes, andorganelles (chloroplast, mitochondrion); Genome mapping methods (genetic and physical);RAPD, RFLP, SNP analyses; Fluorescence In-Situ Hybridization (FISH) techniques;Advances in gene finding and functional prediction; Chain termination and chemical degradation sequencing methods.

UNIT II LARGE SCALE GENOMICS/ FUNCTIONAL GENOMICS ANALYSES 9

Genome-wide association (GWA) analysis; Comparative Genomic Hybridization (CGH); Massively Parallel Signature Sequencing(MPSS); Whole genome shot-gun sequencing and its applications. Introduction of Next Generation Sequencing (NGS).

UNIT III TRANSCRIPTOMICS ANALYSES 9

Gene expression analysis by cDNA and oligonucleotide arrays; Microarray experimental analysis and data analysis.Methylome analysis using microarray; ChIP-on-Chip analysis.Bioinformatic analysis of large-scale microarray data for comparative transcriptomics.

UNIT IV SEPARATION AND PROCESSING OF PROTEINS FOR PROTEOMICS 9

Overview of strategies used for the identification and analysis of proteins; Protein extraction from biological samples (Mammalian Tissues, Yeast, Bacteria, and PlantTissues); 2-DE of proteins for proteome analysis; Liquid chromatography separations in proteomics (Affinity, Ion Exchange, Reversed-phase, and size exclusion); Enzymatic cleavage of proteins. Analysis of complex protein mixtures using Nano-liquid chromatography (Nano-LC) coupled to Mass-spectrometry analysis.

UNIT V MASS SPECTROMETRY AND COMPARATIVE PROTEOMICS 9

Common ionization methods for peptide/protein analysis; Introduction to Mass spectrometers; MALDI-TOF and LC-MS analyses; Comparative proteomics based onglobal in-vitro and in-vivo labeling of proteins/peptides followed by Mass-spectrometry. Analysis of posttranslational modification (PTM) of proteins; Characterization of protein interactions using yeast two-hybrid system and Protein microarrays; Proteomics informatics and analysis of protein functions.

TOTAL:45 PERIODS

OUTCOMES:

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

CO1 have advanced theoretical knowledge on the organization and function of genomes
CO2 know functional genomics analyses
CO3 understand advanced methods and approaches in proteomics

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TEXTBOOKS AND REFERENCES

1. S.P. Hunt and F. J. Livesey, (2000) Functional Genomics
2. N. K. Spur, B. D. Young, and S. P. Bryant (1998) ICRF Handbook of Genome Analysis Volume 1 & 2.
3. G. Gibson and S. V. Muse (2002) A primer of Genome Science
4. R. J. Reece (2004) Analysis of Genes and Genomes
5. Rinaldis E. D. and Lahm A (2007)DNA Microarrays. Horizon bioscience.
6. Simpson R. J.“ Proteins and Proteomics - A Laboratory Manual” .Cold Spring Harbour 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 Statements		Programme Outcome (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	Have advanced theoretical knowledge on the organization and function of genomes	2				2	2		1		1	1	2
CO2	Know Functional genomic analyses	2	2		2		2		2		1	1	2
CO3	Understand advanced methods and approaches in proteomics	3	3		2	2	2		2		1	1	2
Overall CO		2	2		2	2	2		2		1	1	2

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

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BT5072 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.
- learn about immobilisation 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, Halflife, effect of pH and Temperature on enzyme activity Multisubstrate enzymes and kinetics mechanisms; Enzyme induction, repression, covalent modification, Isoenzymes, allosteric effects.

UNIT III 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

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OUTCOMES:

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

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

CO2 get knowledge about enzyme kinetics and different types of enzyme inhibition.

CO3 be exposed to various approaches of enzyme engineering and immobilization.

CO4 learn the applications of enzymes

TEXTBOOKS AND REFERENCES

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

Course Articulation Matrix

Course Outcome Statements		Programme Outcome (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	know about basics such as enzyme' s classification, action and factors affecting its activity.	3	1	1	1	1	-	-	-	1	-	-	2
CO2	gain knowledge about enzyme kinetics and different types of enzyme inhibition.	3	1	2	1	1	-	-	-	1	-	-	1
CO3	have exposure to various approaches of enzyme engineering and immobilization.	3	1	2	1	3	-	1	1	1	-	2	2
CO4	learn the applications of enzymes.	3	1	2	1	1	-	1	1	1	-	2	2
Overall CO		3	2	2	1	2	-	1	1	1	-	1	2

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

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BT5153 **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 the use of theoretical and experimental tools that can give insights into the structure and regulation of metabolic networks.
- identify the optimal strategy for introducing directed genetic changes in the microorganisms with the aim of obtaining better production strains.
- Case studies will be taken up on metabolically-engineered products and processes in various expression systems.

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/over/under determined 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 labeling 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, InsilicoCells: 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

Fundamental of 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-plastic and green chemical synthesis.Study of 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

OUTCOMES:

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

CO1 To gain insights of the metabolic flux analysis both theoretically and experimentally
CO2 To gain experience in the development of genome scale metabolic modelling
CO3 To have a clear understanding on metabolic control analysis
CO4 To understand metabolic engineering using real time examples case

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TEXT BOOKS AND 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, 2010.
5. Voit, E.O. " Computational Analysis of Biochemical Systems : A Practical Guide for Biochemists and Molecular Biologists" . Cambridge University Press, 2000.
6. Scheper, T. " Metabolic Engineering" Vol 73 (Advances in Biochemical Engineering Biotechnology) Springer, 2001.
7. Cortassa, S. et al, " An Introduction to Metabolic and Cellular Engineering" , World Scientific Publishing, 2002.
8. Kholodenko, Boris N and H. V. Westerhoff " Metabolic Engineering in the Post Genomic Era" , Horizon Bioscience, 2004.

