

SCHOOL OF ELECTRICAL AND COMMUNICATION

DEPARTMENT OF BIOTECHNOLOGY

CURRICULUM AND SYLLABI



VTR UGE Regulation 2021

VISION & MISSION OF THE INSTITUTE

Vision:

• To create, translate and disseminate frontiers of knowledge embedded with creativity and Innovation for a positive transformation of emerging society.

Mission:

To nurture excellence in teaching, learning, creativity and research; translate knowledge into practice; foster multidisciplinary research across science, medicine, engineering, technology and humanities; incubate entrepreneurship; instill integrity and honor; inculcate scholarly leadership towards global competence and growth beyond self in a serene, inclusive and free academic environment.

VISION & MISSION OF THE DEPARTMENT

Vision

• To adopt viable strategies to address global socioeconomic challenges in Biotechnology.

Mission

- M1: To educate and nurture socially responsible Biotechnologists who can tackle global challenges.
- M2: To build vital state-of-the-art research facilities that impart core skills to student and faculty.
- M3: To Promote Entrepreneurship and startups.
- M4: To collaborate with world class organizations to enhance the knowledge in Industrial and Research activities.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

- 1. Have a strong foundation in Biotechnology in order to gain competence towards active Research and Industrial career opportunities.
- 2. Have a thorough practical and problem-solving skills towards sustainable developmental goals.
- 3. Have confidence in technical communication skills with an extensive knowledge on sustained career advancement.

PROGRAM OUTCOMES (POs)

- **1. Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- 2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
- **3. Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- 4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- **5.** Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations
- 6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice
- 7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- **8.** Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
- **9.** Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- **10. Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- **11. Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- **12. Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

- 1. Apply knowledge and analytical abilities in Biotechnology to solve the real world problems.
- Develop and implement biotechnology and allied biological sciences to meet the industrial demands and social needs.
- 3. Impart sustainable practices in environmental and biosafety principles.

