SCHEME & SYLLABUS OF
V & VI SEMESTERS
(160 Credits)

NEP II (2022-2026)

VISION AND MISSION OF THE DEPARTMENT

VISION:

To be a center of excellence in education and research in Biotechnology to address the global challenges

MISSION:

1. To offer industry relevant curriculum and research through industry collaborations.
2. To continuously upgrade the infrastructure to develop the facilities for training and research.
3. To provide a good learning environment to help students imbibe professional ethics, communication skills, team spirit and societal commitment.

PROGRAM EDUCATIONAL OBJECTIVES (PEOS)

The Program Educational Objectives are as follows:

1. The graduates of the program are practicing engineering profession in IT sectors (IT system engineers, data analyst and computer programmer), and BT sectors (clinical data coordinator, clinical research associate, Quality controller and Quality assurance analyst, Molecular biologist and Business development executive)
2. The graduates of the program are engaged in higher studies leading to professional degree in specific domain such as biological sciences, computational biology and also engaged in life-long learning.
3. The graduates of the program practice profession with high ethical and moral values and have developed good communication skills and leadership qualities while working as a member of the team or as a team leader.

PROGRAM SPECIFIC OUTCOMES (PSOs):

- Students will be able to conduct the Upstream and Downstream experiments to produce, optimize, separate, purify and characterize biological compounds.
- Students will be able to solve advanced biological problems with the technical skills of Bioinformatics, Biomolecular simulation, Proteomics and Genomics using computational techniques.

- Students will be able to analyse Biopharmaceutical challenges of Biological systems by applying the concepts of Biological sciences

PROGRAMME OUTCOMES (POs)

PO1	**Engineering Knowledge:** Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization respectively to develop to the solution of complex engineering problems.
PO2	**Problem Analysis:** Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development.
PO3	**Design/Development of Solutions:** Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required.
PO4	**Conduct Investigations of Complex Problems:** Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions.
PO5	**Engineering Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems.
PO6	**The Engineer and The World:** Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment.
PO7	**Ethics:** Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws.
PO8	**Individual and Collaborative Team work:** Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication:** Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning:** Recognize the need for and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change.

03-10-2024

SIDDAGANGA INSTITUTE OF TECHNOLOGY, TUMAKURU

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B.E. in Biotechnology

SCHEME OF TEACHING AND EXAMINATION (2022 Scheme) (w.e.f. 2024-25)

V Semester

Sl. No.	Course and Course Code		Course Title	Teaching / Paper setting Dept.	Teaching hrs./week				Examination				Credits
					Lecture	Tutorial	Practical/ Drawing	TW+ SL Component	Duration in hrs.	CIE Marks	SEE Marks	Total Marks	
					L	T	P	S					
1.	PCC	S5BT01	Biomolecular Simulation	BT	42	-	-	48	3	50	50	100	3
2.	IPCC	S5BTI01	Downstream Process Technology	BT	42	0	28	50	3	50	50	100	4
3.	IPCC	S5BTI02	Green Biotechnology and pollution abatement	BT	42	0	28	50	3	50	50	100	4
4.	PCCL	S5BTL01	Biomolecular simulation laboratory	BT	0	0	28	02	3	50	50	100	1
5.	PEC	S5BTPEXX	Professional Elective Course-I	BT	42	-	-	48	3	50	50	100	3
6.	PROJ	S5BTMP01	Mini Project / Extension Survey Project	BT	0	0	56	4	3	100	-	100	2
7.	AEC	SHS04	Research Methodology and IPR **(Board: IEM)**	BT	42	-	-	48	3	50	50	100	3
8.	HSMS	SHS05	Environmental Studies **(Board: CV)**	CV	28	0	0	32	3	50	50	100	2
9.	ARAS	ARAS	Aptitude Related Analytical Skill (Additional Course offered by SIT)	T&P	36	0	0	0	1.5	50	50	100	1
10.	NCMC	NMC01	National Service Scheme (NSS)	NSS CO							-		0
		NMC02	Physical Education (PE) (Sports and Athletics)	PE									
		NMC03	Yoga and Pranayama	YO									
		NMC04	National Cadet Corps	NCC									
			Total		274		140	282	25.5	**500**	**400**	**900**	**23**
		AAP	AICTE Activity Points (Applicable for both Regular and Lateral Entry students)	40 hours community service to be documented and produced for the examination									

Note: **HSMS:** Humanity and Social Science and management Course; **IPCC**: Integrated Professional Core Course, **PCCL**: Professional Core Course laboratory, **PEC**: Professional Elective Course**; PROJ**: Project/Mini Project; **AEC**: Ability Enhancement Course; **NCMC**: Non-Credit Mandatory Course, **L**: Lecture, **T**: Tutorial, **P**: Practical **S= SDA**: Skill Development Activity, **CIE**: Continuous Internal Evaluation, **SEE**: Semester End Evaluation. **TW + SL**: Term Work and Self learning.

Professional Elective Course (PEC) (Offered by the Department)

S5BTPE11	Biomedical imaging and health informatics	**S5BTPE13**	Bioreaction Engineering
S5BTPE12	Marine Biosources and applications	**S5BTPE14**	Animal Biotechnology

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Professional Core Course (IPCC): Refers to Professional Core Course Theory Integrated with practical of the same course. Credit for IPCC can be 04 and its Teaching–Learning hours (L : T : P) can be considered as (3 : 0 : 2) or (2 : 2 : 2). The theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated by only CIE (no SEE). However, questions from the practical part of IPCC shall be included in the SEE question paper. For more details, the regulation governing the Degree of Bachelor of Engineering (B.E.) 2022-23 may please be referred.

National Service Scheme /Physical Education/Yoga: All students have to register for any one of the courses namely National Service Scheme (NSS), Physical Education (PE)(Sports and Athletics), and Yoga(YOG) with the concerned coordinator of the course during the first Week of III semesters. Activities shall be carried out between III semester to the VI semester (for 4 semesters). Successful completion of the registered course and requisite CIE score is mandatory for the award of the Degree. The events shall be appropriately scheduled by the colleges and the same shall be reflected in the calendar prepared for the NSS, PE, and Yoga activities. These courses shall not be considered for vertical progression as well as for the calculation of SGPA and CGPA, but completion of the course is mandatory for the award of Degree.

Mini-project work: Mini Project is a laboratory-oriented/hands on course that will provide a platform to students to enhance their practical knowledge and skills by the development of small systems/applications etc. Based on the ability/abilities of the student/s and recommendations of the mentor, a single discipline or a multidisciplinary Mini-project can be assigned to an individual student or to a group having not more than 4 students.

CIE procedure for Mini-project:

(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two faculty members of the Department, one of them being the Guide. The CIE marks awarded for the Mini-project work shall be based on the evaluation of the project report, project presentation skill, and question and answer session in the ratio of 50:25:25. The marks awarded for the project report shall be the same for all the batches mates.

(ii) Interdisciplinary: Continuous Internal Evaluation shall be group-wise at the college level with the participation of all the guides of the project. The CIE marks awarded for the Mini-project, shall be based on the evaluation of the project report, project presentation skill, and question and answer session in the ratio 50:25:25. The marks awarded for the project report shall be the same for all the batch mates.

No SEE component for Mini-Project.

Professional Elective Courses (PEC): A professional elective (PEC) course is intended to enhance the depth and breadth of educational experience in the Engineering and Technology curriculum. Multidisciplinary courses that are added supplement the latest trend and advanced technology in the selected stream of Engineering. Each group will provide an option to select one course. The minimum number of students' strengths for offering a professional elective is 10. However, this conditional shall not be applicable to cases where the admission to the program is less than 10.

03-10-2024

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B.E. in Biotechnology

SCHEME OF TEACHING AND EXAMINATION (2022 Scheme) (w.e.f. 2024-25)

VI Semester

Sl. No.	Course and Course Code		Course Title	Teaching / Paper setting Dept.	Teaching hrs./week				Examination				Credits
					Lecture	Tutorial	Practical/ Drawing	TW+ SL Component	Duration in hrs.	CIE Marks	SEE Marks	Total Marks	
					L	T	P	S					
1.	IPCC	S6BTI01	Genomics and Proteomics	BT	42	0	28	50	3	50	50	100	4
2.	PCC	S6BT01	Immunology & Immunotechnology	BT	42	28	0	50	3	50	50	100	4
3.	PEC	S6BTPE	Professional Elective Course-II	BT	42	0	0	48	3	50	50	100	3
4.	OEC	OEXX	Open Elective Course-I	BT	42	0	0	48	3	50	50	100	3
5.	PROJ	BTMP	Major Project Phase I	BT	0	0	56	04	3	100	-	100	2
6.	PCCL	S6BTL01	Immunology & Immunotechnology Laboratory	BT	0	0	28	02	3	50	50	100	1
7.	AEC	NHS07	Soft Skills (Offered by SIT)	T&P	36	0	0	0	0	50	00	100	0
8.	NCMC	NMC01	National Service Scheme (NSS)	NSS CO						100	-	100	0
		NMC02	Physical Education (PE) (Sports and Athletics)	PED									
		NMC03	Yoga and Pranayama	PED									
		NMC04	National Cadet Corps	NCC									
			Total		204	28	112	202	18	**500**	**250**	**800**	**17**
		AAP	AICTE Activity Points (Applicable for both Regular and Lateral Entry students)	40 hours community service to be documented and produced for the examination									

Note: **IPCC**: Integrated Professional Core Course, **PCC**: Professional Core Course; **PEC**: Professional Elective Course**; OEC:** Open Elective Course; **PROJ:** Project Phase –I; **PCCL**: Professional Core Course laboratory; **AEC**: Ability Enhancement Course, **SEC**: Skill Enhancement Course; **NCMC**: Non Credit Mandatory Course;**L**: Lecture, **T**: Tutorial, **P**: Practical **S= SDA**: Skill Development Activity, **CIE**: Continuous Internal Evaluation, **SEE**: Semester End Evaluation. **TW + SL**: Term Work and Self learning.

Professional Elective Course (PEC) (Offered by the Department)

S6BTPE11	Bioprocess Equipment Design	S6BTPE13	Vaccine Technology
S6BTPE12	Food Biotechnology	S6BTPE14	System Biology

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National Service Scheme /Physical Education/Yoga: All students have to register for any one of the courses namely National Service Scheme (NSS), Physical Education (PE)(Sports and Athletics), and Yoga(YOG) with the concerned coordinator of the course during the first Week of III semesters. Activities shall be carried out between III semester to the VI semester (for 4 semesters). Successful completion of the registered course and requisite CIE score is mandatory for the award of the Degree. The events shall be appropriately scheduled by the colleges and the same shall be reflected in the calendar prepared for the NSS, PE, and Yoga activities. These courses shall not be considered for vertical progression as well as for the calculation of SGPA and CGPA, but completion of the course is mandatory for the award of Degree.

Professional Elective Courses (PEC): A professional elective (PEC) course is intended to enhance the depth and breadth of educational experience in the Engineering and Technology curriculum. Multidisciplinary courses that are added supplement the latest trend and advanced technology in the selected stream of Engineering. Each group will provide an option to select one course. The minimum number of students' strengths for offering a professional elective is 10. However, this conditional shall not be applicable to cases where the admission to the program is less than 10.

Open Elective Courses:

Students belonging to a particular stream of Engineering and Technology are not entitled to the open electives offered by their parent Department. However, they can opt for an elective offered by other Departments, provided they satisfy the prerequisite condition if any. Registration to open electives shall be documented under the guidance of the Program Coordinator/ Advisor/Mentor. The minimum numbers of students' strength for offering Open Elective Course is 10. However, this condition shall not be applicable to class where the admission to the program is less than 10.