Course Articulation Matrix

Course outcome Statements		Programme Outcome (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	To gain insights of the metabolic flux analysis both theoretically and experimentally	3	3	3	3	3	3	2	2	1	-	-	3
CO2	To gain experience in the development of genome scale metabolic modelling	2	3	3	2	-	-	-	-	-	-	-	3
CO3	To have a clear understanding on metabolic control analysis	3	2	3	3	-	2	3	-	-	-	-	3
CO4	To understand metabolic engineering using real time examples case	3	3	3	3	3	3	2	2	1	-	-	3
	Overall CO	3	3	3	3	3	3	2	2	1	-	-	3

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

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BT5073	NANOBIOTECHNOLOGY	L T P C 3 0 0 3

OBJECTIVES

The course aims to,

- provide fundamental concepts of nanotechnology.
- use the fundamental knowledge for the application of nanotechnology to biological sciences including nanomedicine .

UNIT I NANOSCALE 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 III PROPERTIES AND MEASUREMENT 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 nano carriers; 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 student will be able to,

CO1 Understand fundamental concepts of nanotechnology and nanomaterials

CO2 Have knowledge on the fabrication and characterization of nanomaterials

CO3 Understand nanobiology and modification of nanomaterials

CO4 Know nano-based drug delivery and nanomedicine

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TEXTBOOKS AND REFERENCES

1. Nano biotechnology: 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 OdedShoseyovandIlan Levy, Humana Press; 1 edition 2007.
3. Nano Biotechnology Protocols (Methods in Molecular Biology) by Sandra J Rosenthal And David 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 statements		Programme Outcome (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	understand fundamental concepts of nanotechnology and nanomaterials	2					2				1		2
CO2	have knowledge on the fabrication and characterization of nanomaterials	3		2			2		1				2
CO3	understand nanobiology and modification of nanomaterials	2	2		1	1	2	2	1				3
CO4	know nano-based drug delivery and nanomedicine	3	2		1	1	2	2	2	1		1	3
Overall CO		3	1	1	1	1	2	1	1	-	-	-	3

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

Attested

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BT5071	APPLIED STATISTICS FOR BIOLOGISTS	L T P C
		2 1 0 3

OBJECTIVES

The course aims to,

- Study the fundamentals of statistics.
- Apply the fundamentals of statistics in relation to biological and biotechnological problems.

UNIT I PROBABILITY 9

Random variable-sample spaces-Events-Axiomatic approach to probability, conditional probability, additional theorem, Multiplication theorem, Bayer' s theorem.Problem solving for continuous and discrete random variables, Distribution function, Expectation with properties, Moments, Mean, Variance.Problem solving for continuous and discrete distributions.

UNIT II DISTRIBUTION 9

Bivariate distribution, Conditional and Marginal distribution.Discrete distribution, Binomial, Poisson, Geometric distribution, Continuous distribution.Normal Exponential and Negative Exponential.Gamma distributions, Properties and Problem solving.

UNIT III METHODS OF CORRELATION 9

Correlation coefficient, Properties, Problems.Rank correlation, Regression equations Problems. Curve fitting by the method of least squares, fitting curves of the form $ax+b$,ax^2+bx+c,ab^x and ax^b. Bivariate correlation application to biological problems.

UNIT IV SAMPLING 9

Concept of sampling, Methods of sampling, sampling distributions and Standard Error.Small samples and large samples. Test of hypothesis: Type I,Type II Errors. Critical region, Large sample tests for proportion, Mean-Exact test based on normal, t, f and chi-square distribution. Problems, Test of goodness of fit.

UNIT V DESIGN OF EXPERIMENTS 9

Basic principles of experimentation. Analysis of variance, one-way, Two-way classifications. Randomised block design, Latin square design. Problems solving.

TOTAL:45 PERIODS

OUTCOMES:

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

CO1 Understand basic probability and distribution in statistics.

CO2 learn correlation and regression with sampling in biological experiments.

CO3 design experiments and justify the statistical significance of the results of the experiment in testing hypothesis.

CO4 Understand and apply statistical methods of analysis in biological research.

TEXT BOOKS AND REFERENCES

1. Kapoor, V. K. " Elements of Mathematical statistics" 3rd edition,2002. .
2. Vittal, P.R. and V.Malini." Statistical and Numerical Methods" . Margham Publications. 2012.
3. Veerarajan,T. " Probability, Statistics and Random Processes" .3rd Edition., Tata McGraw-Hill, 2008.
4. Johnson, R. A." Miller& Freund' s Probability and Statistics for Engineers" . 6 ed. PHI, 2003.
5. Arora, P. N. SmeetArora, and Arora, S. " Comprehensive Statistical Methods" . S. Chand & Co,1997.
6. Spiegel, Murray R., J.Schiller and R. AluSrinivasan. " Schaum' s Outlines Probability and Statistics" , 2nd Edition. Tata McGraw-Hill 2000.
7. Kandasamy, P. K. Thilagavathi& K. Gunavathi." Probability Statistics and Queuing Theory" . S. Chand & Co., 2004.

Course Articulation Matrix

Course Outcome Statements		Programme Outcome (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	To understand basic probability and distribution in statistics.	3	-	-	1	-	-	-	-	-	-	-	-
CO2	To be able to learn correlation and regression with sampling in biological experiments.	3	3	3	2	-	-	-	1	1	-	-	1
CO3	To be able to design experiments and justify the statistical significance of the results of the experiment in testing hypothesis.	3	3	3	1	-	-	-	1	1	-	2	3
CO4	To understand and apply statistical methods of analysis in biological research.	3	3	3	2	-	-	-	1	1	-	3	3
Overall CO		3	3	3	2	-	-	-	1	1	-	1	2

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

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BP5071 **ADVANCES IN PHARMACOGENOMICS** **L T P C**
3 0 0 3

OBJECTIVES

The course aims,

- To provide knowledge about Pharmacogenomics and drug design using genomic applications.
- To study the genome applications on drug action and toxicity.