VTR UGE REGULATION 2021 SCHOOL OF ELECTRICAL AND COMMUNICATION DEPARTMENT OF BIOTECHNOLOGY LIST OF COURSES

B. Tech - BIOTECHNOLOGY

Course Code BASIC SCIENCES 1 10211BT101 Microbiology 3 0 0 3 2 10211BT102 Cell Biology 3 0 0 3 3 10211BT102 Cell Biology Lab 0 0 2 1 5 10211BT301 Microbiology Lab 0 0 2 1 6 10211BT302 Biochemistry Lab 0 0 2 1 6 10211BT18 Biochemistry 3 0 0 2 1 7 10211BT104 Molecular Biology Concepts and Techniques 3 0 0 2 1 7 10211BT104 Molecular Biology & Genetic Engineering Lab 0 0 2 1 7 10211BT105 Genetic Engineering 3 0 0 3 1 0 0 2 1 7 10211BT105 Genetic Engineering 3 0 0 3 1 0 <th></th> <th></th> <th>PROGRAM CORE COURSES</th> <th></th> <th></th> <th></th> <th></th>			PROGRAM CORE COURSES				
1 10211BT101 Microbiology 3 0 0 3 2 10211BT102 Cell Biology 3 0 0 3 3 10211BT115 Analytical and Instrumentation Engineering 3 0 0 2 1 5 10211BT301 Microbiology Lab 0 0 2 1 1 6 10211BT302 Biochemistry Lab 0 0 0 2 1 7 10211BT118 Biochemistry 3 0 0 3 0 0 3 6 10211BT104 Molecular Biology:Concepts and Techniques 3 0 0 3 0 0 2 1 7 10211BT104 Molecular Biology & Genetic Engineering Lab 0 0 2 1 1 10211BT105 Genetic Engineering 3 0 0 3 1 0 0 2 1 11 10211BT106 Chemical Reaction Engineering 3 0 0 3 1 0 3 1 0			Course Name	L	Т	Р	С
2 10211BT102 Cell Biology 3 0 0 3 3 10211BT115 Analytical and Instrumentation Engineering 3 0 0 3 4 10211BT301 Microbiology Lab 0 0 2 1 5 10211BT302 Biochemistry Lab 0 0 0 2 1 6 10211BT303 Cell Biology Lab 0 0 0 2 1 7 10211BT118 Biochemistry Lab 0 0 0 2 1 7 10211BT104 Molecular Biology:Concepts and Techniques 3 0 0 3 9 10211BT105 Genetic Engineering 3 0 0 2 1 10 10211BT106 Chemical Reaction Engineering 3 0 0 3 1 0 4 11 10211BT107 Mass Transfer Operations in Biotechnology 3 0 0 3 1 0 4 14 10211BT108 Principles of Chemical Engineering 3 0 0		Course Code	BASIC SCIENCES				
3 10211BT115 Analytical and Instrumentation Engineering 3 0 0 3 4 10211BT301 Microbiology Lab 0 0 2 1 5 10211BT302 Biochemistry Lab 0 0 0 2 1 6 10211BT303 Cell Biology Lab 0 0 0 2 1 7 10211BT103 Cell Biology Lab 0 0 0 2 1 7 10211BT104 Molecular Biology:Concepts and Techniques 3 0 0 3 9 10211BT105 Genetic Engineering 3 0 0 2 1 CHEMICAL ENGINEERING Molecular Biology & Genetic Engineering Lab 0 0 2 1 11 10211BT106 Chemical Reaction Engineering 3 0 0 3 12 10211BT108 Principles of Chemical Engineering 3 0 0 3 13 10211BT10 Bioprocess Engineering 3 0 0 3 14 10211BT110 Bioproce	1	10211BT101	Microbiology	3	0	0	3
4 10211BT301 Microbiology Lab 0 0 0 2 1 5 10211BT302 Biochemistry Lab 0 0 0 2 1 6 10211BT303 Cell Biology Lab 0 0 0 2 1 7 10211BT118 Biochemistry 3 0 0 3 0 0 3 GENETIC ENGINEERING / MOLECULAR BIOLOGY 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 1 0 1 10211BT106 Chemical Reaction Engineering 3 1 0 4 14 10211BT107 Mass Transfer Operations in Biotechnology 3 0 0 3 1 0 4 14 10211BT107 Mass Transfer Operations in Biotechnology 3 0	2	10211BT102	Cell Biology	3	0	0	3
5 10211BT302 Biochemistry Lab 0 0 0 2 1 6 10211BT303 Cell Biology Lab 0 0 0 2 1 7 10211BT118 Biochemistry 3 0 0 3 0 0 3 GENETIC ENGINEERING / MOLECULAR BIOLOGY 8 10211BT104 Molecular Biology:Concepts and Techniques 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 10 10211BT105 Genetic Engineering 3 0 0 3 12 10211BT106 Chemical Reaction Engineering 3 1 0 4 10 10 10 10 3 1 0 4 14 10211BT108 Principles of Chemical Engineering 3 1 0 1 4 10 10 10 10 3 1 </td <td>3</td> <td>10211BT115</td> <td>Analytical and Instrumentation Engineering</td> <td>3</td> <td>0</td> <td>0</td> <td>3</td>	3	10211BT115	Analytical and Instrumentation Engineering	3	0	0	3
6 10211BT303 Cell Biology Lab 0 0 0 2 1 7 10211BT118 Biochemistry 3 0 0 3 GENETIC ENGINEERING / MOLECULAR BIOLOGY 8 10211BT104 Molecular Biology:Concepts and Techniques 3 0 0 3 9 10211BT105 Genetic Engineering 3 0 0 2 1 CHEMICAL ENGINEERING Molecular Biology & Genetic Engineering Lab 0 0 2 1 11 10211BT106 Chemical Reaction Engineering 3 0 0 3 12 10211BT107 Mass Transfer Operations in Biotechnology 3 0 0 3 13 10211BT108 Principles of Chemical Engineering 3 1 0 4 14 10211BT110 Bioprocess Engineering 3 0 0 3 15 10211BT110 Bioprocess Engineering 3 0 0 3 16 10211BT111 Downstream Processing 3 0 0 3 17	4	10211BT301	Microbiology Lab	0	0	2	1
7 10211BT118 Biochemistry 3 0 0 3 GENETIC ENGINEERING / MOLECULAR BIOLOGY 8 10211BT104 Molecular Biology:Concepts and Techniques 3 0 0 3 9 10211BT105 Genetic Engineering 3 0 0 2 1 10 10211BT304 Molecular Biology & Genetic Engineering Lab 0 0 2 1 CHEMICAL ENGINEERING 11 10211BT106 Chemical Reaction Engineering 3 0 0 3 11 10211BT106 Chemical Reaction Engineering 3 0 0 3 12 10211BT107 Mass Transfer Operations in Biotechnology 3 0 0 3 13 10211BT108 Principles of Chemical Engineering 3 0 0 3 14 10211BT112 Unit Operations in Biotech Industry 3 0 0 3 15 10211BT110 Bioprocess Engineering 3 0 0 3 16 10211BT111 Downstream Processing 3 0 0 3 </td <td>5</td> <td>10211BT302</td> <td>Biochemistry Lab</td> <td>0</td> <td>0</td> <td>2</td> <td>1</td>	5	10211BT302	Biochemistry Lab	0	0	2	1