Project Phase-I : Students have to discuss with the mentor /guide and with their help he/she has to complete the literature survey and prepare the report and finally define the problem statement for the project work.

BIOMOLECULAR SIMULATIONS

Contact Hours/ Week:	: 3+0+2 (L+T+P)	**Credits:**	3
Total Lecture Hours:	: 42	**CIE Marks:**	50
Sub. Code:	:S5BT01	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	Know the basic concepts of molecular dynamics (MD) simulations.
2.	Learn molecular mechanics, force-field and atomic interactions.
3.	Understand the preparation of a system for moleculardynamics simulation and its minimization.
4.	Learn the ensemble system and its associated concepts.
5.	Understand the applications of molecular dynamics simulations

UNIT I
Basic concepts of Molecular dynamics simulations: Structural aspects of Biomolecules: Nucleic acids, Proteins, Lipids and Carbohydrates. A brief history of computer simulations; Motivation to perform computer simulation; Introduction to molecular dynamics simulation, Principles of Molecular dynamics simulation: Newton's laws of motions, assumptions in Molecular dynamics simulation; Global Molecular dynamics algorithm; Preparation of Biomolecules for Molecular dynamics simulation: Proteins, Lipids, Nucleic acids and Carbohydrates. Protein modelling (Homology modelling only), Ligand preparation for molecular dynamics simulations and Preparation of the Protein-ligand complex. Protein Solvation: Necessity of solvation, Implicit solvation, explicit solvation. Adding Ions: Necessity of adding ions, points to remember while adding ions. Comparison between all-atom, united- atom and coarse-grained simulations.
9 Hours

UNIT II
Molecular mechanics force field: Bond theory, Bonded and non- bonded interactions in biomolecules, Simple Molecular mechanics force field: Four-component model (inter and intra molecular components); Properties of force fields; Bonded and non-bonded terms in force fields, Bond stretching, Angle bending, Torsion angle, Electrostatic interactions, Van der Waals interactions (Lennard-Jones potential) (only expressions with graphs for bonded and non-bonded terms except Bond stretching where derivation is also included). A simple force-filed model for the simulation of liquid water, Force field parameterization, Transferability of molecules,tools to prepare force-field parameters for ligands. List of force fields for different Biomolecules.
8 Hours

UNIT III
Energy Minimization and ensemble systems: Essentiality of energy minimization; Energy minimization techniques: Non-derivative energy minimization (simplex method and sequential univariate method) and derivative energy minimizations methods (Steepest descents method, line search in one dimension method, and conjugate gradients minimization) System equilibration: Ensembles; Microcanonical ensemble, canonical ensemble, Isothermal-Isobaric ensemble, Grand canonical ensemble; Production run in Molecular dynamics simulation. Simple packages of Molecular dynamics simulation and its force fields: GROMACS, AMBER, and NAMD.
8 Hours

UNIT IV
Molecular dynamics (MD) simulation method: A simple molecular dynamics simulation; Interaction potential and Reduced Units; Time averages and ensemble averages, Calculation of simple thermodynamic properties; Radial distribution function; Phase space; Setting up and running simulation; Choosing the initial configuration (MD and Steered molecular dynamics); Boundaries and periodic boundary condition; Truncating potential and minimum image convention; Long range forces; System initialization: A simple MD algorithm; Calculation of forces; Numerical integration: Verlet algorithm, Velocity Verlet algorithm, Leap frog algorithm, and Predictor Corrector algorithm.
8 Hours

UNIT V
Applications of MD simulations: Simple analysis of MD simulations: RMSD (Root mean square deviation), RMSF (Root mean square fluctuation), Secondary structure prediction, H-bond analysis, MMPBSA (Molecular mechanics Poisson-Boltzmann surface area) analysis, Analysis of protein cavities, Protein domain's orientation analysis, SASA (Solvent accessible surface area), RDF (Radial distribution function), Rg (Radius of gyration). MD simulations for Protein-ligand interactions (One case study);MD simulations for protein domain movement (One case study); MD simulations lipid bilayer and Biphasic system (One case study). **Note:** Scientific articles used as case study, will be open access and freely available journals.
9 Hours

TEXT BOOKS		
1	Andrew R. Leach	Molecular Modeling: Principles and Applications, Pearson, 5th Edition, 2013, 97801956884

REFERENCE BOOKS		
1	Ben Leimkuhler, C Matthews	Molecular Dynamics, Springer International publishing, 4th Edition, 2015, 87801956884
2	Guy FanacisMongelli	Molecular dynamics simulations: Key operations in GROMACS, Walter de Gruyter, 7th Edition, 2018, 87801956884

Course Outcomes:

Upon completion of this course the student will be able to:

CO1	Analyze concepts of molecular mechanics at the atomic level using concepts of biomolecular structures.
CO2	Apply the appropriate force field for MD simulations using the force field parameters
CO3	Classify various energy minimization and system equilibration methods for molecular dynamics simulations.
CO4	Interpret and analyze the aspects of the simulation box for system preparation.
CO5	Apply and interpret the various analysis methods used to evaluate the simulated trajectory.

Academic year- 2024-2025 NEP-2

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
S5BT01	2	1								1			2	

Program Articulation matrix Mapping of course outcomes with program outcomes

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
COs	CO1	2	1											2	
	CO2	2	1											2	
	CO3	2	1											2	
	CO4	2	1											2	
	CO5	2	1								1			2	

1: Low, 2: Medium, 3: High

DOWNSTREAM PROCESS TECHNOLOGY

Contact Hours/ Week:	: 3+0+2 (L+T+P)	**Credits:**	4
Total Lecture Hours:	: 42+0+28	**CIE Marks:**	50
Sub. Code:	:S5BTI01	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1	Study the basic concepts of isolation &purification of products at commercial scale from fermented broth
2	Learn about Industrial Applications of various processes for isolation of products such as enzymes, antibiotics, and organic acids
3.	Study the membrane separation process
4.	Understand the product enrichment operations
5.	Learn about the principle &operation of chromatography techniques

UNIT I
Industrial Bio-separation Process: Introduction, Different sectors in biotechnology, Characterization of starting materials, Characterization of bioprocess, Selection of Operations in Separation Processes, Selection of Separation sequence, Process design criteria for various classes of

Bioproducts (schematic, flow-chart). Characteristics of fermentation broth: Morphology of cells and Structure of Cell Wall.
9 Hours

UNIT II
Primary Separation and Recovery Process: Recovery of High Volume, Low Value products e.g. Citric acid, Ethanol & Penicillin and Low Volume, High Value Products e.g. Recombinant Proteins: Insulin. Intracellular Products, Cell wall, Cell disruption -Physical, Chemical & Enzymatic and Mechanical, Removal of Insoluble, Biomass (and Particulate Debris): Flocculation, Sedimentation, Centrifugation and Filtration.
9 Hours

UNIT IV
Enrichment Operations: Precipitation Methods with Salts: Principle e.g. taking Ammonium Sulfate Salt, Organic Solvents (e.g. Polyethylene Glycol) (Principles & Methods). Extractive Separations: Liquid-Liquid Extraction, Aqueous Two-phase Extractions, Supercritical Extraction, In-situ product removal/Integrated Bioprocessing. Enzyme processing using Ultrafiltration membranes; Separation by Liquid Membranes, Ultra filtration & Reverse osmosis.
8 Hours

UNIT V
Product Resolution & Fractionation: Adsorptive Chromatographic Separation Processes-TLC, PC, Normal Phase, HPLC Principle, Description & Example of Separation of compounds. Hybrid separation technologies, Membrane Chromatography Electro Chromatography-Principle, Gel Permeation Chromatography-Principle, Equipment & Applications, GC (Principle, equipment & applications). Dialysis-Principle, Different Membranes. Crystallization-Principles, Methods & Examples.
8 Hours

TEXT BOOKS		
1	Belter P.A., Cussier E. and Wei, Shan Hu.	Bioseparation–Downstream Processing for Biotechnology, Wiley Interscience Pub, 1988.

REFERENCE BOOKS		
1	Raja Ghosh	Principles of Bioseparations Engineering, 2006
2	Shuler and Kargi	Bioprocess Engineering Prentice Hall, 1992

Course Outcomes:

Upon completion of this course the student will be able to:

CO1	Explain how downstream process is applied in the Pharmaceutical Industry for Production of Life Saving Drugs
CO2	Describe & Apply the Isolation & Purification of Products from Microbial Origin
CO3	Explain the Principles of Membrane Separation Process
CO4	Apply sophisticated Analytical Equipment for Detection of Various Impurities to ascertain its Permissible Level
CO5	Describe the Equipment required for Commercial Scale Downstream Process along with its Operating Procedures

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
S5BTI01	2	2	2	3	2	2		2	3	2		2		

Program Articulation matrix Mapping of course outcomes with program outcomes

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
COs	CO1	2	2			2							2		
	CO2	2	2			2							2		
	CO3		2	2		2							2		
	CO4		2	2		3							2		
	CO5				3	3	2		2	3	2		2		

1: Low, 2: Medium, 3: High

DOWNSTREAM PROCESS TECHNOLOGY LABORATORY

Contact Hours/ Week:	: 0+0+2 (L+T+P)	**Credits:**	0
Total Lecture Hours:	: 28	**CIE Marks:**	50
Sub. Code:	: S5BTI01	**SEE Marks:**	0

Course objectives: This course will enable students to:	
1	Study the Basic Concepts of Isolation & amp; Purification of products atcommercial scale from fermented broth
2	Learn about industrial applications of various processes for isolation of products such as Enzymes, Antibiotics, Organic acids
3	Study the Membrane Separation Process
4	Understand the Product enrichment operations
5	Learn about the Principle & Operation of Chromatography Techniques

List of Experiments

1.	Solid liquid separation- Centrifugation studies
2.	Solid liquid separation-Batch sedimentation
3.	Precipitation of protein from crude yeast extract by ammonium sulphate
4.	Aqueous two-phase extraction
5.	Thin layer Chromatography
6.	Simple distillation
7.	Product enrichment operation by distillation
8.	Estimation of citric acid from fermentation broth
9.	Atmospheric batch drying
10.	Protein isolation and separation by SDS-PAGE
11.	Dialysis method for protein purification
12.	Mechanical cell disruption
13.	Solid liquid separation- Filtration
14.	Freeze drying

TEXT BOOKS		
1	Belter P.A., Cussier E. and Wei, Shan Hu.	Bioseparation- Downstream Processing forBiotechnology, Wiley Blackwell Publications, 1988, 978-0471847373
2	Avinash Upadhyay Kakoli Upadhyay	Biophysical Chemistry, Himalaya Publishing House,2009.

