B.TECH. BIOINFORMATICS

COURSE STRUCTURE

Approved in Academic Council held on 28 June 2023

Department of Biotechnology & Bioinformatics

PROGRAM OUTCOMES

Engineering Graduates will be able to:

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Approved in Academic Council held on 28 June 2023

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, SOLAN

COURSE CURRICULUM OF BT & BI DEPARTMENT- 2023 Batch (165 CREDITS)

B. TECH (BIOINFORMATICS) 1st SEMESTER

S. No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	HSS	21B11HS111	English	2	0	0	**2**	**2**
2	HSS	21B17HS171	English Lab	0	0	2	**1**	**2**
3	Basic Sciences	18B11MA112	Basic Mathematics -1 OR	3	1	0	**4**	**4**
4	Basic Sciences	18B11BT111	Fundamental Biology	3	0	0	**3**	**3**
5	Basic Sciences	18B17BT171	Fundamental Biology lab	0	0	2	**1**	**2**
6	Basic Sciences	18B11PH112	Basic Engineering Physics-I	3	1	0	**4**	**4**
7	Engg Science	19B11CI111	Programming for Problem Solving-II	2	0	0	**2**	**2**
8	Engg Science	18B17GE173	Engineering Graphics	0	0	3	**1.5**	**3**
9	Basic Sciences	18B17PH172	Basic Engineering Physics Lab-I	0	0	2	**1**	**2**
10	Engg Science	19B17CI171	Programming for Problem Solving Lab-II	0	0	4	**2**	**4**
						Total	**17.5**	**23**

B. TECH (BIOINFORMATICS) 2nd SEMESTER

S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Basic Sciences	18B11MA212	Basic Mathematics-II	3	1	0	**4**	**4**
2	Basic Sciences	18B11PH212	Bioinstrumentation Techniques	3	1	0	**4**	**4**
3	Engg Science	18B11EC212	Basic Electrical Sciences	3	1	0	**4**	**4**
4	Engg Science	18B17EC272	Basic Electrical Sciences lab	0	0	2	**1**	**2**
5	Engg Science	18B11CI211	Data Structure & Algorithms	3	1	0	**4**	**4**
6	Engg Science	18B17CI271	Data Structure & Algorithms Lab	0	0	4	**2**	**4**
7	Engg Science	18BI7GE171	Workshop Practices	0	0	3	**1.5**	**3**
8	HSS	23B11HS211	Universal Human Values II: Understanding Harmony	2	1	0	**3**	**3**
9	HSS	23B11HS212	Professional Communication Practice	0	0	2	**Audit**	**2**
						Total	**23.5**	**30**

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, SOLAN

COURSE CURRICULUM OF BT & BI DEPARTMENT- 2023 Batch (165 CREDITS)

B. TECH (BIOINFORMATICS) 3rd SEMESTER

S. No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Basic Sciences	18B11BI311	Cell and Molecular Biology	3	0	0	**3**	**3**
2	Engg Science	20B11BI311	Bioinformatics Data Management	3	1	0	**4**	**4**
3	Professional Core	18B11BI312	Microbiology & Immune System	3	1	0	**4**	**4**
4	Professional Core	18B11BI313	Biological Computation	3	1	0	**4**	**4**
5	Engg Science	20b17BI371	Bioinformatics Data Management Lab	0	0	2	**1**	**2**
6	Basic Sciences	18B17BI371	Cell and Molecular Biology Lab	0	0	2	**1**	**2**
7	Professional Core	18B17BI372	Microbiology & Immune System Lab	0	0	2	**1**	**2**
8	Professional Core	18B17BI373	Biological Computation Lab	0	0	2	**1**	**2**
9	Professional Core	18B17BI374	Linux Lab	0	0	2	**1**	**2**
10	HSS	23B11HS311	Life Skills and Interpersonal Dynamics	2	1	0	**3**	**3**
						Total	**23**	**28**

B. TECH (BIOINFORMATICS) 4th SEMESTER

S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	HSS	18B11HS411	Finance and Accounts	3	0	0	**3**	**3**
2	Basic Sciences	18B11MA411	Bio-Statistics	3	0	0	**3**	**3**
3	Professional Core	18B11BI412	Genetic Engineering and Genomics	3	0	0	**3**	**3**
4	Engg Science	18B11CI415	Object Oriented Programming	3	1	0	**4**	**4**
5	Professional Core	18B11BI413	Structural Biology	3	0	0	**3**	**3**
6	Professional Core	18B11BI414	Programming Languages for Bioinformatics	3	0	0	**3**	**3**
7	Engg Science	18B11CI474	Object Oriented Programming Lab	0	0	2	**1**	**2**
8	Basic Sciences	18B11MA412	Bio-Statistics Lab	0	0	2	**1**	**2**
9	Professional Core	18B17BI472	Genetic Engineering and Genomics Lab	0	0	2	**1**	**2**
10	Professional Core	18B17BI473	Structural Biology Lab	0	0	2	**1**	**2**
11	Professional Core	18B17BI474	Programming Languages for Bioinformatics Lab	0	0	2	**1**	**2**
12	Mandatory Course	23B11GE411	Environmental Studies	2	0	0	2	2
						Total	**26**	**31**

Approved in Academic Council held on 28 June 2023

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, SOLAN

COURSE CURRICULUM OF BT & BI DEPARTMENT- 2023 Batch (165 CREDITS)

B. TECH (BIOINFORMATICS) 5th SEMESTER

S. No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	HSS	18B11HS511	Project Management and Entrepreneurship	3	0	0	**3**	**3**
2	Professional Core	18B11BI511	Design and Analysis of Algorithms	3	0	0	**3**	**3**
3	Professional Core	18B11BT511	Bioprocess Engineering	3	1	0	**4**	**4**
4	Professional Core	18B11BI512	Scripting Languages for Bioinformatics	3	0	0	**3**	**3**
5	Professional Core	18B17BI571	Design and Analysis of Algorithms Lab	0	0	2	**1**	**2**
6	Professional Core	18B17BT571	Bioprocess Engineering Lab	0	0	2	**1**	**2**
7	Professional Core	18B17BI572	Scripting Languages for Bioinformatics Lab	0	0	2	**1**	**2**
8	Professional Core	18B17BI573	Structural Bioinformatics Lab	0	0	2	**1**	**2**
9	Professional Elective		Departmental Elective-I	3	0	0	**3**	**3**
10	Open Elective		Open Elective-I	3	0	0	**3**	**3**
11	Project	18B19BI591	Minor Project Part-I	0	0	2	**1**	**2**
						Total	**24**	**29**

B. TECH (BIOINFORMATICS) 6th SEMESTER

S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Professional Core	18B11BI611	Machine Learning for Bioinformatics	3	0	0	**3**	**3**
2	Professional Core	18B11BI612	Computer Aided Drug Design	3	0	0	**3**	**3**
3	Professional Core	18B17BI671	Machine Learning for Bioinformatics lab	0	0	2	**1**	**2**
4	Professional Core	18B17BI672	Computer Aided Drug Design Lab	0	0	2	**1**	**2**
5	Professional Core	18B17BI673	Advanced Algorithms for Bioinformatics Lab	0	0	2	**1**	**2**
6	Professional Core	18B17BI674	R Language Lab	0	0	2	**1**	**2**
7	Professional Elective		Departmental Elective-II	3	0	0	**3**	**3**
8	Professional Elective		Departmental Elective-III	3	0	0	**3**	**3**
9	Open Elective		Open Elective-II (HSS)	3	0	0	**3**	**3**
10	Project	18B19BI691	Minor Project Part-II	0	0	4	**2**	**4**
11	Mandatory Course		Industrial Training				**Audit**	
						Total	**21**	**27**

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, SOLAN

COURSE CURRICULUM OF BT & BI DEPARTMENT- 2023 Batch (165 CREDITS)

B. TECH (BIOINFORMATICS) 7th SEMESTER

S. No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Professiona l Elective		Departmental Elective- IV	3	0	0	**3**	**3**
2	Open Elective		Open Elective - III	3	0	0	**3**	**3**
3	Open Elective		Open Elective - IV	3	0	0	**3**	**3**
4	Project	18B19BI791	Major Project Part I	0	0	10	**5**	**10**
5	HSS		Indian Constitution	1	0	0	**Audit**	**1**
						Total	**14**	**20**

B. TECH (BIOINFORMATICS) 8th SEMESTER

S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Professional Elective		Departmental Elective- V	3	0	0	**3**	**3**
2	Professional Elective		Departmental Elective- VI	3	0	0	**3**	**3**
3	Open Elective		Open Elective-V	3	0	0	**3**	**3**
4	Project	18B19BI891	Major Project Part II	0	0	14	**7**	**14**
						Total	**16**	**23**
			TOTAL CREDITS				**160**	
			TOTAL HOURS				**205**	
			HSS				**12**	
			Basic Science				**25**	
			Engg Science				**28**	
			Professional CORE				**47**	
			Professional Elective				**18**	
			OE				**15**	
			PROJECT				**15**	
			TOTAL CREDITS				**160**	**160**

Approved in Academic Council held on 28 June 2023

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, SOLAN

COURSE CURRICULUM OF BT & BI DEPARTMENT- 2023 Batch (165 CREDITS)

B. TECH (BIOINFORMATICS)

PROFESSIONAL ELECTIVE-I

S. No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Professional Elective	18B1WBI531	Structural Bioinformatics	3	0	0	**3**	**3**
2	Professional Elective	18B1WBT532	Comparative & Functional Genomics	3	0	0	**3**	**3**
						Total	**3**	**3**

PROFESSIONAL ELECTIVE-II

S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Professional Elective	18B1WBI631	Advanced Algorithms for Bioinformatics	3	0	0	**3**	**3**
2	Professional Elective	18B1WBT632	Infectious Diseases	3	0	0	**3**	**3**
						Total	**3**	**3**

PROFESSIONAL ELECTIVE-III

S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Professional Elective	18B1WBI632	Dataware housing and Mining for Bioinformatics	3	0	0	**3**	**3**
	Professional Elective	18B1WBT634	Bioenergy & Biofuels	3	0	0	**3**	**3**
						Total	**3**	**3**

PROFESSIONAL ELECTIVE-IV

S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Professional Elective	18B1WBI731	Computational Systems Biology	3	0	0	**3**	**3**
2	Professional Elective	18B1WBT734	Intellectual Property Rights & Commercialization	3	0	0	**3**	**3**
3	Professional Elective	18B1WCI742	Artificial Intelligence	2	0	0	**2**	**2**
4	Professional Elective	18B1WCI772	Artificial Intelligence Lab	0	0	2	**1**	**2**
						Total	**3**	**3**

Approved in Academic Council held on 28 June 2023

PROFESSIONAL ELECTIVE-V								
S. No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Professional Elective	18B1WBT831	Genetic Counselling	3	0	0	3	3
2	Professional Elective	18B1WBI831	Computational Molecular Evolution	3	0	0	3	3
3	Professional Elective	18B1WCI843	Data Analytics	3	0	0	3	3
						Total	3	3

PROFESSIONAL ELECTIVE-VI								
S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Professional Elective	18B1WBT833	Diagnostics & Vaccine Manufacture	3	0	0	3	3
2	Professional Elective	18B1WBI834	NGS Data Analysis & Applications	3	0	0	3	3
						Total	3	3

OPEN ELECTIVE-IV								
S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Open Elective	21B1WBT731	Human Disease and Diagnostics	3	0	0	3	3
						Total	3	3

OPEN ELECTIVE-V								
S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
1	Open Elective	21B1WBT833	Computational Biology for Engineers	3	0	0	3	3
						Total	3	3

Approved in Academic Council held on 28 June 2023

B.TECH. BIOINFORMATICS

SYLLABUS

Approved in Academic Council held on 28 June 2023

Fundamental Biology

COURSE CODE: 18B11BT111
COURSE CREDITS: 3
CORE/ELECTIVE: CORE
L-T-P:3-0-0

Pre-requisite: Xth Class Biology

Course Objectives:

1. This is basic foundation biology course for the students having mathematics background.
2. The objectives are to familiarize students with basics of biology.
3. Learn about various living organism.
4. Learn about different biological at molecular or celluar level.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Overview of living system, different life forms and Maintenance of Life.	Familiarity
CO-2	Fundamental understanding of Bio-molecules: Building blocks of living system	Assessment
CO-3	Understanding of structure and function of cell: Prokaryotic and Eukaryotic cells system.	Assessment
CO-4	Understanding the Basic of cellular transport system and cellular inheritance.	Assessment
CO-5	Flow of information in biological system- Central Dogma, DNA replication, Transcription, and Translation	Usage

Course Contents:

Unit	Contents	Lectures required
1	**General Biology:**The nature of life, Characteristics of living organisms, Concept and use of a classification system, brief of five Kingdome and three domain classification system.Concepts of species and hierarchical taxa, biological nomenclature, classical and quantititative methods of taxonomy of plants, animals and microorganisms.	5
2	**Introduction to bio-molecule: Structure and function relationship:**Structure, chemical reactions and biological functions of carbohydrate, lipid, protein and nucleotides.Stablizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc	8
3	**Cell: Basic structure and functions:**Unicellular, colonial and multicellular forms; levels of organization of tissues systems; comparative anatomy Structural and biochemical organization of cell. Prokaryotic and Eukaryotic cells. Cell organelles, their molecular composition, structure and functions.	6

4	**Basic of cellular transport system:**Diffusion , Osmosis, Active transport	4
5	**Cellular inheritance:**Cell division, cell cycle, Mitosis, Meiosis and Inheritance	6
6	**Flow of genetic information:**The DNA, Search for Genetic Material, RNA World, Genetic Code, Central Dogma, replication, transcription and translation, (initiation, elongation and termination).	8
7	**Maintenance of Life:Adjustment and control:** Homeostasis, thermoregulation, and osmoregulation, Speciation and selection.	5
	Total Lectures	**42**

Suggested Text Book(s):

1. Stryer, Lubert (2002). Biochemistry; Fifth edition. W. H. Freeman and Company.
2. Principles of Biochemistry [5th edition], Lehninger.
3. NCERT –XII class Biology

Suggested Reference Book(s):

1. Neill, Campbell (1996). Biology; Fourth edition.The Benjamin/Cummings Publishing Company. p. 309,310. ISBN 0-8053-1940-9.
2. A. W. Haupt, Fundamental of Biology, 3rd ed. McGRAW-HILL

Other useful resource(s):

1. https://nptel.ac.in/courses/122103039/
2. https://nptel.ac.in/syllabus/122103039/

Evaluation Scheme:

S. No.	Exam	Marks	Duration	Coverage/Scope of Examination
1	T-1	15	1 Hour	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Quiz, Assignment, Attendance, etc.

Course Outcomes (COs) contribution to the programme Outcomes (POs):

Course outcomes (Fundamental Biology)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	Average
CO-1	3	2	2	2	1	3	3	1	1	2	1	2	3	2	**1.8**
CO-2	2	2	3	2	1	3	3	-	1	2	1	3	3	2	**1.8**
CO-3	2	3	3	2	2	2	2	-	-	2	2	3	3	2	**1.8**
CO-4	3	2	2	2	3	2	2	1	-	1	2	3	3	2	**2.0**
CO-5	3	3	3	3	3	3	2	1	2	2	3	3	2	3	**2.5**
Average	**2.6**	**2.4**	**2.6**	**2.2**	**2.0**	**2.6**	**2.4**	**1.8**	**1.6**	**1.8**	**1.8**	**2.8**	**2.8**	**2.2**	

Fundamental Biology Lab

COURSE CODE: 18B17BT171
COURSE CREDITS: 1
CORE/ELECTIVE: CORE
L-T-P:0-0-2

Pre-requisite: Xth class biology

Course Objectives:

1. The objective of this course is to familiarize the students with basic biology laboratory techniques specifically used in modern biotechnology area.
2. Learn handling of microorganism
3. To learn about safe laboratory practices
4. To learn ethics, team work and discipline

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Introduction to basic laboratory practices, microscopy, Bio- safety cabinet and sterilization.	Familiarity
CO2	Fundamental understanding of Biological buffers preparation and application.	Familiarity
CO3	Introduction to microscopic examination of different biological system.	Assessment
CO4	Introduction to analytical technique and application in macromolecular estimation.	Assessment
CO5	Able to understand ethics, team work and discipline.	Usage

List of Experiments

S. No.	Description	Hours
1	**Laboratory safety and basic laboratory Instrumentation** Basic laboratory operation: safety procedure, general safety practice and awareness. (personal safety, eye safety, handling of biologically hazardous material, handling of needles, sharps and chemicals)	2
	To study the different parts and application of simple and compound microscope	2
	To study the fundamental component and application of the Bio-safety cabinet (BSL) in biotechnology.	2
	To study the fundamental of different sterilization method in laboratory practices (Autoclave, Radiation sterilization)	2
2	**Biological buffers: (Preparation and application)**Hands on training on different buffer preparation, purification and pH measurement.	2
	Application of purified buffer in different biotechnology experiment.	2
	Collect water from two different water bodies around you and study them for pH, clarity and presence of any living organism.	2

3	**Microscopic Analysis of biological sample** To perform simple and differential staining of given microorganism and classify them (gram staining) Isolation and identification of microbe from given sample: Microscopic examination and motility test. To perform microscopic examination of unicellular eukaryote organism: identification and characterization	2 2 2
4	**Analytical estimation of bio-molecule** Estimation of Different macromolecules by visible spectrophotometer. To study the basic of standard curve preparations and application in biotechnology experiments.	2 2
Total Lab hours		24

Suggested/Resources:

1 Lab manual
2 Laboratory exercises in Microbiology – Harley Prescott
3 Biotechnology Lab Course: Jeffery M.Becker, Guy A. Caldwell, Eve Ann Zachgo
4 Biology 6thedition : Raven - Johnson

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	2	2	3	2	1	3	3	1	2	2	3	3	**2.3**
CO2	2	2	2	3	2	2	3	2	2	-	1	1	**1.9**
CO3	3	3	2	3	2	2	2	2	1	2	1	2	**2.1**
CO4	2	3	2	3	3	2	2	2	2	2	2	2	**2.3**
CO5	1	1	1	2	1	1	-	3	3	2	3	3	**1.8**
Average	**2.0**	**2.2**	**2.0**	**2.6**	**1.8**	**2.0**	**2.0**	**2.0**	**2.0**	**1.6**	**2.0**	**2.2**	

Cell and Molecular Biology

COURSE CODE:18B11BI311

COURSE CREDITS: 3

CORE/ELECTIVE: CORE

: 3-0-0

Pre-requisite: Knowledge of Biology (10+2)

Course Objectives:

1. The objective of the course is to equip students with a detailed knowledge of molecular structure and components of the cell and to understand howmolecules interact within the cell to promote proper growth, division, and development

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Able to describe the chemical components of the macromolecules of life and their functions and the structural differences between prokaryotic and eukaryotic cells or between plant and animal cells.	Familiarity
CO-2	Understand how molecular machines within the cell are constructed and regulated so that they can accurately copy, repair, and interpret genomic information.	Assessment
CO-3	Write, discuss or critique about emerging biology-related topics individually or in groups.	Application

Course Contents:

Unit	Contents	Lectures required
1	**Biological Classification:** Introduction to the organization of eukaryotic and prokaryotic cells.	3
2	**Biomolecules:**Carbohydrates: Chemical structures, nature, properties, Classification and Importance in Biological Systems.Lipids: Structure, Classification, Properties and Function.	2+3
3	Amino acids: Classification, properties, structure, nature. Proteins: Classification, Structure and Function. Enzymes: Classification, Characteristics	3+2
4	Molecular details of the Cell (Cells and Genomes, Cell Chemistry and Biosynthesis, Proteins)	2+2
5	Structural functional significance of sub-cellular organelles (Mitochondria, chloroplast, Endoplasmic reticulum, Golgi apparatus, etc.).	3

6	Nucleic acids:Bases, nucleosides and nucleotides, DNA & RNA structure, rRNA, tRNA and mRNA. Structural organization of DNA and Chromosomes, DNA Replication and Repair.	6
7	Protein trafficking, Protein synthesis; Protein sorting, transport and secretion.	5
8	Flow of information in biology (Central Dogma). DNA replication, DNA polymerases, Transcription	6
9	Cellular transport across membranes; Exocytosis, Endocytosis and Receptor mediated endocytosis.	5
Total lectures		**42**

Suggested Text Book(s):

1. De Robertis, E. D. P. and De Robertis, Jr. E. N. F. "Cell and Molecular Biology". Lea and Febiger, New York
2. Karp, J. "Cell and Molecular Biology, Concepts and Experiments" Jhon Wiley and Sons Inc. USA
3. Stryer, Lubert (2002). Biochemistry; Fifth edition. W. H. Freeman and Company.
4. Lehninger "Principles of Biochemistry"

Suggested Reference Book(s):

1. Lodish H, Berk A, Zipursky LS, Matsudaira P, Baltimore D, Darnell J (2000). *Molecular Cell Biology*. W. H. Freeman and Company
2. Molecular Biology of the Cell Alberts, B., et al. 4th edition (2002) Garland Science
3. Essential Cell Biology Alberts, B., et al; 3rd edition (2010) Garland Science
4. Molecular Cell Biology Damell Jr. J., Lodish, H and Baltimore, D. Scientific American Inc., New York
5. Neill, Campbell (1996). Biology; Fourth edition. The Benjamin/Cummings Publishing Company. p. 309,310. ISBN 0-8053-1940-9.