UNIT I INTRODUCTION TO PHARMACOGENOMICS 9

Pharmacogenetics-The roots of pharmacogenomics, It is not just pharmacogenomics,Genetic drug response profiles, the effect of drugs on Gene expression, pharmacogenomics in drug discovery and drug development.

UNIT II THE HUMAN GENOME 9

Expressed sequence Tags (EST) and computational biology, Microbial genomics,computational analysis of whole genomes, computational genome analysis, Genomic differences that affect the outcome of host pathogen interactions: A template for the future of whole genome-based pharmacological science.

UNIT III ASSOCIATION STUDIES IN PHARMACOGENOMICS 9

Viability and ADR in drug response: contribution of genetic factor, Multiple inherited genetic factors influence the outcome of drug treatments, Plasma binding proteins, Drug targets.

UNIT IV GENOMICS APPLICATIONS FOR DRUG ACTION AND TOXICITY 9

Genomics, Proteomics, Bioinformatics, The pharmaceutical process, applications of pharmaceutical industry, Understanding biology and diseases, Target identification and validation, Drug candidate identification and optimization.

UNIT V PHARMACOGENOMICS AND DRUG DESIGN 9

The need of protein structure information, protein structure and variation in drug targets-the scale of problem, Mutation of drug target s leading to change in the ligand binding pocket.

TOTAL :45 PERIODS

OUTCOMES:

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

CO1 learn about the human genome, gene expression and their effect on drug therapy and toxicity

CO2 know about the influence of epigenetic on therapeutic outcome.

CO3 have a complete understanding about the fundamentals of pharmacogenomics and personalized medicine.

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TEXTBOOKS AND REFERENCES

1. Licinio, Julio and Ma-Li Wong, " Pharmacogenomics: The Search for the Individualized Therapies" , Wiley-VCH, 2002.
2. Chiranjib Chakraborty, and Bhattacharyya, Atane, " Pharmacogenomics: An Approach to New Drugs Development" , 2004.
3. Othstein, Mark, A. " Pharmacogenomics: Social, Ethical and Clinical Dimensions" , Wiley- Liss, 2003.

Course Articulation Matrix

Course Outcome Statements		Programme Outcome (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	Students will learn about the human genome, gene expression and their effect on drug therapy and toxicity	3	2	1	1	1	-	-	-	1	-	-	2
CO2	Students will be able to know about the influence of epigenetic on therapeutic outcome.	3	2	1	1	1	-	-	-	1	-	-	2
CO3	Students will have a complete understanding about the fundamentals of pharmacogenomics and personalized medicine.	3	2	1	1	1	-	-	2	1	-	-	2
Overall CO		3	2	1	1	1	-	-	1	1	-	-	2

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

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BC5071 **STRUCTURAL BIOLOGY** **L T P C**
2 0 2 3

OBJECTIVES

The course aims to,

- familiarize about the structural aspects of protein and DNA
- understand about biophysical techniques for structure determination
- learn about X-Ray Crystallography, NMR and cryoelectron microscopy

UNIT I STRUCTURE OF MACROMOLECULES - DNA 12

Scope of structural biology – implications, drug discovery, 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 - helical transitions. Non-uniform helical DNA Structure. Unusual DNA structures - hairpins, bulges, cruciform, triplexes, tetraplexes

UNIT II PROTEIN STRUCTURE AND FUNCTION 12

Fundamentals of protein structure, Structural Hierarchy, Motifs and domains: domain structures, Types of proteins, Complex proteins, methods to secondary structural elements and prediction, study of prototype protein under each category - alpha, beta, alpha-beta structures, lysozyme, immunoglobulins, thioredoxin, transferases, membrane proteins, structure of viruses; engineering and design of protein structures.

UNIT III X-RAY CRYSTALLOGRAPHY 12

Elementary crystallography: Introduction: symmetry in crystals, lattices and unit cells, crystal systems, Bravais lattices, Elements of symmetry, Symmetry operation: classes of symmetry operations, space groups concepts. X-ray diffraction - Bragg's law - reciprocal lattice and its application to geometrical Crystallography.

UNIT IV MODEL BUILDING AND REFINEMENT 12

X-ray scattering: Concept of resolution, Atomic scattering factor - diffraction by a space lattice - structure factor equation - electron density and Fourier Transform, solving phases, model building and refinement, R-factors, B-factor, ccp4 suite, and structure viewers. **Tutorial/Lab exercises –** Demonstration and practice of growing protein crystals (lysozyme, Thaumatin etc.,) by hanging drop and vapor diffusion methods, analysis of diffraction data and structure solution, exercise on refinement and model validation

UNIT V NMR AND CRYO-ELECTRON MICROSCOPY 12

Principle of Nuclear Magnetic Resonance - advantages, Nuclear spin, NMR sensitivity, shielding and deshielding effects, Nuclear Overhauser effect (NOE). Spectral parameters: chemical shift, spin-spin splitting, coupling, spin-spin splitting, proton spin decoupling, 1D- NMR spectra, 2D-NMR spectroscopy, Introduction to the principles of cryo-electron microscopy.