REFERENCE BOOKS		
1	Shuler and Kargi	Bioprocess Engineering Prentice Hall, 1992
2	WolfR. Vieth	Bioprocess Engineering–Kinetics, Mass Transport,Reactors and Gene Expression – InterscienceePublication, 1992

Course Outcomes:

Upon completion of this course the student will be able to:

CO1	Explain how Downstream Process is applied in the Pharmaceutical Industry for Production of Life Saving Drugs
CO2	Describe & Apply the Isolation & Purification of Products from Microbial origin
CO3	Explain the Principles of Membrane Separation Process
CO4	Apply sophisticated Analytical Equipment for Detection of Various Impurities to ascertain its Permissible Level
CO5	Describe the Equipment required for Commercial Scale Downstream

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Course	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
S5BTI01	2	2	2	3	2	2		2	3	2	2			2

Program Articulation matrix Mapping of course outcomes with program outcomes

		POs											**PSOs**		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
COs	**CO1**	2	2			2						2	2		
	CO2	2	2			2						2	2		
	CO3		2	2		2						2	2		
	CO4		2	2		3						2	2		
	CO5				3	3	2		2	3	2	2	2		

1: Low, 2: Medium, 3: High

GREEN BIOTECHNOLOGY AND POLLUTION ABATEMENT

Contact Hours/ Week:	: 3+0+2 (L+T+P)	**Credits:**	4
Total Lecture Hours:	: 42+0+28	**CIE Marks:**	50
Sub. Code:	:S5BTI02	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	Recognize the various global and regional environmental concerns due to natural causes and/or human activities, and the impact of these on various forms of life including native biodiversity.
2.	Understand the physiology of a microorganism and how their structure dictates their function in the environment.
3.	Enable students to acquire comprehensive knowledge of environmental biotechnological processes for wastewater treatment, bioremediation and metal recovery.
4.	Understand the bases for microbial metabolism of environmental contaminants and to know various techniques to modify and augment microorganisms in the laboratory and environment.
5.	Understand the principles of composting and Phytoremediation

UNIT I
Bioremediation: Definition, approaches to bioremediation, environmental modification, microbial seeding. Bioengineering approaches to the bioremediation of pollutants – engineering of bioremediation processes – needs and limitations. Xenobiotics, biodegradation of lignin, hydrocarbons, plastic.
8 Hours

UNIT II
Bioremediation of contaminated soils: Diversity and magnitude of soil contaminants, criteria for bioremediation, biological mechanism of transformation, strategies for bioremediation, Case studies of bioremediation. Biodegradable organic pollutants - Pesticides, aerobic and anaerobic bacteria degradation, cometabolic degradation, degradative capacities of fungi.
8 Hours

UNIT III
Bioremediation of various ecosystems: Bioremediation of contaminated water (oil slicks, heavy metals), bioremediation of industrial wastes - distillery-processes and production in the distillery, characteristics of effluent and treatment, textile industry- source and origin of dyes, Environmental impact of dyes and its intermediates and treatment, leather – processes and production, characteristics of effluent, Environmental impact of tannery effluents and treatment, paper and pulp manufacturing industries, Processes and production.
9 Hours

UNIT IV
Bioremediation Techniques: Bioaerosols, Biofiltration, microbial control of environmental pollution –role of genetic engineering in environmental pollution abatement, catabolic plasmids as natural vectors, genetic engineering of genes for augmenting pollution abatement in microbes and plants, use of immobilized microbes for waste recycling, immobilized enzymes in pollution abatement.
8 Hours

UNIT V
Composting and Phytoremediation: Exploitation of agricultural wastes for food, feed and fuel, humus formation, sludge composting, vermi composting, aerobic and anaerobic composting. Introduction to phytoremediation, phytoextraction, phytostabilization, phytoremediation of inorganics, translocation mechanisms for inorganics, plant accumulation.
9 Hours

TEXT BOOKS		
1.	Indu shekhar Thakur	Environmental Biotechnology, Basic concepts and Applications, I K International Publishing House Pvt. Ltd 2nd Edition, 2013, 9380578474.

REFERENCE BOOKS		
1	D. K. Maheshwari and R. C. Dubey	Bioremediation of Pollutants Hardcover IK International Publishing House Pvt. Ltd; 1st Edition, 2012, 9381141053.
2	Pradipta Kumar Mohaptra	Text book of Environmental Biotechnology, I K International Pvt. Ltd. 1st edition, 2013, 818823754X

Course Outcomes:

Upon completion of this course the student will be able to:

CO1	Describe the various methods of bioremediation of xenobiotics.
CO2	Explain the biological mechanism of transformation of xenobiotics in various environmental conditions.
CO3	Discuss the different types of treatment for industrial effluents.
CO4	Recognize and apply genetic engineering practices in environmental biotechnology.
CO5	Illustrate the application of microbes and plants in treating solid waste management as well as heavy metals.

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Course	PO1	PO2	PO3	PO4	PO5		PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
S5BTI02	2	2	2	3	2		2		2	3	2				2

Program Articulation matrix Mapping of course outcomes with program outcomes

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
COs	CO1	2	2			2									2
	CO2	2	2			2									2
	CO3		2	2		2									2
	CO4		2	2		3									2
	CO5				3	3	2		2	3	2				2

1: Low, 2: Medium, 3: High

GREEN BIOTECHNOLOGY AND POLLUTION ABATEMENT LABORATORY

Contact Hours/ Week:	: 0+0+2 (L+T+P)	**Credits:**	1
Total Lecture Hours:	: 28	**CIE Marks:**	50
Sub. Code:	:S5BTI02	**SEE Marks:**	0

Course objectives: This course will enable students to:	
1	Study the basic concepts of isolating microorganisms from different environmental conditions.
2	Understand the impact of xenobiotics on growth of microbes
3	Learn the techniques of identifying contaminants in the water sample by PCR.
4	Study the interaction of natural material with petrochemical compounds.
5	Understand the importance of medicinal plants against disease causing microbes.

List of Experiments

1.	Introduction and Orientation/ Review of Microbial Techniques
2.	Isolation and Characterization of Bacteria from Crude Petroleum Oil Contaminated Soil
3.	Isolation of xenobiotic degrading bacteria by selective enrichment technique
4.	Growth Response of Bacteria on Petroleum Fuel (Diesel)
5.	Enrichment for Uric Acid Utilizing Bacteria
6.	Environmental Detection of Streptomycin-Producing Streptomyces spp.by Using strb1 and 16S rDNA-Targeted PCR
7.	Molecular Detection of Fecal Coliforms (E. coli) in Water by PCR
8.	Estimation of fluoride in drinking water.
9.	Estimation of residual chlorine in drinking water
10.	Interaction of Plant Seeds with Diesel for Potential Use in the remediation of Diesel fuel Contaminated Soils
11.	Detection of Alkyl benzene sulfonate-Degrading Microorganisms
12.	In vitro evaluation of medicinal plants against pathogenic microbes

TEXT BOOK		
1	S. K. Agarwal	Environmental Biotechnology Principles and Applications Pearson, 5th Edition, 2013, 97801956884

REFERENCE BOOKS		
1	Martin Alexander	Biodegradation and Bioremediation Academic Press Inc; 2nd edition 1999, 978-0120498611
2	Jayanta Kumar Patra	A Practical Guide to Environmental Biotechnology, Springer Verlag, Singapore; 1st ed. 2020 978-9811562518

Course Outcomes:

Upon completion of this course the student will be able to:

CO1	Analyze diversity, function, ecological adaptation of microorganisms within the environment
CO2	Describe the importance of microbial life to key ecosystem process and the role of biotechnology to address environmental issues
CO3	Perform the techniques of identifying contaminants in the water sample by PCR.
CO4	Interpret the interaction of natural material with petrochemical compounds.
CO5	Analyze case studies representatives of key areas of environmental biotechnology

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
S5BTI02	2	2	2	3	2	2		2	3	2	2			2

Program Articulation matrix Mapping of course outcomes with program outcomes

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
COs	CO1	2	2			2						2			2
	CO2	2	2			2						2			2
	CO3		2	2		2						2			2
	CO4		2	2		3						2			2
	CO5				3	3	2		2	3	2	2			2

1: Low, 2: Medium, 3: High

BIOMOLECULAR SIMULATION LABORATORY

Contact Hours/ Week:	: 0+0+2 hours	**Credits:**	1
Total Lecture Hours:	: 28	**CIE Marks:**	50
Sub. Code:	:S5BTL01	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	Learn the basic concepts in preparing the protein, ligand and other bio molecular system.
2.	Perform the preparation of Protein-ligand complex followed by systemminimization
3.	Learn to perform system equilibration and molecular dynamics production run.
4.	Learn the basic analysis tools and perform molecular dynamics simulation in Desmond
5	Perform the complete moleculardynamics simulation using GROMACS and DESMOND

List of Experiments:

1.	Protein preparation and protein modelling using Modeller and other tools
2.	Ligand preparation and preparation of ligand force field
3.	Preparing other biomolecules for molecular dynamics simulation for GROMACS simulation package
4.	Preparation of the protein-ligand complex, vacuum minimization, periodic boundary condition, system solvation, adding ions and energy minimization
5.	System equilibration in NVT and NPT ensemble system and production run
6.	RMSD, RMSF, Rg, SASA and secondary structure analysis
7.	Hydrogen bond, protein pocket analysis
8.	MMPBSA analysis on simulation trajectory
9.	PCA analysis on simulation trajectory
10.	A simple protein-ligand simulation and result analysis using GROMACS
11.	A simple protein-ligand simulation and result analysis using DESMOND
12.	Open ended experiment

TEXT BOOK		
1	Andrew R. Leach	Molecular Modeling: Principles and applications, Pearson, 5th edition, 2013, 97801956884

REFERENCE BOOKS		
1	Ben Leimkuhler, C Matthews	Molecular Dynamics, Springer International publishing, 4th Edition, 2015, 87801956884
2	Guy Fanacis Mongelli	Molecular dynamics simulations: Key operations in GROMACS, Walter de Gruyter, 7th Edition, 2018, 87801956884

Course Outcomes:

Upon completion of this course the student will be able to:

CO1	Prepare the protein, ligand and bio molecular system suitable for performing molecular dynamics simulation
CO2	Perform basic MD operations to prepare protein-ligand complex followed by system minimization.
CO3	Carryout system equilibration of ensemble systems and perform molecular dynamics simulation using GROMACS package.
CO4	Use various data analysis tools to validate the system.
CO5	Independently perform an open-ended experiment.

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
S5BTL01	2	2	2	3	2	2		2	3	2	2		2	

Program Articulation matrixMapping of course outcomes with program outcomes

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
COs	CO1	2	2			2						2		2	
	CO2	2	2			2						2		2	
	CO3		2	2		2						2		2	
	CO4		2	2		3						2		2	
	CO5				3	3	2		2	3	2	2		2	

1: Low, 2: Medium, 3:High

BIOMEDICAL IMAGING AND HEALTH INFORMATICS

Contact Hours/ Week:	: 3+0+0 (L+T+P)	**Credits:**	3
Total Lecture Hours:	: 42	**CIE Marks:**	50
Sub. Code:	: S5BTPE11	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	Study basic skills and knowledge in health imaging
2.	Understand the role of nuclear imaging
3.	Understand the role of information in health management
4.	Study the health management systems
5.	Learn ethical and diversity issues in health informatics.