Other useful resource(s):

1.Link to NPTEL course contents: https://nptel.ac.in/courses/102104056/

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Cell and Molecular Biology)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	2	2	2	2	2	1	2	**1.9**
CO-2	2	2	2	2	2	1	1	2	2	2	1	2	**1.8**
CO-3	2	2	2	2	2	1	1	1	2	-	2	2	**1.5**
Average	**2.0**	**2.0**	**2**	**2**	**2**	**1.3**	**1.3**	**1.6**	**2.0**	**1.3**	**1.33**	**2.0**	

Cell and Molecular Biology lab

COURSE CODE: 18B17BI3731

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

: 0-0-2

Pre-requisite: Knowledge of Biology (10+2)

Course Objectives:

1. The objective of this course is to familiarize the students with laboratory techniques specifically in microbiology and molecular biology
2. At the end of the course, the student will be able to identify and analyze various applications in the field of microbiology and biotechnology.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Students will learn the basic laboratory practices	Introductory
CO2	Students will learn use and handling microscope	Technical
CO3	The students will be able demonstrate isolation of single bacterial colony through serial dilution	Technical
CO4	Students will able to prepare buffer and extraction of genomic DNA from *E. coli*	Technical/ Assessment

List of Experiments

S.No	Description	Hours
1	laboratory practices	2
2	Introduction to Microscope	2
3	To prepare slides of prokaryotic and eukaryotic cell to observe under microscope.	2
4	Calculation of Molarity, Normality	2
5	Carbohydrate estimation	2
6	To study the biosafety cabinet used in microbiology lab	2
7	Preparation of isolated single bacterial colony through serial dilution.	2
8	To observe difference in cultured plate prepared in laminar air flow and open air	2
9	General Instrumentations for lab. Practices; 1. pH meter	2
10	2. Spectrophotometer	2
11	Introduction to agarose gel electrophoresis	2
12	Preparation of buffer for genomic DNA extraction and	2
13	Isolation of genomic DNA	2
14	Isolation of genomic DNA (continued)	2
Total Lab hours		**28**

Suggested Books/Resources:

1. Harley – Prescott Laboratory exercises in Microbiology
2. Biotechnology Lab course : Jeffery M.Becker, Guy A. Caldwell, Eve Ann Zachgo
3. Biology 6thedition : Raven – Johnson
4. Campbell --- Biology 7th edition
5. NPTL
6. Laboratory Manuals

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	2	2	2	2	2	2	2	2	2	2	1	2	**1.9**
CO2	2	2	2	2	2	1	1	2	2	2	1	2	**1.75**
CO3	2	2	2	2	2	1	1	1	2	-	2	2	**1.72**
CO4	2	2	2	2	2	1	1	1	2	2	-	2	**1.72**
Average	**2.0**	**2.0**	**2**	**2**	**2**	**1.25**	**1.25**	**1.5**	**2.0**	**2**	**1.33**	**2.0**	

Biological Computation

COURSE CODE:18B11BI313

COURSE CREDITS: 4

CORE/ELECTIVE: CORE

: 3-1-0

Pre-requisite: Introduction to Bioinformatics

Course Objectives:

1. To use & develop tools to curate (compare &analyze) biological data.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Basic algorithms used in Pairwise and Multiple alignments.	Usage
CO-2	Understanding the methodologies used for database searching, and determining the accuracies of database search.	Usage
CO-3	Application of probabilistic model to determine important patterns.	Familiarity
CO-4	Prediction of structure from sequence and subsequently testing the accuracy of predicted structures.	Usage
CO-5	Determine the protein function from sequence through analyzing data.	Usage
CO-6	Analysis and development of models for better interpretation of biological data to extract knowledge.	Assessment

Course Contents:

Unit	Contents	Lectures required
1	**Introduction** Meaning of sequence, sequence similarity, homology, meaning of alignment.	1
2	**Pairwise Sequence Alignment**Different scoring models, Substitution matrices (PAM and BLOSUM), Pairwise Alignment: Concept of Global and Local Alignment, Dot matrix method, Dynamic programming (Needleman-Wunsch algorithm, Smith-Waterman algorithm, Choosing of best scoring matrix, gap penalties, Significance of score, EVD, FASTA and BLAST algorithms, Information theory and Shanon Entropy.	13
3	**Multiple Sequence alignment**Multiple Sequence Alignment methods (MSA), Scoring of a MSA, Progressive (CLUSTALW and PILEUP), Iterative (Genetic) and Hidden Markov Model (HMM) methods of MSA, Local MSA (Profile and BLOCK analysis, and Pattern searching, and Expectation Maximization (EM) Algorithm (MEME) and Gibbs Sampler.	6
4	**Structural Alignment Tools and Protein Tertiary Structure Prediction** Structure alignment algorithms & Homology modeling.	3

5	**Markov Chains and HMM** Frequent words in DNA, Consensus word analysis, Transaction and emission matrix, Development of training set, CpG island prediction using HMM, Application of HMM in gene finding, and Multiple sequence alignment by HMM method.	7
6	**Phylogenetic Analysis** Phylogenetic tree and terminology, different methods of Phylogenetic tree prediction: maximum parsimony, distance (UPGMA, NJ), maximum likelihood methods, bootstrapping, Jacknifing and Phylogenetic analysis by using Bayesian Network.	7
7	**RNA Structure Analysis** Terminology of RNA secondary structure, inferring structure by comparative sequence analysis, RNA secondary structure prediction, Nussinov folding algorithm, energy minimization and Zuker folding algorithm.	5
Total lectures		**42**

Suggested Text Book(s):

1. D.W. Mount *Bioinformatics: Genome and Sequence Analysis*: (2001) Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.
2. Ian Korf, Mark &Josaph: *BLAST*, Oreilly Publisher, 2003
3. R. Durbin, S. Eddy, A. Krogh and G. Mitchison, *Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids.* Cambridge University Press.
4. A.D. Baxevanis& B.F.F. Oulette*Bioinformatics – A practical guide to the Analysis of Genes and Proteins*,2002, Willey International publishers.
5. M.J. Bishop and C.J. Rawlings (editors), *DNA and Protein Sequence Analysis---A Practical Approach* IRL Press at Oxford University Press, ISBN 0 19 963464 7 (Pbk)
6. J. Pevsner (2002) Bioinformatics and Functional Genomics; Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York

Suggested Reference Book(s):

6. J. Setubal and J. Meidanis(1997) *Introduction to Computational Molecular Biology,* PWS Publishing Co.
7. J. Pevsner (2002) Bioinformatics and Functional Genomics; Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.

Other useful resource(s):

1. https://onlinecourses.nptel.ac.in/noc19_bt01/preview

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus

4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Biological Computation)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	3	3	3	1	1	-	1	1	1	3	**1.9**
CO-2	3	3	3	3	3	1	1	-	1	1	1	3	**1.9**
CO-3	3	3	3	3	3	1	1	-	1	1	1	3	**1.9**
CO-4	3	3	3	3	3	1	1	-	1	1	1	3	**1.9**
CO-5	3	3	3	3	3	1	1	-	1	1	1	3	**1.9**
CO-6	3	3	3	3	3	1	1	-	1	1	1	3	**1.9**
Average	**3**	**3**	**3**	**3**	**3**	**1**	**1**	**-**	**1**	**1**	**1**	**3**	

Biological Computation Lab

COURSE CODE: 18B11BI373

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: Basic Programming Skills

Course Objectives:

3. To use and develop bioinformatics programs for comparing &analyzing biological sequence data to identify probable function.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Basic algorithms used in Pairwise and Multiple alignments.	Assessment
CO2	Understanding the methodologies used for database searching, and determining the accuracies of database search.	Assessment
CO3	Application of probabilistic model to determine important patterns.	Assessment
CO4	Prediction of structure from sequence and subsequently testing the accuracy of predicted structures.	Assessment
CO5	Determine the protein function from sequence through analysis of data.	Assessment
CO6	Analysis and development of models for better interpretation of biological data to extract knowledge.	Assessment

List of Experiments

S.No	Description	Hours
1.	Overview of Practical classes conducted in the IInd Semester course of "Structural Biology" on RCSB, Visualization softwares, and tools related to secondary and tertiary structure predictions.	4
2.	Different sequence formats such as FASTA, PIR, EMBL, PDB, etc. Different sequence databases, retrieval of sequences from those databases and different ways to store the sequences. Calculation of the score of a pairwise alignment by using a scoring pattern (Take Home).	4
3.	Select a protein family for your mini-project and find out its superfamily. Also select another protein family which belongs to above superfamily and closer to your protein family.	4
4.	Find out structural and functional information about above protein families and superfamily.	4
5.	Write a program to align two sequences using Needleman-Wunsch algorithm?	4
6.	Use EBI (European Bioinformatics Institute) Needle sequence alignment tool to align above two sequences and compare your result with that of Needle tool	4
7.	Use of BLAST on line server to retrieve sequences from a database Develop a program based on BLAST algorithm to carry out database search?	4
8.	Use Clustaw software or on line server to align sequences from a family.	4

9.	Develop a Multiple Sequence Alignment (MSA) program based on ClustalW algorithm.	4
10.	Develop a program to identify motif from a set of sequences. Use on-line motif identification tools to predict motif in a set of sequences.	4
11	Use of Phylip package to infer phylogenetic tree in distance, maximum parsimony (MP) and maximum likelihood (ML) methods.	4
12	Use of Phylip package to determine robustness of inferred tree determined by each method.	4
Total Lab hours		**48**

Suggested Books/Resources:

1. http://hmmer.org/.
2. https://blast.ncbi.nlm.nih.gov/Blast.cgi
3. https://www.genome.jp/tools-bin/clustalw
4. http://meme-suite.org/
5. http://evolution.genetics.washington.edu/phylip.html
6. https://www.rcsb.org/
7. Mount D.W. : Bioinformatics: Genome and Sequence Analysis: (2001), Cold Spring Harbor Laboratory Press, New York.
8. Korf Ian &JosaphMark : BLAST, Oreilly Publisher, 2003
9. Durbin R., Eddy S., Krogh A. and G. Mitchison : Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids. Cambridge University Press
10. Pevsner J. : Bioinformatics and Functional Genomics; Cold Spring Harbor Laboratory Press, New York.
11. Baxevanis AD &OuletteBFF : Bioinformatics – A practical guide to the Analysis of Genes and Proteins, Willey International publishers

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	3	1	1	-	2	1	1	3	**2.00**
CO2	3	3	3	3	3	1	1	-	2	1	1	3	**2.00**
CO3	3	3	3	3	3	1	1	-	2	1	1	3	**2.00**
CO4	3	3	3	3	3	1	1	-	2	1	1	3	**2.00**
CO5	3	3	3	3	3	1	1	-	2	1	1	3	**2.00**
CO6	3	3	3	3	3	1	1	-	2	1	1	3	**2.00**
Average	**3**	**3**	**3**	**3**	**3**	**1**	**1**	**-**	**2**	**1**	**1**	**3**	

Microbiology and Immune System

COURSE CODE:18B11BI312

COURSE CREDITS: 4

CORE/ELECTIVE: CORE

L-T-P: 3-1-0

Pre-requisite: None

Course Objectives:

1. The objective of the course is to develop an understanding of basic microbiological and immunological principles and be able to understand different classes of disease causing microorganisms and how they activate and counter-act the host immune system.
2. To provide an understanding of the principles of microbiology and immunology and techniques that can serve as a platform for other courses built on biological concepts.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Usage of scientific terminologies to describe & express fundamental concepts in Microbiology and Immunology.	Familiarity
CO-2	Able to apply basic principles to understand host-microbe relationship in different Infectious diseases.	Assessment
CO-3	Able to connect and integrate the knowledge obtained for applications related to Microbes, their tools and database.	Usage
CO-4	Able to connect and integrate the knowledge obtained for and applications related to Immunology, Vaccines related informatics.	Usage
CO-5	Able to connect and integrate the knowledge of microbiology and immunology from the perspective of a bioinformatician with special emphasis on microbe-immune interface.	Assessment

Course Contents:

Unit	Contents	Lectures required
1	**History and Introduction to Microbial World**: Brief history, contributions of important microbiologists, immunologists. Origin of life and the microbial world, different classes of microbes, good and the bad microbes.	3
2	**Forms of microorganisms:** Prokaryotes: Archaea & Bacteria, Cyanobacteria Eukaryotes: Fungi, Algae, Protozoa Viruses – structure, classification, Viral Replication (Lytic and Lysogenis cycle)	3
3	**Morphology and cell structure of microorganisms:** Morphological features and characteristics of microorganisms, Gram positive and Gram negative bacteria.	2

4	**Methods in microbiology**: Pure culture techniques, Principles of microbial nutrition, culture media and types (simple, complex, enriched, enrichment, selective & differential), replica plating techniques	4
5	**Growth of microorganisms**: Growth curve of microbes, binary fission, enumeration techniques, effect of environmental conditions on growth, extremophiles, preservation techniques	3
6	**Microbial Control:** Theory and practice of sterilization, Antibiotics and Concept of Resistance, Physical and chemical control methods in practice.	4
7	**Genetics and Resistance** –Plasmids, Bacterial Conjugation, Transformation, Transduction, and Mutation	4
8	**Introduction to Fundamental Concepts in Immunology:** Immunology-Specificity, memory, discrimination of self from non- self, Innate and Acquired immunity, Humoral and cell-mediated immune responsePhagocytes and antimicrobial peptide effectors. Cells of the immune system, cytokines, complement system	4
9	**Antibody, Antigens and Immune receptors:** Immunoglobins: structure and function, immunoglobin classes and functions, monoclonal and polyclonal antibody, types of vaccines, active and passive immunization	4
10	**Antigens:** Immunogenicity, antigenicity, epitopes-B cell epitopes, T cell epitopes, haptens, Antigen Recognition by immune system: recognition of antigens by T and B Cells: Antigen processing and presentation, MHCs, role of MHC molecules in antigen presentation and co-stimulatory signals.	4
11	**Antigen- antibody interactions:** Concept, precipitation – double diffusion, radial immunodiffussion, immunoelectrophoresis, agglutination, ABO blood typing.	4
12	**Bioinformatics-Immunology and Infectious diseases:** Bioinformatics Resources and tools for Human Microbiota and Infectious Agents, Immunoinformatics.	2
13	**Failure of Host Defence Mechanisms:** Bacterial Persistence and survival strategies, Autoimmunity, Hypersensitivity	1
Total lectures		**42**

Suggested Text Book(s):

1. Madigan, M.T., Martinko, J.M., Parker, J: Brock Biology of Microorganisms. 10th Edition.: Publisher: Prentice Hall 2003
2. Prescott, Harley and Klein: Microbiology, 6th Edition, McGraw Hill 2005.
3. Pelczar, Chan and Krieg: Microbiology by; Tata McGraw Hill.
4. Roger Y. Stanier,: General Microbiology
5. R. Ananthanarayan and CK JayaramPaniker: Textbook of Microbiology
6. Kindt, T.J., Goldsby, R.A. and Osborne, B.A. (2007). KubyImmunology .W.H. Freeman and Co., New York, 7th Ed.

7. Roit, I. (2012). Essential Immunology. Blackwell Scientific Publications, Oxford, 12th Ed.
8. Pathogenomics: Genome analysis of pathogenic microbes by Hacker J and Dorbindt U. ed. Wiley-VCH

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Microbiology and Immune System)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	1	2	1	3	3	-	1	-	2	2	**1.9**
CO-2	2	2	1	2	1	3	3	-	2	1	2	2	**1.90**
CO-3	2	2	1	2	1	2	2	-	2	-	2	2	**1.8**
CO-4	3	3	1	2	1	2	2	-	-	-	2	2	**2**
CO-5	3	3	3	2	3	3	3	-	2	2	2	2	**2.54**
Average	**2.4**	**2.4**	**1.4**	**2.0**	**1.4**	**2.6**	**2.6**	**0.0**	**1.8**	**1.5**	**2.0**	**2.0**	

Microbiology and Immune System Lab

COURSE CODE: 18B17BI372

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: Good Laboratory Practices

Course Objectives:

1. The objective of this course is to demonstrate basic microbiological and immunological principles, approaches that enable study of microbe-host immune- interface and enable students to translate the theoretical foundation in the subject into practical understanding.
2. Techniques and methods to study different classes of microbes, immune system related molecules will be performed.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Students will be able to understand and apply basic microbiological techniques and correlate them with their fundamental concepts in the subject.	Introductory
CO2	Students will be able to understand and apply basic immunological techniques and correlate them with their fundamental concepts in the subject.	Introductory
CO3	At the end of the course, students are expected to gain a broad appreciation of the basic methods and their application in the field of microbiology, handle microbial cultures independently, to study applied aspects of microbiology.	Technical
CO4	At the end of the course, students are expected to gain a broad appreciation of the basic methods and their application in the field of immunology along with applied aspects of immunology.	Technical
CO5	At the end of the course, students are expected to gain a broad appreciation of the basic methods and their application in the field of microbiology and immunology along with handle microbial cultures independently, to study applied aspects of microbiology.	Usage

List of Experiments

S.No	Description	Hours

1.	**Culture Techniques for Microorganisms:** General microbiology procedures and Equipments - use and Safety Considerations, GLP. **a.** Preparation of culture media for different classes of microbes (bacteria and fungi) **b.** Bacterial growth curve: Spectrophotometry **c.** Culture and Isolation of microorganisms – soil, air, water **d.** Quantification, Purification of microorganisms	**10**
2.	**Microscopy and Staining:** Handling, microscopic examination of different classes of microorganisms: Bacteria, fungi ***a.*** Simple and differential staining of different shapes and sizes of bacteria – *acid fast, gram staining* **b.** Microscopic examination of specific fungi using Lactophenol cotton blue staining	**4**
3.	**Identification/Characterization Techniques for Microorganisms:** **a.** Preservation techniques **b.** Biochemical characterization **c.** Antimicrobial Susceptibility (Disk-diffusion) Test	**6**
4.	**Antigen – Antibody Interactions:** **a.** Double diffusion **b.** Radial Immunodiffusion **c.** Rocket Immunoelectrophoresis **d.** ABO Blood typing	**8**
Total Lab hours		**28**

Suggested Books/Resources:

1. Benson, Harold J: Microbiological Applications: Laboratory Manual in General Microbiology, McGraw-Hill Higher Education, 2007.
2. Cappuccino, James G.: Microbiology: A Laboratory Manual, Pearson Education Sherman, Natalie Asia, 2004.
3. Harley, John P.: Laboratory Exercises in Microbiology, Tata McGraw Hill, 2003.
4. Dubey, R.C., Maheshwari, D.K.: Practical microbiology, S. Chand and Company Ltd, New Delhi, 2003

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	2	2	2	1	-	2	3	3	3	-	1	3	**2.2**
CO2	3	2	2	2	2	2	1	2	3	-	2	3	**2.18**
CO3	2	3	-	2	2	2	2	3	3	2	1	2	**2.18**
CO4	3	3	3	2	1	2	3	-	2	2	2	3	**2.36**
CO5	2	2	3	3	3	2	2	3	-	3	3	3	**2.63**
Average	**2.4**	**2.4**	**2.5**	**2**	**2**	**2**	**2.2**	**2.75**	**2.75**	**2.33**	**1.8**	**2.8**	

Linux Lab

COURSE CODE: XXXXXXXX

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: None

Course Objectives:

6. To Understand and master Linux and UNIX based OS environment and understanding to various Linux flavors.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	To understand Unix environment	Familiarity
CO2	Familiarize with Unix and Linux commands.	Familiarity
CO3	To learn and master Bash and Shell scripting	Usage
CO4	To learn automating script-based job scheduling in Unix	Usage
CO5	To learn and master administrating and managing superuser-based managing accounts.	Usage
CO6	To run command line scripts of Perl and Python	Usage

List of Experiments

S.No	Description	Hours
1.	Introduction to Unix and Shell	2
2.	Installing Fedora	2
3.	Unix directories and pathnames and Rules for entering unix commands	2
4.	Configuring your Linux environment	2
5.	Working with Hard drives, Listing and Finding Directories and Files	2
6.	Manipulating Files in Unix	2
7.	Comparing, Sorting, Modifying, Combining, and Splitting Files, Searching for Lines in a File or Pipeline	2
8.	Replacing or Removing Text From a File or Pipeline	2
9.	Using vi to Edit a Text File and Command-Line Editing in the Korn Shell	2
10.	Writing Bourne Shell Scripts and awk scripts	2
11.	Additional commands	2
12.	Network commands	2

Total Lab hours	**24**

Suggested Books/Resources:

1. Practical Linux, Drew Streib et al Que, Indianapolis, 2000
2. Practical Unix, Steve Moritsugu et al, Que, Indianapolis, 2000
3. Linux: a practical approach , B. Mohamed Ibrahim 2006

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	2	2	1	1	1	1	1	1	**1.83**
CO2	3	3	3	3	3	1	1	1	1	1	1	3	**2.00**
CO3	3	3	2	3	2	3	2	1	1	1	2	1	**2.00**
CO4	3	3	3	2	3	2	1	1	1	1	1	1	**1.83**
CO5	2	2	3	3	3	3	1	1	1	1	1	1	**1.83**
CO6	2	3	3	3	2	2	2	2	2	2	2	2	**2.25**
Average	**2.67**	**2.83**	**2.80**	**2.80**	**2.60**	**2.20**	**1.20**	**1.00**	**1.00**	**1.00**	**1.20**	**1.40**	

Genetic Engineering and Genomics

COURSE CODE:18B11BI412

COURSE CREDITS: 3

CORE/ELECTIVE: CORE

L-T-P: 3-0-0

Pre-requisite: Molecular Genetics

Course Objectives:

4. Familiarize the students with the basic concepts in genetic engineering.
5. Acquaint the students to versatile tools and techniques employed in genetic engineering and recombinant DNA technology.
6. To make the students familiar with basic concepts of technologies.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Students will become aware of concept of genetic engineering and genomics and its applications.	Familiarity and Basics
CO-2	Students will have knowledge of tools and strategies used in genetic engineering.	Technical and strategies
CO-3	Student will acquire knowledge about gene libraries and isolation of genes.	Technical and application
CO-4	Student will develop understanding of DNA and genome sequencing technologies.	Technical and strategies
CO-5	Student will be able to explore domains of genomic technologies.	Application

Course Contents:

Unit	Contents	Lectures required
1	**Introduction:** Genetic engineering, Recombinant DNA technology: gene cloning - concept and basic steps - rDNA Glossary, Genomics Concept scope and applications	3
2	**DNA modifying enzymes and cloning techniques:** Restriction Endonucleases, DNA Ligation Enzymes and, DNA, Gene cloning methods and strategies: Cloning of PCR products, TA cloning, DNA Modifying Enzymes: Nucleases, Kinases, phosphatases, Reverse transcriptase	6
3	**Cloning and Expression Vectors:** Plasmid Vectors, Vectors based on Lambda Bacteriophage, Cosmids, M13 Vectors, Vectors for Cloning Large DNA Molecules, Expression Vectors	6
4	**Construction & Screening of genomic libraries:** Genomic library, cDNA library, Growing& Storing Libraries, cDNA Cloning (5'&3' RACE)	4

5	**Gene transfer Methods**: Gene Transfer methods plants and animal cells, Transgenic plants and animals and their applications	4
6	**Structural genomics:** Genome Analysis, Genomics: Organization and structure of Genomes, genome complexity Sequencing genes and short stretches of DNA: Basic DNA Sequencing, Next generation sequencing technologies	7
7	**Mapping and sequencing genomes**: Introduction, Molecular Markers Genetic and Physical Mapping of Genomes, *Sequencing of whole genomes,* Sequence analysis of genomic DNA for identification of genes and other features data and molecular phylogenetics	6
8	**Functional Genomics:** RNA expression analysis Comparative genomics	4
9	**Application domains of genome technologies**: Genomics and Medicine, Genomics and Agriculture	2
Total lectures		**42**

Suggested Text Book(s):

1. Principles of Gene Manipulation and Genomics SEVENTH EDITION S.B. Primrose and R.M. Twyman.
2. Recombinant DNA: A Short Course by JD Watson, J. Tooze and DT Kurtz.
3. Discovering Genomics, proteomics & bioinformatics. Second edition by A Malcolm Campbell, Davidson College; Laurie J. Heyer Davidson College ; With Foreword by Francis S. Collins

Suggested Reference Book(s):

1. From Genes to Genomes: Concepts and Applications of DNA Technology by JW Dale and M Schantz
2. Molecular Biotechnology: Principles & Applications of Recombinant DNA Glick BR and Pasternak JJ
3. Genetic Engineering :Amita Rastogi and Neelam Pathak

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (Cos) contribution to the ProgrammeOutcomes(Pos)

Course outcomes (Genetic Engineering and Genomics)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average

CO-1	3	3	3	3	3	2	2	2	3	3	2	3	**2.67**
CO-2	3	3	3	3	3	2	2	2	3	3	2	3	**2.67**
CO-3	3	3	3	3	3	2	2	2	3	3	2	3	**2.67**
CO-4	3	3	3	3	3	2	2	2	3	3	2	3	**2.67**
CO-5	3	3	3	3	3	2	2	2	3	3	2	3	**2.67**
Average	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**	**2.00**	**2.00**	**2.00**	**3.00**	**3.00**	**2.00**	**3.00**	

Genetic Engineering and Genomics Lab

COURSE CODE: 18B17BI472

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: None

Course Objectives:

7. The objective of the course is to give practical exposure to student about basic tools and techniques employed in recombinant DNA technology and genomics.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Students will be able to isolate and analyze plasmid vectors.	Technical
CO2	Students will be cut and ligate DNA fragments/vectors with help of restriction enzymes and ligase.	Technical
CO3	The students will be able to prepare competent cells	Technical
CO4	The students will be able demonstrate bacterial transformation with given vectors	Technical
CO5	Students will be able to perform genome annotations, gene and molecular marker prediction	Technical