TOTAL : 60 PERIODS

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OUTCOMES:

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

CO 1 learn structural and functional aspects of protein and DNA

CO 2 understand biophysical techniques

CO 3 understand principles of macromolecular structure determination

TEXTBOOKS AND 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 N.Gautham Bioinformatics (2006) Narosa publications. ISBN-13: 9781842653005

6 VasanthaPattabhai and N.Gautham Biophysics (2002) Narosa Publishers ISBN 1-4020-0218-1

7 George H. Stout, Lyle H. Jensen, X-Ray Structure Determination: A Practical Guide, 2nd Edition.ISBN 0471607118. 2007

8 G. E. Schulz. Principles of Protein Structure. Springer 2013

9 Rick NG, Wiley Blackwell. Drugs: From discovery to approval 3rd edition (2015)

10 Ed Donald J Abraham Wiley-Interscience. Burger' s Medicinal Chemistry and Drug discovery. Volume 2, Drug Discovery and development.6th Edition (2003). ISBN 0471370282

11 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

12 The Nuclear Overhauser Effect in Structural and Conformational Analysis, by David Neuhaus Wiley-VCH; 2 edition, 2000, ISBN-10: 0471246751, ISBN-13: 978-0471246756

13 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 Statements		Program Outcome (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	learn Structural and functional aspects of protein and DNA	3	3	3	2	3	–	–	–	–	–	–	–
CO2	understand Biophysical Techniques	3	3	3	2	3	–	–	–	–	–	–	–
CO3	understand principles of macromolecular structure determination	3	3	3	2	3	–	–	–	–	–	–	–
Overall CO		3	3	3	2	3	–	–	–	–	–	–	–

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

Attested

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BC5006 **COMPUTATIONAL SYSTEMS BIOLOGY** **L T P C**
3 0 0 3

OBJECTIVES

The course aims to,

- Introduce Systems Biology concepts, Graph theory, network models and properties
- Familiarize with data resources and tools, kinetic modeling and flux balance analysis
- Understand network motifs, SBML and genome scale modeling

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 students will be able to,

CO1 Understand Systems Biology concepts, network models and properties from biological networks' perspective

CO2 Understand the design of kinetic models, flux balance analysis and interpret results

CO3 Get acquainted with the steps involved in genome scale modeling

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TEXTBOOKS AND 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 Statements		Program Outcome (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	Understand Systems Biology concepts, network models and properties from biological networks' perspective	3	3	3	2	3	–	–	–	–	–	–	–
CO2	Understand the design of kinetic models, flux balance analysis and interpret results	3	3	3	2	3	–	–	–	–	–	–	–
CO3	Get acquainted with the steps involved in genome scale modeling	3	3	3	2	3	–	–	–	–	–	–	–
Overall CO		3	3	3	2	3	–	–	–	–	–	–	–

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

Attested

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BC5007 **SIGNAL PROCESSING IN BIOTECHNOLOGY** **L T P C**
3 0 0 3

OBJECTIVES

The course aims to,

- Understand the Concepts of Signal Processing
- Familiarize students with Signals and Transforms
- Learn 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 this course the students will be able to,

CO1 Understand the concepts of Signal Processing

CO2 Learn Signals, Transforms and Detection Theory

CO3 Learn theory and applications of signal processing in biotechnology

TEXT BOOKS AND 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.

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Course Articulation Matrix:

Course Outcome Statements		Program Outcome (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	Understand the concepts of Signal Processing	3	3	3	2	3	–	–	–	–	–	–	–
CO2	Learn Signals, Transforms and Detection Theory	3	3	3	2	3	–	–	–	–	–	–	–
CO3	Learn theory and applications of signal processing in biotechnology	3	3	3	2	3	–	–	–	–	–	–	–
Overall CO		3	3	3	2	3	–	–	–	–	–	–	–

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

BC5008 HIGH PERFORMANCE COMPUTING L T P C
3 0 0 3

OBJECTIVES

The course aims to,

- Understand Parallel processing concepts
- Learn Parallel programming languages and GPU
- Learn applications of parallel programming concepts in Bioinformatics 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

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TOTAL :45 PERIODS

OUTCOMES:

At the end of this course students will be able to

CO1. Understand Parallel Computing concepts and GPU

CO2. Learn Parallel Programming Language

CO3. Apply Parallel Computing concepts to solve Computational Biology Problems

TEXTBOOKS AND 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 Statements		Program Outcome (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	Understand Parallel Computing concepts and GPU	2	3	3	2	3	–	–	–	–	–	–	–
CO2	Learn Parallel Programming Language	2	3	3	2	3	–	–	–	–	–	–	–
CO3	Apply Parallel Computing concepts to solve Computational Biology Problems	2	3	3	2	3	–	–	–	–	–	–	–
Overall CO		2	3	3	2	3	–	–	–	–	–	–	–

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

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BC5072	SYNTHETIC BIOLOGY	L T P C
		3 0 0 3

OBJECTIVES

The course aims to

- Familiarize with the concepts of modern DNA assembly techniques to build biological circuits
- Familiarize with the principles of designing biological circuits with control levels

UNIT I SYNTHETIC BIOLOGY – BIOLOGICAL COMPONENTS/CIRCUITS 9

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 ENGINEERING PRINCIPLES IN BIOLOGY 10

Structure and expression and regulation in prokaryotic and eukaryotic systems, Advanced biotechnological methods comprising cloning, mutagenesis, polymerase chain reaction, synthesis of nucleic acids, DNA sequence determination, synthetic genomics, CRISPR-Cas9, directed evolution, alternative splicing and computational modeling. Experimental characterisation of structural and functional properties of biomolecules

UNIT III 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 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 this course the students will be able to

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

CO2 Apply a scientific approach to the planning and overview of executing replicating systems with new properties that can be regulated

CO3 Critically analyse the results and generate testable hypotheses for synthetic biology experiments