GENETIC ENGINEERING / MOLECULAR BIOLOGY 8 10211BT104 Molecular Biology:Concepts and Techniques 3 0 0 3 9 10211BT105 Genetic Engineering 3 0 0 2 1 CHEMICAL ENGINEERING Molecular Biology & Genetic Engineering Lab 0 0 2 1 CHEMICAL ENGINEERING 3 0 0 3 0 0 3 11 10211BT106 Chemical Reaction Engineering 3 0 0 3 12 10211BT107 Mass Transfer Operations in Biotechnology 3 0 0 3 13 10211BT108 Principles of Chemical Engineering 3 1 0 4 14 10211BT112 Unit Operations in Biotech Industry 3 0 0 3 15 10211BT110 Bioprocess Engineering 3 0 0 3 16 10211BT111 Downstream Processing 3 0 0 3 17	6	10211BT303	Cell Biology Lab	0	0	2	1
8 10211BT104 Molecular Biology:Concepts and Techniques 3 0 0 3 9 10211BT105 Genetic Engineering 3 0 0 2 1 10 10211BT304 Molecular Biology & Genetic Engineering Lab 0 0 2 1 CHEMICAL ENGINEERING 3 0 0 3 0 0 3 11 10211BT106 Chemical Reaction Engineering 3 0 0 3 12 10211BT107 Mass Transfer Operations in Biotechnology 3 0 0 3 13 10211BT108 Principles of Chemical Engineering 3 1 0 4 14 10211BT112 Unit Operations in Biotech Industry 3 0 0 3 15 10211BT110 Bioprocess Engineering 3 0 0 3 16 10211BT111 Downstream Processing 3 0 0 3 17 10211BT113 Metabolic Engineering Lab 0 0 2 1 19 10211BT117 Pl	7	10211BT118	Biochemistry	3	0	0	3
9 10211BT105 Genetic Engineering 3 0 0 3 10 10211BT304 Molecular Biology & Genetic Engineering Lab 0 0 2 1 CHEMICAL ENGINEERING 11 10211BT106 Chemical Reaction Engineering 3 0 0 3 12 10211BT106 Chemical Reaction Engineering 3 1 0 4 14 10211BT107 Mass Transfer Operations in Biotechnology 3 0 0 3 13 10211BT108 Principles of Chemical Engineering 3 1 0 4 14 10211BT112 Unit Operations in Biotech Industry 3 0 0 3 15 10211BT110 Bioprocess Engineering 3 0 0 3 16 10211BT113 Metabolic Engineering 3 0 0 3 17 10211BT113 Metabolic Engineering Lab 0 0 2 1 19 10211BT117 Plant and Animal Biotechnology	GEN	ETIC ENGINEERIN	G / MOLECULAR BIOLOGY				
10 10211BT304 Molecular Biology & Genetic Engineering Lab 0 0 2 1 CHEMICAL ENGINEERING 11 10211BT106 Chemical Reaction Engineering 3 0 0 3 12 10211BT107 Mass Transfer Operations in Biotechnology 3 0 0 3 13 10211BT108 Principles of Chemical Engineering 3 1 0 4 14 10211BT112 Unit Operations in Biotech Industry 3 0 0 3 15 10211BT110 Bioprocess Engineering 3 0 0 3 16 10211BT111 Downstream Processing 3 0 0 3 17 10211BT113 Metabolic Engineering 3 0 0 3 18 10211BT114 Green Biotechnology & Pollution Abatement 2 0 0 2 1 21 10211BT305 Bioprocess Engineering Lab 0 0 2 1 21 10211BT305 Bioprocess Engineering Lab 0 0 2 1 21 <td>8</td> <td>10211BT104</td> <td>Molecular Biology:Concepts and Techniques</td> <td>3</td> <td>0</td> <td>0</td> <td>3</td>	8	10211BT104	Molecular Biology:Concepts and Techniques	3	0	0	3
CHEMICAL ENGINEERING 11 10211BT106 Chemical Reaction Engineering 3 0 0 3 12 10211BT107 Mass Transfer Operations in Biotechnology 3 0 0 3 13 10211BT108 Principles of Chemical Engineering 3 1 0 4 14 10211BT112 Unit Operations in Biotech Industry 3 0 0 3 INDUSTRIAL BIOTECHNOLOGY Interpretender 3 0 0 3 15 10211BT110 Bioprocess Engineering 3 0 0 3 16 10211BT113 Metabolic Engineering 3 0 0 3 17 10211BT113 Metabolic Engineering 3 0 0 3 18 10211BT114 Green Biotechnology & Pollution Abatement 2 0 0 2 19 10211BT305 Bioprocess Engineering Lab 0 0 2 1 21 10211BT306 Downstream Processing Lab 0 0 2 1 21 10211BT3	9	10211BT105	Genetic Engineering	3	0	0	3
11 10211BT106 Chemical Reaction Engineering 3 0 0 3 12 10211BT107 Mass Transfer Operations in Biotechnology 3 0 0 3 13 10211BT108 Principles of Chemical Engineering 3 1 0 4 14 10211BT112 Unit Operations in Biotech Industry 3 0 0 3 INDUSTRIAL BIOTECHNOLOGY 15 10211BT110 Bioprocess Engineering 3 0 0 3 16 10211BT111 Downstream Processing 3 0 0 3 17 10211BT113 Metabolic Engineering 3 0 0 3 18 10211BT114 Green Biotechnology & Pollution Abatement 2 0 0 2 19 10211BT117 Plant and Animal Biotechnology 3 0 0 3 20 10211BT305 Bioprocess Engineering Lab 0 0 2 1 21 10211BT306 Downstream Processing Lab 0 0 2 1 21 10211BT202	10	10211BT304	Molecular Biology & Genetic Engineering Lab	0	0	2	1
12 10211BT107 Mass Transfer Operations in Biotechnology 3 0 0 3 13 10211BT108 Principles of Chemical Engineering 3 1 0 4 14 10211BT112 Unit Operations in Biotech Industry 3 0 0 3 INDUSTRIAL BIOTECHNOLOGY 3 0 0 3 0 0 3 16 10211BT111 Downstream Processing 3 0 0 3 17 10211BT113 Metabolic Engineering 3 0 0 3 18 10211BT114 Green Biotechnology & Pollution Abatement 2 0 0 2 19 10211BT117 Plant and Animal Biotechnology 3 0 0 3 20 10211BT305 Bioprocess Engineering Lab 0 0 2 1 21 10211BT305 Bioprocess Engineering Lab 0 0 2 1 21 10211BT306 Downstream Processing Lab 0 0 2 1 21 10211BT202 Bioinformatics	CHE	MICAL ENGINEER	NG				
13 10211BT108 Principles of Chemical Engineering 3 1 0 4 14 10211BT112 Unit Operations in Biotech Industry 3 0 0 3 INDUSTRIAL BIOTECHNOLOGY 10211BT110 Bioprocess Engineering 3 0 0 3 16 10211BT111 Downstream Processing 3 0 0 3 17 10211BT113 Metabolic Engineering 3 0 0 3 18 10211BT114 Green Biotechnology & Pollution Abatement 2 0 0 2 19 10211BT107 Plant and Animal Biotechnology 3 0 0 3 20 10211BT305 Bioprocess Engineering Lab 0 0 2 1 21 10211BT306 Downstream Processing Lab 0 0 2 1 21 10211BT202 Bioinformatics 2 0 2 3 22 10211BT202 Bioinformatics 2 0 2 3 23 10211BT307 Immunology and Immunotechnology 3<	11	10211BT106	Chemical Reaction Engineering	3	0	0	3