List of Experiments

S.No	Description	Hours
1	Introduction to rDNA laboratory, w.r.t. working bench, types of instruments and their handling, lab. Preparation of stock solutions of buffers for use in gel running, gel loading, their autoclaving; preparation of working buffers, antibiotic stocks, and storage of buffers required in rDNA practicals with detailed methodology	4
2	Plasmid DNA Preparation: Preparation of LB medium with and without antibiotics for the growth of bacterial cultures, Growth of *E. coli*, Isolation of Plasmid DNA, Electrtrophoresis of Plasmid DNA and Interpretation of results	4
3	Restriction of given plasmid or λ DNA with the restriction enzyme *Eco*RI and HindIII or any other Restriction Enzymes	4
4	To perform ligationof λ/*Eco*R I digest using T4 DNA Ligase Electrophoresis of the uncut and digested DNA and Interpretation of the results Electrophoresis of ligated samples by agarose gel electrophoresis, Interpretation of the results	4
5	Preparation of competent cells of *E. coli* transformation	4

6	Transformation of E.coli. DH5 α cells with Empty puc/ pcambia1301/and Confirmation of transformed cells by scoring the expression of LacZ gene.	4
7	DNASTAR MODULES	4
8	PRIMER Designing	4
9	Unknown Gene Prediction Tools and Packages	4
10	Molecular Markers Prediction (SSR and SNP)	4
11	Overview of Genomic Resources: Data retrieval and analysis	4
12	Tools for expression data analysis	4
Total Lab hours		**48**

Suggested Books/Resources:

1. Lab Manual.
2. Discovering Genomics, proteomics & bioinformatics. Second edition by A Malcolm Campbell, Davidson College; Laurie J. Heyer Davidson College ; With Foreword by Francis S. Collins
3. Virtual Lab

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (Cos) contribution to the ProgrammeOutcomes(Pos)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	3	2	2	2	3	3	2	3	**2.67**
CO2	3	3	3	3	3	2	2	3	3	3	2	3	**2.75**
CO3	3	3	3	3	3	2	2	3	3	3	2	3	**2.75**
CO4	3	3	3	3	3	2	2	3	3	3	2	3	**2.75**
CO5	3	3	3	3	3	2	2	3	3	3	2	3	**2.75**
Average	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**	**2.00**	**2.00**	**2.80**	**3.00**	**3.00**	**2.00**	**3.00**	

Structural Biology

COURSE CODE:18B11BI413

COURSE CREDITS: 3

CORE/ELECTIVE: CORE

L-T-P: 3-0-0

Pre-requisite: None

Course Objectives:

7. To visualize, analyze and compare structures of proteins and nucleic acids (DNA), and their subunits. To identify and understand similar structural units (folds and domains) in proteins those have different functions.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Understand the relationship between protein structure and its function.	Familiarity
CO-2	Understand the methods of characterizing protein's structure using X-ray and NMR methods	Familiarity
CO-3	Implementation of bioinformatics tools in understanding protein structures. Understanding the classification of protein databases.	Usage
CO-4	Introduction to protein engineering	Familiarity
CO-5	Understand the structural diversity in nucleic acids.	Familiarity

Course Contents:

Unit	Contents	Lectures required
1	**Introduction:** Structural biology and its significance, Overview of amino acids and their various groups. Unnatural amino acids	1
2	**Protein structure:** Primary and Secondary Structure	2
3	**Motifs &Supersecondary Structure, Tertiary Structure & Fold Types:** Different types of secondary structures, Super-secondary structure and their classes, structural and functional domain, tertiary structures of proteins and their classes and sub-classes, Quaternary structures and cooperativity	2
4	**Covalent and Non-covalent Forces:** H-bonding, base stacking & hydrophobic interaction, paired interaction, torsion angle, solvent interaction in Protein, Role of free energy in Random and Natural states of polypeptide chain	4
5	**Mechanisms of Protein Folding:** Characterization of Folding Pathways and Mutagenesis Studies	2
6	Interactions of small molecule: Protein-Protein, Protein-DNA and Protein-RNA Interactions	2
7	**Types of protein:** Membrane Proteins, Fibrous Proteins, Metalloproteins, Carbohydrate Binding Proteins and Metalloenzymes: Structure and Function.	4

8	**Protein Structure Determination by X-ray diffraction:** Isolation, purification & crystallization of proteins, Basic principles of X-ray diffraction studies, Phase determination, calculation of Electron Density Map, Interpretation of Electron Density Map, Refinement of the Structures	4
9	**Techniques:** Circular Dichroism and Optical Rotation, Fluctuation Spectroscopy, Mass Spectrometry	2
10	**NMR Techniques for protein structure determination:** 1D NMR, 2D NMR (COSY & NOSY) Basic NMR Principles and Parameters, Vector & Product Operator Formalisms, Heteronuclear Correlation Experiments, Resonance Assignment Strategies, Protein Structure Determination	2
11	**Protein secondary structure prediction:** Principles of secondary structure prediction, Various secondary structure prediction tools (Chou-Fasman, GOR-IV, Neural network), Comparisons of various secondary structure prediction tools	4
12	**Structural Classification of Proteins:** Principle of protein structure classification (VAST, DALI, SSP), Protein structure classification Database (SCOP, CATH, DSSP), Profiles and Protein Families	3
13	**Protein Design:** Structural Scaffolds and Enzymatic Function. Introduction to protein engineering, examples and applications of industrially important enzymes	3
14	Nucleic Acid Structures: DNA Tertiary structure(A- and B- DNA, Major and Minor Grooves of DNA, Z-DNA, Mechanism of specific base sequence recognization in B-DNA, Triple helix DNA, Tetraplex DNA, Introduction to RNA secondary structure	3
Total lectures		**42**

Suggested Text Book(s):

1. Introduction to Protein Structure, Carl Branden and John Tooze, Garland Publishing Inc., New York
2. Bioinformatics: sequence and Genome Analysis, DW Mount, Cold Spring Harbor Laboratory Press, 200
3. Creighton T.E. ed. Protein structure. A practical approach. (2004) Oxford University Press

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes &Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Structural Biology)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	1	1	1	2	2	2	2	**1.75**
CO-2	2	3	3	3	3	1	1	1	2	2	1	2	**2**
CO-3	2	2	2	2	3	1	1	1	2	2	1	2	**1.75**
CO-4	2	3	3	3	2	1	1	1	2	3	2	2	**2**
CO-5	2	3	3	3	2	1	1	1	2	3	2	2	**2**
Average	**2**	**2.6**	**2.6**	**2.6**	**2.6**	**1**	**1**	**1**	**2**	**2.4**	**0.6**	**2**	

Structural Biology Lab

COURSE CODE: 18B17BI473

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: Thermodynamics and Chemical Processes, Microbiology

Course Objectives:

1. To visualize, analyze and compare structures of proteins and nucleic acids (DNA), and their subunits.
2. To develop the ability to design, predict, analyze and compare the protein structures.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Understand the relationship between protein structure and its function.	Familiarity
CO2	Understand the methods of characterizing protein's structure using X-ray and NMR methods	Familiarity
CO3	Implementation of bioinformatics tools in understanding protein structures. Understanding the classification of protein databases.	Usage
CO4	Introduction to protein engineering	Familiarity
CO5	Understand the structural diversity in nucleic acids.	Familiarity

List of Experiments

S.No	Description	Hours
1	Understanding Protein structures and Visualization	2
2	Drawing helical wheel for alpha helix	2
3	Using Rasmol and PyMOL for 3-D visualization	2
4	Analysis of protein-protein interaction and protein-DNA interaction	2
5	Advanced PyMOL usage	2
6	Use of PDBsum for structural analysis	2
7	Protein-Ligand interactions: LIGPLOT	2
8	Secondary structure prediction methods	2
9	PROSITE - Protein signature patterns	2
10	Understanding Ramachandran plots and X-Ray Crystallography	2
11	RNA secondary structure visualization	2
Total Lab hours		**22**

Suggested Books/Resources:

1. Introduction to Protein Structure, Carl Branden and John Tooze, Garland Publishing Inc., New York
2. Bioinformatics: sequence and Genome Analysis, DW Mount, Cold Spring Harbor Laboratory Press,

200

3. Creighton T.E. ed. Protein structure. A practical approach. (2004) Oxford University Press

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Structural Biology)	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**Average**
CO1	2	2	2	2	2	1	1	1	2	2	2	2	**1.75**
CO2	2	3	3	3	3	1	1	1	2	2	1	2	**2**
CO3	2	2	2	2	3	1	1	1	2	2	1	2	**1.75**
CO4	2	3	3	3	2	1	1	1	2	3	2	2	**2**
CO5	2	3	3	3	2	1	1	1	2	3	2	2	**2**
Average	**2**	**2.6**	**2.6**	**2.6**	**2.6**	**1**	**1**	**1**	**2**	**2.4**	**0.6**	**2**	

Programming Languages for Bioinformatics

COURSE CODE:18B11BI414

COURSE CREDITS: 3

CORE/ELECTIVE: CORE

L-T-P: 3-0-0

Pre-requisite: None

Course Objectives:

1. To familiarize and master the programming skills in Perl and Python.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Write and execute a script in Perl.	Usage
CO-2	Enable routine and module calls and their implementation using Bioperl.	Familiarity
CO-3	Able to formulate stepwise implementation of a Perl script (from developing a pseudo-code to execute a successful bug-free code) for a given problem in Bioinformatics.	Usage
CO-4	Write and execute a script in Python.	Usage
CO-5	Enable routine and module calls and their implementation using Biopython.	Familiarity
CO-6	Able to formulate stepwise implementation of a Python script (from developing a pseudo-code to execute a successful bug-free code) for a given problem in Bioinformatics.	Usage

Course Contents:

Unit	Contents	Lectures required
1	Crash course in C	2
2	Programming basics	1
3	Sequences and Strings: Storing a DNA sequence, Concatenation, Transcription, Translation	2
4	Arrays and Scalar list, Strings to Array, Operations on Strings	2
5	Subroutines and Command line arguments	3
6	Modules, Calling modules	2
7	Hashes, Data Structures in Perl	4
8	Reading files and writing output formats	3
9	Regular expressions and Perl Operations	3
10	Parsing genbank, PDB, BLAST, and other file formats	3
11	Object-oriented programming, Complex Data Structures, Relational Databases	4

12	BioPerl	3
13	Introduction to Python	3
14	BioPython	4
15	Applications of Python and BioPython	3
Total lectures		**42**

Suggested Text Book(s):

a. Beginning Perl for Bioinformatics By James Tisdall, O'Reilly Media (2001)
b. Mastering Perl for Bioinformatics By James Tisdall, O'Reilly Media (2003)
c. Python For Bioinformatics By Sebastian Bassi, Chapman and Hall (2010)

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	2	2	1	1	1	1	1	1	**1.83**
CO2	3	3	3	3	3	1	1	1	1	1	1	3	**2.00**
CO3	3	3	2	3	2	3	2	1	1	1	2	1	**2.00**
CO4	3	3	3	2	3	2	1	1	1	1	1	1	**1.83**
CO5	2	2	3	3	3	3	1	1	1	1	1	1	**1.83**
CO6	2	3	3	3	2	2	2	2	2	2	2	2	**2.25**
Average	**2.67**	**2.83**	**2.80**	**2.80**	**2.60**	**2.20**	**1.20**	**1.00**	**1.00**	**1.00**	**1.20**	**1.40**	

Programming Languages for Bioinformatics Lab

COURSE CODE: 18B17BI474

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: C, Object-oriented data structures.

Course Objectives:

1. To master programming skills in Perl and Python and implement those skills using BioPerl and BioPython.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Write and execute a script in Perl.	Usage
CO2	Enable routine and module calls and their implementation using Bioperl.	Familiarity
CO3	Able to formulate stepwise implementation of a Perl script (from developing a pseudo-code to execute a successful bug- free code) for a given problem in Bioinformatics	Usage
CO4	Write and execute a script in Python	Usage
CO5	Enable routine and module calls and their implementation using Biopython.	Familiarity
CO6	Able to formulate stepwise implementation of a Python script (from developing a pseudo-code to execute a successful bug- free code) for a given problem in Bioinformatics	Usage

List of Experiments

S.No	Description	Hours
1.	Installing and learning how to run Perl, Good programming practices	2
2.	File Handling	2
3.	Understanding Sequences and Strings, Operation on Strings - Motif finding	2
4.	Writing a subroutine and calling, Translation of DNA to Protein Sequences	2
5.	Mutating a DNA sequence and generating a random DNA sequence	2
6.	Reading from various file formats	2
7.	Installing Bioperl, Translation of DNA to Protein Sequences using Bioperl	2
8.	Reading and Parsing PDB files using Bioperl	2
9.	Automating BLAST and Parsing BLAST Output using Bioperl	2
10.	Python File handling	2
11	Gene Expression Analysis with Python	2
12	Using BioPython – Part I	2
13	Using BioPython – Part II	2

Total Lab hours	**26**

Suggested Books/Resources:

1. Pauline M. Doran, “Bioprocess Engineering Principles” 8th ed., Academic press, New York, 2003.
2. M.L. Shuler and F. Kargi, "Bioprocess Engineering--basic Concepts", 2nd Edn. Prentice-hall Of India Pvt Ltd (2008).
3. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, "Principles of Fermentation Technology", Â Elsevier India Pvt Ltd. (2007).

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	2	2	1	1	1	1	1	1	**1.83**
CO2	3	3	3	3	3	1	1	1	1	1	1	3	**2.00**
CO3	3	3	2	3	2	3	2	1	1	1	2	1	**2.00**
CO4	3	3	3	2	3	2	1	1	1	1	1	1	**1.83**
CO5	2	2	3	3	3	3	1	1	1	1	1	1	**1.83**
CO6	2	3	3	3	2	2	2	2	2	2	2	2	**2.25**
Average	**2.67**	**2.83**	**2.80**	**2.80**	**2.60**	**2.20**	**1.20**	**1.00**	**1.00**	**1.00**	**1.20**	**1.40**	

Environmental Studies

COURSE CODE: 23B11GE411

COURSE CREDITS: 2

CORE/ELECTIVE: Mandatory Course

L-T-P: 2-0-0

Pre-requisite: None

Course Objectives:

1. Identify environmental problems arising due to engineering and technological activities and the science behind those problems.
2. Estimate the population- economic growth, energy requirement and demand.
3. Analyze material balance for different environmental systems
4. Realize the importance of ecosystem and biodiversity for maintaining ecological balance.
5. Identify the major pollutants and abatement devices for environmental management and sustainable development.
6. Recognizing the major concepts of environmental studies, developing problem solving ability, forecasting the global climate change

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Introducing basic concept of environmental studies, interdisciplinary nature and scope of the subject	Familiarity
CO-2	Understanding ecosystem services and its functioning as well as equitable use of natural resources.	Assessment
CO-3	Understanding Pollution, A threat to the environment and finding its solutions, Pollutant sampling and monitoring of samples.	Assessment
CO-4	Correlating the concept of Biodiversity and its importance to human mankind	Usage
CO-5	Understanding social issues and their impact on the environment.	Usage
CO-6	Role of Information Technology in environment and human health	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Unit 1: Multidisciplinary nature of environmental studies:** The Multidisciplinary nature of environmental studies: Definition, scope and importance, Need for public awareness, Types of Ecosystems, World Biomes, Ecosystem functioning, Biogeochemical cycles. Ecolabeling /Ecomark scheme	4
2	**Unit 2: Natural resources, their consumption & Protection:** Natural resources, their consumption & Protection: Water, Land Energy (Renewable, non-renewable, wind, solar, hydro, Biomass), Mineral, Forest, & Food resources, Role of an individual in conservation of natural resources, Equitable use of resources. Implications of energy use on the environment. Introduction to sustainable development: Sustainable Development Goals (SDGs)- targets and indicators, challenges and strategies for SDGs.	5
3	**Unit 3: Pollution- a threat to environment:** Pollution- a threat to environment: Air, Water & Land pollution, sources & causes, Space pollution, causes & effects, toxicity limits of pollutants. Critical issues concerning global Environment (Urbanization, population growth, global warming, climate change, acid rain, ozone depletion etc.) and the Roots in: Cultural, Social, Political, Commercial, industrial, territorial domains	5
4	**Unit 4: Environmental standards & Quality:** Environmental standards & Quality: Air, Water & Soil Quality, Pollutant sampling, pollution control systems. Green Chemistry and its applications	4
5	**Unit 5: Biodiversity and its conservation:** Biodiversity loss: Diversity of flora and fauna, species and wild life diversity, Biodiversity hotspots, threats to biodiversity	4
6	**Unit 6: Social Issues and the Environment:** Waste land reclamation, consumerism and waste products, eco-consumerism, dematerialization, green technologies, eco-tourism. Water conservation, rain water harvesting, watershed management. Major International organizations and initiatives: United Nations Environment Programme (UNEP), International Union for Conservation of Nature (IUCN),World Commission on Environment and Development (WCED), United Nations Educational, Scientific and Cultural Organization (UNESCO), Intergovernmental Panel on Climate Change (IPCC)	4
7	**Unit 7: Environmental Management:** Environment protection act, Air (prevention and control of population) act; Water (prevention and control of pollution) act, Wildlife protection act, Forest conservation act, Issues involved in the enforcement of environmental legislation National Environmental Policy; Function of pollution control boards (SPCB and CPCB), their roles and responsibilities Environmental management system. Life cycle analysis; Cost-benefit analysis, Environmental audit and impact assessment; Environmental risk assessment. Pollution control and management; Waste Management- Concept of 3R (Reduce, Recycle and Reuse) and sustainability;	4

8	**Case studies and fieldwork based upon projects**: The students are expected to be engaged in some of the following or similar identified activities: • Discussion on one national and one international case study related to the environment and sustainable development. • Field visits to identify local/regional environmental issues, make observations including data collection and prepare a brief report. • Documentation of campus biodiversity/Documentation of local biodiversity. • Campus environmental management activities such as solid waste disposal, water management, and sewage treatment.	**Self study hours (recommended 2 hours /week)***
Total lectures		**30**

*** Formal instructions /Guidance related to the project topics**

Suggested Text Book(s):

1. Environmental Studies By: M. P. Poonia and S.C. Sharma, Khanna Publishers
2. Textbook of Environmental Studies for UG Courses - Erach Bharucha, University Press
3. Joseph, B., 2005, Environmental Studies, Tata McGraw Hill, India.

Suggested Reference Book(s):

1. Nebel, B.J. & Wright, R.T., 1993, Environmental Science, 8th Edition, Prentice Hall, USA.
2. Chiras D D.(Ed.). 2001. Environmental Science – Creating a sustainable future. 6th ed. Jones & Barlett Publishers.
3. David Laurance. 2003. Environment Impact assessment, Wiley publications.
4. Chhokar KB, Pandya M & Raghunathan M. 2004. Understanding Environment. Sage publications, NewDelhi .

Other useful resource(s):

1. Issues of the journal: Down to Earth, published by Centre for Science and Environment.
2. Audio visuals from: Discovery, National Geographic etc.
3. https://nptel.ac.in/courses/120108002/
4. https://nptel.ac.in/courses/120108005
5.https://www.ugc.ac.in/pdfnews/1084504_Draft-Guidelines-and-Curriculum-Framework-for-Environment-Education-at-UG-level.pdf

Bioprocess Engineering

COURSE CODE:18B11BT511

COURSE CREDITS: 4

CORE/ELECTIVE: CORE

: 3-1-0

Pre-requisite: Thermodynamics and Chemical Processes, Microbiology, Biochemistry

Course Objectives:

1. Learn various bioprocess related terms and principles
2. Learn about microbial growth kinetics in various mode of fermentation
3. Learn about the principles and application of Mass transfer and Sterilization
4. Develop an understanding of important concepts and design aspects of bioreactors
5. Learn about the functioning of various bioreactors
6. Learn about the principle of scaling up and scaling down of bioprocesses

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Able to use correct biological terms to describe & analyze phenomena/ problems in bioprocesses	Familiarity
CO-2	Able to apply engineering principles to address issues in various bioprocesses	Assessment
CO-3	Able to analyze bacterial growth kinetics (homogeneous reaction) in batch /continuous/ Fed-batch reactor and sterilization	Assessment
CO-4	Able to understand and to solve problems related to bioprocess phenomena including mixing, Mass transfer and sterilization	Assessment
CO-5	To develop a strong foundation about bioreactor designs and their applications	Usage
CO-6	Able to understand the basis of bioprocess scale up and the related basic design calculations	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction:**Role of bioprocess engineer, Microbial process development, Quality control management, Fermentation Economics	3
2	**Kinetics of Microbial growth:** Batch culture, Kinetic implications of endogenous and maintenance metabolism. Continuous culture, Modifying continuous reactors: Chemostat with recycle and multistage Chemostat Systems. Modifying batch reactors: Fed- batch operation, Perfusion systems.	7
3	**Sterilization:**Design of batch and continuous sterilization processes, kinetics of thermal death of cells and spores.	2
4	**Mixing:**Mixingequipments, flow patterns in reactors, mixing mechanism, power consumption and shear properties of sparged and agitated vessels and various mixing agitators.	4

5	**Mass Transfer:**Role of diffusion in bioprocessing, film theory, convective mass transfer, oxygen uptake in cell cultures. Oxygen transfer in fermenters: measuring dissolved-oxygen concentration, estimating oxygen solubility, mass transfer correlation, measurement of k_La, oxygen transfer in large vessels.	7
6	**Strain Improvement and Media Formulation:**Strain improvement of industrially important microorganisms, Media formulation industrial fermentations.	5
7	**Immobilized Cell Systems (ICS):** Immobilization and its limitations, Active and passive immobilization, applications of immobilized cell biocatalysts. Diffusional limitations in ICS. Bioreactor considerations.	3
8	**Bioreactor design and analysis:**Bioreactor configurations and its utilities, Analysis of ideal and non-ideal reactors. Multiphase reactors: packed-bed reactors, bubble-column bioreactors, fluidized bed bioreactors, trickle-bed reactors. Practical considerations for bioreactor construction, Bioreactors instrumentation and control. Bioprocess Considerations: Animal cell cultures & plant cell cultures	6
9	**Scale up and Scale down:**Scale up of bioprocesses and its difficulties. Scale up criteria for bioreactors based on oxygen transfer, power consumption and impeller tip speed. Scale down.	5
Total Lectures		**42**

Suggested Text Book(s):

1. Pauline M. Doran, “Bioprocess Engineering Principles”, 8th ed., Academic press, New York, 2003.
2. M.L. Shuler and F. Kargi, "Bioprocess Engineering--basic Concepts", 2nd Edn. Prentice-hall Of India Pvt Ltd (2008).
3. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, "Principles of Fermentation Technology", Â Elsevier India Pvt Ltd. (2007).

Suggested Reference (s):

1. KlaasVan’t Riet, Johannes Tramper, “Basic Bioreactor Design”, 2nd ed., Marcel Dekker, Inc., New York, 1991.
2. Bailey and Ollis, “Biochemical Engineering Fundamentals”, 2nd ed., McGraw-Hill Book Company, New York, 1986.
3. MccabeL.Warren, Smith C. Julian and Peter Harriott, “Unit Operations of Chemical Engineering”, 6th ed., McGraw Hill International Edition, New York, 2001.
4. Abhilasha S. Mathuriya, “Industrial Biochnology” 1st ed., Ane Books Pvt. Ltd., New Delhi, 2009.