TEXTBOOKS AND 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 Statements		Program Outcome (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	Describe how the regulation of the genes and properties of gene products can be altered with synthetic biology methods	2	3	3	2	3	–	–	–	–	–	–	1
CO2	Apply a scientific approach to the planning and overview of executing replicating systems with new properties that can be regulated	2	3	3	3	3	–	–	–	–	–	–	1
CO3	Critically analyse the results and generate testable hypotheses for synthetic biology experiments	2	3	3	3	3	–	–	–	–	–	–	1
Overall CO		2	3	3	3	3	–	–	–	–	–	–	1

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

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OPEN ELECTIVE COURSES (OEC)

OE5091 BUSINESS DATA ANALYTICS L T P C
3 0 0 3

OBJECTIVES:

- To understand the basics of business analytics and its life cycle.
- To gain knowledge about fundamental business analytics.
- To learn modeling for uncertainty and statistical inference.
- To understand analytics using Hadoop and Map Reduce frameworks.
- To acquire insight on other analytical frameworks.

UNIT I OVERVIEW OF BUSINESS ANALYTICS 9

Introduction – Drivers for Business Analytics – Applications of Business Analytics: Marketing and Sales, Human Resource, Healthcare, Product Design, Service Design, Customer Service and Support – Skills Required for a Business Analyst – Framework for Business Analytics Life Cycle for Business Analytics Process.

Suggested Activities:

- Case studies on applications involving business analytics.
- Converting real time decision making problems into hypothesis.
- Group discussion on entrepreneurial opportunities in Business Analytics.

Suggested Evaluation Methods:

- Assignment on business scenario and business analytical life cycle process.
- Group presentation on big data applications with societal need.
- Quiz on case studies.

UNIT II ESSENTIALS OF BUSINESS ANALYTICS 9

Descriptive Statistics – Using Data – Types of Data – Data Distribution Metrics: Frequency, Mean, Median, Mode, Range, Variance, Standard Deviation, Percentile, Quartile, z-Score, Covariance, Correlation – Data Visualization: Tables, Charts, Line Charts, Bar and Column Chart, Bubble Chart, Heat Map – Data Dashboards.

Suggested Activities:

- Solve numerical problems on basic statistics.
- Explore chart wizard in MS Excel Case using sample real time data for data visualization.
- Use R tool for data visualization.

Suggested Evaluation Methods:

- Assignment on descriptive analytics using benchmark data.
- Quiz on data visualization for univariate, bivariate data.

UNIT III MODELING UNCERTAINTY AND STATISTICAL INFERENCE 9

Modeling Uncertainty: Events and Probabilities – Conditional Probability – Random Variables – Discrete Probability Distributions – Continuous Probability Distribution – Statistical Inference: Data Sampling – Selecting a Sample – Point Estimation – Sampling Distributions – Interval Estimation – Hypothesis Testing.

Suggested Activities:

- Solving numerical problems in sampling, probability, probability distributions and hypothesis testing.
- Converting real time decision making problems into hypothesis.

Suggested Evaluation Methods:

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- Assignments on hypothesis testing.
- Group presentation on real time applications involving data sampling and hypothesis testing.
- Quizzes on topics like sampling and probability.

UNIT IV ANALYTICS USING HADOOP AND MAPREDUCE FRAMEWORK 9

Introducing Hadoop– RDBMS versus Hadoop–Hadoop Overview – HDFS (Hadoop Distributed File System) – Processing Data with Hadoop– Introduction to MapReduce – Features of MapReduce – Algorithms Using Map-Reduce: Matrix-Vector Multiplication, Relational Algebra Operations, Grouping and Aggregation – Extensions to MapReduce.

Suggested Activities:

- Practical – Install and configure Hadoop.
- Practical – Use web based tools to monitor Hadoop setup.
- Practical – Design and develop MapReduce tasks for word count, searching involving text corpus etc.

Suggested Evaluation Methods:

- Evaluation of the practical implementations.
- Quizzes on topics like HDFS and extensions to MapReduce.

UNIT V OTHER DATA ANALYTICAL FRAMEWORKS 9

Overview of Application development Languages for Hadoop – PigLatin – Hive – Hive Query Language (HQL) – Introduction to Pentaho, JAQL – Introduction to Apache: Sqoop, Drill and Spark, Cloudera Impala – Introduction to NoSQL Databases – Hbase and MongoDB.

Suggested Activities:

- Practical – Installation of NoSQL database like MongoDB.
- Practical – Demonstration on Sharding in MongoDB.
- Practical – Install and run Pig
- Practical – Write PigLatin scripts to sort, group, join, project, and filter data.
- Design and develop algorithms to be executed in MapReduce involving numerical methods for analytics.

Suggested Evaluation Methods:

- Mini Project (Group) – Real time data collection, saving in NoSQL, implement analytical techniques using Map-Reduce Tasks and Result Projection.

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the student will be able to:

- Identify the real world business problems and model with analytical solutions.
- Solve analytical problem with relevant mathematics background knowledge.
- Convert any real world decision making problem to hypothesis and apply suitable statistical testing.
- Write and Demonstrate simple applications involving analytics using Hadoop and MapReduce
- Use open source frameworks for modeling and storing data.
- Apply suitable visualization technique using R for visualizing voluminous data.