UNIT I
Biomedical Imaging: Introduction to Biomedical Imaging, its history and development, Imaging with ionizing radiation: Physics of x-ray imaging, X-ray generators and detectors. Dual-energy X-ray absorptiometry (DEXA), Computed Tomography: Principles of image formation and reconstruction techniques, Computed Tomography: Instrumentation and Data analysis
9 Hours

UNIT II
Nuclear Imaging modalities: Scintigraphy, positron emission tomography (PET) & single-photon emission computed tomography (SPECT), Magnetic Resonance Imaging: Physical foundations of Magnetic Resonance Imaging: Image formation. Role of fluorophores,Ultrasound Imaging, spectral imaging, and medical image processing labs.Outlook and trends in biomedical imaging. Use of fluorophores in imaging.
8 Hours

UNIT III
Health Informatics: Aim and scope, historical perspectives, concepts, definitions and activities in Health informatics, introduction to the application of information technology to integrated hospital information systems and patient-specific information; nursing, radiology, pathology, and pharmacy services, Future trends, research in health informatics, training and career opportunities.
9 Hours

UNIT IV
Hospital management and Information systems: Hospital Management and Information Systems (HMIS), its need, benefits, capabilities, development, functional areas. Modules forming HMISand Internet, Pre-requisites for HMIS, why HMIS fails, health information system, disaster management plans, advantages of HMIS. Health Level 7 (HL7). Study of picture archival & communication systems (PACS), PACS Administrator, PACS Technology overview, PACS Administration: The Business Perspective.
8 Hours

UNIT V
Electronic Health Records: Pathology Laboratory Module, Blood Bank Module, Operation Theatre Module, Medical Stores Module, Pharmacy Module, Inventory Module, Radiology Module, Medical Records Index Module, Administration Module, Personal Registration Module, Employee Information Module, Financial modules, Health & Family Welfare, Medical Research, Communication, General Information.
8 Hours

TEXT BOOKS		
1	Phillip Olla, Phillip Olla, Joseph Tan	Digital Health Care: Perspectives, Applications, and Cases, First edition, 2023

REFERENCE BOOKS		
1	Edward H. Shortliffe, James J. Cimino	Medical Imaging: Technology and Applications: 0387289860, 2019, Springer, 1st edition
2	Edward H. Shortliffe, James J. Cimino	Foundation of Knowledge: Integrating Informatics into Healthcare Practice, 2nd edition, 2021, Jones & Bartlett Learning; 1284182096

Course Outcomes:

Upon completion of this course the student will be able to:

CO1	Understand the different instrumentation related to medical imaging
CO2	Comprehend the mechanism of action of nuclear-based medical imaging
CO3	Relate the need of information technology in Healthcare sector
CO4	Analyse the role of information technology in healthcare data management system
CO5	Appreciate the role of electronic databases in the healthcare system

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Course	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**		**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
S5BTL01	2	1			3		1	1	1						2

Program Articulation matrix Mapping of course outcomes with program outcomes

		POs											**PSOs**		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
COs	**CO1**	2				3									2
	CO2	2	1			3	1	1							3
	CO3	2	1												1
	CO4	2	1				1	1	1						1
	CO5	1	1			2									

1: Low, 2: Medium, 3: High

MARINE BIORESOURCES AND APPLICATIONS

Contact Hours/ Week:	: 3+0+0 (L+T+P)	**Credits:**	3
Total Lecture Hours:	: 42	**CIE Marks:**	50
Sub. Code:	: S5BTPE12	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	Understand the ocean environment and its ecosystem
2.	Learn the concepts of marine bioactive components.
3.	Understand the concepts of marine pharmacology resources.
4.	Understand the toxic environment of marine ecosystem
5.	Study the different sources of marine pollution.

UNIT I

THE OCEANIC ENVIRONMENT: Classification of the marine environment – Geography of the Global Ocean, biotic and abiotic divisions, Marine life: Marine microbes, Marine algae and plants (seaweeds, sea grasses, mangrove plants), Invertebrates: sponges, cnidarians, polychaetes, crustaceans, molluscs, echinoderms, arthropods, Noncraniate (non-vertebrate) chordates, Vertebrates, Marine fishes (bony, cartilaginous, jawless fishes) Marine tetrapods, Marine zoogeography with reference to Indian, Artic and Antartic oceans, Adaptations of organisms to different habitats. Wealth of the sea-Economically important marine animals-fin fishes, shrimp, crab, edible oysters and pearl oysters

8 Hours

UNIT II

BIOACTIVE COMPOUNDS FROM THE OCEAN: Important products isolated from marine organisms and their uses, Seaweed: Nutritional Value, Bioactive Properties, and Uses. Seafood Processing Wastes: Chitin, Chitosan, and other compounds, Seaweed Hydrocolloids; agarose, agar, alginates, carrageenans, chitin, chitosans and glucosamines- Biological Activities, uses and importance, Marine enzymes; Isolation and applications, Marine enzymes in Cancer, Biotechnological Applications of Marine Enzymes from Algae, Bacteria, Fungi, and Sponges, Antifreeze Proteins, Cold-Adapted Enzymes, applications. marine flavourants, lectins, heparin and carotene. Microbial Enzymes in Biotechnology. Probiotics for Animal Health, Production and Applications for Human Health, Biomedical Applications of Enzymes from Marine Actinobacteria.

8 Hours

UNIT III
PHARMACEUTICALLY IMPORTANT PRODUCTS: Need, importance and potentialities of marine drugs and sources. Drugs and Pharmaceuticals from Marine Sources, Development and problems in Marine Drug Development, Global Interests and Commercial Status. Marine Microalgae, Bioactive compounds from Microalgae, Bioactive natural products – anti-bacterial, anti-fungal, anti-viral, anti-inflammatory, anti-tumour, anti-parasitic and anti-helminthic, nutraceuticals. Marine Sources of Carotenoids, Isolation, Characterization, Antioxidant Activities of carotenoids. Marine Products; B-carotene, vitamins, immunomodulators, anticancer and cytotoxic compounds from marine sources- their extraction process and characterization. Marine Lipids, PUFA, Omega-3 PUFA-Rich Oils from Marine Fish, Health Benefits. Seafood Proteins as Dietary Component, Bioactive Peptides from Seafood, Isolation of Seafood Peptides, Functional Roles of Marine Peptides in Foods. Marine Sources of Vitamins and Minerals with examples. Marine 16.07.2023 Annexure-II 18 Nutraceuticals for Food Fortification and Enrichment, examples. Marine Sponge Compounds with Anti-inflammatory Activity. Safety Hazards with Marine Products and Their Control.
8 Hours

UNIT IV
MARINE TOXINS AND TOXICOLOGY: Classifications of Marine Based-Toxins. Seafood Poisoning, Toxicity related to seafood, Different Routes of Exposure of Marine Toxins. Puffer Fish Poisoning (PEP), Scombroid Fish Poisoning, Saxitoxin, Brevetoxins, Ciguatera Fish Poisoning, Paralytic Shellfish Poisoning, Neurotoxic Shellfish Poisoning., Marine Invertebrate Toxins, Limu-Make-o-Hana (the Deadly Seaweed of Hana). Diarrhoeic Shellfish Poisoning (DSP). The Cone Shells. Sea Snakes, Venomous Fish. Tetrodotoxin, Amnesic Shellfish poisoning, Azaspiracid, Palytoxin Poisoning, Other Marine Biotoxin; Conotoxins, nodularin, cylindrospermopsin, microcystins, anatoxins, yessotoxin, and palytoxin (PTX) and their effects on human health. Treatments of Marine-Based Food Poisoning, Prevention Aspects of Marine Toxin for Humans. Safety Hazards with Marine Products and Their Control, Food-Borne Hazards, Types, Algal Toxins Influenza Viruses: A Threat to Marine Mammals Populations.
9 Hours

UNIT V
MARINE POLLUTION: Sources of marine pollution, its dynamics, transport paths and agents. Composition of domestic, industrial and agricultural discharges. Their fate in the marine environment. Toxicity and treatment methods. Oil pollution: Sources, composition, and its fate in marine habitats. Toxicity and treatment methods. Thermal and radioactive pollution: sources, effects, and remedial measures. Solid dumping, mining and dredging operations: their effects on marine ecosystem. Role of biotechnology in marine pollution control. Biofouling and biodeterioration: Agents and protection methods. Global environmental monitoring methods: status, objectives and limitations. Bioinformatics Techniques on Marine Genomics, Omics Approaches in Marine Biotechnology: genomics, proteomics, transcriptomics, nutrigenomics, and metabolomics. Applications of Omics Tools in Blue Biotechnology.
9 Hours

TEXT BOOKS		
1	Vazhiyil Venugopal	Marine Products for Healthcare: Functional and Bioactive Nutraceutical Compounds from the Ocean (Functional Foods and Nutraceuticals Book 13) 1st Edition, 2009,CRC Press

REFERENCE BOOKS		
1	Philip V. Mladenov	Marine Biology: A Very Short Introduction (2nd edn), Online, 2020, ISBN: 9780198841715, Oxford University Press
2	Se-Kwon Kim	Springer Handbook of Marine Biotechnology, (1st Ed.),2015, ISBN: 978-3-642-53970-1, Springer Handbooks.

Course Outcomes:

Upon completion of this course the student will be able to:

CO1	Classify the various marines organisms based on their geographic location
CO2	Analyze the various bioactive components from marine life by assessing their biological potential
CO3	Identify the various biological and pharmaceutical potential of the marine products
CO4	Classify the marine based toxin by various biological assessments
CO5	Understand the source, dynamics and outcomes of the marine pollution

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
S5BTPE12	3	2												2

Program Articulation matrix Mapping of course outcomes with program outcomes

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
COs	CO1	3	2												2
	CO2	3	2												2
	CO3	3	2												2
	CO4	3	2												2
	CO5	3	2												2

1: Low, 2: Medium, 3: High

BIOREACTION ENGINEERING

Contact Hours/ Week:	: 3+0+0 (L+T+P)	**Credits:**	3
Total Lecture Hours:	: 42	**CIE Marks:**	50
Sub. Code:	: S5BTPE13	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	Understand the rate mechanism of reactions
2.	Learn the various types of inhibition and kinetics of cell and enzyme
3.	Study the effect of mass transfer on the cellular and enzymatic reactions
4.	Understand the concepts and operations of bioreactors
5.	Learn the immobilized cells reactions in chemostat and plug flow reactors and compare them.

UNIT I
Homogeneous reactions: Introduction, Elementary and Non-Elementary reactions, Representation of elementary reaction, Molecularity and order of reaction, Basic reaction theory: Reaction rate. Effect of temperature on reaction rate, General reaction kinetics for biological systems, Zero-order kinetics, First order kinetics, Second order kinetics, Enzyme Kinetics, Michelis-Meneten kinetics, Lineweaver-burk plot, Eadie-Hofstee plot, Langmuir plot.
9 Hours

UNIT II
Regulation of enzyme activity: Reversible inhibition, Competitive inhibition, Noncompetitive inhibition, Uncompetitive inhibition, Partial inhibition, Irreversible inhibition, Numerical Conceptual Allosteric regulation, Kinetics of enzyme deactivation, Cell growth kinetics, Batch growth and numerical conceptuals.
8 Hours

UNIT III
Heterogeneous Reactions: Heterogeneous reactions in bioprocessing, Concentration gradients and reaction rates in solid catalysts, Steady state shell mass balance, **Concentration Profile**-First order kinetics and spherical geometry.
9 Hours

UNIT IV
Reactor engineering: Bioreactor engineering in perspective, Bioreactor configuration-Stirred tank, Bubble column, Airlift reactor, Stirred and Air-driven reactors-comparison, Packed bed, Fluidized bed, Trickle bed, Disposable bioreactors. **Ideal reactor operation:**- Batch operation of a mixed reactor: Enzyme reaction, Cell culture, Total time for batch reaction cycle.
8 Hours

UNIT V
Chemostat: Fed-batch operations of a mixed reactor, Continuous operation of a mixed reactor- Enzyme reaction, Cell culture, Chemostat with immobilized cells, Chemostat Cascade, Chemostat with cell recycle, Continuous operation of a plug flow reactor-Enzyme reaction, Cell culture. Comparison between Major models of reactor operation, Evaluation of Kinetic and yield parameters in chemostat culture.
8 Hours

TEXT BOOKS		
1	Paulin M. Doran	Bioprocessing Engineering, Principles, Elsevier, 2nd Edition, 2012, 012220851X

REFERENCE BOOKS		
1	Octave Levenspiel	Chemical Reaction Engineering, Wiley Publisher, 3rd Edition, 2006, 9788126510009
2	Michael L. Shuler, FikretKargi	Basic Concepts in Bioprocess Engineering, Prentice Hall, 2nd Edition, 2015, 978-0130819086

Course Outcomes:

Upon completion of this course the student will be able to:

CO1	Classify types of reactions with respect to order, molecularity and MM kinetic equations.
CO2	Analyse the effects of inhibition and allosteric regulations on enzyme kinetics and determine kinetic parameters.
CO3	Describe the mechanism of internal mass transfer and reactions in solid biocatalyst.
CO4	Illustrate the various bioreactor configurations and also design the model for ideal reactor operations.
CO5	Design model for cell culture and enzymatic reaction in chemostat and PFR.