Other useful resource(s):

1. NPTEL Course Content:
   - i) Bioreactors by Prof. Suraish Kumar, IIT Madras https://nptel.ac.in/courses/102106053/
   - ii) Industrial Biotechnology by Prof. Debabrata Das, IIT Kharagpur…. https://nptel.ac.in/courses/102105058/
   - iii) Aspects of Biochemical Engineering by Prof. Debabrata Das, IIT Kharagpur https://nptel.ac.in/courses/102105064/
2. Link to topics related tocourse:
   - i) Mass Transfer by Prof. Bishnupada Mandal, IIT Guwahati https://nptel.ac.in/courses/103103034/13#

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Unit 1-2
2	T-2	25	1.5 Hours	Unit 1-5
3.	T-3	35	2 Hours	Whole Syllabus
4.	Teaching Assessment	25	Entire Semester	Inform class time to time (Quizzes, Presentation, Assignments)

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Bioprocess Engineering)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	-	1	1	1	-	-	2	1	3	2	-	3	**1.75**
CO-2	3	2	2	1	-	-	-	1		1	-	3	**1.86**
CO-3	3	3	3	3	2	-	2	1	2	1	-	2	**2.20**
CO-4	3	3	3	1	-	-	-	1	2	1	-	1	**1.88**
CO-5	3	1	2	1	2	2	-	1	-	2	-	1	**1.67**
CO-6	3	3	3	3	-	2	2	1	3	1	2	2	**2.27**
Average	**3.00**	**2.17**	**2.33**	**1.67**	**2.00**	**2.00**	**2.00**	**1.00**	**2.50**	**1.33**	**2.00**	**2.00**	

Bioprocess Engineering Lab

COURSE CODE:18B17BT571

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

: 0-0-2

Pre-requisite: Microbiology Lab, Biochemistry Lab

Course Objectives:

1. Provide exposure to the students with hands on experience on various practices in Bioprocess Engineering.
2. Enable students to link the theoretical knowledge of bioprocess engineering with the experiments.
3. Learn how to operate bench scale fermentor
4. Learn how to determine various Monod's Kinetics parameter

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Able to apply practical knowledge to understand the various important process engineering aspects involved in biotechnology industries	Familiarity
CO2	Able to design experiments and analyze various data related to various practices in bioprocess engineering	Assessment
CO3	Ability to apply theoretical concepts for data analysis and interpretation and their documentation	Assessment and Usage
CO4	Able to run fermenter and also to analyze their results	Usage
CO5	Able to understand and determine various growth kinetics parameters in a batch culture	Assessment and Usage
CO6	Able to work in a team to accomplish the experiments and to document the experiments properly in lab note books	Assessment

List of Experiments

S.No.	Description	Hours
1	Introduction of Lab and lab safety	1
2	Describe the various parts of the bench-top fermenter (bioreactor) along with their functions.	1
3	To determine the thermal death point of a microbial culture.	2
4	To determine the thermal death time of a microbial culture.	2
5	To estimate the reducing sugar concentration in a given sample using DNS method.	2
6	To estimate the sugar concentration in fresh and spent media using DNS method.	2
7	To establish the correlation between OD and dry cell weight.	2

8	To study the different phase of microbial growth.	2
9	To study growth kinetics parameters of *E. coli*. a) Specific growth rate (μ) h^{-1} b) Maximum specific growth rate (μ_m) h^{-1} c) Saturation constant (K_s) gm/l d) Growth yield coefficient ($Y_{x/s}$) gm cell/gm substrate. e) Productivity of biomass gm cell/litre/h.	4
10	To study the effect of varying carbon substrate on specific growth rate	2
11	Determination of Volumetric mass transfer coefficient (K_La) using dynamic gassing out method (Virtual Lab)	2
12	Preparation of Immobilized yeast cells in calcium alginate beads	2
Total Lab hours		**24**

Suggested/Resources:

1. M.L. Shuler and F. Kargi, "Bioprocess Engineering--basic Concepts", 2nd Edn. Prentice-hall Of India Pvt Ltd (2008).
2. Lab Manual
3. Pauline M. Doran, “Bioprocess Engineering Principles”, 8th ed., Academic press, New York, 2003.
4. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, "Principles of Fermentation Technology", Â Elsevier India Pvt Ltd. (2007).
5. http://iitd.vlab.co.in/?sub=63

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the Programme Outcomes(POs):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	1	3	1	2	1	2	1	3	**2.17**
CO2	3	3	3	3	2	2	1	2	1	2	-	3	**2.27**
CO3	3	3	3	3	2	2	1	2	1	2	-	3	**2.27**
CO4	3	3	3	3	1	2	2	3	2	2	2	3	**2.42**
CO5	3	3	3	3	1	2	3	3	3	2	2	3	**2.58**
CO6	-	-	-	-	-	-	-	-	3	3	1	3	**2.5**
Average	**3.00**	**3.00**	**3.00**	**3.00**	**1.40**	**2.20**	**1.60**	**2.40**	**1.83**	**2.17**	**1.50**	**3.00**	

Scripting Language for Bioinformatics

COURSE CODE: 18B11BI512

COURSE CREDITS: 3

CORE/ELECTIVE: CORE

: 3-0-0

Pre-requisite: Basic programming principal

Course Objectives:

1. To apply, and develop scripting languages codes and implement them towards the analysis of biological data. Additionally to Develop web based applications for the problems in biology. All students will be able to develop their own websites.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Able to apply design principles to develop web based applications specially for biological data analysis	Familiarity
CO-2	To understand working on world wide web through implementations	Familiarity and Assessment
CO-3	Use various methods from computational biology to implement their programmatic versions	Assessment
CO-4	Able to design new web pages and web sites	Assessment and Usage
CO-5	Able to developed programs to describe and analyze problems in biology	Assessment and Usage

Course Contents:

Unit	Contents	Lecture Hours
1	Introduction to Internet and World Wide Web. An overview of scripting languages, with applications towards biological data and sequence analysis. Complexity of DNA problems and their computational implications and applications. Introduction to HTML, DHTML, XML. accessing different objects of the HTML page, Dynamic page generation, Cascading Style Sheets (CSS).	**12**
2	JAVASCRIPT: Document object model, Elements of the document object model, basic principles of JS, object based programming using JavaScript; data types and structures, array and string handling, function implementations, XML: DTD, XML schemas, XML document structure, retrieving data from database in XML format; various bio based versions of XML.	**10**
3	PHP: PHP beginning to advanced level, data types, array and string handling, mathematical expressions and functions in PHP, PHP programming (implementation of object model), Database connectivity using PHP.	**12**

4	Hands-on practice on above mentioned programming languages. Implementation of programming skills for solving problems in biology. Development of bioinformatics based small applications and web based applications.	**8**
Total Lectures		**42**

Suggested Text Book(s):

1. HTML the complete reference, 2004, TMH.
2. Beginning PHP and Professional PHP, 2009, Wrox, Wiley Dreamtech.
3. JavaScript: The complete Reference, 2004, TMH.

Suggested Reference Book(s):

1. Biological Sequence Analysis: Probabistic models of proteins and nucleic acids (1998) Durbin R., et al, Cambridge University press.
2. Many other reference and text books on these scripting languages available in the library.

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Scripting Languages for Bioinformatics)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	1	3	2	2	2	1	3	2	3	2	**2.08**
CO-2	3	2	2	2	-	-	-	1	-	1	2	2	**1.88**
CO-3	3	3	3	3	2	2	1	1	2	1	-	2	**2.09**
CO-4	3	3	3	1	-	-	-	-	2	2	2	1	**2.13**
CO-5	3	2	2	2	2	2	-	-	-	2	-	1	**2.00**
Average	**2.8**	**2.4**	**2.2**	**2.2**	**2**	**2**	**1.5**	**1**	**2.33**	**1.6**	**2.33**	**1.6**	

Scripting Language for Bioinformatics Lab

COURSE CODE:18B17BI572

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: Basic concepts in programming

Course Objectives:

1. To apply, and develop scripting languages codes and implement them towards the analysis of biological data.
2. Additionally to develop web based applications.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	To understand working on world wide web through implementations for client and server side programming	Familiarity
CO2	Able to developed programs to describe and analyze problems in biology.	Assessment
CO3	Able to design new web pages and web sites.	Assessment
CO4	To understand coordination of HTML, Java Script and PHP.	Assessment
CO5	Able to develop web based applications especially for biological data analysis.	Assessment and Usage

List of Experiments

S.No	Description	Hours
1	Introduction to HTML, DHTML, XML and accessing different objects of the HTML page and dynamic page generation.	2
2	HTML code for basic understanding of the syntax including the use of nesting of lists.	2
3	HTML code for creating a webpage including hyperlinks and images.	2
4	Construction of DTD schema,a sample xml document to represent evolutionary tree.	2
5	Construction of XML schema, a sample xml document to represent a pathway.	2
6	Implementation of Session, request, report objects in an ASP application.	2
7	Create a MySql/ MSacessesdatabase tables and execute all SQL queries.	2
8	Development of a PHP program to take set of sequences and find out conserved sequences.	2
9	Write a PHP program to construct a pathway.	2
10	Write a PHP program to connect mysql database and execute all SQL commands.	2
11	Construct a PHP interface for a given ER model.	2
12	Write a PHP program to find out ORFs existing in a given genomic sequence.	2

13	Write a PHP program to find out annotation and sequence from a fasta file	2
Total Lab hours		**26**

Suggested/Resources:

a. A P Thomas: HTML the complete reference, 2nd Edition, TMH, 2004.
b. A P Thomas, F Schneider: JavaScript: The complete Reference, 2nd Edition, TMH, 2004.
c. D W Mercer *et al*: Beginning PHP and Professional PHP, Wrox, Wiley Dreamtech, 2009.
d. R Durbin *et al*: Biological Sequence Analysis: Probabistic models of proteins and nucleic acids, Cambridge University press, 1998.

Evaluation Scheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assesment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	2	2	1	3	2	2	2	1	3	2	3	2	**2.08**
CO2	3	2	3	2	1	-	-	1	-	1	2	3	**2.00**
CO3	2	3	2	3	3	2	1	1	2	2	-	2	**2.09**
CO4	3	3	3	1	-	1	-	-	2	2	2	2	**2.11**
CO5	3	2	2	2	2	2	-	-	-	2	-	1	**2.00**
Average	**2.6**	**2.4**	**2.2**	**2.2**	**2**	**1.75**	**1.5**	**1**	**2.33**	**1.8**	**2.33**	**2**	

Structural Bioinformatics Lab

COURSE CODE:18B17BI573

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

: 0-0-2

Pre-requisite: Structural Biology

Course Objectives:

To develop the ability to design, predict, analyze and compare the protein structures as well as predict the function of target proteins.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Understanding the fundamental concepts of structural biology (chemical building blocks, structure, superstructure, folding, etc.)	Familiarity
CO2	To Understand and use structural databases and software for structure visualization	Familiarity
CO3	To understand the algorithms used in Structure determination and quality assessment	Assessment
CO4	To perform protein structure comparison and the hierarchical nature of biomacromolecular structure classification	Usage
CO5	To understand the methodology of protein structure prediction and assessment	Assessment
CO6	To understand the methodology of sequence- and structure-based functional site prediction	Assessment

List of Experiments:

S.No	Description	Hours
1	Homology modeling using Swiss-Modeller and Modeler standalone software	2
2	Searching and analyzing SCOP and CATH database; analysis of protein structure (protein ligand and protein-protein complexes) using pdbsum, ligplot and dimplot	2
3	Prediction protein secondary structure using above methods and comparison, calculating Q3 value and SOV score.	2
4	Prediction of tertiary structure of protein sequences (using Modeller and GenThreader)	2
5	Error estimation and precison of predicted protein structures (Procheck, What IF, Errat, Verify3D, etc.)	2
6	Comparing protein structures (using CE, DALI, Comparer, SARF2, SSAP, VAST) and statistical analysis of results	2
7	Secondary structure assignment of protein structure using DSSP, STRIDE, DEFINE and P-Curve and statistical analysis of results	2

8	Predicting structural domains (using PRODOM) and binding sites (acSite, SiteMatch, SiteFinder, etc.)	2
9	Ab initio prediction of various energy components of protein structure and validation of structure	2
10	Prediction of PBSA and GBSA energy components using molecular simulation technique	2
11	Filling of gaps in protein structure, energy minization and validation of protein structure	2
12	Setting of MD simulation job of protein structure, interpretation of results and refinement of structure.	2
Total Lab hours		**24**

Suggested/Resources:

1. Structural Bioinformatics (2nd Edition), Jenny Gu (Editor), Philip E. Bourne (Editor)
2. D.W. Mount Bioinformatics: Genome and Sequence Analysis: (2001) Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.
3. Molecular Modeling: Principles & Applications, Andrew R. Leach, Prentice Hall

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	2	2	1	1	1	1	1	1	**1.83**
CO2	3	3	3	3	3	1	1	1	1	1	1	3	**2.00**
CO3	3	3	2	3	2	3	2	1	1	1	2	1	**2.00**
CO4	3	3	3	2	3	2	1	1	1	1	1	1	**1.83**
CO5	2	2	3	3	3	3	1	1	1	1	1	1	**1.83**
CO6	2	3	3	3	2	2	2	2	2	2	2	2	**2.25**
Average	**2.67**	**2.83**	**2.80**	**2.80**	**2.60**	**2.20**	**1.20**	**1.00**	**1.00**	**1.00**	**1.20**	**1.40**	

Machine learning for Bioinformatics

COURSE CODE:18B11BI611

COURSE CREDITS: 3

CORE/ELECTIVE: CORE

L-T-P: 3-0-0

Pre-requisite: Molecular biology, Python

Course Objectives:

1. Learn what is machine learning
2. Learn algorithms used in machine learning.
3. Learn how to implement machine learning for biological problems.
4. Apply machine learning to practical projects.
5. Use machine learning and data mining in one project.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Different types of machine learning and its utility in bioinformatics	Familiarity
CO-2	Application of Hidden Markov Model and Artificial neural networks to different types of bioinformatics data	Assessment
CO-3	Determination of Bayesian Network (BN) from expression data.	Assessment
CO-4	Application of symbolic machine learning (SML) methods to predict cleavage site of HIV- protease from training data of positive and negative cases.	Assessment
CO-5	Optimization of weights in a supervised and unsupervised neural network, and application of supervised learning to predict sub- cellular localization of a protein.	Assessment
CO-6	Application of stochastic context-free grammar (SCFG) to predict RNA secondary structure.	Assessment

Course Contents:

Unit	Contents	Lectures required
1	**Introduction:** Overview of intelligent systems and machine learning	1
2	**Hidden Markov Model (HMM):** Viterbi algorithm, Forward algorithm,	10
	Backward algorithm, Profile-HMM, Baum-Welch algorithm to optimize HMM-profile, Multiple alignment and database searching using profile- HMM	
3	**Symbolic Machine Learning:** Nearest neighbour approach to predict secondary structure, Decision tree methods, Identification tree methods	6
4	**Bayesian Network (BN):**Calculation of statistical significance by using Bayesian methods, Factorization and Markov blanket rule, d-separation, Equivalence classes, Learning of Bayesian network, Learning of Gaussian network	9
5	**Artificial Intelligence (AI):**Search strategies, logic, deduction, and pathways comparison	4

6	**Artificial Neural Network (ANN):**Basics and introduction to terminologies, Supervised and non-supervised learning, Feed forward back propagation error method, Application of ANN methods: Protein sub-cellular localization and secondary structure prediction	**7**
7	**Stochastic Context Free Grammar (SCFG):**Transformational grammar, Parsing, Chomsky hierarchy (regular, context-free, context-sensitive, and unrestricted grammar), Automata, Context-free grammar, Application of SCFG for prediction of secondary structure of RNA	**5**
Total Lectures		**42**

Suggested Text Book(s):

a. R. Durbin, S. Eddy, A. Krogh, and G. Mitchison (1998), Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids. Cambridge University Press
b. Edward Keedwell and Ajit Narayanan (2005), Intelligent Bioinformatics: The Application of Artificial Intelligence Techniques to Bioinformatics Problems, Wiley
c. P Baldiand S Brunak, BIOINFORMATICS: The Machine Learning Approach

Suggested Reference Book(s):

1. Olson et al., 2018. Data-driven advice for applying machine learning to bioinformatics problems
2. Husmeier D, Dybowski R, and Roberts S (2005), Probabilistic Modeling in Bioinformatics and Medical Informatics, Springer
3. Nat Cell Biol. 2001 Aug;3(8):E190-5. Review. PubMed PMID: 11483980
4. Kim JB, Porreca GJ, Song L, Greenway SC, Gorham JM, Church GM, Seidman CE, Seidman JG. Polony multiplex analysis of gene expression (PMAGE) in mouse hypertrophic cardiomyopathy. Science. 2007 Jun 8;316(5830):1481-4. PubMed PMID: 17556586
5. MacBeath G, Schreiber SL. Printing proteins as microarrays for high-throughput function determination. Science. 2000 Sep 8;289(5485):1760-3. PubMed PMID: 10976071.
6. Shankar J, Wu TD, Clemons KV, Monteiro JP, Mirels LF, et al. (2011) Influence of 17b-Estradiol on Gene Expression of Paracoccidioides during Mycelia-to- Yeast Transition. PLoS ONE 6(12): e28402. doi:10.1371/journal.pone.0028402
7. Mary V. Relling, William E. Evans Nature. Author manuscript; available in PMC 2016 Jan 13.
8. Published in final edited form as: Nature. 2015 Oct 15; 526(7573): 343–350. doi: 10.1038/nature15817

Other useful resource(s):

1. Link to NPTEL course contents:https://nptel.ac.in/courses/106104019/
2. Link to topics related tocourse:
   i. https://www.advancedsciencenews.com/machine-learning-for-bioinformatics-and-neuroimaging/
   ii. https://www.tutorialspoint.com/artificial_intelligence/artificial_intelligence_neural_networks.htm
   iii. https://www.analyticsvidhya.com/blog/2017/09/understaing-support-vector-machine-example-code/

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Machine learning for Bioinformatics)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	2	2	2	2	2	1	2	**1.92**
CO-2	2	2	2	2	2	1	1	2	2	2	1	2	**1.75**
CO-3	2	2	2	2	2	1	1	1	2	-	2	2	**1.73**
CO-4	2	2	2	2	2	1	1	1	2	2	-	2	**1.73**
CO-5	2	2	2	2	2	1	1	1	2	-	-	2	**1.7**
CO-6	2	2	2	2	2	1	1	1	-	-	-	2	**1.67**
Average	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**1.16**	**1.16**	**1.33**	**2.0**	**2.0**	**1.33**	**2.0**	

Machine learning for Bioinformatics Lab

COURSE CODE:18B17BI671

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: None

Course Objectives:

1. Develop an understanding of important concepts and their implementation in machine learning in the context of biological problems.
2. Implementation in machine learning in the context of biological problems

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Implementation of KNN using Perl/Python	Assessment
CO2	Implementation of ANN using Perl/Python	Assessment
CO2	Application of Hidden Markov Model for CpG island prediction	Assessment
CO3	Application of HMMER package and Pfam database	Assessment
CO4	Application of Transformational Grammars in bioinformatics	Assessment
CO5	Application of SVM in bioinformatics	Assessment

List of Experiments

S.No	Description	Hours
1	Calculation of sensitivity, specificity, accuracy for a given classifier	2
2	Implementation of crisp KNN for a microarray file	2
3	Implementation of fuzzy KNN for a microarray file	2
4	Identification tree construction using See5 and Weka	2
5	Implementation of perceptron on LOGIC GATES	2
6	Calculation of AAC and DPC for SVM and ANN input files	2
7	Calculation of pseudo amino acid composition	2
8	Implementation of ANN using SNNS software	2
9	Implemenation of SVM using SVM-light, LIBSVM and Weka	2
10	Implementation of HMM for prediction of CpG islands	2
11	HMM using HMMER package	2
12	Stochastic context free grammar	2
Total Lab hours		**24**

Suggested/Resources:

1. http://hmmer.org/.
2. https://www.cs.waikato.ac.nz/ml/weka/https://nptel.ac.in/courses/106104019/26
3. https://www.rulequest.com/download.html

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	2	2	1	1	1	1	1	1	**1.83**
CO2	3	3	3	3	3	1	1	1	1	1	1	3	**2.00**
CO3	3	3	2	3	2	3	2	1	1	1	2	1	**2.00**
CO4	3	3	3	2	3	2	1	1	1	1	1	1	**1.83**
CO5	2	2	3	3	3	3	1	1	1	1	1	1	**1.83**
Average	**2.67**	**2.83**	**2.80**	**2.80**	**2.60**	**2.20**	**1.20**	**1.00**	**1.00**	**1.00**	**1.20**	**1.40**	

Computer Aided Drug Design

COURSE CODE: 18B11BI612

COURSE CREDITS: 3

CORE/ELECTIVE: CORE

: 3-0-0

Pre-requisite: None

Course Objectives:

1. To design potential lead molecules against any disease that may be explored further as a potential candidate for the drug development.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Feasibility study of a drug development project	Familiarity
CO-2	Design and optimize lead molecules against drug target, and using ligand-basedapproach	Usage
CO-3	Determination of pharmacophore from lead molecules and active sites and use ofpharmacophore for lead discovery	Usage
CO-4	Development of potential drug molecule and pharmacophore databases for virtualscreening	Assessment
CO-5	Use of molecular fragments for lead discovery and implementation of statisticalapproaches for lead molecule discovery	Usage
CO-6	Bioavailability prediction of a drug and working capability in drug designing softwarelike, Discovery Studio and molecular dynamics software like AMBER 8.0, On-line tools, etc.	Assessment

Course Contents:

Unit	Contents	Lectures required
1	**Introduction:** Drug design: A billion dollar baby and drug design techniquesteam work, Economic factors involved in drug design, Irrational vs.	**4**
	rational approaches, Drug target identification & computer-aided drug design processes, Case study related to drug target identification (Viral Targets -HIV Example)	
2	**Computational Approaches to Drug Design:** Structure-based (receptor fitting)and ligand-based (receptor mapping) molecule design, lead molecules design in a research environment (crossing the barriers), tools used in both environments	**3**
3	**Receptor Fitting (Lead discovery& refinement)**: Utility, Binding-site predictions: Stereoelectronic factors, receptor flexibility, tight binding; Docking: Introduction, search algorithms, scoring (MM, Grid, etc.), validation of results, comparisons of search and scoring methods; Docking processes and analysis of results; *De novo* design, database searching & high throughput virtual screening(HTVS); and applications. Introductions to docking & molecular modeling packages (DS Studio; Schrodinger Inc, Ligbuilder, etc.)	**9**
4	**Receptor Fitting (Lead optimization)**: Molecular simulation methods used for binding and free energy calculation, Calculation on Free Energy Perturbation(FEP) of 1. Thermolysin with 2 ligands, Molecular mechanics Poisson-Boltzmann surface area methods: molecular basis of HIV protease drug	**4**

	resistance	
5	**Receptor Mapping (Pharmacophore)**: The pharmacophore concept, Determination of pharmacophore from a set of active molecules, Design of pharmacophore using various algorithms, Creating pharmacophore model from active site, Practical utility (searching compound databases) and A case study of new lead design	**5**
6	**Chemoinformatics:** Introduction, representing 2D & 3D structures, 2D chemical database applications & molecular descriptors and their classifications, database searching and applications in CADD	**4**
7	**Receptor Mapping (Quantitative structure activity relationship (QSAR))**: QSAR methodology, biological and physicochemical parameters, feature selection(PLS, PCA, MLR, etc.), model building and validation, QSAR applications in drug design, Quantitative structure-property relationships (QSPR), CoMFA, 3D and nD-QSAR methods	**6**
8	**Fragment-based Lead Discovery**: Fragment and substructure discovery and evaluation, virtual fragment scanning (trends, applications and web-based tools) & capture methods for fragment-based discovery	**4**
9	**ADMET**: Oral bioavailability, drug half-life in the bloodstream, BBB permeability, toxicity, Lipinski rule of five, The impact of physiochemical properties on the control of drug-like properties.	**4**
Total Lectures		**42**