REFERENCES:

1. VigneshPrajapati, " Big Data Analytics with R and Hadoop" , Packt Publishing, 2013.
2. Umesh R Hodeghatta, UmeshaNayak, " Business Analytics Using R – A Practical Approach" , Apress, 2017.
3. AnandRajaraman, Jeffrey David Ullman, " Mining of Massive Datasets" , Cambridge University Press, 2012.
4. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, " Essentials of Business Analytics" , Cengage Learning, second Edition, 2016.
5. U. Dinesh Kumar, " Business Analytics: The Science of Data-Driven Decision Making " , Wiley, 2017.
6. A. Ohri, " R for Business Analytics" , Springer, 2012
7. Rui Miguel Forte, " Mastering Predictive Analytics with R" , Packt Publication, 2015.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	3	1
CO2	2	1	1	2	1	1
CO3	1	1	2	3	3	1
CO4	2	2	1	2	1	1
CO5	1	1	2	2	1	1
CO6	1	1	1	3	2	1

OE5092	INDUSTRIAL SAFETY	LT P C
		3 0 0 3

OBJECTIVES:

- Summarize basics of industrial safety
- Describe fundamentals of maintenance engineering
- Explain wear and corrosion
- Illustrate fault tracing
- Identify preventive and periodic maintenance

UNIT I INTRODUCTION 9

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT II FUNDAMENTALS OF MAINTENANCE ENGINEERING 9

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT III WEAR AND CORROSION AND THEIR PREVENTION 9

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT IV FAULT TRACING 9

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment' s like, I. Any one
machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT V PERIODIC AND PREVENTIVE MAINTENANCE 9

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

TOTAL: 45 PERIODS

OUTCOMES:

CO1: Ability to summarize basics of industrial safety
CO2: Ability to describe fundamentals of maintenance engineering
CO3: Ability to explain wear and corrosion
CO4: Ability to illustrate fault tracing
CO5: Ability to identify preventive and periodic maintenance

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Audels, Pump-hydraulic Compressors, Mcgrew Hill Publication, 1978.
2. Garg H P,Maintenance Engineering, S. Chand and Company,1987.
3. Hans F. Winterkorn ,Foundation Engineering Handbook, Chapman & Hall London,2013.
4. Higgins & Morrow , Maintenance Engineering Handbook,Eighth Edition,2008

OE5093 OPERATIONS RESEARCH LT P C
3 0 0 3

OBJECTIVES:

- Solve linear programming problem and solve using graphical method.
- Solve LPP using simplex method
- Solve transportation , assignment problems
- Solve project management problems
- Solve scheduling problems

UNIT I LINEAR PROGRAMMING 9

Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

UNIT II ADVANCES IN LINEAR PROGRAMMING 9

Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis

UNIT III NETWORK ANALYSIS – I 9

Transportation problems -Northwest corner rule, least cost method,Voges' s approximation method - Assignment problem -Hungarian algorithm

UNIT IV NETWORK ANALYSIS – II 9

Shortest path problem: Dijkstra' s algorithms, Floyds algorithm, systematic method -CPM/PERT

UNIT V NETWORK ANALYSIS – III 9

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models

TOTAL: 45 PERIODS

OUTCOMES:

CO1: To formulate linear programming problem and solve using graphical method.
CO2: To solve LPP using simplex method
CO3: To formulate and solve transportation, assignment problems
CO4: To solve project management problems
CO5: To solve scheduling problems

Attested

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010
2. Hitler Libermann, Operations Research: McGraw Hill Pub. 2009
3. Pant J C, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Pannerselvam, Operations Research: Prentice Hall of India 2010
5. Taha H A, Operations Research, An Introduction, PHI, 2008

OE5094 COST MANAGEMENTOF ENGINEERING PROJECTS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the costing concepts and their role in decision making
- Infer the project management concepts and their various aspects in selection
- Interpret costing concepts with project execution
- Develop knowledge of costing techniques in service sector and various budgetary control techniques
- Illustrate with quantitative techniques in cost management

UNIT I INTRODUCTION TO COSTING CONCEPTS 9

Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.

UNIT II INTRODUCTION TO PROJECT MANAGEMENT 9

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member,Importance Project site: Data required with significance, Project contracts.

UNIT III PROJECT EXECUTION AND COSTING CONCEPTS 9

Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

UNIT IV COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL 9

Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.

UNIT V QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT 9

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

TOTAL:45 PERIODS

OUTCOMES:

CO1 – Understand the costing concepts and their role in decision making CO2– Understand the project management concepts and their various aspects in selection CO3– Interpret costing concepts with project execution

CO4–Gain knowledge of costing techniques in service sector and various budgetary control techniques

CO5 - Become familiar with quantitative techniques in cost management

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓			✓	✓		✓	✓
CO2	✓	✓	✓		✓				✓		✓	✓
CO3	✓	✓	✓		✓	✓					✓	✓
CO4	✓	✓	✓		✓		✓				✓	✓
CO5	✓	✓	✓		✓	✓	✓				✓	✓

REFERENCES:

1. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher, 1991
2. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988
3. Charles T. Horngren et al Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi, 2011
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting, 2003
5. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd, 2007

OE5095 **COMPOSITE MATERIALS** **L T P C**
3 0 0 3

OBJECTIVES:

- Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
- Identifythe various reinforcements used in composite materials.
- Compare the manufacturing process of metal matrix composites.
- Understand the manufacturing processes of polymer matrix composites.
- Analyze the strength of composite materials.

UNIT I INTRODUCTION **9**

Definition – Classification and characteristics of Composite materials - Advantages and application of composites - Functional requirements of reinforcement and matrix - Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II REINFORCEMENTS **9**

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers - Properties and applications of whiskers, particle reinforcements - Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures - Isostrain and Isostress conditions.

UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES **9**

Casting – Solid State diffusion technique - Cladding – Hot isostatic pressing - Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving - Properties and applications.

UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITES **9**

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding - Properties and applications.