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
S5BTPE13	2	2	1									2		

Program Articulation matrix Mapping of course outcomes with program outcomes

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
COs	CO1	2	1										2		
	CO2	2	2										2		
	CO3	2	2										2		
	CO4	2	2	1									2		
	CO5	2	2	1									2		

1: Low, 2: Medium, 3: High

ANIMAL BIOTECHNOLOGY

Contact Hours/ Week:	: 3+0+0(L+T+P)	**Credits:**	3
Total Lecture Hours:	: 42	**CIE Marks:**	50
Sub. Code:	: S5BTPE14	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	Understand the basic concepts of animal cell culture techniques
2.	Know about the media preparation and culture characters
3.	Learn about animal cell culture tools and methods.
4.	Learn about the production of transgenic animals and its applications
5.	Learn about cell culture techniques for the improvements of animals and its ethics.

UNIT I

Introduction to animal biotechnology: Introduction, History and Scope; Cell culture Laboratory design & Equipment's: Layout; Maintenance of sterility; CO_2 incubator; Inverted stage microscope Biosafety cabinet, flow cytometer. Cell culture vessels; Cryopreservation; Media and reagents, CO_2 and bicarbonates buffering, Different Types culture Media-Natural and Artificial Media. Features of MEM, DMEM, RPMI, role of antibiotics in media.

8 Hours

UNIT II

Animal cell culture: Initiation of Cell culture-Preparation and Sterilization of media, Primary animal cell culture: Isolation of Explants, Disaggregation of explants, contamination. Monolayer culture. Secondary culture; Trypsinization; Passage, split ratio, criteria for sub culture. Different tissue culture techniques; Continuous cell lines; Suspension culture; Organ culture etc.; Behavior of cells in culture conditions: Morphology, division, growth pattern; Development of cell lines Characterization and maintenance of cell lines. Hemocytometer, electronic cell counter.

8 Hours

UNIT III

Animal cell culture applications: Application of animal cell culture for in vitro testing of drugs: MTT, assay for cytotoxicity: dye exclusion and dye inclusion, Development of spheroids and organoids in cancer research, Applications of IPSCs and organs on chip. Application of cell culture technology in production of human and animal viral vaccines, Hybridoma Culture- monoclonal antibody Production and its applications. Cell culture

products- interferons, hybrid antibodies.
8 Hours

UNIT IV
Development and use of transgenic animals: Transgenic animals; Transgenic-mice methodology: Mammalian virus vector- Retroviral vector method, SV40 vector DNA microinjection method, Engineered-embryonic stem cell method, Nuclear reprogramming method, Transgenic animals produced- Mice, Rabbits, etc Transgene integration. Targeted gene transfer- Gene disruption and Gene replacement. Knocking in and knocking out of genes; Applications: transgenic animals as bioreactors for production of proteins of pharmaceutical value.
9 Hours

UNIT V
Biotechnology for animal improvement: Conventional methods of animal improvement: cross breeding, artificial insemination, in vitro fertilization, embryo transfer technology; Ethical issues related to IVF. Cryopreservation- procedure and applications. Gene mapping, marker assisted selection and genetic improvement of desired characters of domestic animals. Detection of Transgene and transgene function. Rapid diagnosis of diseases in live-stock via: RIA, ELISA and PCR.
9 Hours

TEXT BOOKS		
1	Freshney RI	Culture of Animal Cells, Wiley-Blackwell Publisher, 8th Edition. (2021) 978-1-119-51304-9
2	Gorakh Mal, Manishi Mukesh, Sanjeev K. Gautam, Birbal Singh	Advances in Animal Biotechnology, Springer Publications. (2019) 978-3030213084

REFERENCE BOOKS		
1	John RW, Masters,	Animal Cell Culture: Practical Approach, 3rdEdn, Oxford. (2000) 978-0199637973
2	Anchal Singh, Ashish S. Verma Anchal Singh, Ashish S. Verma	Animal Biotechnology: Models in Discovery and Translation, Second Edition, Academic press in imprint of Elsevier. (2020) 978-0128117101

Course Outcomes:

Upon completion of this course the student will be able to:

CO1	Apply the basics and principles of animal biotechnology
CO2	Theoretical Knowledge of basics animal cell culture techniques
CO3	Application of stem cells, cloning, large animal models for disease and development of therapies and treatments
CO4	Apply the gene transfer techniques for the development of transgenic animal production
CO5	Apply the basic Knowledge of Breeding Technology, diagnosis techniques using ELISA, PCR and RIA.

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
S5BPE13	2	2												2

Program Articulation matrix Mapping of course outcomes with program outcomes

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
COs	CO1	2	2												3
	CO2	2	2												3
	CO3	2	2												3
	CO4	2	2												3
	CO5	2	2												3

1: Low, 2: Medium, 3: High

RESEARCH METHODOLOGY AND IPR

Contact Hours/ Week:	: 3+0+0 (L+T+P)	**Credits:**	3
Total Lecture Hours:	: 42	**CIE Marks:**	50
Sub. Code:	: SHS04	**SEE Marks:**	50

UNIT-I
RESEARCH METHODOLOGY: Objectives and motivation of research - Types of research - Research approaches - Significance of research - Research methods verses methodology - Research and scientific method - Importance of research methodology - Research process - Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations- Criteria of good research. Defining the research problem: Definition of research problem - Problem formulation - Necessity of defining the problem - Technique involved in defining a problem.
8Hours

UNIT-II
LITERATURE SURVEY AND DATA COLLECTION: Importance of literature survey - Sources of information - Assessment of quality of journals and articles - Information through internet. Effective literature studies approaches, analysis, plagiarism, and research ethics. Data - Preparing, Exploring, examining and displaying. Referencing methods
8Hours

UNIT-III
RESEARCH DESIGN AND ANALYSIS: Meaning of research design - Need of research design - Different research designs - Basic principles of experimental design - Developing a research plan - Design of experimental set-up - Use of standards and codes. Overview of Univariate/Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.
8Hours

UNIT-IV
INTELLECTUAL PROPERTY RIGHTS (IPR): Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.
9Hours

UNIT-IV
PATENT RIGHTS (PR): Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs. Licenses, Licensing of related patents, patent agents, Registration of patent agents.
9Hours

Course Outcomes:

Upon completion of this course the student will be able to:

CO1	Describe the research process & formulate research problem
CO2	Perform literature review, manage data & practice research ethics
CO3	Practice basic principles of experimental design, use standard codes and carry out research analysis
CO4	Distinguish between types of innovation, describe patenting procedure, maintenance and role of IPR establishments
CO5	Identify the significance of patent rights, licensing, technology transfer & manage patenting system

TEXT BOOKS		
1	Prof. Kothari C. R.	"Research methodology: Methods and techniques", New Age International, 5th Edition, 2023. ISBN-13: 978-9389802559
2	R. Ganesan	"Research Methodology for Engineers", MJP Publishers, Chennai, 2011.

REFERENCE BOOKS		
1	Cooper Donald R, Schindler Pamela S and Sharma JK	"Business Research Methods", Tata McGraw Hill Education, 11th Edition, 2012.
2	Catherine J. Holland	"Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets", Entrepreneur Press, 2007.
3	David Hunt, Long Nguyen, Matthew Rodgers	"Patent searching: tools &techniques", Wiley, 2007.
4	The Institute of Company Secretaries of India, Statutory body under an Act of parliament	"Professional Programme Intellectual Property Rights, Law and practice", September 2013.

5	Peter S. Menel Mark A. Lemley, Robert P. Merges	"Intellectual Property in the New Technological- Vol. I Perspectives, 2021.
6	Laura R. Ford	"The Intellectual Property of Nations: Sociological and Historical Perspectives on a Modern Legal Institution Paperback -2021.

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
SHS04		3	2			1	2	1	1		2	1	1	1

Program Articulation matrix Mapping of course outcomes with program outcomes

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
COs	CO1		3	2			1	2	1			2	1		
	CO2		3	2				2	1	1		2		1	
	CO3		3	2				2	1			2			1
	CO4		3	2				2				2	1	1	1
	CO5		3	2				2				2	1	1	1

1: Low, 2: Medium, 3: High

ENVIRONMENTAL STUDIES

Contact Hours/ Week:	: 2+0+0 (L+T+P)	**Credits:**	2
Total Lecture Hours:	: 28	**CIE Marks:**	50
Sub. Code:	: SHS05	**SEE Marks:**	50

COURSEOBJECTIVES:	
Thiscoursewillenablestudentsto:	
1	Describe the problems of depletion of natural resources due to deforestation, agricultural practices, and adverse environmental effects, pesticides, soil erosion, mining.
2	Explain the different types of energy- renewable, non-renewable and energy conservation, the impact of environmental pollution on water quality, air quality, soil pollution and noise pollution.
3	Describe solid waste management- disposal, treatment of different types of solid waste including MSW, e-waste, biomedical waste, the societal impact of environmental issues- ozone layer depletion, GHG effects, water conservation and harvesting and environmental protection & Acts

UNIT I

Introduction: Components of Environment and their interactions

Natural Resources: Forest Resources-Deforestation, Causes of deforestation, Environmental effects of deforestation and solutions • Water resources, World's water reserves, Hydrological cycle • Land resources, Land degradation. Soil erosion, Causes and prevention, Soil conservation and its types• Numerical problems on rainfall & run off

6 Hours

UNIT II

Energyand resources: • Types of Energy-Renewable, Non-renewable& sustainable energy & their advantages and disadvantages• Renewable energy sources- Solar energy, Wind energy, Tidal energy, Ocean thermal energy. Geothermal energy, Hydroelectric power, Biomass energy, Hydrogen energy, Thermal power- environmental impacts • Conservation of energy • Numerical problems on Solar energy, Windpower

6 Hours

UNIT III
Environmental pollution:•Sources of pollution -Natural and anthropogenic sources• Pollutants – Classification & their effects on environment• Air Pollution -Composition of clean air,Sources of air pollution, Effect of air pollution on human health and climate • Water quality – Potable water, Wholesome water, Sources of water pollution Polluted water & Contaminated water• Common impurities in water (physical, chemical and bacteriological), Effects of impurities on human health • Soil Pollution – Sources, effects, and its control • Noise pollution- Sources of noise, Effects on human health & its control Numerical problems on pH, hardness of water, noise pollution
6 Hours

UNIT IV
Solid Waste Management: • Refuse, Garbage, Rubbish, Ash, types of solid waste• Necessity of safe disposal, Impacts on human health and environment• Classification of solid wastes- Quantity and composition of MSW, Collection of solid waste- methods• Disposal of solid waste- Sanitary land-fill• E-waste-Problems and solutions• Biomedical waste-Impacts on human health, storage, treatment methods and disposal• Numerical problems on moisture content, density & proportioning of landfill
5 Hours