Suggested Text Book(s):

1. David C Young : Computational Drug Design (A guide for computational and medicinal chemists) Wiley & Sons, Inc., New Jersey, USA
2. Holtje H.-D, Sippl W., Rognan D. and FolkersG. : Molecular Modeling, Basic Principles and Applications Wiley-VCHGmbH& Co. KGaA
3. Leach AR : Molecular Modeling: Principles and Applications: Prentice Hall, Edinburg UK.
4. Zartler ER & Shapiro MJ : Fragment-based Drug Discovery (A practical approach), Wiley & Sons, Inc., West Sussex, UK Flower DR : Drug design: cutting edge approaches, RSC publication, Cambrige, UK

Suggested Reference Book(s):

1. Merz KM, D Ringe, : Drug Design: Structure and Ligand-based Approaches. Reynolds CH Cambridge University Press
2. Opera TI :Chemoinformatics in Drug Discovery, Wiley-VCH, GMBH
3. Hubbard RE : Structure-based drug discovery (An overview), RSC publication, Cambrige, UK

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	2	2	1	1	1	1	1	1	**1.83**
CO2	3	3	3	3	3	1	1	1	1	1	1	3	**2.00**
CO3	3	3	2	3	2	3	2	1	1	1	2	1	**2.00**
CO4	3	3	3	2	3	2	1	1	1	1	1	1	**1.83**
CO5	2	2	3	3	3	3	1	1	1	1	1	1	**1.83**
C06	2	3	3	3	2	2	2	2	2	2	2	2	**2.25**
Average	**2.67**	**2.83**	**2.80**	**2.80**	**2.60**	**2.20**	**1.20**	**1.00**	**1.00**	**1.00**	**1.20**	**1.40**	

Computer Aided Drug Design Lab

COURSE CODE: 18B17BI672

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: None

Course Objectives:

1. To design potential lead molecules against any disease that may be explored further as a potential candidate for the drug development.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Feasibility study of a drug development project	Familiarity
CO2	Design and optimize lead molecules against drug target, and using ligand-basedapproach	Usage
CO3	Determination of pharmacophore from lead molecules and active sites and use ofpharmacophore for lead discovery	Usage
CO4	Development of potential drug molecule and pharmacophore databases for virtualscreening	Assessment
CO5	Use of molecular fragments for lead discovery and implementation of statisticalapproaches for lead molecule discovery	Usage
CO6	Bioavailability prediction of a drug and working capability in drug designing softwarelike, Discovery Studio and molecular dynamics software like AMBER 8.0, On-line tools, etc.	Assessment

List of Experiments

S.No	Description	Hours
1	Installation of various drug design software and assignment 'Project'	2
2	Generation of 3D optimized structure of a "Ligand" molecule	2
3	Preparation of target and ligand molecules for docking	2
4	"Virtual library Preparation" of lead molecules	2
5	Docking of ligands into a receptor (active site)	2
6	Flexible docking of ligand with target	2
7	Fragment docking using '*De Novo'* Receptor and '*De Novo'* Links (LUDI algorithm)	2
8	Pharmacophore modeling of ligands	2
9	Pharmacophore-based database searching and *de novo* design of ligand against an active site	2
10	Development of 3D QSAR model by using "Discovery Studio"	2
11	ADME property and toxicity predictions of lead molecule (using TOPKAT)	2
12	Energy minimization and molecular dynamics (MD) target molecule by using"Simulation" module of "Discovery Studio"	2
13	Estimates binding free energy of ligands and receptor using CHARMmimplicitsolvation models	2
Total Lab hours		**26**

Suggested Books/Resources:

1. David C Young : Computational Drug Design (A guide for computational and medicinal chemists) Wiley & Sons, Inc., New Jersey, USA

2. Holtje H.-D, Sippl W., Rognan D. and FolkersG. : Molecular Modeling, Basic Principles and Applications Wiley-VCHGmbH& Co. KGaA
3. Leach AR : Molecular Modeling: Principles and Applications: Prentice Hall, Edinburg UK.
4. Accelrys: User Manuals Discovery Studio.
5. AMBER : AMBER 11 Users' Manual, Scripps Research Institute, USA
6. GROMACS:Gromacs User Manual

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	2	2	1	1	1	1	1	1	**1.83**
CO2	3	3	3	3	3	1	1	1	1	1	1	3	**2.00**
CO3	3	3	2	3	2	3	2	1	1	1	2	1	**2.00**
CO4	3	3	3	2	3	2	1	1	1	1	1	1	**1.83**
CO5	2	2	3	3	3	3	1	1	1	1	1	1	**1.83**
CO6	2	3	3	3	2	2	2	2	2	2	2	2	**2.25**
Average	**2.67**	**2.83**	**2.80**	**2.80**	**2.60**	**2.20**	**1.20**	**1.00**	**1.00**	**1.00**	**1.20**	**1.40**	

Advanced Algorithms for Bioinformatics Lab

COURSE CODE:18B17BI673

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: Basics of algorithms and programming, data structures. Some knowledge of object-oriented technology and is also desirable

Course Objectives:

1. Develop the ability to design, implement and manipulate algorithms.
2. Develop computer programs for Bioinformatics solutions to life and health science problems.
3. Apply programming concepts to various biological examples and real life applications.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Able to understand algorithmic principles	Familiarity
CO2	To write programs for specific computational biology problems	Assessment
CO3	Analyze problems in biology and able to design new protocols and algorithms for biological data analysis	Assessment
CO4	Able to analyze biological data through programs	Assessment
CO5	Implement algorithms for bioinformatics problems and their assessments	Assessment and Usage

List of Experiments

S.No	Description	Hours
1	Program to solve the US change problem.	2
2	Program to deal with Tower of Hanoi problem.	2
3	Program to generate Fibonacci series using recursive algorithm and few other programs.	2
4	Program to generate distinct sub-strings in a given DNA sequence using combinatorial and other methods.	2
5	Program to generate palindrome of a string and for a nucleotide sequence, translation and reverse translation, find out the GC content in a sequence.	2
6	Program to implement dynamic programming to solve local, semi-global, and global alignment of biological sequences.	2
7	Program to generate redundant nucleotide sequences from given amino acid sequence using standard genetic code system and ambiguous character codes.	2
8	Implementation of fragment assembly algorithms to make contigs.	2
9	Program to predict genes using statistical approaches.	2
10	Program to predict genes using similarity based approaches.	2
11	Program to generate restriction map of DNA sequence using Brute force algorithm.	2

12	Program to generate restriction map of DNA sequence using PDP (Partial Digest Problem) algorithm.	2
13	Motif finding algorithms implementations in DNA and Protein sequences.	2
14	RNA structure algorithms and their implementations.	2
Total Lab hours		**28**

Suggested/Resources:

a. P A Pevzner: Computational Molecular Biology: An algorithmic approach,PHI, 2004.
b. N C Jones and P A Pevzner: An Introduction to Bioinformatics Algorithms, Ane Books, 2004.
c. G. Benson and R. Page: Algorithms in Bioinformatics, Springer Verlag, 2004.
d. C J Date: An Introduction to Database Systems, Addison-Wesley Longman Publishing Co., USA, 1990.
e. I IMandoiu and A Zelikovsky: Bioinformatics Algorithms: Techniques and Applications, Wiley Interscience Press, 2008.
f. R Durbin*et al*: Biological Sequence Analysis: Probabistic models of proteins and nucleic acids, Cambridge University press, 1998.

EvaluationScheme:

1.	Mid Sem. Evaluation	20 Marks
2.	End Sem. Evaluation	20 Marks
3.	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	2	2	1	3	2	2	2	1	3	2	3	3	**2.17**
CO2	3	2	3	2	1	-	-	-	1	1	2	3	**2.00**
CO3	2	2	2	2	3	2	-	1	2	3	-	1	**2.00**
CO4	2	3	3	2	1	1	1	-	2	2	2	2	**1.91**
CO5	3	2	2	2	2	2	-	-	-	2	2	1	**2.00**
Average	**2.4**	**2.2**	**2.2**	**2.2**	**1.8**	**1.75**	**1.5**	**1**	**2**	**2**	**2.25**	**2**	

R Language Lab

COURSE CODE:18B17BI674

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: Basic concepts in programming

Course Objectives:

1. Students will learn how to program in R and how to use R for effective data analysis.
2. Students will learn how to install and configure software/packages necessary for a statistical programming environment; discuss generic programming language concepts as they are implemented in a high-level statistical language.
3. The course covers practical issues in statistical computing which includes programming in R, reading data into R, accessing R packages, writing R functions, debugging, and organizing and commenting R code.
4. Topics in statistical data analysis and optimization will provide working biological and real life examples.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO 1	Able to apply various approaches in R Software and tools to understand concept of Statistics	Familiarity
CO 2	Use various programming techniques in R to implement algorithmic methods from computational biology to describe and analyze problems in biology	Familiarity and Assessment
CO 3	Implement various packages of R for their application in bioinformatics	Assessment
CO 4	To understand Bioconductor and its association with Bioinformatics	Assessment
CO 5	To apply R with universal features through available packages	Usage

List of Experiments

S.No	Description	Hours
1	Introduction of R and R-studio, overview and History of R.	2
2	R-console input and evaluation, Data Types, Basic Arithmetic operation.	2
3	Reading Tabular data and large tables: File handling.	2
4	Textual data formats, Connection: interface to outside world.	2
5	Sub setting- Basics, lists, Matrices, Partial matching, Removing missing values	2
6	Vectorized operations.	2
7	Control structure- introduction, if-else, for loops, while loops, Repeat, Next, Break.	2
8	R-functions, Loop function and debugging.	2
9	Scoping Rules- Symbol binding, rules and optimizing examples, Coding standardDates and times.	2
10	Bioconductors: Introduction.	2
11	Simulation in R- str function, Generate random numbers, Simulating linearModels, Random sampling.	2
12	R-profiler- collect detailed information on how your R functions are running and to identify bottlenecks that can be addressed. The profiler is a key tool in helpingYou optimize your programs.	2
13	Bioconductors package usage for analysis of genomic data - I	2
14	Bioconductors package usage for analysis of genomic data - II	2
Total Lab hours		**28**

Suggested/Resources:

1. An Introduction to R
2. Quick-R
3. R for Beginners
4. Kim Seefeld's R-introduction for Biostatistics
5. P Dalgaard:Introductory Statistics with R, 2nd Edition, Springer Nature, 2008.
6. W P Krijnen: Applied Statistics for Bioinformatics using R, 2009.
7. R Gentlemen: R programming for Bioinformatics, CRC Press, 2008.

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	2	2	3	2	2	2	1	3	2	3	3	**2.33**
CO2	3	3	3	2	1	1	-	-	1	1	2	3	**2.00**
CO3	2	2	2	3	3	2	1	1	3	3	1	2	**2.08**
CO4	3	3	3	2	2	1	1	-	2	3	3	2	**2.27**
CO5	3	2	2	2	2	2	-	1	1	2	2	3	**2.00**
Average	**2.8**	**2.4**	**2.4**	**2.4**	**2**	**1.6**	**1.33**	**1**	**2**	**2.2**	**2.2**	**2.6**	

Phytopharmaceuticals and Biologicals

COURSE CODE: 18B1WBT531

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Basic understanding of biology

Course Objectives:

a. The objective of the course is to develop an understanding and basic knowledge on Indian medicinal herbs, its commercial value, quality control and industrial standards for commercialisation of phytopharmaceuticals and biologicals.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Able to understand pharmacopoeial standards of ayurvedic products	Familiarity
CO-2	Able to understand the phytopharmaceuticals, monographs and quality control of medicinal herbs	Usage
CO-3	Able to understand the extraction and evaluation process of phytopharmaceuticals	Technical
CO-4	Able to understand pharmacopoeial standards of Indian Pharmacopoeia	Familiarity
CO-5	Able to understand the monographs, specifications and quality control of biologicals	Usage

Course Contents:

Unit	Contents	Lectures required
1	Intoduction to phytopharmaceuticals – medicinal herbs & its importance and biologicals. Over view of Ayurvedic and Indian Pharmacopoeia	**4**
2	Pharmacopoeial standards of Ayurvedic (Used by manufacturers, regulators and other stakeholders for quality control of medicinal herbs and finished products against internationally recommended specifications).	**7**
3	Monographs of medicinal herbs, specifications and standards for identification, evaluation, processes and clinical applications	**8**
4	Evaluation of physiochemical parameters of herbal drugs, extraction, Identification & Assay of Herbals Drugs	**6**
5	Pharmacopoeial standards of Indian Pharmacopoeia (Used by manufacturers, regulators and other stakeholders for quality control of active pharmaceutical ingredients (APIs) and finished products against internationally recommended specifications).	**3**
	Monographs on Blood and Blood related products, Monographs on Human Vaccines (The specifications cover the various tests for critical quality parameters	

6	of the vaccine, procedures and acceptance criteria)	**7**
7	Monographs of Erythropoietin Injection, Interferon Injection, streptokinase solution, Human Insulin, etc. Bacterial Endotoxin Test, Sterility Test, Test for Microbial Contamination, etc.	**7**
Total lectures		**4 2**

Suggested Text Book(s):

1. The Ayurvedic Pharmacopoeia Of India, First Edition, Published By Pharmacopoeia Commission For Indian Medicine & Homoeopathy Ghaziabad (2016)
2. Indian Pharmacopoeia published by the Indian Pharmacopoeia Commission (IPC)

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Phytopharmaceuticals and Biologicals)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	2	2	2	2	2	1	2	1.9
CO-2	2	2	2	2	2	1	1	2	2	2	1	2	1.75
CO-3	2	2	2	2	2	1	1	1	2	2	2	2	1.75
CO-4	2	2	2	2	2	1	1	1	2	2	1	2	1.6
CO-5	2	2	2	2	2	1	1	2	2	2	1	2	1.75
Average	2.0	2.0	2	2	2	1.25	1.25	1.5	2.0	2	1.25	2.0	

Bioenergy and Biofuels

COURSE CODE: 18B1WBT634

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Microbiology, Bioprocess Engineering, Downstream Processing, Bioresource Technology

Course Objectives:

The shortage of fossil fuels and its environmental consequences, Bioenery and Biofuel technology seems to be a alternative for generation of energy and fuels. This sector facing various technical, process and social problems for implementation. Based on these aspects the objectives of the course are framed as

1. Introduction of existing and possible Bioenergy and Biofuels technoloies
2. Discussion of technical, process and economic issues related to first, second and third generation biofuels along with Physico chemical techniques

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Advantages and disadvantages of Bioenergy and Biofuels over fossil fuels	Familiarity
CO-2	Technical barriers in Bioenergy and Biofuel Technology	Assessment
CO-3	Whole biorefinery approaches for economical implementation into the market	Usage
CO-4	Conversion technologies of waste to Biofuels, Bioproducts, and Bioenergy	Usage
CO-5	Conversion of waste and Mixed feedstock to Biofuels, Bioenergy and Bioproducts	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction to Biofuels and Bioenergy:** Definition, Global Energy Outlook, Sustainability, Biomass Feedstocks, Processes and Technologies, Environment and Ecology	4
2	**Crop Oils, Biodiesel, and Algae Fuels:** Vegetable Oils, Algae Oil Extraction of Straight Vegetable Oil, Manufacture of Biodiesel	12
3	**Ethanol from Corn and Lignocellulosics:** Fuel Ethanol from Corn, Corn Ethanol as Oxygenated Fuel, Chemistry of Ethanol Fermentation, Corn-to-Ethanol Process Technology, By- Products/Coproducts of Corn Ethanol, Ethanol as Oxygenated and Renewable Fuel, Ethanol Vehicles, Lignocellulose and Its Utilization, Lignocellulose Conversion, Agricultural Lignocellulosic Feedstock, Cellulosic Ethanol Technology; Energy Balance for Ethanol Production from Biomass, Process Economics and Strategic Direction.	12
4	**Fast Pyrolysis and Gasification of Biomass:** Biomass and Its Utilization, Analysis and Composition of Biomass, Chemistry of Biomass Gasification, Fast	7

	Pyrolysis of Biomass, Biomass Gasification Processes, Utilization of Biomass Synthesis Gas	
5	**Conversion of Waste to Biofuels, Bioproducts, and Bioenergy & Mixed Feedstock:** Types of Waste and Their Distributions, Strategies for Waste Management, Waste Preparation and Pretreatment for Conversion, Technologies for Conversion of Waste to Energy and Products, Economic and Environmental Issues Related to Waste Conversion, Future of the Waste Industry, Advantages and Disadvantages of Mixed Feedstock, Transportation, Storage, and Pretreatment, Gasification Technologies, Liquefaction Technologies, Future of Mixed Feedstock.	**7**
Total Lectures		**42**

Suggested Text Book(s):

1. Biofuels and Bioenergy: Processes and Technologies by Sunggyu Lee and Y. T. Shah, CRC Press
2. Bioenergy and Biofuel from Biowastes and Biomass by Samir K. Khanal, Rao Y. Surampalli, Tian C. Zhang, Buddhi P. Lamsal, R. D. Tyagi and C.M. Kao, ASCE Publishers .

Suggested Reference Book(s):

1. Review and research articles from Science Direct, Springer, Wiley and PubMed Publishers

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	1	3	1	2	1	2	1	3	2.17
CO2	3	3	3	3	2	2	1	2	1	2	-	3	2.27
CO3	3	3	3	3	2	2	1	2	1	2	-	3	2.27
CO4	3	3	3	3	1	2	2	3	2	2	2	3	2.42
CO5	3	3	3	3	1	2	3	3	3	2	2	3	2.58
Average	3.00	3.00	3.00	3.00	1.40	2.20	1.60	2.40	1.60	2.00	1.00	3.00	

Intellectual Property Rights and Commercialization

COURSE CODE: 18B1WBT734

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: None

Course Objectives:

b. To provide an insight and understanding about different aspects of protection of inventions and research developments
c. Learn about procedures for filling protection through Intellectual Property Rights.
d. To provide scopes of protection of diverse intellectual properties and its commercialization for socio-economic improvement.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	To enable students with basic concepts and knowledge of intellectual property rights.	Awarness
CO-2	To apply and execute different types of IP protection in research and academics.	Assessment and technical skills
CO-3	Able to understand about the mechanisms of different IP protections, registrations and applications	Technical
CO-4	To be capable of tackling issues related to IP and its commercialization	Assessment
CO-5	Able to learn the strategies for effective IP management and commercialization	Analytical skills
CO-6	To apply the knowledge of IPR for the benefit generation and for mass utilization	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction**:Introduction of Intellectual properties and rights conferred . Integration of Intellectual Property, Bioethics and Biosafety for biological and applied sciences in research and academia.	4
2	**Types of IP tools**:Different types of IPR(Patents, copyrights and related rights, Trademark, Tradesecret, Integrated circuit layout, Geographical indications, Traditional knowledge, Industrial designs and PBR) Drafting Patent Application and Documentation Revocation of Patent, Litigation and Infringement Rationale of different IPR ,their mechanism of protection and provisions in Law	10
3	**International Agreements** and Treaties:International IP treaties (Madrid Agreement, Trademark law treaty, Patent Law treaty etc.) WIPO, EPC, WTO, and TRIPS. International agreements relevant to biotechnology-associated IP	8

4	**Commercialization**: Methods of commercialization,Impact of commercialization. Financing	6
5	**IP Management for value addition:** Strategies for IP Management and commercialization. IP audit, IP insurance Bioentreprenuership management	4
6	**Licensing/Assignment** :Types of licensing and modes to carry out, Assignments and its benefits, Compulsory Licensing Commercialization for social and economic prosperity with case studies	8
Total lectures		**42**

Methodology

The course will be covered through lectures, presentations and vedios. Apart from discussions on topics covered through lectures and assignments, students have to carry out research paper analysis.

Suggested Text Book(s):

i. Intellectual Property Rights & Copyright By Bouchoux.
ii. Intellectual Property Licensing Strategies by Thompson Reuters

Suggested Reference Book(s):

1. Intellectual Property Rights, the WTO and Developing Countries: The TRIPS ...Book by Carlos María Correa
2. Perspectives on Commercializing Innovation by F. Scott Kieff (Editor), Troy A. Paredes (Editor

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Intellectual Property Rights & Commercialization)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	1	1	1	1	1	2	2	**15**

CO-2	2	2	1	2	2	2	1	1	1	1	1	2	**1.5**
CO-3	2	2	2	2	3	1	1	1	2	2	1	2	**1.7**
CO-4	2	2	3	3	2	1	1	1	2	2	2	2	**1.9**
CO-5	2	2	2	2	2	1	2	1	1	2	1	2	**1.6**
CO-6	2	2	2	2	2	2	1	1	2	2	2	2	**1.8**
Average	**3.4**	**3.4**	**2**	**2.1**	**2.1**	**1.3**	**1.1**	**1**	**1.5**	**1.6**	**1.5**	**2**	

Peptide Therapeutics

COURSE CODE: 18B1WBT631

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: General Chemistry

Course Objectives:

1. To develop an understanding of important concepts and design aspects of peptides
2. To learn various therapeutic applications of peptides.
3. Apply basic knowledge to design peptides for various therapeutic purposes

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Able to understand various peptide design consideration and other important structural aspects of peptides	Familiarity
CO-2	Able to understand and learn the concept of solid phase peptides synthesis	Familiarity
CO-3	To develop methods of peptides and proteins for their quality control and apply them in handling Therapeutic peptides and proteins	Assessment
CO-4	To understand the mechanism of action of Antibiotic, Anticancer, Antihypertensive and Opioid peptides	Usage
CO-5	To develop a strong foundation therapeutic peptide design and their applications	Usage

Course Contents:

Unit	Contents	Lectures required
1	Peptides, synthetic peptides & their classification based on structure, engineering bioactive peptide based therapeutic molecules,	**7**
2	Principle and practice of solid phase peptide synthesis, solid	**7**
	support, protection scheme, peptide acid and amide, Purification of peptides, quality control of peptides	
3	Antimicrobial host defense peptides, Anticancer peptides, Opioid Peptides, Antihypertensive Peptides, Peptides in clinical trial ,chemical biology of Oxytocin, valinomycin and enkephalins	**18**
4	Preformulationstudies, Formulation development, Aggregation in protein formulation, novel formulation approaches, Lyophilization, Pharmaceutical Processing, and Handling of Therapeutic Peptides and Proteins	**6**
5	Circular dichroism, UV, IR, Mass and fluorescence spectroscopy of peptides	**4**
	Total lecture	**42**

Suggested Text Book(s):

1. Ajay K Banga, "Therapeutic peptides and protein: formulation processing and delivery system, Second edition, Taylor and Francis.
2. Lehninger Principles of Biochemistry Cox, M.M. and Nelson, D.L. and Lehninger A. L. 4th edition.
3. Biochemistry- J.M. Berg, J.L.Tymoczko, and LubertStryer; 5th edition W.H. Freeman and Company, New York, USA.