14 10211BT112 Unit Operations in Biotech Industry 3 0 0 3 INDUSTRIAL BIOTECHNOLOGY 15 10211BT110 Bioprocess Engineering 3 0 0 3 16 10211BT111 Downstream Processing 3 0 0 3 17 10211BT113 Metabolic Engineering 3 0 0 3 18 10211BT114 Green Biotechnology & Pollution Abatement 2 0 0 2 19 10211BT117 Plant and Animal Biotechnology 3 0 0 3 20 10211BT305 Bioprocess Engineering Lab 0 0 2 1 21 10211BT306 Downstream Processing Lab 0 0 2 1 21 10211BT306 Downstream Processing Lab 0 0 2 1 PHARMACEUTICAL & MEDICAL BIOTECHNOLOGY 2 0 2 3 0 0 3 23 10211BT307 Immunology and Immunotechnology 3 0 0 3 0 0	12	10211BT107	Mass Transfer Operations in Biotechnology	3	0	0	3
INDUSTRIAL BIOTECHNOLOGY 15 10211BT110 Bioprocess Engineering 3 0 0 3 16 10211BT111 Downstream Processing 3 0 0 3 17 10211BT113 Metabolic Engineering 3 0 0 3 18 10211BT114 Green Biotechnology & Pollution Abatement 2 0 0 2 19 10211BT117 Plant and Animal Biotechnology 3 0 0 3 20 10211BT305 Bioprocess Engineering Lab 0 0 2 1 21 10211BT306 Downstream Processing Lab 0 0 2 1 21 10211BT306 Downstream Processing Lab 0 0 2 1 22 10211BT202 Bioinformatics 2 0 2 3 23 10211BT116 Immunology and Immunotechnology 3 0 0 3 24 10211BT307 Immunology Lab 0 0 2 1	13	10211BT108	Principles of Chemical Engineering	3	1	0	4
15 10211BT110 Bioprocess Engineering 3 0 0 3 16 10211BT111 Downstream Processing 3 0 0 3 17 10211BT113 Metabolic Engineering 3 0 0 3 18 10211BT114 Green Biotechnology & Pollution Abatement 2 0 0 2 19 10211BT117 Plant and Animal Biotechnology 3 0 0 3 20 10211BT305 Bioprocess Engineering Lab 0 0 2 1 21 10211BT306 Downstream Processing Lab 0 0 2 1 21 10211BT306 Downstream Processing Lab 0 0 2 1 22 10211BT306 Downstream Processing Lab 0 0 2 1 PHARMACEUTICAL & MEDICAL BIOTECHNOLOGY 2 0 2 3 0 0 3 23 10211BT116 Immunology and Immunotechnology 3 0 0 3 0 0 3 24 10211BT307	14	10211BT112	Unit Operations in Biotech Industry	3	0	0	3
1610211BT111Downstream Processing30031710211BT113Metabolic Engineering30031810211BT114Green Biotechnology & Pollution Abatement20021910211BT117Plant and Animal Biotechnology30032010211BT305Bioprocess Engineering Lab00212110211BT306Downstream Processing Lab0021PHA-KMACEUTICAL & MEDICAL BIOTECHNOLOGY2210211BT202Bioinformatics20232310211BT116Immunology and Immunotechnology30032410211BT307Immunology Lab0021	IND	USTRIAL BIOTECH					
17 10211BT113 Metabolic Engineering 3 0 0 3 18 10211BT114 Green Biotechnology & Pollution Abatement 2 0 0 2 19 10211BT117 Plant and Animal Biotechnology 3 0 0 3 20 10211BT305 Bioprocess Engineering Lab 0 0 2 1 21 10211BT306 Downstream Processing Lab 0 0 0 2 1 PHARMACEUTICAL & MEDICAL BIOTECHNOLOGY 2 0 2 3 0 0 3 22 10211BT202 Bioinformatics 2 0 2 3 23 10211BT116 Immunology and Immunotechnology 3 0 0 3 24 10211BT307 Immunology Lab 0 0 2 1	15	10211BT110	Bioprocess Engineering	3	0	0	3
1810211BT114Green Biotechnology & Pollution Abatement20021910211BT117Plant and Animal Biotechnology30032010211BT305Bioprocess Engineering Lab000212110211BT306Downstream Processing Lab00021PHARMACEUTICAL & MEDICAL BIOTECHNOLOGY20232210211BT202Bioinformatics20232310211BT116Immunology and Immunotechnology30032410211BT307Immunology Lab0021	16	10211BT111	Downstream Processing	3	0	0	3
19 10211BT117 Plant and Animal Biotechnology 3 0 0 3 20 10211BT305 Bioprocess Engineering Lab 0 0 0 2 1 21 10211BT306 Downstream Processing Lab 0 0 0 2 1 PHARMACEUTICAL & MEDICAL BIOTECHNOLOGY 2 0 2 3 0 0 3 22 10211BT202 Bioinformatics 2 0 2 3 23 10211BT116 Immunology and Immunotechnology 3 0 0 3 24 10211BT307 Immunology Lab 0 0 2 1	17	10211BT113	Metabolic Engineering	3	0	0	3
20 10211BT305 Bioprocess Engineering Lab 0 0 2 1 21 10211BT306 Downstream Processing Lab 0 0 0 2 1 PHARMACEUTICAL & MEDICAL BIOTECHNOLOGY 2 1 2 0 2 3 22 10211BT202 Bioinformatics 2 0 2 3 23 10211BT116 Immunology and Immunotechnology 3 0 0 3 24 10211BT307 Immunology Lab 0 0 2 1	18	10211BT114	Green Biotechnology & Pollution Abatement	2	0	0	2
21 10211BT306 Downstream Processing Lab 0 0 2 1 PHARMACEUTICAL & MEDICAL BIOTECHNOLOGY 2 0 2 3 2 0 2 3 22 10211BT202 Bioinformatics 2 0 2 3 3 0 0 3 23 10211BT116 Immunology and Immunotechnology 3 0 0 3 2 1 24 10211BT307 Immunology Lab 0 0 2 1	19	10211BT117	Plant and Animal Biotechnology	3	0	0	3
PHARMACEUTICAL & MEDICAL BIOTECHNOLOGY2210211BT202Bioinformatics20232310211BT116Immunology and Immunotechnology30032410211BT307Immunology Lab0021	20	10211BT305	Bioprocess Engineering Lab	0	0	2	1
22 10211BT202 Bioinformatics 2 0 2 3 23 10211BT116 Immunology and Immunotechnology 3 0 0 3 24 10211BT307 Immunology Lab 0 0 2 1	21	10211BT306	Downstream Processing Lab	0	0	2	1
23 10211BT116 Immunology and Immunotechnology 3 0 0 3 24 10211BT307 Immunology Lab 0 0 2 1	PHA	RMACEUTICAL &	MEDICAL BIOTECHNOLOGY				
24 10211BT307 Immunology Lab 0 0 2 1	22	10211BT202	Bioinformatics	2	0	2	3
	23	10211BT116	Immunology and Immunotechnology	3	0	0	3
TOTAL 55	24	10211BT307	Immunology Lab	0	0	2	1
			TOTAL				58