UNIT V
Sustainable development: Issues on energy utilization, water conservation, concept of 3 R's, Rain water harvesting- methods • Global environmental issues: Population growth, Urbanization, Global warming, Acid rains, Ozone layer depletion & controlling measures. • Environmental acts, Regulations, Role of state & central governments, • Numerical problem on carbon foot print & rainwater harvesting.
5 Hours

TEXTBOOKS:

1	Joseph,B	Environmental Studies (2009), India: Tata McGraw-Hill. ISBN: 9781283922524
2	Tripathi, A. K	Environmental Studies(2016), India: Energy and Resources Institute. ISBN:9788179935828

REFERENCES:		
1	Erach Bharucha	Environmental studies for Undergraduate Courses, 1st Edition, University Press, (2013)
2	Santhosh KumarGarg	Environmental Science and Engineering Ecology and Environmental Studies, Khanna Publishers, (2015), ISBN-10 : 8174092188 ISBN-13:978-8174092182

COURSEOUTCOMES:

Upon completion of this course the student will be able to:

CO1	Explain the importance of forestation, effects of deforestation, land degradation, adverse effects of mining on environment, using the principles of natural sciences compute the runoff from rainfall & estimates the conservation of water for beneficial use of humans.
CO2	Choose appropriate renewable energy sources by formulating, reviewing the literature, calculating the power potential of solar & wind energy and using the principles of natural sciences.
CO3	Explain the effects of pollution of air, water, soil & noise on humans and the environment, identify and analyze the pollution problems related to air, water, soil & noise and quantify pollution levels & draw valid inferences using the principles of engineering sciences
CO4	Describe Impact of solid waste on human health and environment, its safe disposal. Use population data & compute percapita solid waste generation, land area requirement for sanitary landfill
CO5	Appreciate the importance of sustainable development, current global environmental issues, present state & central governments protection acts, compute carbon footprint using data(vehicles/industries) & asses its impact on the environment.

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Course	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
SHS05	2					2								1

Program Articulation matrix Mapping of course outcomes with program outcomes

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
COs	CO1	2					2								1
	CO2	2					2								1
	CO3	2					2								1
	CO4	2					2								1
	CO5	2					2								1

1: Low, 2: Medium, 3: High

Semester VI

GENOMICS AND PROTEOMICS

Contact Hours/ Week:	: 3+0+2 (L+T+P)	**Credits:**	4
Total Lecture Hours:	:42	**CIE Marks:**	50
Sub. Code:	: S6BTI01	**SEE Marks:**	50

Course objectives:
This course will enable students to:

1.	Grasp the concepts of chromosome content, gene localization within the genome, and the roles of non-coding and repetitive DNA segments in the context of genomics.
2.	Gain a deep understanding of advanced DNA sequencing techniques and related concepts essential for executing genome projects.
3.	Develop a comprehensive understanding of protein sequencing techniques and the use of mass spectrometry for protein identification in proteomics.
4.	Gain a thorough understanding of various techniques used for protein identification and expression analysis in quantitative proteomics
5.	Understand the bioinformatics techniques for analyzing genomics and proteomics data using computational tools and algorithms.

UNIT I

Introduction to Genomics: Major Differences between Eukaryotic, Bacterial and Archaea chromosomes. General features of the Eukaryotic genome and chromosomes. C value paradox, organization of eukaryotic genomes into chromosomes. Analysis of chromosomes using Genome Browser, BioMart. Analysis of chromosomes by the ENCODE project (scope and conclusions). Eukaryotic genome (noncoding and repetitive DNA sequence, Transposon derived repeats). Gene content of eukaryotic chromosomes, finding genes in eukaryotic genomes.

8 Hours

UNIT II

Genome Sequencing & Genome Projects: DNA sequencing methods: Sanger dideoxy method, Maxam Gilbert method, Automated Fluorescence method. Introduction to Next Generation Sequencing technology (NGS). Significant applications of NGS technologies. Comparison of NGS technologies with Sanger sequencing. Workflow of NGS experiments (from experimental design to analysis) – the experimental design and sample preparation, generating sequence data to FASTQ analysis and Genome assembly. Software: FASTQC and velvet. Genome analysis: Main types of genome analysis: Denovo sequencing,sequencing, transcriptome and epigenetics. Large scale –model organism sequencing projects: 1001 genome project, genome 10k project

	8 Hours

UNIT III
Introduction to Proteomics: Structural Organization of Proteins. Proteomics: introduction, basic principles of proteomics. The origin and scope of proteomics. Proteomics and the new biology. Overview of analytical proteomics. Evolution from protein chemistry to proteomics. Protein sequencing and techniques: Protein sequencing by Edman technique. Molecular biology techniques mass spectrometry techniques. Mass spectrometry-based methods for protein identification: Proteomics approaches: The bottom-up approach and top-down methods. Steps involved in proteomics. Ionization techniques: MALDI and ESI: Concepts, principles and methodology.
8 Hours

UNIT IV
Mass spectrometry: Basic principles and instrumentation. Schematic representation of a mass spectrometer. Mass analysers, ion trap and LTQ orbitrap. Quantitative proteomics and protein modifications: Protein quantification: Introduction, types of quantification, principles, and methodology. Isobaric tagging for relative and absolute quantitation (iTRAQ), Tandem mass tag (TMT), stable isotope labelling by amino acids in cell.
9 Hours

UNIT V
Bioinformatics analysis of genomics and proteomics data: Concepts of Genomic and proteomics data, file formats, public databases, analyzing genome and proteome data. Functional analysis of genomics and proteomics data: GO term identification and enrichment analysis, pathway analysis, analysis of protein-protein-interactions. Protein domain and motif analysis.
9 Hours

TEXT BOOKS		
1	Richard M. Twyman	Principles of Proteomics, Garland Science, 2nd Edition, 2008, 978-0133779421
2	Devarajan Thangadurai, Jeyabalan Sangeetha	Genomics and Proteomics, 978-981-5179-93-4, Apple Academic Press Inc, 978-1771881142, 2015, 1st edition

REFERENCE BOOKS		
1	S.B. Primrose and R.M.Twyman	Principles of Genome analysis and Genomics, Blackwell Publishing, 3 rd Edition, 2003, 978 1405101202
2	Gibson G & Muse SV	A Primer of Genome Science, Sinauer Associates, 2 nd Edition, 2004, 978-1025101156

Course Outcomes: Upon completion of this course the student will be able to:	
CO1	Describe the concepts of chromosome content, gene localization within the genome, and the functions of non-coding and repetitive DNA segments in genomics.
CO2	Apply the advanced DNA sequencing techniques and related concepts for executing genome projects.
CO3	Illustrate protein sequencing techniques and Apply the concept of mass spectrometry for protein identification in proteomics.
CO4	Apply various techniques used for protein identification and expression analysis in quantitative proteomics.
CO5	Develop proficiency in bioinformatics techniques for analyzing genomics and proteomics data using computational tools and algorithms.

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Course	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
S6BTI01	2	2											2	

Program Articulation matrix Mapping of course outcomes with program outcomes

		POs											**PSOs**		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
COs	**CO1**	2	1											2	
	CO2	2	1											2	
	CO3	2	2											2	
	CO4	2												2	
	CO5	2	2											2	

1: Low, 2: Medium, 3: High

GENOMICS AND PROTEOMICS LABORATORY

Contact Hours/ Week:	: 3+0+2 (L+T+P)	**Credits:**	0
Total Lecture Hours:	: 28	**CIE Marks:**	50
Sub. Code:	: S6BTI01	**SEE Marks:**	0

Course objectives: This course will enable students to:	
1.	Grasp the concepts of chromosome content, gene localization within the genome, and the roles of non-coding and repetitive DNA segments in the context of genomics.
2.	Gain a deep understanding of advanced DNA sequencing techniques and related concepts essential for executing genome projects.
3.	Develop a comprehensive understanding of protein sequencing techniques and the use of mass spectrometry for protein identification in proteomics.
4.	Gain a thorough understanding of various techniques used for protein identification and expression analysis in quantitative proteomics
5.	Understand the bioinformatics techniques for analyzing genomics and proteomics data using computational tools and algorithms.

List of Experiments

1	Working with SRA database for uploading and downloading genomics data
2	Working with PRIDE database for uploading and downloading proteomics data
3	NGS raw data quality checking and validation
4	NGS raw data trimming and validation
5	De novo assembly for RNA data sets
6	Functional analysis of Genomic and proteomics data sets using Gene ontology (GO)
7	Differential expression analysis of Gene / protein list
8	Integrated transcriptomic and proteomics data analysis and protein-protein interaction analysis
9	References genome alignment of Whole Genome (WGS) data sets
10	References genome alignment of Whole Exome (WES) data sets
11	Working with genome browser and genome visualization
12	Demo on CLC genomic workbench

TEXT BOOKS		
1	Richard M. Twyman	Principles of Proteomics, Garland Science, 2nd Edition, 2008, 978-0133779421
2	Devarajan Thangadurai, Jeyabalan Sangeetha	Genomics and Proteomics, 978-981-5179-93-4, Apple Academic Press Inc, 978-1771881142, 2015, 1st edition

REFERENCE BOOKS		
1	S.B. Primrose and R.M.Twyman	Principles of Genome analysis and Genomics, Blackwell Publishing, 3 rd Edition, 2003, 978 1405101202
2	Gibson G & Muse SV	A Primer of Genome Science, Sinauer Associates, 2 nd Edition, 2004, 978-1025101156

Course Outcomes: Upon completion of this course the student will be able to:	
CO1	Describe the concepts of chromosome content, gene localization within the genome, and the functions of non-coding and repetitive DNA segments in genomics.
CO2	Apply the advanced DNA sequencing techniques and related concepts for executing genome projects.
CO3	Illustrate protein sequencing techniques and Apply the concept of mass spectrometry for protein identification in proteomics.
CO4	Apply various techniques used for protein identification and expression analysis in quantitative proteomics.
CO5	Develop proficiency in bioinformatics techniques for analyzing genomics and proteomics data using computational tools and algorithms.

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Course	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
S6BTI01	2	2											2	

Program Articulation matrix Mapping of course outcomes with program outcomes

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
COs	CO1	2	1											2	
	CO2	2	1											2	
	CO3	2	2											2	
	CO4	2												2	
	CO5	2	2											2	

1: Low, 2: Medium, 3: High

IMMUNOLOGY AND IMMUNOTECHNOLOGY

Contact Hours/ Week:	: 3+1+0 (L+T+P)	**Credits:**	4
Total Lecture Hours:	: 42+28+0	**CIE Marks:**	50
Sub. Code:	: S6BT01	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	Study the different types of cells and organs of immune system
2.	Understand the importance of B-cell and T-cell functions in immune response.
3.	Learn the concepts of tolerance, hypersensitivity reactions and autoimmune diseases.
4.	Study the mechanism of transplantation and role of immunosuppressant.
5.	Understand the concepts of immunological techniques in diagnosis of diseases.

UNIT I
The Immune System: Introduction - Anatomy of immune system, cells and organs of the immune system - Primary and secondary Lymphoid organs, antigens, different characteristics of antigens, mitogens, hapten, immunogen and adjuvants. **Classification of Immune Responses:** Types of immune response – Racial, special and individual, Classification of immune system – innate - Skin and mucosal surface, Physiological Barriers, Phagocytic Barriers, Inflammation and adaptive immunity.
8+5 Hours

UNIT II
Humoral Mediated Immunity: B-lymphocytes and their activation - T-cell dependent activation and T-cell independent activation; structure and function of immunoglobulins, immunoglobulin classes and subclasses,

idiotypes and anti-idiotypic antibodies, genetic control of antibody production.