UNIT V STRENGTH **9**

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TOTAL: 45 PERIODS

OUTCOMES:

- CO1 - Know the characteristics of composite materials and effect of reinforcement in composite materials.
- CO2 – Know the various reinforcements used in composite materials.
- CO3 – Understand the manufacturing processes of metal matrix composites.
- CO4 – Understand the manufacturing processes of polymer matrix composites.
- CO5 – Analyze the strength of composite materials.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		✓	✓	✓								
CO2		✓✓	✓	✓	✓						✓	
CO3			✓	✓	✓		✓				✓	
CO4			✓	✓	✓		✓				✓	
CO5				✓	✓		✓					

Attested

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REFERENCES:

1. Cahn R.W. - Material Science and Technology – Vol 13 – Composites, VCH, WestGermany.
2. Callister, W.D Jr., Adapted by Balasubramaniam R, Materials Science and Engineering, An introduction, John Wiley & Sons, NY, Indian edition, 2007.
3. Chawla K.K., Composite Materials, 2013.
4. Lubin.G, Hand Book of Composite Materials, 2013.

OE5096 WASTE TO ENERGY L T P C
3 0 0 3

OBJECTIVES:

- Interpret the various types of wastes from which energy can be generated
- Develop knowledge on biomass pyrolysis process and its applications
- Develop knowledge on various types of biomass gasifiers and their operations
- Invent knowledge on biomass combustors and its applications on generating energy
- Summarize the principles of bio-energy systems and their features

UNITI INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE 9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNITIIBIOMASS PYROLYSIS 9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNITIII BIOMASS GASIFICATION 9

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNITIV BIOMASS COMBUSTION 9

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNITV BIO ENERGY 9

Properties of biogas (Calorific value and composition), Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

TOTAL: 45 PERIODS

OUTCOMES:

CO1 – Understand the various types of wastes from which energy can be generated
CO2 – Gain knowledge on biomass pyrolysis process and its applications
CO3 – Develop knowledge on various types of biomass gasifiers and their operations
CO4 – Gain knowledge on biomass combustors and its applications on generating energy
CO5 – Understand the principles of bio-energy systems and their features

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓									✓
CO2	✓		✓									✓
CO3	✓	✓	✓		✓							✓
CO4	✓	✓	✓		✓		✓					✓
CO5	✓	✓	✓		✓							✓

REFERENCES:

1. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.

AUDIT COURSES (AC)

AX5091 ENGLISHFOR RESEARCHPAPERWRITING L T P C
2 0 0 0

OBJECTIVES

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNITI INTRODUCTION TO RESEARCH PAPER WRITING 6

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT II PRESENTATION SKILLS 6

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

UNIT III TITLE WRITING SKILLS 6

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS 6

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT V VERIFICATION SKILLS 6

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission

TOTAL: 30 PERIODS

OUTCOMES

CO1 –Understand that how to improve your writing skills and level of readability
CO2 –Learn about what to write in each section
CO3 –Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3										✓		✓
CO4										✓		✓
CO5										✓		✓

REFERENCES

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
4. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman' s book 1998.

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AX5092 **DISASTER MANAGEMENT** **L T P C**
2 0 0 0

OBJECTIVES

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION **6**

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS **6**

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA **6**

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT **6**

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT **6**

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People' s Participation in Risk Assessment. Strategies for Survival

TOTAL :30 PERIODS

OUTCOMES:

CO1: Ability to summarize basics of disaster
CO2: Ability to explain critical understanding of key concepts in disaster risk reduction and humanitarian response.
CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5: Ability to develop the strengths and weaknesses of disaster management approaches

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies" , Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. Nishitha Rai, Singh AK, " Disaster Management in India: Perspectives, issues and strategies " ' New Royal book Company,2007.
3. Sahni, Pardeep Et.Al. ," Disaster Mitigation Experiences And Reflections" , Prentice Hall Of India, New Delhi,2001.

AX5093 SANSKRIT FOR TECHNICAL KNOWLEDGE L T P C
2 0 0 0

OBJECTIVES

- Illustrate the basic sanskrit language.
- Recognize sanskrit, the scientific language in the world.
- Appraise learning of sanskrit to improve brain functioning.
- Relate sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.
- Extract huge knowledge from ancient literature.

UNIT I ALPHABETS 6

Alphabets in Sanskrit

UNIT II TENSES AND SENTENCES 6

Past/Present/Future Tense - Simple Sentences

UNIT III ORDER AND ROOTS 6

Order - Introduction of roots

UNIT IV SANSKRIT LITERATURE 6

Technical information about Sanskrit Literature

UNIT V TECHNICAL CONCEPTS OF ENGINEERING 6

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

TOTAL: 30 PERIODS

OUTCOMES

- CO1 - Understanding basic Sanskrit language.
- CO2 - Write sentences.
- CO3 - Know the order and roots of Sanskrit.
- CO4 - Know about technical information about Sanskrit literature.
- CO5 - Understand the technical concepts of Engineering.

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3												✓
CO4												✓
CO5												✓

REFERENCES

1. " Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. " Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. " India' s Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi, 2017.

AX5094	VALUE EDUCATION	L T P C
		2 0 0 0

OBJECTIVES

Students will be able to

- Understand value of education and self-development
- Imbibe good values in students
- Let the should know about the importance of character

UNIT I

Values and self-development–Social values and individual attitudes. Workethics,Indianvisionofhumanism.Moralandnon-moralvaluation.Standards and principles. Value judgements

UNIT II

Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love fornature, Discipline

UNIT III

Personality and Behavior Development-Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour.

Universal brother hood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

UNIT IV

Character and Competence–Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively.

TOTAL: 30 PERIODS

OUTCOMES:

Students will be able to

- Knowledge of self-development.
- Learn the importance of Human values.
- Developing the over all personality.