		PROGRAM ELECTIVE COURSES				
INI	DUSTRIAL DOMAIN	1				
1	10212BT101	Fluid Mechanics and Transport phenomena	3	0	0	3
2	10212BT102	Bioenergy	3	0	0	3
3	10212BT103	Food Processing Technology	3	0	0	3
4	10212BT104	Agricultural Biotechnology	3	0	0	3
5	10212BT105	Algal Biotechnology	3	0	0	3
6	10212BT106	Nanobiotechnology and application	3	0	0	3
7	10212BT107	Fermentation Technology	3	0	0	3
8	10212BT108	Protein Engineering	3	0	0	3
9	10212BT109	Process Instrumentation and dynamic control	3	0	0	3

10	10212BT110	Bioreactor design and Instrumentation control	3	0	0	3
11	10212BT111	Valorisation	3	0	0	3
12	10212BT112	Environmental Biotechnology	3	0	0	3
13	10212BT113	Enzyme technology and Biotransformation	3	0	0	3
14	10212BT114	Synthetic Biology	3	0	0	3
ME	DICAL DOMAIN		1			
15	10212BT115	Cancer Biology	3	0	0	3
16	10212BT116	Molecular Pathogenesis	3	0	0	3
17	10212BT117	Biopharmaceutical Technology	3	0	0	3
18	10212BT118	Stem cell Technology	3	0	0	3
19	10212BT119	Biosensor and Instrumentation	3	0	0	3
20	10212BT120	Biomaterials	3	0	0	3
21	10212BT121	Biochips and Microarray technologies	3	0	0	3
22	10212BT122	Plant Biotechnology	3	0	0	3
23	10212BT123	Animal Biotechnology	3	0	0	3
24	10212BT124	Tissue Engineering	3	0	0	3
25	10212BT125	Herbal and Phytochemical Engineering	3	0	0	3
26	10212BT126	Medical Genomics and Proteomics	3	0	0	3
27	10212BT127	Cellular Engineering	3	0	0	3
28	10212BT128	Bioprinting	3	0	0	3
29	10212BT129	Augmented Reality & Virtual Reality	3	0	0	3
30	10212BT130	Precision Agricultural Biotechnology	3	0	0	3
31	10212BT143	Computational Biology: Techniques and Application	2	0	2	3
32	10212BT144	Advanced Biochemistry	3	0	0	3
FO	OD BIOTECHNOLO	GY DOMAIN				
33	10212BT131	Principles of Functional Food and Applications	3	0	0	3
34	10212BT132	Nutraceuticals	3	0	0	3
35	10212BT133	Food Preservation and Packaging Technologies	3	0	0	3
36	10212BT134	Marine Biotechnology and Aquaculture	3	0	0	3
37	10212BT135	Food Safety, Quality and Regulation	3	0	0	3
38	10212BT136	Storage Engineering	3	0	0	3
		INDEPENDENT LEARNING				_
39	10214BT501	Community service project	0	0	2	1
40	10214BT601	Minor Project I	0	0	4	2
41	10214BT602	Minor Project II	0	0	4	2
42	10214BT701	Major Project	0	0	18	9