Cell-Mediated Immunity: Thymus derived lymphocytes (T cells) - their ontogeny and types- T_H cells, T_S cells, Tc cells and T_D cells, mechanism of T cell activation,MHC Complex – Structure, classification and its biological role, antigen presenting cells (APC) – professional and non-professional, macrophages, dendritic cells, Langerhans cells, mechanism of phagocytosis, Antigen processing and presentation – class I and class II MHC.

9+5Hours

UNIT III

Immune Regulation and Tolerance: Complement activation - classical, properdin and lectin pathway and their biological functions, complement fixation test, cytokines and their role in immune response, immunotolerance and its types - Low zone, High zone, Classical and Infectious tolerance, Theories of Tolerance Induction – central and peripheral, Hypersensitivity & its types - immediate and delayed type; Coombs and Gells classification.

Immunological Disorder: Overview of Autoimmunity, criteria and causes of autoimmune diseases - Autoimmune haemolytic anemia, myasthenia gravis and rheumatoid arthritis.

8+6 Hours

UNIT IV

Transplantation Immunology: Immunological basis of graft and its types - autograft, allograft, isograft and xenograft, types of rejection – hyperacute, acute and chronic and mechanism of graft rejection, role of HLA in graft rejection; cellular and molecular mechanism – direct and indirect presentation, tissue typing, immunosuppression - definition and immunosuppressive drugs – glucocorticoids, cytostatics, antibodies and drugs on immunophilins.

Tumor of the Immune System: Tumor specific antigens and its types – TSA and TAA, tumor potent immune response – NK cells and Macrophages.

8+6 Hours

UNIT V

Molecular Immunology: Application of PCR technology to produce antibodies, Production of monoclonal and polyclonal antibodies and their applications. Stem cells isolation, culturing and applications to immunology.

Immunological Techniques: Antigen antibody interaction – Precipitation reactions, Agglutination reactions, Blood typing- A, B, ABO & Rh, principles and applications of ELISA, Radioimmunoassay (RIA), immuno-electrophoresis, Immunofluorescence, chemiluminescence assays and flow cytometry.

9+6 Hours

TEXT BOOKS		
1	Kuby	Immunology, W. H. Freeman & Company, 8th Edition, 2018, 1319114709
2	Abul Abbas Andrew Lichtman Shiv Pillai -	Cellular and Molecular Immunology is included 9th Edition, 2017, 9780323479783 is included.

REFERENCE BOOKS		
1	Roitt I	Essential Immunology, Wiley-BlackwellPublications, 13th Edition, 2017, 9781118415771
2	Ashim K Chakravarthy	Immunology &Immunotechnology, Oxford University Press, 1st Edition, 2011, 9780195676884

Course Outcomes:

Upon completion of this course the student will be able to:

CO1	Classify and describe the functions of the cells and organs of the immune system in defensive mechanism.
CO2	Illustrate the immune response against infectious antigens.
CO3	Interpret and analyse the role of complement system and tolerance against foreign elements and compare different types of hypersensitivity reactions.
CO4	Analyse the mechanism of graft rejection in transplantation and the importance of immunosuppressant.
CO5	Outline the concepts of vaccine and antibody production and apply immunological techniques to diagnose diseases.

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Course	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
S6BTI01	2	2												2

Program Articulation matrix Mapping of course outcomes with program outcomes

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
COs	CO1	2	1												2
	CO2	2	1												2
	CO3	2	2												2
	CO4	2	2												2
	CO5	2	2												2

1: Low, 2: Medium, 3: High

BIOPROCESS EQUIPMENT AND DESIGN

Contact Hours/ Week:	: 3+0+0 (L+T+P)	**Credits:**	3
Total Lecture Hours:	: 42	**CIE Marks:**	50
Sub. Code:	: S6BTPE11	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	Impart the fundamental and mechanical design of equipment
2.	Understand concept of designing the fermenter/reactor
3.	Learn the validation of evaporator design results.
4.	Study the designing of the Heat exchanger
5.	Study design aspects of distillation in industries.

UNIT I
Introduction: Basic considerations in design. General design procedure. Various components of process equipment. Design Considerations. Types of supports for vessels - Bracket, Lug, Leg, Saddle and Skirt supports. Flange thickness calculation. Design of vessel closures – Flat plates, Formed heads, Elliptical & Hemispherical heads.
7 Hours

UNIT II
Reaction Vessels/Fermenter: Design of jackets. Design of reaction tanks with agitation and jacket. Types of agitators, baffles. Power requirement calculations. Design of tank dimensions and agitation system components. Drive calculations & selection of accessories. Numerical conceptual.
9 Hours

UNIT III
Evaporator: Design of Evaporator – Single effect evaporator, Factors affecting the design, parts of evaporators- calendria, vapour drum, nozzles, calculation of diameter of calendria and thickness, mechanical design, Numerical conceptual.
9 Hours

UNIT IV
Heat Exchanger (HE): Design of Shell and Tube Heat exchanger by Kern method, Standard and codes of HE, Types of HE, Parts & functions of HE, Calculations of number of tubes, Individual & overall heat transfer coefficients, Pressure drop calculations, Numerical conceptual.
8 Hours

UNIT V
Distillation Column: Introduction, reflux considerations, total reflux, minimum reflux, optimum reflux ratio, feed point location, McCabe-Thiele method – procedure, Distillation column design, Plate Contactors-Bubble Cap, sieve plate, Valve plates, Diameter of column. Numerical conceptual.
9 Hours

TEXT BOOKS		
1	M. V. Joshi	Process Equipment Design, Macmillan & Co. India, Delhi, 3rd Edition, Reprint 2009, 9780333924181

REFERENCE BOOKS		
1	Perry & Green	Chemical Engineers Handbook, McGraw Hill, 9th Edition, 2009, 9780071422949
2	R.K. Sinnott	Chemical Engineering Design- Vol 6, Elsevier publications, 4th Edition, 2012 Coulson and Richardson's Chemical Engineering Series 2005, 750665386

Course Outcomes:

Upon completion of this course the student will be able to:

CO1	Describe the concepts of basic fundamentals of design of equipment.
CO2	Design of fermenter/reactor
CO3	Design of evaporator according to the process conditions
CO4	Design of Heat Exchanger at different loads
CO5	Design of Distillation column according to the feed conditions

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
S6BTPE11	2	2	2									2		

Program Articulation matrix Mapping of course outcomes with program outcomes

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
COs	CO1	2	1	1									1		
	CO2	2	2	2									3		
	CO3	2	2	2									3		
	CO4	2	2	2									3		
	CO5	2	2	2									3		

1: Low, 2: Medium, 3: High

FOOD BIOTECHNOLOGY

Contact Hours/ Week:	: 3+0+0(L+T+P)	**Credits:**	3
Total Lecture Hours:	: 42	**CIE Marks:**	50
Sub. Code:	: S6BTPE12	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	Learn the various constituents of food, intrinsic and extrinsic parameters that influence the food.
2.	Understand the Characteristics, manufacturing process and role of biotechnology in the food industry.
3.	Know the various types of microorganisms found in foods and their detection.
4.	Understand the different types of food preservation techniques.
5.	Understand the principles of fluid foods and measurement of various rheological properties.

UNIT I

Food science: Introduction, constituents of food, colloidal systems in food, stability of colloidal systems, types of food starches, soluble fiber (pectin, gums, mucilage), protein rich foods, popular fats and oils in foods, factors leading to rancidity and reversion, prevention of rancidity, commercial uses of fats and oils.

Intrinsic and extrinsic parameters of foods: Minerals in foods. Aroma compounds in foods, Food flavours, Browning reactions; Food additives: Vitamins, amino acids, minerals. Aroma substances flavour enhancers (monosodium glutamate, nucleotides). Sugar substitutes (sorbitol Sweeteners-saccharin, cyclamate). Food colours. Anti-nutritional factors and Food contaminants. Chemical changes during processing of volatile compounds.

9 Hours

UNIT II

Food industry: Characteristics of Food Industry. Food manufacturing& processing: Objectives of food processing, effect of processing on food constituents, methods of evaluation of food, proximate analysis of food constituents, Nutritional value, labeling of constituents (soya foods, organic foods, dietary foods (for individuals, for specific groups), nutritional food supplements). Food packaging, edible films. Factors influencing food product development: marketing, and promotional

strategies, Market Place, ecologically sustainable production; Risks and benefits of food industry.

Biotechnology in food industry: Applications of Biotechnology to food industry, impact on nutritional quality, utilization of enzymes (hydrolases and lipases), applications of immobilized enzymes in food industry, economic aspects, enzyme generation of flavor and aroma compounds, flavor lipid modifications. Tissue Culture techniques, microbial transformations, regulatory and social aspects of BT

9 Hours

UNIT III

Microorganisms in foods: Primary Sources of microorganisms found in Foods Synopsis of Common Food-borne bacteria, genera of Molds, genera of Yeasts. Microbial spoilage of vegetables, fruits, fresh and processed meats, poultry and seafood.

Detection of microorganisms: Culture, Microscopic and Sampling Methods; SPC, Membrane Filters, Microscope colony Counts, Agar Droplets, Dry Films, Most probable Numbers (MPN), Dye-reduction, Roll Tubes, Direct Microscopic Count (DMC), Microbiological examination of surfaces, Air Sampling, Metabolically Injured Organisms, Enumeration and detection of food-borne organisms.

8 Hours

UNIT IV

Food preservation: Food Preservation using irradiation: Characteristics of Radiations of Interest in Food Preservation, Principles underlying the Destruction of Microorganisms by Irradiation, Processing of Foods for Irradiation, Application of Radiation. Legal Status of Food Irradiation, Effect of Irradiation on Food constituents; Food Preservation with Low Temperatures, Food Preservation with High Temperatures, Preservation of Foods by Drying.Packaging materials; Characteristics, properties and their design. Packaging requirement for Different processed and unprocessed foods.

8 Hours

UNIT V

Food technology: Properties of fluid foods, Measurement of rheological parameters, properties of granular food and powders; properties of solids foods. Measurement of food texture. Thermal properties of frozen foods. Prediction of freezing rates: Qualitative explanation via Plank's equation,

and Neumann problem. Food freezing equipment: Air blast freezers, Plate freezers and immersion freezers. Food dehydration: Estimation of drying time, constant rate period and falling rate period dehydration. Equipment: fixed tray dehydration, cabinet drying, tunnel drying. Freeze Dehydration, calculation of drying times, Industrial freeze-drying. Equipment related to pulping, Fruit juice extraction, Dehulling, and distillation. Conceptual numerical.
8 Hours

TEXT BOOKS		
1	William C. Frazier, Dennis C. Westhoff, N.M. Vanitha	Food Microbiology, McGraw Hill. 5th Edition, 2017, 978-1259062513.
2	Jay, James M, Loessner, Martin J, Golden, David A.	Modern Food Microbiology, Springer. 7th Edition. 2008, 978-0-387-23413-8.

REFERENCE BOOKS		
1	Gustavo F Gutierrez Lopez, Gustavo V BarbosaCanovas	Food Science and Food Biotechnology, CRC Press Inc, 1st Edition, 2003, 9781566768924.
2	S. Bielecki, J. Polak, J. Tramper. Elsevier,	Food Biotechnology, Elsevier Science Ltd, 1st Edition, 2000, 978-0444505194.