Suggested Reference Book(s):

1. Gregory A. Grant, "Synthetic peptides A Users Guide" 2nd ed. W. H. Freeman and Company

EvaluationScheme:

Assessment	Max. marks	Duration	Course Covered
T1 Test	15	1 hr.	Syllabus covered upto T-1
T2 Test	25	1.5 hrs.	Syllabus covered upto T-2
End Term Test	35	2 hrs.	Whole Syllabus
Teacher Assessment (Based on Assignments, quizzes etc.)	25	Whole Sem	Inform class time to time
Total	**100**		

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Peptide Therapeutics	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	3	2	2	2	1	-	-	2	3	3	3	1.92
CO-2	2	3	3	3	2	2	-	-	2	3	3	3	2.17
CO-3	3	3	3	3	3	2	-	-	2	3	3	3	2.33
CO-4	3	3	2	3	3	2	-	-	2	3	3	3	2.25
CO-5	3	3	2	3	2	2	-	-	2	3	3	3	2.17
Average	2.60	3.00	2.40	2.80	2.40	1.80	0.00	0.00	2.00	3.00	3.00	3.00	

Nano-Biotechnology

COURSE CODE: 18B1WBT633

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Basic of Physics, Chemistry and Biology

Course Objectives:

1. Introduction to Nanomaterial and various material used for obtaining nano-materials
2. Learn various approaches or methods used for nanomaterial synthesis.
3. To learn various analytical techniques used for nanomaterial characterization.
4. Learn various applications of nanomaterial in health care, agriculture and environmental monitoring

Course Outcomes

S. No.	Course Outcomes	Level of Attainment
CO-1	Introduction to Nano (Basics to Nanoscience and Nanotechnology)	Familiarity
CO-2	Introduction to the two approaches (bottom up and top down) followed for the synthesis of nanomaterial and fundamental properties of Nano-materials(Nano-effect)	Assessment & Technical
CO-3	Introduction to various technique used for the characterization of nanostructures and nanomaterial.	Assessment & Technical
CO-4	Fundamental understanding of nanomaterial/nano-biotechnological application in health and disease.	Usage
CO-5	Fundamental understanding of nanomaterial/nano-biotechnological application in Environment and food - detection and mitigation	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction, History &Applications:**Various definitions and Concept of Nano-biotechnology & Historical background. Fundamental sciences and broad areas of Nano-biotechnology. Various applications of Nano- biotechnology, Cell – Nanostructure interactions	6
2	**Synthetic methodologies:**Introduction to the two approaches (bottom up and top down) followed for the synthesis of nanomaterials: Lithography method, Electrochemical method, Mechanical Method, Chemical Synthesis, Chemical vapour deposition, Molecular self-assembly, Laser Induced assembly.	10
3	**Techniques used for the characterization of nanoparticles:**Principles of microscopy-light, electron, fluorescent confocal, scanning and transmission microscopes, different fixation and staining techniques for	13
	EM. Principles of spectroscopy-UV, visible, CD, FTIR, NMR, and ESR spectroscopy, structure determination using X-ray diffraction, analysis using light scattering.	
4	**Nano-biotechnologicalapplications in health and disease:**Properties of different types of nanoparticles normally used in health and disease. Diagnostics and theranostics application of nanomaterials in health sciences.	6
	Nanobiotechnological applications in Environment andfood - detection and mitigation: Properties of different types of nanoparticles normally used in	

5	environmental and food sciences. Detection and removal of toxic metal ion from polluted sample and detection and removal of pathogen form food sample.	**7**
Total Lectures		**42**

Suggested Text Book(s):

1. C. A. Mirkin and C. M. Niemeyer. Nanobiotechnology - II more concepts and applications. (2007) - Wiley VCH.
2. P. Boisseau, P. Houdy, M. Lahmani, Nanoscience: Nanobiotechnology and Nanobiology

Suggested Reference Book(s):

1. A. Nouailhat, An Introduction to Nanoscience and Nanotechnology, Wiley
2. D.A Phoenix, W. Ahmed, Nanobiotechnology, One Central Press Ltd, UK
3. L. Filipponi, D. Sutherland, Nanotechnologies: Principles, Applications, Implications and Hands-on Activities.Directorate- European commission

Other useful resource(s): Link to NPTEL course contents

- https://nptel.ac.in/courses/118107015/
- https://onlinecourses.nptel.ac.in/noc17_bt17/preview
- http://videos.gitam.edu/nptel/nano.html

Evaluation Scheme:

S. No.	Exam	Marks	Duration	Coverage/Scope of Examination
1	T-1	15	1 Hour	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Quiz, Assignment, Attendance, etc.

Course Outcomes (COs) contribution to the programme Outcomes (POs):

Course outcomes (NanoBiotech.)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	1	1	2	3	2	1	1	1	2	2	1.7
CO-2	2	3	2	2	3	2	2	2	1	1	3	2	2.1
CO-3	3	3	2	2	3	2	2	2	1	1	3	2	2.2
CO-4	2	2	3	3	2	3	2	2	2	2	3	2	2.3
CO-5	2	2	3	3	2	3	3	2	2	1	3	2	2.3
Average	2.2	2.4	2.2	2.2	2.4	2.6	2.2	1.8	1.4	1.2	2.8	2.0	

Infectious diseases

COURSE CODE: 18B1WBT632

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Microbiology, Immunology

Course Objectives:

1. Learn to define the basic concepts related to infectious diseases, immunology and epidemiology.
2. Able to understand the basic forms, functions, behaviour, and diversity of infectious agents and their interactions with the host
3. Able to analyse the underlying principles of mode of action and resistance towards the agents used to treat infectious diseases

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	The students would have knowledge of infectious diseases for practical use in medicine and biotechnology.	Familiarity
CO-2	The students would have in-depth knowledge of basic concepts related to infectious diseases, immunology and epidemiology.	Assessment
CO-3	The students would develop knowledge and understanding of the basic form, function, behavior, and diversity of infectious agents and their interaction with the host.	Assessment
CO-4	The students would develop knowledge and skill about important techniques used to study host –pathogen interactions.	Assessment/Usage
CO-5	The students would have sound knowledge of mode of action and resistance towards the agents used to treat infectious diseases.	Assessment/Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction to infectious diseases Infectious and non- infectious diseases, Epidemiology of infectious diseases. Infectious agents, socio economic impact of infectious diseases	**6**
2	Host response to infections Bacterial, mycobacterial, viral, helminth, fungal	**3**
3	Biology of infectious agents Morphology, classification, life cycle, pathogenecity, mechanism of replication in bacteria, viruses, protozoa and fungal pathogens	**5**
4	Pathology of Infectious diseases Pathogenesis, Clinical pathology, Gross pathology, Microscopic pathology.	**4**
5	Biology of major Infectious diseases HIV/AIDS, Tuberculosis, malaria, dengue, West Nile virus, chikungunya virus, diarrheal diseases, sexually transmitted infections, influenza, viral hepatitis, Ebola	**8**
6	Diagnostic techniques for infectious diseases Immunohistology, Immunohistochemistry/In situ hybridization, Polymerase chain reaction based methods, Flow Cytometry.	**5**
7	Antimicrobials against infectious agents Antimicrobial agents, mechanism of action, Antibiotic resistance, various mechanisms of antibiotic resistance	**5**
8	Emerging infectious diseases and their Social Impact Emergenceof SARS, Zika virus, Ebola and other newly reported diseases along with their Social	

	and Scientific Impact.	**4**
9	Biological Weapons Introduction, Concept and examples	**2**
Total Lectures	**42**	

Suggested Text Book(s):

1. Evolution of infectious disease. Ewald PW. Oxford University Press, New York.1994. ISBN 0-19-511139-7.
2. Emerging Infections 1. Scheld WM, Armstrong D and Hughes JM, Editors. ASM Press, Washinton, DC. 1998. ISBN 1-55581-123-3
3. Emerging Infections 2. Scheld WM, Craig WA and Hughes JM, Editors. ASM Press, Washington, DC. 1998. ISBN 1-55581-141-8.
4. Emerging Viruses. Morse SS, Editor. Oxford University Press, New York. 1993. ISBN 0-19-510-484-6.
5. Modern Infectious Disease Epidemiology: Concepts, Methods, Mathematical Models, and Public Health (Statistics for Biology and Health) Kramer; 2010

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Infectious diseases)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	3	3	3	3	3	3	3	2	2	1	3	2.6
CO-2	3	3	3	3	3	3	3	3	3	2	-	3	2.9
CO-3	1	3	3	3	1	1	3	3	3	3	-	3	2.5
CO-4	3	1	3	3	3	3	2	1	-	-	3	2	2.4
CO-5	1	2	3	3	-	-	3	3	2	2	2	2	2.3
Average	2	2.4	3	3	2.5	2.5	2.8	2.6	2.5	2.25	2	2.6	

Genetic Counselling

COURSE CODE: 18B1WBT831

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Molecular Biology, Genetics

Course Objectives:

1. To provide an understanding of the basis of genetic counseling, diagnostic testing and management for a variety of types of disorders and also the ethical and legal considerations.
2. The students will understand the nature of the non-directive counseling process and the need to educate the patient and family to make informed decisions relating to complex genetic situations.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	To understand basics of genetic counselling, the nature of the directive and non-directive genetic counselling process and to counsel the patients with genetic diseases and help them in decision making.	Familiarity
CO-2	To understandgenetic basis of various diseases (Chromosomal, monogenic and oligogenic disorder).	Assessment
CO-3	To understand gene therapy, its role in genetic disorders and recent developments in gene therapy.	Assessment
CO-4	To understand risk assessment in genetic counseling and ethical issues in genetic counselling.	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Genetic Counselling an overview:**Counseling, diagnostic testing and management of genetic disorders.	**2**
2	**Human chromosomal disorders:** mutations, types of mutations, chromosomal aberrations, quad screen test, Amniocentesis, karyotyping, Down's syndrome, Patau's syndrome, Edward's syndrome, Turner's syndrome, X- chromosome related syndromes.	**6**
3	**Human allelic diseases (monogenic and oligogenic):** Cystic fybrosis. Glucose-6-phospho dehydrogenase deficiency Bradet- Biedl syndrome and some important autosomal recessive and dominant disorders	**6**
4	**Muscle disorders:** Duchenne muscular dystrophy, Becker's muscular dystrophy, limb-girdle muscular dystrophies and cardiac muscle disorders.	**4**
5	**Neurological disorder:** Alzheimer, Hutington, Parkinson, Lewy body dementia and Schizophrenia	**4**
6	**Genetic basis of neoplastic disorders:** Retinoblastoma, Wilms tumor, Colectral cancer, and Blooms syndrome	**6**
7	Prenatal Genetic counseling	**2**

8	**Gene therapy:** Principles of molecular genetic-based therapies and treatment with recombinant proteins or genetically engineered vaccines The technology of classical gene therapy Gene therapy for inherited disorders Gene therapy for neoplastic disorders The ethics of human gene therapy	**7**
9	**Genetic counseling risk assessment**	**3**
10	**Genetic counseling and ethical issues**	**2**
Total Lectures		**42**

Suggested Text Book(s):

1. Strachan T and Read AP (2010) Human Molecular Genetics -4, Garland Science, 4th Ed.
2. Pasternak JJ (2005) An introduction to Human Molecular Genetics: Mechanisms of Inherited Diseases. *Hoboken (New Jersey): John Wiley & Sons*, 2nd Ed.
3. Evans C (2006) Genetic Counselling A psychological approach. New York, NY, US: Cambridge, 1St Ed.

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Genetic Counseling)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	3	3	2	2	2	1	3	2	2	1	3	2.1
CO-2	2	2	3	2	2	1	-	3	2	2	1	3	2
CO-3	2	3	2	2	2	1	-	3	2	3	1	2	2
CO-4	2	3	2	2	2	2	-	3	2	3	1	2	2
Average	2.0	2.75	2.5	2	2	1.5	1	3	2	2.5	1	2.5	

Comparative and Functional Genomics

COURSE CODE: 18B1WBT532

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Molecular Biology, Biochemistry

Course Objectives:

1. The course is intended to provide thorough understanding of the genomics i.e. modern technologies in whole genome sequencing, genome mining, comparative genomics, global gene function technologies, protein structure & function technologies at the genome level, etc.
2. The course will explore that how technological innovations fostered by the Human Genome Project, will lead to significant advances in our understanding of diseases that have a genetic basis and, more importantly, how health care will be delivered from this point forward

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Students will have a thorough understanding of various genomic technologies such as whole genome mapping & sequencing, genome annotation, global gene cloning and gene expression technologies, comparative genomics, introduction to pharmacogenomics	Familiarity
CO-2	The students will know the vast amount of genome information in publically available databases and how to access and best utilize for practical purposes.	Assessment
CO-3	Able to analyze the gene expression data sets to derive the biologically meaning information	Assessment
CO-4	Able to apply the knowledge of function genomics in public health	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction to genomics:**Genome organization of Model organism- E. coli, Yeast, Mice, A. thaliana, Human etc. Genome statistics	**3**
2	**First and 2nd generation sequencing:**Sanger sequencing and next generation sequencing; Reverse termination sequencing, Single cell RNA sequencing or single cell RNA sequencing and Applications	**8**
3	**Comparative genomics:**Genome Annotation i.e. Mining Genomic Sequence Data, gene prediction methods, Physical mapping,	**8**
	Metagenomics, evolutionary relationship, Genome Analysis, Functional maps (Transcriptome, proteome, metabolome) Metabolic network maps	
4	**Functional genomics tools:**Hybridization and sequencing based approaches. Serial Analysis of Gene Expression-SAGE, DNA- Microarray, Application of DNA Microarray, cDNA-PCR, etc.	**8**
5	**SNP:**SNP Technologies: Platforms & Analysis Haplotyping: Concepts and Applications and relevance in cancer Biology	**7**
6	**Regulation of gene expression:**Gene Function Technologies (Gene Targeting, Gene Silencing (RNAi), micro RNA-human and Drosophila	**4**
7	Biomarkers Pharmacogenomics: Concepts and Applications in Healthcare Role of genotype in drug metabolism Identification & Utilisation of cancer bio-marker	**4**
Total Lectures		**42**

Suggested Text Book(s):

1. Discovering Genomics, proteomics & bioinformatics. Second edition by A Malcolm Campbell, Davidson College; Laurie J. Heyer Davidson College ; With Foreword by Francis S. Collins
2. Molecular Biology of the Gene (1987) Watson J. D., Hopking N., Robast J. and Steiz, J.
3. BIOINFORMATICS: A Practical Guide to the Analysis of Genes and Proteins (Third edition) Andreas D. Baxevanis& B. F. Francis Ouellette

Suggested Reference Book(s):

1. . Ronaghi M. Pyrosequencing sheds light on DNA sequencing. Genome Res. 2001 10. Jan;11(1):3-11. Review. PubMed PMID: 11156611
2. Schulze A, Downward J. Navigating gene expression using microarrays—a technology review. Nat Cell Biol. 2001 Aug;3(8):E190-5. Review. PubMed PMID: 11483980
3. Kim JB, Porreca GJ, Song L, Greenway SC, Gorham JM, Church GM, Seidman CE, Seidman JG. Polony multiplex analysis of gene expression (PMAGE) in mouse hypertrophic cardiomyopathy. Science. 2007 Jun 8;316(5830):1481-4. PubMed PMID: 17556586
4. MacBeath G, Schreiber SL. Printing proteins as microarrays for high-throughput function determination. Science. 2000 Sep 8;289(5485):1760-3. PubMed PMID: 10976071.
5. Shankar J, Wu TD, Clemons KV, Monteiro JP, Mirels LF, et al. (2011) Influence of 17b-Estradiol on Gene Expression of Paracoccidioides during Mycelia-to- Yeast Transition. PLoS ONE 6(12): e28402. doi:10.1371/journal.pone.0028402
6. Mary V. Relling, William E. Evans Nature. Author manuscript; available in PMC 2016 Jan 13.
7. Published in final edited form as: Nature. 2015 Oct 15; 526(7573): 343–350. doi: 10.1038/nature15817

Other useful resource(s):

1. Link to NPTEL course contents:https://nptel.ac.in/courses/102104056/

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course 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	Average
CO-1	2	2	2	2	2	2	2	2	2	2	1	2	1.9
CO-2	2	2	2	2	2	1	1	2	2	2	1	2	1.75
CO-3	2	2	2	2	2	1	1	1	2	-	2	2	1.7
CO-4	2	2	2	2	2	1	1	1	2	2	-	2	1.7
Average	2.0	2.0	2	2	2	1.25	1.25	1.5	2.0	2	1.33	2.0	

Computational Molecular Evolution

COURSE CODE: 18B1WBI831

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Basic knowledge of computational biology, evolutionary biology, and functional genomics

Course Objectives:

1. The objective of the course is to develop functional and evolutionary genomic understanding of biological entities for various kinds of lineages for biological data types such as DNA, RNA, Genes, and Proteins etc.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Able to understand the holistic approaches of molecular evolution	Familiarity
CO-2	Combining acquisition, integration and management of experimental evolutionary data with computer aided analysis	Assessment
CO-3	Use various methods from computational genomics and proteomics to learn their functional aspects of controlling biological processes by incorporating evolutionary information	Assessment
CO-4	Able to analyze various kind of biological sequence data and identify their limiting factors to propose new design principles for the analysis of biological data	Assessment and Usage
CO-5	Applications of evolutionary analysis through various available approaches	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction:**Introduction to molecular evolution and its role in the regulation of various biological processes. Introduction to evolutionary biology, functional genomics, basics of data types for biological sequences their importance and applications in further analysis.	**6**
2	**Biomolecules:**To understand various entities and their role in evolution: Genes, operons, regulons, stimulons, genomes, proteins, proteomes etc.	**6**
3	**Codon usage and patterns:**Patterns of base composition and codon usage, gene duplication, pseudogenes, orphan genes, gene gain and gene loss processes, overlapping and nested genes, exonization, intron and RNA editing, functional convergence, hypothetical proteins and their annotations.	**6**
4	**Mutation and selection:**Various kinds of mutations and selection pressure and related theories.	**6**
5	**New data and evolution:**Description of models, methods and algorithms that are most useful for analysing the ever-increasing supply of molecular sequence data, with a view to furthering our understanding of the evolution of genes, proteins, and genomes.	**10**
	Models of evolution: Models of nucleotide substitution, models of amino acid and codon substitution, phylogeny reconstruction: Overview, Maximum Likelihood	

6	methods, Bayesian methods, comparison of methods and tests on trees, molecular clock and estimation of species divergence times, neutral and adaptive protein evolution, simulating molecular evolution	**8**
Total Lectures		**42**

Suggested Text Book(s):

1. Molecular Evolution by Dan Graur and Wen-Hsiung Li, Sinauer Associated Inc. Pub., USA .
2. Computational Molecular Evolution by Ziheng Yang, Oxford Series in Ecology and Evolution.
3. Molecular Evolution: A phylogenetic approach Rodric DM Page and Edward C Holmes, Blackwell Science Ltd.

Suggested Reference Book(s):

1. Inferring Phylogenies J. Felsenstein, . Sinauer Associated Inc. Pub., USA.
2. Bioinformatics and Molecular Evolution by Paul G Higgs, Blackwell Publishing.
3. Molecular Evolution and Phylogenetics Masatoshi Nei and Sudhir Kumar, Oxford University Press.

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Computational Molecular Evolution)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	3	2	3	1	1	3	2	3	2	2.17
CO-2	2	2	3	2	2	-	-	-	1	1	2	2	1.89
CO-3	3	3	2	2	2	2	1	1	3	2	1	3	2.08
CO-4	2	2	3	1	1	-	-	-	2	2	2	1	1.78
CO-5	3	2	3	2	2	3	-	-	-	2	-	1	2.25
Average	2.4	2.2	2.6	2	1.8	2.67	1	1	2.25	1.8	2	1.8	

Diagnostics & Vaccine Manufacturing

COURSE CODE: 18B1WBT833

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Immunology

Course Objectives:

1. To familiarize the students with the principles & applications of the latest state-of-the-art bio-molecular diagnostic techniques/technology used in laboratories the world over.
2. The safety aspects, quality control, quality assurance and validation of PCR based diagnostics and laboratory safety.
3. Knowledge of various technologies employed in vaccine production and examine their use in developing vaccines against human and animal pathogens. The safety aspects, quality control, quality assurance and validation of vaccine production and will also be covered.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	The students would be able to identify and analyze what DNA based approach and methodology should be used for diagnostic purpose in different settings, their comparative advantages and limitations.	Usage
CO-2	The students would be able to identify and analyze what antigen - antibody based approach and methodology should be used for diagnostic purpose in different settings, their comparative advantages and limitations.	Usage
CO-3	The students would have in-depth knowledge of various types of vaccines and approaches used for their production.	Familiarity
CO-4	The students would have in-depth knowledge of quality control and assurance considerations used in the industry for diagnostics.	Assessment & Technical
CO-5	The students would have in-depth knowledge of antimicrobial susceptibility and its application in the industry for diagnostics.	Assessment & Technical

Course Contents:

Unit	Contents	Lectures required
1	**General Introduction**: Biotechnology in the diagnosis of infectious diseases and vaccine development, Biotechnology in Vaccine production, Recent developments in vaccine technology.	2
2	**Immunodiagnostics:** Antigen – Antibody Interaction, Lattice Theory, Precipitin Curve, Simple Immunodiffusion (Radial Immunodiffusion – Qualitative, Quantitative); Double Diffusion (Mechanism of Reaction of Identity, Partial – Identity, and Non- Identity); Immunoelectrophoresis; Rocket Electrophoresis, Western Blot, Immunofluorescence, Agglutination – Antibody titer, Prozone Phenomenon, Direct and Indirect Agglutination, Hemagglutination, ABO Blood	10

	typing, Agglutination Inhibition; Immunofluorescence, Radioimmunossay (including advantages and disadvantages).	
3	**ELISA:** Theory, Designing an ELISA method, Types – Direct, Indirect, Sandwich, Competitive, Dot ELISA.	**2**
4	**PCR:** concept, protocol, strategy. Types of PCR – Strategy and Applications - Nested, Semi-nested, Real time, RT-PCR, Asymmetric PCR, Inverse PCR, Multiplex PCR.	**3**
5	**QC & QA of PCR and Real Time based diagnostics**: Theory, Application, and Trouble shooting. Importance of controls. Best Fit Assay, Optimization and Standardization of PCR based diagnostics.	**3**
6	**AST**: Concept, KB Method. Laboratory methodologies for bacterial antimicrobial susceptibility testing – concepts, antibiotics –, resistance, mechanism. Disk diffusion, tube dilution, microbroth dilution methods.	**4**
7	Biosafety and biosecurity in the medical microbiology laboratory and animal facilities.	**2**
8	Different types of vaccines, i.e., sub-unit vaccines, recombinant vaccines, synthetic vaccines, idiotypic based - vaccines, DNA	**3**
	vaccines, glycoconjugate vaccines, deletion vaccines.	
9	Examples of different vaccines - Rabies vaccines, PPRV vaccines, Chimeric vaccines – JEV/DENV/Westnile, Meningococcal conjugate & protein based vaccines, Oral B subunit + whole cell cholera vaccine, Multicellular Parasite vaccines, Novel Vaccines against *Mycobacterium tuberculosis,* Mycoplasma vaccines, Protozoal &rickettsial vaccines.	**8**
10	Genetic basis of attenuation, vaccine vectors, large-scale production of vaccines and automation. . Vaccine delivery system and approaches to enhance immunogenicity - immunomodulators and, immunomodulation adjuvant. Delivery of particulate antigens through liposomes, microspheres etc.	**5**
Total lectures		**42**

Suggested Text Book(s):

1. Burtis, C. A., Ashwood, E. R.,:Tietz textbook of Clinical Chemistry &Bruns, D. E. Molecular Diagnostics, Saunders, 2006
2. World Organization for: Manual of Diagnostic Tests and Vaccines for Animal Health Terrestrial Animals, Volumes I & II, 6th Edition, 2010.
3. Rao, J. R.:Molecular Diagnostics: current technology and Applications, Horizon Bioscience, U. K., 2006.
4. Review and Research Publications available on-line
5. Immunology: Kuby

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Diagnostics & Vaccine Manufacturing)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	1	1	1	1	1	1	1	0	0	0	2	1
CO-2	1	2	3	1	1	1	1	0	0	2	2	2	1.33
CO-3	1	2	2	2	1	2	1	1	1	2	2	1	1.5
CO-4	2	2	2	3	1	1	3	1	1	1	1	3	1.75
CO-5	1	2	3	2	2	2	1	2	2	2	2	3	2
Average	1.6	1.8	2.2	1.8	1.2	1.4	1.4	1	0.8	1.4	1.4	2.2	

Traditional Bioprocesses & their upscaling

COURSE CODE: 18B1WBT832

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Microbiology, Bioprocess Engineering, Downstream Processing

Course Objectives:

Traditional bioprocess gives the lying fundamentals of the pre-historic bioprocess technologies and its scaleup studies on the industrial sectors. Moreover, these gives insights about the technological developments till the existing industrial bioprocesses. Bioprocessing of biopharmaceuticals and immobilization technology also gives an opportunity to study the recent advancements in this field. By keeping the mentioned points, the course objectives were framed as follows

1. Introduction of traditional bioprocesses and its upscaling
2. Discussion of bioprocessing of biopharmecuticals, recent advances in Immobilization technology and Fermentation technology

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Introduction to Traditional Bioprocesses and its production technologies	Familiarity
CO-2	Bioprocessing of Biopharmaceuticals	Assessment
CO-3	Recent trends in Immobilization technology and bioreactor technology	Assessment
CO-4	Upscaling studies of bioprocess products	Usage
CO-5	Scale up considerations of different bioprocess commodities	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Traditional Bioprocesses: Introduction and Technology Advancemnets:** Industrial production of organic acids (Citric acid; Glutamic acid; Lactic acid; Kojic acid; Ascorbic acid) ; Industrial production of Antibiotics (Pencillins; Cephalosporins; Tetracyclins); Industrial production of Amino acids (Lysine;	14
	Threonine; Aspartate)	
2	**Bioprocessing of Biopharmaceuticals:** Overview of USP and DSP aspects of Biopharmaceuticals; Upstream processing of Mab production; Downstream Processing of Mab's ; Process optimization for Mab production; Protein therapeutics	6
3	**Recent advances in Reactor technology:** Bioreactors for solid state fermentation ; Photobioreactors for microalgal products; Bioreactors for pharmaceuticals	9
4	**Advances of enzyme immobilization techniques:**Sol-gel chemistry and immobilization; Immobilization on nano-particles; Cross-linked Enzyme Aggregates; Surface analysis technology of Immobilized Enzymes	5
5	**Scale up considerations of different bioprocess commodities:** Bioprocess aspects of sugar alcohols; Production of flavours in food industries; Flavour production in fermented foods; Bioprocess aspects of Nutraceuticals; Probiotics, Prebiotics and Synbiotics;	8
Total lectures		42

Suggested Text Book(s):

1. Microbial Technology: Microbial processes by Henry J. Peppler, D. Perlman
2. Microbial Biotechnology by Alexander N. Glazer and Hiroshi Nikaido
3. Industrial Biotechnology by Wim Soetaert and Erick J. Vandamme
4. Immobilization of Enzymes and Cells by Jose M.Guisan
5. Biofilms in Medicine, Industry and Environmental Biotechnology by Piet Lens et al.