		OPEN ELECTIVE COURSES				
S. No.	Course Code	Course Name	L	Т	Р	С
1	10213BT101	Biochips	3	0	0	3
2	10213BT102	Biosensors	3	0	0	3
3	10213BT103	Biomaterials Engineering	3	0	0	3
4	10213BT104	Bio-Inspired Design: Principles and Practice	3	0	0	3
5	10213BT105	Engineering Advances i1n Food Preservation	3	0	0	3

Specializations: a. Food and Precision Agriculture

a. 1'00'	u anu i recision Agi	iculture				
S.No	Course Code	Course Name	L	Т	Р	С
1	10212BT131	Principles of Functional Food and Applications	3	0	0	3
2	10212BT135	Food Safety, Quality and Regulation	3	0	0	3
3	10212BT133	Food Preservation, Packaging Technologies	3	0	0	3
4	10212BT132	Nutraceuticals	3	0	0	3
5	10212BT130	Precision Agricultural Biotechnology	3	0	0	3
6	10212BT104	Agricultural Biotechnology	3	0	0	3

b. Regenerative Medicine, Health Diagnostics and Disease control

S.No	Course Code	Course Name	L	Т	Р	С
1	10212BT117	Biopharmaceutical Technology	3	0	0	3
2	10212BT125	Herbal and Phytochemical Engineering	3	0	0	3
3	10212BT115	Cancer Biology	3	0	0	3
4	10212BT118	Stem Cell Technology	3	0	0	3
5	10212BT126	Medical Genomics and Proteomics	3	0	0	3
6	10212BT116	Molecular Pathogenesis	3	0	0	3

Minor in Bioprocess control and devices

S.No	Course Code	Course Name	L	Т	Р	C
1	10213BT107	Bioprocess Control components	3	0	0	3
2	10213BT108	Advanced Analytical and Instrumentation bioprocess applications	3	0	0	3
3	10213BT109	Biosensors	3	0	0	3
4	10213BT110	Biochips	3	0	0	3
5	10213BT111	Biomaterials	3	0	0	3
6	10213BT112	Computational applications in Bioprocess	3	0	0	3

Honors in Bioengineering

S.No	Course Code	Course Name	L	Т	Р	C
1	10212BT137	Instrumentation and Process Control	3	0	0	3
2	10212BT138	Biomolecular Modelling	3	0	0	3
3	10212BT139	Biomechanics	3	0	0	3
4	10212BT140	Bionanotechnology	3	0	0	3
5	10212BT141	Biochemical Engineering	3	0	0	3
6	10212BT142	OMICS Technologies	3	0	0	3