Course Outcomes:

Upon completion of this course the student will be able to:

CO1	Describe the various constituents of food, intrinsic and extrinsic parameters that influences the food.
CO2	Explain the Characteristics, manufacturing process and role of biotechnology in food industry
CO3	Analyze the different types of Sources of microorganisms found in Foods and their detection.
CO4	Apply different types to food preservation techniques for various types of food products. Illustrate the principles of fluid foods and measurement of various rheological properties.
CO5	Illustrate the principles of fluid foods and measurement of various rheological properties.

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
S6BTPE12	1	2												2

Program Articulation matrix Mapping of course outcomes with program outcomes

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
COs	CO1	2	1												2
	CO2	2	1												2
	CO3	2	2												2
	CO4	2	2												2
	CO5	2	2												2

1: Low, 2: Medium, 3: High

VACCINE TECHNOLOGY

Contact Hours/ Week:	: 3+0+0(L+T+P)	**Credits:**	3
Total Lecture Hours:	: 42	**CIE Marks:**	50
Sub. Code:	: S6BTPE13	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	Study the various forms of vaccines
2.	Learn the techniques of vaccine production and their delivery methods
3.	Equip with various techniques for vaccine production
4.	Learn various methods of delivery of vaccines
5.	Give an exposure on the regulatory and biosafety measures of vaccine

UNIT I
Vaccines: Vaccines - definition, History of vaccine development, requirements for immunity, Basics of immunization- Epitopes, linear and conformational epitopes, characterization and location of APC, MHC and immunogenicity; immunization programs androle of WHO in immunization programs
8 Hours

UNIT II
Types and methods of application: Active and passive immunization; Viral/bacterial/parasite vaccine differences, methods of vaccine preparation - Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, edible vaccines, reverse vaccinology, combination vaccines, therapeutic vaccines; Peptide vaccines, conjugate vaccines; Cell based vaccines. Uses of nanoparticles in vaccine application. Reverse Vaccinology
10 Hours

UNIT III
Delivery methods: Needle free Vaccine delivery, ISCOMS, Adjuvant delivery systems, Intranasal and inhaled vaccine delivery, liquid jet and solid dose injectors, development of gene-based vectors, topical method of delivery, intranasal method, benefits and disadvantages of each method of delivery
8 Hours

UNIT IV
Techniques in vaccine production Purification, preservation and formulation techniques. Commercial production of DPT, TT, polio, rabies and hepatitis vaccines, case studies of different vaccinations, Covid vaccines case study
8 Hours

UNIT V
Regulatory and biosafety measures: Quality assurance in vaccine production. Regulatory issues - Environmental concerns with the use of recombinant vaccines - Disease security and biosecurity principles and OIE guidelines
8 Hours

TEXT BOOKS		
1	Blaine A. Pfeifer, Andrew Hill	Vaccine Delivery Technology: Methods and Protocols, 2021 [1st ed.] 9781071607947, 9781071607954

REFERENCE BOOKS		
1	Camilla Foged, Thomas Rades, Yvonne Perrie, Sarah Hook (eds.)	Advances in Delivery Science and Technology Subunit Vaccine Delivery, 2016 1 ed. 978-1-4939-1416-6, 978-1-4939-1417-3

Course Outcomes:

Upon completion of this course the student will be able to:

CO1	Describe the principle of vaccination for immunization processes and elaborate on their applications
CO2	Elaborate on the types of vaccines and their method of application
CO3	Describe the vaccine formulation, purification and preservation
CO4	Explain the advanced methods of vaccine delivery
CO5	Discuss the quality measures and regulatory issues concerned with vaccine production

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Course	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
S6BTPE13	2	2												2

Program Articulation matrix Mapping of course outcomes with program outcomes

		POs											**PSOs**		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
COs	**CO1**	3	1												2
	CO2	3	2												2
	CO3	3	2												2
	CO4	3	2												2
	CO5	3	2												2

1: Low, 2: Medium, 3: High

SYSTEM BIOLOGY

Contact Hours/ Week:	: 3+0+0(L+T+P)	**Credits:**	3
Total Lecture Hours:	: 42	**CIE Marks:**	50
Sub. Code:	: S6BTPE14	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	Understand the basic concepts of biological networks, their models, tools and statistical measures to characterize their properties.
2.	Learn the basic concepts, principles and methods of metabolic engineering networks and flux balance analysis
3.	Understand the process of drug development, from target identification to final drug registration via computational tools.
4.	Understand the process of drug development and techniques used in assessing the structural similarities.
5.	Understand the use of Proteomics in developing personalized medicines and drugs for globally important diseases

UNIT I
Introduction: Introduction and basic concepts in biological systems. Genotype-phenotype mapping - Concepts of genotypes and phenotypes, genotype networks and fitness landscapes. Gene regulation networks - Negative and positive regulation in transcription networks. Feed-forward loops - Oscillatory circuits. Optimality and robustness - Robustness in biological systems. Principles of optimality. Stochasticity in biological processes
9 Hours

UNIT II
Network biology: Introduction to Static Networks, Network Biology and Applications, Reconstruction of Biological Networks, Dynamic Modelling of Biological Systems: Introduction, Solving ODEs & Parameter Estimation, Constraint based approaches to Modelling Metabolic Networks, Perturbations to Metabolic Networks, Elementary Modes, Applications of Constraint based Modelling, Metabolic Flux balance Analysis, Modelling Regulation, Host-pathogen interactions, Robustness of Biological Systems.
9 Hours

UNIT III
Drug design and development: Rational Approaches to Drug Design and Development, Drug targets, Lead Identification and Modification,

Computer-Aided Drug Design, Drug Delivery, Pre-clinical and Clinical Testing. Steps in Computational drug 16.07.2023 MKV-TEMPLATE for IPCC (26.04.2022) Annexure-III design: Molecular Modelling, Importance of the Bioactive Conformation, Molecular Mimicry, Structural Similarities and Superimposition Techniques, Three – Dimensional Description of Binding Site Environment and Energy Calculation, Automatic Docking Methods, Database Search Approaches, Structure Construction Methods with known and unknown 3D Structures of the Receptor, Web based programs available for molecular modelling, molecular docking, energy minimization techniques, ADME studies and validations.

8 Hours

UNIT IV

Biological system modelling: Modeling the Activity of Single Gene - A Probabilistic Model of a Prokaryotic Gene and its regulation. Modeling Biochemical Networks - Atomic-Level Simulation and Modeling ofBiomacromolecules, Kinetic Models of Excitable Membranes and Synaptic Interactions - Stochastic Simulation of Cell Signaling Pathways -Analysis of Complex Dynamics in Cell Cycle Regulation.Modeling Large Biological Systems from Functional Genomic Data: Parameter Estimation -Cellular Simulation - Towards a Virtual Biology Laboratory - Computational Cell Biology: The Stochastic Approach, Computer Simulation of the Whole Cell - Computer Simulation of the Cell: Human, Erythrocyte Model and its Application - Software for Modeling and Simulation – E-CELL, V-CELL and GROMOS.

8 Hours

UNIT V

Proteomics and systems biology: Application in Drug Discovery and Development, Systems Biology Approaches and Tools for Analysis of Interactomes and Multi-target Drugs, Translational Bioinformatics and Systems Biology Approaches for Personalized Medicine, Systems Biology Methods for Disease Treatment and Translational Medicine: Systems Biology and Inflammation, Systems Biology of Cardiovascular Drugs, Cancer Systems Biology, Systemic Lupus Erythematosus: From Genes to Organ Damage, Systems Biology of Influenza, Methods in Systems Biology of Experimental Methamphetamine Drug Abuse, Systems Biology and Theranostic Approach to Drug Discovery and Development to Treat Traumatic Brain Injury.

8 Hours

TEXT BOOKS		
1	Edda Klipp, Ralf Herwig	Systems Biology in Practice-Concepts, Implementation and Application- I Edition, Wiley VCH, 2005.
2	Lilia Alberghina, Hans V. Westerhoff	Systems Biology: Definitions and Perspectives- Springer, 2005.

REFERENCE BOOKS		
1	Hiroaki Kitano	Foundations of Systems Biology- new edition, MIT Press, 2001
2	James M. Bower, Hamid Bolouri	Computational Modeling of Genetic and Biochemical Networks- new edition, MIT Press, 2000.

Course Outcomes:

Upon completion of this course the student will be able to:

CO1	Apply different dynamic programming algorithms on biological systems
CO2	Describe signal transduction at cell membranes.
CO3	Employ signal transduction databases for their laboratory use & research
CO4	Apply the principles of computer simulation to understand the structural behavior of whole cell
CO5	Apply molecular modeling software to analyze the interactions

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Course	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
S6BTPE14	2	2		1	2								2	

Program Articulation matrix Mapping of course outcomes with program outcomes

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
COs	CO1	3	2			2								2	
	CO2	3	2			2								2	
	CO3	3	2		1	2								2	
	CO4	3	2			2								2	
	CO5	3	2			2								2	

1: Low, 2: Medium, 3: High

IMMUNOLOGY AND IMMUNOTECHNOLOGY LAB

Contact Hours/ Week:	: 0+0+2(L+T+P)	**Credits:**	1
Total Lecture Hours:	: 28	**CIE Marks:**	50
Sub. Code:	: S6BTL01	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	Understand the basic concept of Blood Grouping and Rh typing.
2.	Isolate and identify different types of lymphocytes from blood sample.
3	Study the importance of antigen-antibody interaction in various techniques.
4	Study the basics of blotting technique and their importance in diagnosis of antigen/antibody.
5	Study different types of body fluids for the presence of antibodies and antigens like blood, urine and saliva.

List of Experiments:

1.	Agglutination techniques: (a) Blood group identification (b) Rh typing.
2.	Separation of Lymphocytes from blood.
3.	Total red blood cell (RBC) count using hemocytometer (micro dilution & macro dilution method).
4.	Total white blood cell (WBC) count.
5.	Ouchterlony double diffusion: antigen-antibody patterns.
6.	Radial immunodiffusion.
7.	Countercurrent immunoelectrophoresis.
8.	Rocket immunoelectrophoresis.
9.	Dot Elisa.

10.	Western Blot.
11.	Southern Blot – Demo
12.	Northern Blot – Demo
13.	Latex Agglutination
14.	Alkaline Hemoglobin Electrophoresis

TEXT BOOKS		
1	Harper and Row	Principles of Microbiology and Immunology, Parker International, 1st Edition,1968, 006356131X

REFERENCE BOOKS		
1	Gabriel Virella	Medical Immunology, CRC Press, 7th Edition**,** 2019, 0367224887
2	Thomas J. Kindt, Barbara A. and Osborne	Kuby Immunology, W. H. Freeman, 6th Edition, 2006, 9780716767640.

Course Outcomes:

Upon completion of this course the student will be able to:

CO1	Describe the immune-technique which are used as diagnostic tools in detection of various diseases.
CO2	Analyze and interpret the basic concept of Blood Grouping and Rh typing.
CO3	Isolate and identify different types of lymphocytes from blood sample.
CO4	Explain the principle blotting technique and their importance in diagnosis of antigen /antibody.
CO5	Analyse variety of body fluids for the presence antibodies and antigens like blood, urine and saliva.

CORRELATION BETWEEN COURSE OUTCOMES WITH PROGRAM OUTCOMES

Program articulation matrix

Course	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
S6BTL01	2			2	2	2			2			2			2

Mapping of Course Outcomes (COs) to Program Outcomes (POs) & Program Specific Outcomes (PSOs)

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
COs	CO1	2			2	2	2			2		2			2
	CO2	2			2	2	2			2		2			2
	CO3	2			2	2	2			2		2			2
	CO4	2			2	2	2			2		2			2
	CO5	2			2	2	2			2		2			2