Suggested Reference Book(s):

1. Review / Research articles from Science Direct, Springer, Wiley and Pub Med

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	1	3	1	2	1	2	1	3	2.17
CO2	3	3	3	3	2	2	1	2	1	2	-	3	2.27
CO3	3	3	3	3	2	2	1	2	1	2	-	3	2.27
CO4	3	3	3	3	1	2	2	3	2	2	2	3	2.42
CO5	3	3	3	3	1	2	3	3	3	2	2	3	2.58
Average	3.00	3.00	3.00	3.00	1.40	2.20	1.60	2.40	1.60	2.00	1.00	3.00	

Structural Bioinformatics

COURSE CODE: 18B1WBI531

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Structural Biology

Course Objectives:

1. To develop the ability to design, predict, analyze and compare the protein structures as well as predict the function of target proteins.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Understanding the fundamental concepts of structural biology (chemical building blocks, structure, superstructure, folding, etc.)	Familiarity
CO-2	To Understand and use structural databases and software for structure visualization	Familiarity
CO-3	To understand the algorithms used in Structure determination and quality assessment	Assessment
CO-4	To perform protein structure comparison and the hierarchical nature of biomacromolecular structure classification	Usage
CO-5	To understand the methodology of protein structure prediction and assessment	Assessment
CO-6	To understand the methodology of sequence- and structure-based functional site prediction	Assessment

Course Contents:

Unit	Contents	Lectures required
1	**Introduction of protein structure:**Overview of syllabus and protein structure (amino acids and peptide bonds; primary, secondary, super-secondary, tertiary and quaternary structure of proteins).	3
2	**Fundamental concepts of structural biology:**Chemical	6
	building blocks, structure, superstructure, folding, etc.; the physical forces that shape macromolecules; structural databases (protein data bank, SCOP database, CATH database and other structure based databases)	
3	**Secondary structure of protein:**Computational methods for prediction of secondary structure of protein sequences (Chou- Fasmann, GOR and Neural Networks) and reliability (Q3 value and SOV score)	3
4	**Tertiary structure of protein:**Prediction of tertiary structures of protein sequences (Homology and Threading methods); structure quality assessment.	6

5	**Protein structures comparison and alignment:**General approach of alignment and comparison, comparison algorithm & optimization, statistical analysis of results, multiple structural alignment.	**3**
6	**Analysis of 3D structures:**Secondary structure assignment, assignment of hydrogen bonds, coulomb hydrogen bond calculation, empirical hydrogen bond calculation, assignment methods of secondary structure (DSSP, STRIDE, DEFINE, P- Curve)	**3**
7	**Identifying structural domains in protein:**How structural domains are defined? First and second generation algorithms for domain assignments, domain assignment based on graph theoretical methods, prediction of binding sites and characterization.	**3**
8	**Ab initio protein structure prediction:**Empirical force field for biomolecular simulations, Potential Energy Function (bond length potential, bond angle potential, torsional potential, van der Waals potential and coulomb potential), classical representations of electrostatics (Poisson-Boltzmann, Generalized Born and Colombic).	**6**
9	**Energy minimization techniques:**Concept of local and global minima, energy minimization protocol, energy minimization algorithms (steepest descent, conjugate gradient, Newton Raphson)	**3**
10	**Molecular Dynamics simulations:**Monte Carlo Simulations, Techniques for efficient conformational search: Simulated Annealing, Calculation of Free energy using simulation techniques.	**6**
Total Lectures		**42**

Suggested Text Book(s):

1. Structural Bioinformatics (2nd Edition), Jenny Gu (Editor), Philip E. Bourne (Editor)
2. D.W. Mount Bioinformatics: Genome and Sequence Analysis: (2001) Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.
3. Molecular Modeling: Principles & Applications, Andrew R. Leach, Prentice Hall

Evaluation Scheme:

Assessment	**Max. marks**	**Duration**	**Course Covered**
T1 Test	15	1 hr.	Syllabus covered up to Test-1
T2 Test	25	1.5 hrs.	Syllabus covered up to Test-2
End Term Test	35	2 hrs.	Whole Syllabus
Teacher Assessment (Based on Assignments, quizzes etc.)	25	Whole Semester	Inform class time to time
Total	**100**		

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	2	2	1	1	1	1	1	1	1.83
CO2	3	3	3	3	3	1	1	1	1	1	1	3	2.00
CO3	3	3	2	3	2	3	2	1	1	1	2	1	2.00
CO4	3	3	3	2	3	2	1	1	1	1	1	1	1.83
CO5	2	2	3	3	3	3	1	1	1	1	1	1	1.83
CO6	2	3	3	3	2	2	2	2	2	2	2	2	2.25
Average	2.67	2.83	2.80	2.80	2.60	2.20	1.20	1.00	1.00	1.00	1.20	1.40	

Advanced Algorithms for Bioinformatics

COURSE CODE: 18B1WBI631

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Basics of data structures, algorithms, and basic methods in computational biology

Course Objectives:

1. The overall objective of the course is to develop an understanding of algorithms implementation for solving problems in biology.
2. To evaluate existing algorithms, possible improvements and for their implementations.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Able to apply algorithmic principles to address problems in biology	Analytical
CO-2	Use various methods from computational biology to implement their algorithmic versions	Usage
CO-3	Analyze problems in biology and able to design new protocols and algorithms for biological data analysis	Analytical
CO-4	Able to analyze the algorithms in computational biology and identify their limiting factors to propose new design principles	Analytical
CO-5	Assessment of biological complexity through algorithmic principles	Analytical

Course Contents:

Unit	Contents	Lectures required
1	**Introduction:**An overview of Algorithms, Sequence and String search algorithms with mathematical formulations for similarity and distance scoring systems with their algorithmic implementations.	**6**
2	**Genome Assembly:**Complexity of DNA problems and their simulatory solutions. Genome assembly algorithms, their computational	**7**
	implications and applications.	
3	**Graph based Algorithms:**Graph algorithms in bioinformatics and their applications to fragment assembly, Eulerian and Hamiltonian Cycle Problem, Interval graph algorithm, shortest superstring problem and its mapping with traveling salesman problem.	**4**
4	**Motif and Regulatory element's Algorithms:**Algorithms for finding regulatory motifs in genomic sequences through profiles and consensus approaches. Brute Force Motif Search, Median String Search algorithms and their refinements. Algorithms for Sequencing by hybridization (SBH), use of spectrum approach to solve SBH problem.	**5**
5	**Gene prediction:**Algorithmic approaches for Contig assembly to super- contigs. Computational challenges for gene prediction, popular algorithms and their implementations for gene prediction. Exon chaining and Spliced Alignment Problems.	**7**
6	**Brute Force and branch and bound algorithms:**Brute Force and branch and bound algorithms for Partial Digest Problem, restriction mapping, partial digest	

	and double digest problems and their solutions through multiset and homometric sets.	**5**
7	**MSA advancedments:**Progresssive and iterative refinements of MSA algorithms, Barton-Sternberg Iterative Refinement Algorithm, STAR and TREE alignment approaches, Greedy and Entropy approach for MSA.	**5**
8	**Graph based MSA advancements:**Partial Order (PO)-MSA, and A- Bruijn Alignment (ABA) algorithm for MSA. Combinatorial dynamic programming approach for MSA.	**3**
Total Lectures		**42**

Suggested Text Book(s):

1. Computational Molecular Biology: An algorithmic approach (2004), P.A. Pevzner, PHI.
2. An Introduction to Bioinformatics Algorithms (2004) N.C. Jones and P.A. PevznerAne Books.
3. Algorithms in Bioinformatics (2004), G. Benson and R. Page (Eds): Springer Verlag.

Suggested Reference Book(s):

1. Bioinformatics Algorithms: Techniques and Applications, I.I. Mandoiu and A Zelikovsky,

   Wiley Interscience Press.

2. Biological Sequence Analysis: Probabistic models of proteins and nucleic acids (1998) Durbin R., et al, Cambridge University press.

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Advanced Algorithms for Bioinformatics)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	3	1	3	2	2	2	1	3	2	3	3	2.25
CO-2	3	2	2	1	-	1	-	-	-	1	2	3	1.88
CO-3	3	3	3	3	2	2	2	1	2	-	-	2	2.30
CO-4	3	3	3	1	-	-	-	-	2	1	2		2.14
CO-5	3	1	2	2	2	2	-	1	-	2	-	1	1.78
Average	2.8	2.4	2.2	2	2	1.75	2	1	2.33	1.5	2.33	2.25	

Datawarehousing and Mining for Bioinformatics

COURSE

CODE:18B

1WBI632

COURSE

CREDITS:

3

ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Molecular Biology, Biochemistry

Course Objectives:

1. Learn to develop and use datawarehouse
2. Learn feature selection methods
3. Learn methods for data mining.
4. Apply data mining techniques in biological datasets.
5. Learn and apply cross-validation.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Students will have a thorough understanding of various datawarehousing components and architecture.	Familiarity
CO-2	Students will understand various types of data models.	Assessment
CO-3	Students will understand how to perform feature selection and derive association rules	Assessment
CO-4	Students will understand how to perform various types of data mining, including clustering, neural networks etc.	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Knowledge Discovery Process -** Understanding the business intelligence cycle	**2**
2	**Introduction to Data warehousing** – Components of data warehouse, Architecture, lifecycle & related core terms.	**2**
3	**Types of Data warehouse design methodologies** – Top Down Approach, Bottom Down approach, Hybrid design Approach	**3**
4	**Data Models** - Dimensional Data Modeling (Star Schema, Snowflake Schema); Relational Data Modeling; Conceptual, Physical & Logical Data Model.	**3**
5	**Multidimensional Analysis** – OLAP & OLTP Approaches	**2**
6	**Building & Maintaining the data warehouse** – ETL design & development;	**2**
7	**Introduction to Data Mining** - concepts and techniques for the	**2**
	discovery of patterns hidden in large data sets	
8	**Grouping of data** - Classification and Clustering Methods; Decision Tree, Neural Network, Nearest Neighbor, Genetic Algorithm	**7**

9	**Feature Selection Methods -** Wrapper & Filter Approach**,** Correlation analysis,PCA	**7**
10	**Association Rule Learning Based Methods -** Apriori Algorithm	**7**
11	**Statistical techniques involved in data mining** – regression based model development	**1**
12	**Cross Validation Techniques -** Jackkniffing, Bootstrapping, Sensitivity, Specifcity, Accuracy	**2**
	Total Number of Lectures	**42**

Suggested Text Book(s):

a. Kimball, R., Margy, R. : The Data Warehouse Toolkit, 2nd Edition: The Complete Guide to Dimensional Modeling, John Wiley &SonsMolecular Biology of the Gene (1987) Watson J. D., Hopking N., Robast J. and Steiz, J.
b. Inmon, B. :Building the Data Warehouse, John Wiley & Sons.

Suggested Reference Books(s):

1. Pei, Han and Kamber, Data mining: Concepts and techniques third edition, Elsevier, 2011
2. Data Mining: Practical Machine Learning Tools and TechniquesKim JB, Porreca GJ, Song L, Greenway SC, Gorham JM, Church GM, Seidman CE,
3. Introduction to Data Mining, Tan, Steinbach and Vipin Kumar, Pearson Education, 2016

Other useful resource(s):

a. Link to NPTEL course contents:https://onlinecourses.nptel.ac.in/noc18_cs14/preview
b. Link to topics related tocourse:

iv. https://nptel.ac.in/courses/102104063
v. https://nptel.ac.in/courses/102106069/
vi. https://nptel.ac.in/courses/102106026/

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Datawarehousing and Mining for BI)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	2	2	2	2	2	1	2	1.9
CO-2	2	2	2	2	2	1	1	2	2	2	1	2	1.75
CO-3	2	2	2	2	2	1	1	1	2	-	2	2	1.7
CO-4	2	2	2	2	2	1	1	1	2	2	-	2	1.7
Average	2.0	2.0	2	2	2	1.25	1.25	1.5	2.0	2	1.33	2.0	

Department of Biotechnology & Bioinformatics

Intellectual Property Rights and Commercialization

COURSE CODE:

18B1WBT732

COURSE CREDITS: 3

CORE/ELECTIVE:

ELECTIVE L-T-P: 3-0-0

Pre-requisite: None

Course Objectives:

1. To provide an insight and understanding about different aspects of protection of inventions and research developments
2. Learn about procedures for filling protection through Intellectual Property Rights.
3. **To provide scopes of protection of diverse intellectual properties and its commercialization for socio-economic improvement.**

.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	To enable students with basic concepts and knowledge of intellectual property rights.	Awarness
CO-2	To apply and execute different types of IP protection in research and academics.	Assessment and technical skills
CO-3	Able to understand about the mechanisms of different IP protections, registrations and applications	Technical
CO-4	To be capable of tackling issues related to IP and its commercialization	Assessment
CO-5	Able to learn the strategies for effective IP management and commercialization	Analytical skills
CO-6	To apply the knowledge of IPR for the benefit generation and for mass utilization	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction**:Introduction of Intellectual properties and rights conferred . Integration of Intellectual Property, Bioethics and Biosafety for biological and applied sciences in research and academia.	4
2	**Types of IP tools**:Different types of IPR(Patents, copyrights and related rights, Trademark, Tradesecret, Integrated circuit layout, Geographical indications, Traditional knowledge, Industrial designs and PBR) Drafting Patent Application and Documentation Revocation of Patent, Litigation and Infringement Rationale of different IPR ,their mechanism of protection and provisions in Law	10
3	**International Agreements** and Treaties:International IP treaties (Madrid Agreement, Trademark law treaty, Patent Law treaty etc.) WIPO, EPC, WTO, and TRIPS. International agreements relevant to biotechnology-associated IP	8
4	**Commercialization**: Methods of commercialization,Impact of commercialization. Financing	6

5	**IP Management for value addition:** Strategies for IP Management and commercialization. IP audit, IP insurance Bioentreprenuership management	4
6	**Licensing/Assignment** :Types of licensing and modes to carry out, Assignments and its benefits, Compulsory Licensing Commercialization for social and economic prosperity with case studies	8
Total lectures		**42**

Suggested Text Book(s):

1. Intellectual Property Rights & Copyright By Bouchoux.
2. Intellectual Property Licensing Strategies by Thompson Reuters

Suggested Reference Book(s):

1. Intellectual Property Rights, the WTO and Developing Countries: The TRIPS ...Book by Carlos María Correa
2. Perspectives on Commercializing Innovation by F. Scott Kieff (Editor), Troy A. Paredes (Editor

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Intellectual Property Rights & Commercialization)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	1	1	1	1	1	2	2	**15**
CO-2	2	2	1	2	2	2	1	1	1	1	1	2	**1.5**
CO-3	2	2	2	2	3	1	1	1	2	2	1	2	**1.7**
CO-4	2	2	3	3	2	1	1	1	2	2	2	2	**1.9**
CO-5	2	2	2	2	2	1	2	1	1	2	1	2	**1.6**
CO-6	2	2	2	2	2	2	1	1	2	2	2	2	**1.8**
Average	**3.4**	**3.4**	**2**	**2.1**	**2.1**	**1.3**	**1.1**	**1**	**1.5**	**1.6**	**1.5**	**2**	

Diagnostics & Vaccine Manufacturing

COURSE

CODE:18B1WBT833

COURSE CREDITS: 3

Approved in Academic Council held on 28 June 2023

CORE/ELECTIVE:

ELECTIVE L-T-P: 3-0-0

Pre-requisite: Immunology

Course Objectives:

1. To familiarize the students with the principles & applications of the latest state-of-the-art bio-molecular diagnostic techniques/technology used in laboratories the world over.
2. The safety aspects, quality control, quality assurance and validation of PCR based diagnostics and laboratory safety.
3. Knowledge of various technologies employed in vaccine production and examine their use in developing vaccines against human and animal pathogens. The safety aspects, quality control, quality assurance and validation of vaccine production and will also be covered.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	The students would be able to identify and analyze what DNA based approach and methodology should be used for diagnostic purpose in different settings, their comparative advantages and limitations.	Usage
CO-2	The students would be able to identify and analyze what antigen - antibody based approach and methodology should be used for diagnostic purpose in different settings, their comparative advantages and limitations.	Usage
CO-3	The students would have in-depth knowledge of various types of vaccines and approaches used for their production.	Familiarity
CO-4	The students would have in-depth knowledge of quality control and assurance considerations used in the industry for diagnostics.	Assessment & Technical
CO-5	The students would have in-depth knowledge of antimicrobial susceptibility and its application in the industry for diagnostics.	Assessment & Technical

Course Contents:

Unit	Contents	Lectures required
1	**General Introduction**: Biotechnology in the diagnosis of infectious diseases and vaccine development, Biotechnology in Vaccine production, Recent developments in vaccine technology.	2
2	**Immunodiagnostics:** Antigen – Antibody Interaction, Lattice Theory, Precipitin Curve, Simple Immunodiffusion (Radial Immunodiffusion – Qualitative, Quantitative); Double Diffusion (Mechanism of Reaction of Identity, Partial – Identity, and Non- Identity); Immunoelectrophoresis; Rocket Electrophoresis, Western Blot, Immunofluorescence, Agglutination – Antibody titer, Prozone Phenomenon, Direct and Indirect Agglutination, Hemagglutination,	10
	ABO Blood typing, Agglutination Inhibition; Immunofluorescence, Radioimmunossay (including advantages and disadvantages).	
3	**ELISA:** Theory, Designing an ELISA method, Types – Direct, Indirect, Sandwich, Competitive, Dot ELISA.	2
4	**PCR:** concept, protocol, strategy. Types of PCR – Strategy and Applications - Nested, Semi-nested, Real time, RT-PCR, Asymmetric PCR, Inverse PCR, Multiplex PCR.	3
5	**QC & QA of PCR and Real Time based diagnostics**: Theory, Application, and Trouble shooting. Importance of controls. Best Fit Assay, Optimization and Standardization of PCR based diagnostics.	3
6	**AST**: Concept, KB Method. Laboratory methodologies for bacterial antimicrobial	

	susceptibility testing – concepts, antibiotics –, resistance, mechanism. Disk diffusion, tube dilution, microbroth dilution methods.	**4**
7	Biosafety and biosecurity in the medical microbiology laboratory and animal facilities.	**2**
8	Different types of vaccines, i.e., sub-unit vaccines, recombinant vaccines, synthetic vaccines, idiotypic based - vaccines, DNA vaccines, glycoconjugate vaccines, deletion vaccines.	**3**
9	Examples of different vaccines - Rabies vaccines, PPRV vaccines, Chimeric vaccines – JEV/DENV/Westnile, Meningococcal conjugate & protein based vaccines, Oral B subunit + whole cell cholera vaccine, Multicellular Parasite vaccines, Novel Vaccines against *Mycobacterium tuberculosis,* Mycoplasma vaccines, Protozoal &rickettsial vaccines.	**8**
10	Genetic basis of attenuation, vaccine vectors, large-scale production of vaccines and automation. . Vaccine delivery system and approaches to enhance immunogenicity - immunomodulators and, immunomodulation adjuvant. Delivery of particulate antigens through liposomes, microspheres etc.	**5**
Total lectures		**42**

Suggested Text Book(s):

1. Burtis, C. A., Ashwood, E. R.,:Tietz textbook of Clinical Chemistry &Bruns, D. E. Molecular Diagnostics, Saunders, 2006
2. World Organization for: Manual of Diagnostic Tests and Vaccines for Animal Health Terrestrial Animals, Volumes I & II, 6th Edition, 2010.
3. Rao, J. R.:Molecular Diagnostics: current technology and Applications, Horizon Bioscience, U. K., 2006.
4. Review and Research Publications available on-line
5. Immunology: Kuby

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Diagnostics & Vaccine Manufacturing)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	1	1	1	1	1	1	1	0	0	0	2	1
CO-2	1	2	3	1	1	1	1	0	0	2	2	2	1.33
CO-3	1	2	2	2	1	2	1	1	1	2	2	1	1.5
CO-4	2	2	2	3	1	1	3	1	1	1	1	3	1.75
CO-5	1	2	3	2	2	2	1	2	2	2	2	3	2
Average	1.6	1.8	2.2	1.8	1.2	1.4	1.4	1	0.8	1.4	1.4	2.2	

Industrial Enzymes Technologies

COURSE CODE:18B1WBT731 COURSE

CREDITS: 3 CORE/ELECTIVE: ELECTIVE L-

T-P: 3-0-0

Pre-requisite: Enzyme production purification and applications

Course Objectives:

1. The objective of the course is to develop an understanding of important aspects of production and purification of industrially important enzyme and their application in industry.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	To develop an understanding of basic concepts of enzymes.	Familiarity
CO-2	To understand the basic mechanism of action and working behaviour of enzymes	Assessment
CO-3	To familiarize the students with various applications of enzymes in laboratory as well as Industrial scale.	Assessment
CO-4	To conceptualize about immobilized enzyme technology, and other specific enzymes and their applications.	Usage
CO-5	To familiarize the students with present potential of enzyme in industrial application and improved activity of the enzyme using various molecular biology techniques.	Usage
CO-6	To understand the principle and function of enzyme in various adverse conditions like high temperature and pH(s).	Assessment

Course Contents:

Unit	Contents	Lectures required
1	**Enzymes: Basic concepts:**Enzymes as powerful and highly specific catalysts, Classification of enzymes, free energy and enzymes, the formation of the transition state, catalytic strategies. General properties: Enzyme specificity, stability and structure, Factors affecting enzyme activity; effect of pH and Temperature, Substrate and Enzyme concentration.	5
2	**Enzyme kinetics**: Michaelis-Menten kinetics, evaluation of parameters in the Michaelis-Menten equation, 3-D structure of active site, Kinetics of single and bi-substrate enzyme catalysed reactions, Inhibition & its kinetics.	5
3	**Enzyme preparation techniques:** Sources of enzymes, production,Recovery and purification of intracellular products: cell disruption, chromatographic techniques. Analytical assays of purity level of enzymes.	3
4	**Enzyme preparation and application in industries:** Application of enzymes in leather, glucose syrup production, starch and sugar industry, Dairy and food industry, Beverage industry, Textile industry. Hydrolysis of starch and cellulose. Catalytic functions of Cellulase, lipase, esterase laccase amylase, glucose isomerase, protease, xylanase, invertase, peroxidises. Other applications of enzymes in solution: medical applications of enzymes, non-hydrolytic enzymes in current and developing industrial technology.	10
5	**Enzyme engineering:** Mechanisms and manifestations of protein denaturation. Strategies for enzyme stabilization: Physical and chemical modifications, Selection, directed evolution and Rational design. design and construction of mutant enzymes, Bifunctional and polyfunctional enzyme, Enzyme in organic solvents.	5
6	**Immobilized-enzyme technology**: Introduction, enzyme immobilization method: Entrapment, carrier-binding and cross-linking method. Medical and analytical applications of immobilized enzymes.	8

7	**Specified Enzymes and applications:** Thermozymes, Cold adapted enzymes, Ribozymes, Hybrid enzymes, Diagnostic enzymes, Therapeutic enzymes: Characteristics, principles and applications.	6
Total Lectures		**42**

Suggested Text Book(s):

1. Devasena, T., "Enzymology", 1st ed., Oxford University Press, 2010
2. Berg, J.M., Tymoczko, J.L. and Stryer, L., "Biochemistry", 5th ed., W.H. Freeman and Company, New York, 2002.
3. Nelson D.L., Cox M.M., "Lehninger Principles of Biochemistry", 5th ed., W.H. Freeman and Company, New York, 2008.