Suggested reading

1. Chakroborty, S.K.“ Values and Ethics for organizations Theory and practice” , Oxford University Press, New Delhi

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AX5095	CONSTITUTION OF INDIA	L T P C
		2 0 0 0

OBJECTIVES

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals , constitutional
- Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION:

History, Drafting Committee, (Composition &Working)

UNIT II PHILOSOPHYOFTHE INDIANCONSTITUTION:

Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES:

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT IV ORGANS OF GOVERNANCE:

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT V LOCAL ADMINISTRATION:

District' s Administration head: Role and Importance, • Municipalities: Introduction, Mayor and

role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT VI ELECTION COMMISSION:

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

OUTCOMES:

Students will be able to:

- DiscussthegrowthofthedemandforcivilrightsinIndiaforthebulkofIndiansbeforethe arrival of Gandhi in Indian politics.
- Discusstheintellectualoriginsoftheframeworkofargumentthatinformedtheconceptualization
- of social reform sliding to revolution in India.
- DiscussthecircumstancessurroundingthefoundationoftheCongressSocialistParty[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- DiscussthepassageoftheHinduCodeBillof1956.

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Suggested reading

1. TheConstitutionofIndia,1950(BareAct), Government Publication.
2. Dr. S. N. Busi, Dr. B. R.AmbedkarframingofIndianConstitution,1st Edition,2015.
3. M.P. Jain,IndianConstitutionLaw,7th Edn.,Lexis Nexis,2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis,2015.

AX5096 PEDAGOGY STUDIES L T P C
2 0 0 0

OBJECTIVES

Students will be able to:

- Review existing evidence on there view topic to inform programme design and policy
- Making under taken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

UNIT I INTRODUCTION AND METHODOLOGY:

Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions - Overview of methodology and Searching.

UNIT II THEMATIC OVERVIEW

Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

UNIT III EVIDENCE ON THE EFFECTIVENESS OFPEDAGOGICALPRACTICES

Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches - Teachers ' attitudes and beliefs and Pedagogic strategies.

UNIT IV PROFESSIONAL DEVELOPMENT

Professional development: alignment with classroom practices and follow up support - Peer support - Support from the head teacher and the community - Curriculum and assessment - Barriers to learning: limited resources and large class sizes

UNIT V RESEARCH GAPS AND FUTURE DIRECTIONS

Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment - Dissemination and research impact.

TOTAL: 30 PERIODS

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OUTCOMES

Students will be able to understand:

- Whatpedagogicalpracticesarebeingusedbyteachersinformalandinformalclassrooms in developing countries?
- What is the evidence on the effectiveness soft he sepedagogical practices, in what conditions, and with what population of learners?
- How can
- teacher education(curriculum and practicum)and the school curriculum and guidance materials best support effective pedagogy?

Suggested reading

1. Ackers, HardmanF(2001)ClassroominteractioninKenyanprimaryschools,Compare,31(2): 245-261.
2. AgrawalM (2004)Curricular reform in schools: The importance of evaluation, JournalofCurriculumStudies,36(3):361-379.
3. AkyeampongK(2003)TeachertraininginGhana-doesitcount?Multi-siteteachereducationresearchproject(MUSTER) country report 1.London:DFID.
4. Akyeampong K,LussierK, PryorJ, WestbrookJ (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33(3): 272–282.
5. Alexander RJ(2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. ChavanM (2003) Read India: Amass scale, rapid, ‘ learningtoread ’ campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf

AX5097	STRESS MANAGEMENT BY YOGA	L T P C 2 0 0 0

OBJECTIVES

- To achieve overall health of body and mind
- To overcome stress

UNIT I

Definitions of Eight parts of yoga.(Ashtanga)

UNIT II

Yam and Niyam - Do`s and Don' t' sin life - i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Ahinsa, satya, astheya, bramhacharya and aparigraha.

UNIT III

Asan and Pranayam - Various yog poses and their benefits for mind & body - Regularization of breathing techniques and its effects-Types of pranayam

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

SUGGESTEDREADING

1. ' YogicAsanasforGroupTarining-Part-I" :JanardanSwamiYogabhyasiMandal, Nagpur
2. " Rajayogaorconquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department),Kolkata

AX5098	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	L T P C 2 0 0 0

OBJECTIVES

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To a waken wisdom in students

UNIT I

Neetishatakam-holistic development of personality - Verses- 19,20,21,22 (wisdom) - Verses-29,31,32 (pride & heroism) – Verses- 26,28,63,65 (virtue) - Verses- 52,53,59 (dont' s) - Verses-
71,73,75,78 (do' s)

UNIT II

Approach to day to day work and duties - Shrimad BhagwadGeeta: Chapter 2-Verses 41, 47,48 - Chapter 3-Verses 13, 21, 27, 35 Chapter 6-Verses 5,13,17,23, 35 - Chapter 18-Verses 45, 46, 48.

UNIT III

Statements of basic knowledge - Shrimad BhagwadGeeta: Chapter2-Verses 56, 62, 68 Chapter 12 -Verses 13, 14, 15, 16,17, 18 -Personality of role model - shrimadbhagwadgeeta - Chapter2-Verses 17, Chapter 3-Verses 36,37,42 - Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Study of Shrimad- Bhagwad- Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and man kind to peace and prosperity
- Study of Neetishatakam will help in developing versatile personality of students.

Suggested reading

1. Gopinath, Rashtriya Sanskrit Sansthanam P, Bhartrihari' s Three Satakam, Niti-
   sringar-vairagya, New Delhi,2010
2. Swami Swarupananda , Srimad Bhagavad Gita, Advaita Ashram, Publication Department, Kolkata, 2016.

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