PROGRAM CORE COURSES BASIC SCIENCES

Course Co	de		Course Title	L	T	P	C						
10211BT1	01		MICROBIOLOGY	3	0	0	3						
Course Category			Program Core										
Preamble			This course introduces the Biotechnology student to the concepts and techniques used in Microbiology.										
Prerequisit	e Courses	6	NIL										
Course Outcomes	Upon su	icces	ssful completion of the course, students will i	be able	e to:								
CO Nos.			Course Outcomes		(Base	ledge L 1 on revi s Taxon	ised						
CO1			the concepts of microbiology and the ba dentify micro organisms	sic		K2							
CO2	Explain life cycl		diversity of different micro-organisms with th	eir	r K2								
CO3			e appropriate culture techniques for grow crobial species	ing	g K3								
CO4			d apply the principles of physical and chemi control the growth of micro organisms	cal	ll K3								
CO5	Make minerali		e of Microbes on bio- products and bio Kation										

Correlation of COs with POs:

CO Nos.	Course Outcomes				Prog	ramı	ne O	utcoi	nes ((POs	5)			S] Ou	ograi pecifi itcom PSOs)	c es
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the concepts of micro biology and the basic methods to identify micro organisms	Н	М	М	М								Н	М	М	М
CO2	Explain the diversity of different micro- organisms with their life cycles	н	М	L									Н	М	L	L
CO3	Identify the appropriate culture techniques for growing different microbial species	м	М	Н	М								Н		L	М

CO4	prine and to co	trate and apply the ciples of physical chemical methods ontrol the growth of co organisms	Н	Н	Н	М		М		L				Н	Н	Н	Н
CO5	on b	te use of Microbes io- products and bio eralization		М	Н	М	Н	М	Н				М	Н	Н	Н	Н
H – Hig	h; M-	Medium; L- Low		•				•								•	
Course	Cont	ent:															
UNIT I		INTRODUCTIO	N											9	9 hou	urs	
History	of M	licrobiology, Basics	s of	Mie	crobi	ial e	xist	ence	e, C	lass	sific	ation	n, N	omer	nclati	ure a	and
Identific	cation	of microorganism	s, N	Aicro	oscoj	pic (exar	nina	atior	1 0	f n	nicro	orga	nism	s, lig	ght a	and
electron	micro	oscopy; principles o	of di	ffere	ent st	tainii	ng n	neth	ods	suc	ch a	s Gr	am s	taini	ng, a	icid 1	fast
staining	, caps	ular staining, flagel	lar s	taini	ng, f	funga	al st	aini	ng.								
	taining, capsular staining, flagellar staining, fungal staining. MICROBIAL STRUCTURE AND													ļ	9 hou	urs	
UNIT I	I	MULTIPLICATION Colony morphology and arrangement of bacterial cells; Structure and multiplication of the structure and multiplication of t								lication of bacteria.							
					acte	rial c	ells	; Str	ucti	ire a	and	mul	tiplic	atior	nofb	acte	ria,
Colony	morpl		nent	ofb									-				
Colony viruses,	morpl algae	nology and arrangen	nent nen	of b tion									-				
Colony viruses,	morpl algae ophage	nology and arrangen and fungi. Special 1	nent nent cyc]	of b tion le).	oflit	fe his	story	y of	Act	ino			-	ast, N		plası	
Colony viruses, Bacteric UNIT I	morpl algae ophago II	nology and arrangen and fungi. Special 1 e (Lytic, Lysogenic	nent nent cyc] J TR	of b tion le). ITI(of lit	fe his	story	y of ROV	Act VTI	ino H	myo	cetes	, Yea	ast, N	/yco) hou	plası urs	ma,
Colony viruses, Bacteric UNIT I Nutritio	morpl algae ophago II nal cla	nology and arrangen and fungi. Special 1 e (Lytic, Lysogenic MICROBIAL NU	nent nent cycl J TR porg	of b tion le). ITIC	of lif ON 4 ms b	fe his AND pased	on on	y of ROV cart	Act WTI	ino H end	erg	vetes	, Yea	ast, N	/yco 9 hou sour	plass urs ces a	ma,
Colony viruses, Bacteric UNIT I Nutritio differen	morph algae ophago II nal cla t med	nology and arrangen and fungi. Special 1 e (Lytic, Lysogenic MICROBIAL NU assification of micro	nent cycl J TR oorg l cul	of b tion le). ITI(anis lture	of lif ON 4 ms b (def	fe his AND based	o GI on , co	y of ROV cart	Act WTI bon, ex,	ino H eno selo	ergy ecti	ve, d	, Yea	ast, N	Ayco) hou sour l, en	plass urs ces a riche	ma, and ed);
Colony viruses, Bacteric UNIT I Nutritio differen Definitio	morpl algae ophago II nal cl t med on of	nology and arrangen and fungi. Special 1 e (Lytic, Lysogenic MICROBIAL NU assification of micro ia used for bacteria	nent cycl J TR porg l cul nd u	of b tion le). ITI(anis lture nbal	of lif ON 4 ms b (def ance	fe his AND based fined d gro	o GH on , co	y of ROV cart ompl h, gr	Act VTI oon, ex, rowt	H end seld	ergy ecti urv	ve, d	, Yea	ast, N ctron entia feren	Ayco 9 hou sour 1, en t met	plass urs ces a riche thod	ma, and ed); s to
Colony viruses, Bacteric UNIT I Nutritio differen Definitio quantify	morpl algae ophago II nal cla t med on of 7 bac	nology and arrangen and fungi. Special r e (Lytic, Lysogenic MICROBIAL NU assification of micro ia used for bacteria growth, balanced ar	nent ment cycl J TR Doorg I cul nd u:	of b tion le). ITI(anis lture nbal	of lif <u> ON 4</u> ms b (def ance namb	fe his AND based fined d gro per,	G G G G G G G G G G	y of ROV cart ompl h, gr ble	Act VTI Don, ex, cowt	H end seld th c	my erg ecti urv m	y and y and ve, d e and ethoo	, Yea	ast, N etron entia feren ounti	Ayco) hou sour l, en t met ing	plass urs ces a riche thods with	ma, and ed); s to
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LEARNING	GRESOURCES
Text Books	 Pelczar M.J., "Microbiology", 5thEdition, Tata McGraw-Hill, 2001. Prescott L.M., Harley J.P.and Klein D.A., "Microbiology", 4thEdition, Wm. Brown Publishers, 2010. Ananthanarayanan R and Jayaram PanikerC.K., "Textbook Microbiology",10thEdition, Orient Longman, 2017. Talaron K., Talaron A., Casita, Pelczar and Reid, "Foundations Microbiology", W.C. Brown Publishers, 1993.
Reference Books	 Casida L.E., "Industrial Microbiology", New Age International, 1968. Schlegel H.G., "General Microbiology", 7thEdition, Cambridge University Press, 1993. Tortora J., Funke R. and Case L, "Microbiology an Introduction", 3rd Edition, Benjamin/Cummings publishing, 1989.
Reference videos	https://www.youtube.com/watch?v=cQuX8tfwlYA https://www.youtube.com/watch?v=gVf9D-fcbU4 https://www.youtube.com/watch?v=8AhDxAQaDOA https://www.youtube.com/watch?v=9sLN1tGRvyc https://www.youtube.com/watch?v=jQGXGWBmVsA
Reference NPTEL	https://nptel.ac.in/courses/102103015
Reference research/ review articles	 Badar, R. A., Carmona, J. L., Collantes, J. G., Lojo, D. R., Ocampo, S. M., Ursua, R. L., & Bercede, D. H. (2022). Staining capability of plant extracts for the identification of gram-positive and gram-negative bacteria: A systematic review. Asian Journal of Biological and Life Sciences, 11(2), 277. Kamiński, B., & Paczesny, J. (2024). Bacteriophage Challenges in Industrial Processes: A Historical Unveiling and Future Outlook. Pathogens, 13(2), 152. Figueroa-Bossi, N., Balbontín, R., & Bossi, L. (2022). Basic bacteriological routines. Cold Spring Harbor Protocols, 2022(10), pdb-prot107849. Mancuso, G., Midiri, A., Gerace, E., & Biondo, C. (2021). Bacterial antibiotic resistance: The most critical pathogens. Pathogens, 10(10), 1310. De Simeis, D., & Serra, S. (2021). Actinomycetes: A never-ending source of bioactive compounds - An overview on antibiotics production. Antibiotics, 10(5), 483.