Suggested Reference Book(s):

1. Pye, E.K. and Wingard, L.B., "Enzyme Engineering II", Plenum Press, 1974.
2. Illanes A, "Enzyme Biocatalysis", Springer Science, 2008.

Other useful resource(s):

https://nptel.ac.in/course.php?disciplineId=102

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course 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	Average
CO-1	2	2	3	1	1	2	2	3	2	2	1	2	1.9
CO-2	1	2	2	2	2	1	-	2	2	2	1	3	1.8
CO-3	2	2	2	2	2	2	1	1	2	-	2	2	1.8
CO-4	2	3	2	1	2	1	-	1	3	2	-	2	1.9
CO-5	1	3	1	3	2	2	1	2	1	2	1	3	1.8
CO-6	1	1	-	2	2	2	2	1	2	2	1	3	1.7
Average	1.5	2.1	1.6	1.8	1.8	1.6	1	1.6	2	2	1.2	2.5	

NGS Data Analysis and Applications

COURSE CODE: 18B1WBI834 COURSE

CREDITS: 3 CORE/ELECTIVE: ELECTIVE L-

T-P: 3-0-0

Pre-requisite:

Course Objectives:

1. To acquire basic knowledge of Next Generation Sequencing approaches in genomic research.
2. To understand computational and statistical principles for analysing genomic data.
3. To understand and formulate questions to investigate deep sequencing data.

Course Outcomes

S.No.	Course Outcomes	Level of Attainment
CO-1	The students will acquire knowledge of Next Generation Sequencing technologies used in genomics and genetics research.	Familiarity
CO-2	The students will learn about the various platforms used in NGS.	Assessment
CO-3	The students will learn about the tools and techniques used in NGS data analysis.	Usage
CO-4	The students willknowtheapplications and scopes of genomics research using the latest genome-wide data centric approaches.	Assessment

Course Contents:

Unit	Contents	Lectures required
1	**Overview of Sequencing Technologies**: Historical perspective of sequencing technologies. Overview of modern sequencing technologies. Sanger Sequencing. Next Generation sequencing platforms. Whole genome sequencing.	4
2	**Next Generation Sequencing Data analysis:** Data acquisition and base calling. Quality of sequencing data. Read mapping and genome assembly. Structural and functional annotation of genomes. Statistics and algorithms used in different steps in data analysis.	10
3	**Technologies for Transcriptomics and Regulatory Genomics:** Chip-seqAnlysis. Peak finding. Motif Discovery. RNA-seq Analysis. Differential gene expression analysis. Exome sequencing and analysis. Exome sequencing.	9
4	**Software and pipelines for NGS Data Analysis:** Chip-seq analysis Piplines. RNA-seq analysis pipelines. Software used for assembly and differential gene analysis. Basics of Genome Browsers. Annotation pipelines.	9
5	**Genome Sequencing and Applications in Genetics Studies**: Algorithms and application in studying regulation of gene expression. Emerging technologies of single cell gene expression analysis. Metagenomics. Variant detection. Time series analysis. Pathway Analysis.	10
Total lectures		**42**

Suggested Text Book(s):

1. Genomic Data Analysis by Megahed Mohammad, LAP Lambert Academic Publishing
2. Deep Sequencing Analysis by Noam Shomrom, Springer.

Course 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

CO-1	2	2	1	2	2	2	2	1	2	2	2	2
CO-2	1	2	1	2	2	2	2	2	2	2	1	2
CO-3	2	3	3	3	3	2	3	2	2	1	2	2
CO-4	2	3	3	3	3	2	3	2	2	1	2	2

Computational Biology for Engineers

COURSE CODE: 21B1WBT833

COURSE CREDITS: 03

Open Elective

L-T-P: 3-0-0

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Understanding the importance of biological information and its application using computers	Familiarity
CO-2	Students will learn about various biological data resources and information retrieval systems used in Bioinformatics.	Usage
CO-3	Students will learn about various tools for Biological database searching	Assessment
CO-4	Students will learn how to analyze biological sequence to obtain deep knowledge of biological functions of genes and proteins	Assessment
CO-5	Students will understand how to perform protein structure visualization and its importance in computational drug design	Usage

Course Contents:

S. No.	Unit	Topics Covered	Contact Hrs.
1	UNIT I	**History, scope and importance of Computational Biology:** Important contributions, aims and tasks of Bioinformatics, applications of Bioinformatics,Challenges and opportunities, the central dogma of molecular biology	2
2	UNIT II	**Biological databases and information resources:** Importance of biological databases, primary and secondary databases, DNA and protein sequence databases, Retrieval methods for DNA sequence, protein sequence and protein structure information, structure databases, bibliographic databases, Literature databases,Common sequence file formats, PubMED, GenBank, NCBI, EMBL, DDBJ, ExPASY	8
3	UNIT III	**Biological sequence analysis:** Sequence analysis of biological data, Significance of sequence alignment, pairwise sequence alignment methods, Dynamics programming in sequence alignment, Use of scoring matrices and gap penalties in sequence alignments, multiple sequence alignment, Tools and application of sequence alignments	10

Approved in Academic Council held on 28 June 2023

4	UNIT IV	**Biological Database Searching using heuristics:** Dynamic programming vs. heuristics, FASTA and BLAST programs.	4
5	UNIT V	**Structural analysis of biological molecules:** Protein structure, protein structure prediction strategies, Homology modeling, Threading/Fold recognition, *Ab initio*modelling, molecular visualization tools.	9
6	UNIT VI	**Computational approaches in drug discovery:** Chemical databases, Drug target identification, Structure-based drug design**,** Ligand-based drug design, Molecular docking, HTS (High-Throughput Screening) vs. virtual screening, Pharmacophoremodelling.	9
	Total Number of Lectures		**42**

Suggested Text Book(s):

1. Essential Bioinformatics: Jin Xiong
2. Bioinformatics: D.W. Mount
3. Introduction to Bioinformatics by Arthur Lesk
4. Bioinformatics: Databases, tools and Algorithms by OrpitaBosu and SimminderKaurThukral
5. Knowledge discovery in Bioinformatics: Xiaouha Hu, Yi Pan

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

HUMAN DISEASE AND DIAGNOSTICS

COURSE CODE: 21B1WBT731
COURSE CREDITS: 3
Open Elective L-T-P: 3-0-0

Course Objectives

1. The objective of the course is to develop an understanding of Human disease and basic methods used in diagnosis

Course Outcomes

Sr. No.	Course outcomes	Level of Attainment
CO I	Basic understanding of the human pathogens	Familiarity
CO II	Compare and contrast of DNA and RNA as relate to testing reagent	Familiarity
CO III	Able to understand biomolecule based diagnostic procedures	Assessment
CO IV	Describe the laboratory techniques used to detect: microorganisms, DNA polymorphisms and Cancer	Usage
CO V	To develop a strong foundation and thorough understanding of important diseases and diagnostic procedures	Usage

Modules

S. No.	Contents	Contact Hrs.
1	**Introduction to clinical samples;** Philosophy and general approach to clinical specimens (BSL 1-4)), Sample collection (Blood, nasal swab or throat sample, urine, spinal fluid, synovial fluid, amniotic fluid) - method of collection, preservation, transport and processing of samples	**5**
2	**Pathogens and Diagnosis;** Bacterial infection e.g., Tuberculosis, Diarrhea Viral infection e.g., COVID 19, Dengue fever Fungal infections e.g., Candidiasis, Mucormycosis Protozoan diseases e.g., Amoebiosis	**12**
3	**Protein based diagnosis concept and therapeutic agent;** Concept of antigen and antibody. Antigen – Antibody Interaction, ABO Blood typing, ELISA (HIV), Vaccine	**5**
4	**Health biomarker-life style based disorders**; Hormone based diagnostic techniques and their examples (TSH) and Vitamins, Lipid Biomarker Biosensors – types, applications e.g., glucose level Application and importance telemedicine,	**5**
5	**Cancer and Biomarker**; EGFR, PD-L1 (metastatis cancer), BRCA1/2, Esterogen receptor, progesterone receptor, TP53, Pharmacogenomics (Warfarin, Herceptin), PSA biomarker (Prostate cancer)	**8**
6	**Forensic science & COVID testing**; DNA fingerprinting (VNTR) and polymorphism studies (SNP, etc), RT-PCR (RNA or DNA viruses) e.g., SARS-CoV-2- COVID19), C_T Value-pathological burden	**7**
	Total Number of Lectures	**42**

REFERENCE & TEXT BOOKS;

1. Burtis, Carl A., Ashwood, Edward R, Bruns, David E., "*Tietz textbook of Clinical Chemistry & Molecular Diagnostics*" USA: Saunders, 2006.
2. World Organization for Animal Health: "*Manual of Diagnostic Tests and Vaccines for Terrestrial Animals"* Volumes I & II, 6th Edition, 2010.
3. Rao, Juluri R., Fleming, Colin C., Moore, John E., "*Molecular Diagnostics: current technology and Applications"*, Horizon Bioscience, U. K., 2006.
4. Mahon, Connie R., Lehman, Donald C., Manuselis, George, "*Textbook of Diagnostic Microbiology*". USA: Saunders, 2007.
5. Goldsby, Richard A., Kuby, Janis, "*Immunology*", New York: WH Freeman and Company, 2003.

Evaluation Scheme:

Assessment	Max. marks	Duration	Course Covered
Test-1	15	1 hr.	Syllabus covered upto T-1
Test-2	25	1.5 hrs.	Syllabus covered upto T-2
Test-3	35	2 hrs.	Entire Syllabus
Teacher Assessment	25	Entire Semester	Based on Assignments, quizzes etc.

Artificial Intelligence

COURSE CODE: 18B1WCI742

COURSE CREDITS: 2 CORE/ELECTIVE:

ELECTIVE L-T-P: 2-0-0

Pre-requisites: Data Structure, Discrete Structure

Course Objectives:

1. Describe introductory techniques in Artificial Intelligence
2. Heuristic search and adversarial search, Logic for knowledge representation and reasoning
3. Reasoning under uncertainty
4. Machine Learning
5. Apply introductory techniques in Artificial Intelligence to solve realistic problems.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Determine the characteristics of a given problem that an intelligent system must solve.	Familiarity
CO-2	Apply Bayes rule to determine the probability of a hypothesis given evidence.	Assessment
CO-3	Identify examples of knowledge representations for reasoning under uncertainty.	Assessment
CO-4	List the differences among the three main styles of learning: supervised, reinforcement, and unsupervised.	Assessment
CO-5	Identify examples of classification tasks, including the available input features and output to be predicted.	Assessment

Course Contents:

Unit	Contents	Lectures Required
1	**Introduction:** Intelligence, Definitions of Intelligent Agents **Single-Agent Search:** Breadth-first, Depth-first and Iterative Deepening Search, Heuristic Search (A* search), Stochastic Local Search (Simulated Annealing, Genetic algorithms)	7
2	**Adversarial Search:** Minimax Search, Alpha-beta pruning, Stochastic Games and Expectiminimax **Knowledge Representation and Logic:** Propositional Logic, Propositional Inference , First-Order Logic, Propositional Inference (Forward chaining, Backward chaining)	7
3	**Reasoning Under Uncertainty:** Probability Bayes Rule , Bayesian Networks, Bayesian Inference	7
4	**Machine Learning**: Definition and examples of broad variety of machine learning tasks, including classification, Inductive learning, Simple statistical-based learning, such as Naive Bayesian Classifier, decision trees, The over-fitting problem, Measuring classifier accuracy	11
Total lectures		**32**

Suggested Text Book(s):

1. Artificial Intelligence a Modern Approach, 3rd Edition. Prentice Hal
2. Artificial Intelligence Hardcover by Elaine Rich and Kevin Knight

Suggested Reference Book(s):

1. Paradigms of Artificial Intelligence Programming: Case Studies in Common Lisp by Peter Norvig
2. Machine Learning by Tom M. Mitchell
3. Prediction Machines: The Simple Economics of Artificial Intelligence by Ajay Agrawal , Joshua

Gans , Avi Goldfarb

Other useful resource(s):

1. Link to NPTEL course contents:
   - **i.** https://nptel.ac.in/courses/106105077/
   - **ii.** https://nptel.ac.in/courses/106105079/
2. Link to topics related to course:
   - **i.** https://www.ibm.com/developerworks/library/cc-beginner-guide-machine-learning-ai- cognitive/index.html
   - **ii.** https://ai.google/education/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment		Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Artificial Intelligence)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	3	1	1	2	1	2	1	2	2	2	**1.9**
CO-2	3	3	3	1	3	2	1	2	1	2	3	2	**2.2**
CO-3	3	3	3	3	2	1	2	2	2	2	3	2	**2.3**
CO-4	3	3	3	3	2	1	2	2	2	2	3	2	**2.3**
CO-5	3	3	3	3	2	1	2	2	2	2	2	2	**2.3**
Weightage	**3**	**3**	**3**	**2.2**	**2**	**1.4**	**1.6**	**2**	**1.6**	**2**	**2.6**	**2**	

Artificial Intelligence Lab

COURSE CODE: 18B1WCI772

COURSE CREDITS: 1

CORE/ELECTIVE: ELECTIVE L-T-P: 0-

0-2

Pre-requisite: None

Course Objectives:

1. Describe introductory techniques in Artificial Intelligence
2. Heuristic search and adversarial search, Logic for knowledge representation and reasoning
3. Reasoning under uncertainty
4. Machine Learning
5. Apply introductory techniques in Artificial Intelligence to solve realistic problems.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Determine the characteristics of a given problem that an intelligent system must solve.	Familiarity
CO-2	Apply Bayes' rule to determine the probability of a hypothesis given evidence.	Assessment
CO-3	Identify examples of knowledge representations for reasoning under uncertainty.	Assessment
CO-4	List the differences among the three main styles of learning: supervised, reinforcement, and unsupervised.	Assessment
CO-5	Identify examples of classification tasks, including the available input features and output to be predicted.	Assessment

List of Experiments:

S.No	Description	Hours
1	Implementation of DFS and BFS Searching Algorithms	**2**
2	Implementation of A* Algorithm	**2**
3	Study of Prolog Language	**2**
4	Write simple fact for the statements using PROLOG.	**2**
5	Write predicates One converts centigrade temperatures to Fahrenheit, the other checks if a temperature is below freezing	**2**
6	WAP in turbo prolog for medical diagnosis and show that advantage and disadvantage of green and red cuts.	**2**
7	Write a program to solve the Monkey Banana problem	**2**
8	Study of LISP Language	**2**
9	Write a program to solve water jug problem using LISP	**2**
10	Consider House-votes dataset provided in lab. The task is to predict whether the voter is a republican or a democrat based on their votes using Naive Bayes algorithm with 5-fold cross validation. It has 16 binary attributes and 2 classes.	**2**
11	In Experiment 10, Estimate the accuracy of Naive Bayes algorithm using 5-fold cross validation on the house-votes data set.	**2**
12	In Experiment 10, Estimate the precision, recall, accuracy, and F-measure using 10-fold cross-validation.	**2**

<table>
<tr><td>13</td><td>Consider Breast Cancer data set provided in class. It has 9 numeric attributes and 2 types of cancer to be predicted. Compare the performance of 10 machine learning models for given classification data set for the data partition of 70-30%.

<table><tr><td>Model</td><td>Sensitivity</td><td>Specificity</td><td>Precision</td><td>Recall</td><td>Accuracy</td><td>F-Score</td></tr><tr><td>M1</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>M2</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>...</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>M10</td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table></td><td>2</td></tr>
<tr><td>14</td><td>Ensemble the models from Experiment 13 for given data set on data partition of 70-30%.<table><tr><td>Model</td><td>Combination</td><td>Sensitivity</td><td>Specificity</td><td>Precision</td><td>Recall</td><td>Accuracy</td></tr><tr><td>E1</td><td>M1, M5, M6, M7, M10</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>E2</td><td>M1, M2, M4</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>E3</td><td>M2, M4, M6, M8, M10</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>E4</td><td>M5, M7, M8</td><td></td><td></td><td></td><td></td><td></td></tr></table></td><td>2</td></tr>
<tr><td colspan="2">Total Lab hours</td><td>28</td></tr>
</table>

Suggested Books/Resources:

1. Paradigms of Artificial Intelligence Programming: Case Studies in Common Lisp by Peter Norvig
2. Programming in Prolog-Springer by William F. Clocksin, Christopher S. Mellish
3. Machine Learning by Tom M. Mitchell
4. Prediction Machines: The Simple Economics of Artificial Intelligence by Ajay Agrawal , Joshua Gans , Avi Goldfarb
5. Artificial Intelligence a Modern Approach, 3rd Edition. Prentice Hal
6. Artificial Intelligence Hardcover by Elaine Rich and Kevin Knight
7. Link to topics related to course:
    - **i.** https://www.ibm.com/developerworks/library/cc-beginner-guide-machine-learning-ai- cognitive/index.html
    - **ii.** https://ai.google/education/

Evaluation Scheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Attendance	15 Marks
4	Lab Assessment	45 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO-1	3	3	3	2	1	2	1	2	1	2	2	2	**2**
CO-2	3	3	3	2	3	2	1	2	1	2	3	2	**2.3**
CO-3	3	3	3	3	2	1	2	2	2	2	3	2	**2.3**
CO-4	3	3	3	3	2	1	2	2	2	2	3	2	**2.3**
CO-5	3	3	3	3	2	1	2	2	2	2	2	2	**2.3**
Average	**3**	**3**	**3**	**2.6**	**2**	**1.4**	**1.6**	**2**	**1.6**	**2**	**2.6**	**2**	

Data Analytics

COURSE CODE: 18B1WCI843 COURSE

CREDIT: 3 CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisites: Linear algebra, calculus, probability theory and statistics

Course Objectives:

Data Analytics is the science of analyzing data to convert information to useful knowledge. This knowledge could help us understand our world better, and in many contexts enable us to make better decisions. While this is the broad and grand objective, the last 20 years has seen steeply decreasing costs to gather, store, and process data, creating an even stronger motivation for the use of empirical approaches to problem solving.

Course outcomes:

S.No.	Course outcomes	Level of Attainment
CO-1	Gaining factual knowledge regarding data acquisition, data cleansing, and various aspects of data analytics and visualization	Familiarity
CO-2	Learning the principles of data analytics and its underlying methods and algorithms	Assessment
CO-3	Learning to apply the methods of data collection and data analytics to solve business and related problems in support of business decision- making	Assessment
CO-4	Developing the skills necessary to use related software tools to perform data collection, cleansing, and analytics	Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction to the course, Descriptive Statistics, Probability Distributions	**5**
2	Inferential Statistics through hypothesis tests, Permutation & Randomization Test	**4**
3	Regression, ANOVA(Analysis of Variance)	**5**
4	Differentiating algorithmic and model based frameworks Regression : Ordinary Least Squares, Ridge Regression, Lasso Regression, K Nearest Neighbours Regression & Classification	**7**
5	Bias-Variance Dichotomy, Model Validation Approaches Logistic Regression, Linear Discriminant Analysis Quadratic Discriminant Analysis Regression and Classification Trees Support Vector Machines	**8**
6	Ensemble Methods: Random Forest, Neural Networks, Deep learning	**4**
7	Clustering, Associative Rule Mining, Challenges for big data anlalytics	**4**
8	Creating data for analytics through designed experiments, Creating data for analytics through Active learning Creating, data for analytics through Reinforcement learning	**5**
Total lectures		**42**

Suggested Reference Book(s):

1 Hastie, Trevor, et al. The elements of statistical learning. Vol. 2. No. 1. New York: Springer, 2009.

Approved in Academic Council held on 28 June 2023

2. Montgomery, Douglas C., and George C. Runger. Applied statistics and probability for engineers. John Wiley & Sons, 2010.

Other useful resource(s):

1. Link to NPTEL course contents: https://onlinecourses.nptel.ac.in/noc15_mg05/preview

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Data Analytics)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	1	1	1	2	2	2	2	**1.8**
CO-2	2	3	3	3	3	1	1	1	2	2	1	2	**2**
CO-3	2	2	2	2	3	1	1	1	2	2	1	2	**1.8**
CO-4	2	3	3	3	2	1	1	1	2	3	2	2	**2.1**
Average	**2**	**2.5**	**2.5**	**2.5**	**2.5**	**1**	**1**	**1**	**2**	**2.3**	**1.5**	**2**	