Course Cod	e		Course Title	L	Т	Р	C			
10211BT102	2		CELL BIOLOGY	3	0	0	3			
				L	1 1					
Course Cate	gory		Program Core							
Preamble			<i>This course enables comprehension of c their interactions.</i>	ellular	structui	re and				
Prerequisite	Prerequisite Courses10210BM101 – Biology for engineerings									
	To a second set of the second									
Course Outcomes	Upon su	ісс	essful completion of the course, students	will be	able to:					
CO Nos.			Course Outcomes		(Bas	vledge L ed on rev 1's Taxon	ised			
CO1	Underst	and	d basics of cell structure and organelle fu	nction		K2				
CO2			te the cellular transport mechanisms, sig	naling		K2				
CO3	Illustrat signalin		the significant of different hormones a nodels.	ind its		K2				
CO4	Make us receptor		of signal transduction pathways in cells an nase.	d their		K3				
CO5			cell culturing methods to maintain the ce c metabolite production.	ll lines		K3				
Correlation o	f COs wit	th l	POs:							

Correlation of COs with POs:

CO Nos.	Course Outcomes	Programme Outcomes (POs)													Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	Understand basics of cell structure and organelle function		Н										Н	М			
CO2	Demonstrate the cellular transport mechanisms in and out of the cell	Н	Н										Н	М			
CO3	Illustrate the significant of receptors and its signaling models.		Н										Н	М			
CO4	Make use of signal transduction pathways in cells and their receptor kinase		Н		Н	Н							Н	Н	Н		

CO5	met cell	bly the cell culturing hods to maintain the lines for specific abolite production.	Н	Н]	Η	Η							Н	Н	Н	М
H – Hig	h; M	- Medium; L- Low															
Course	Con	tent:															
UNIT I		CELL STRUCT ORGANELLES	UR	E .	AND	F	UN	CT	[ON		OF	T]	HE		9 ho	ours	
Structur	e of	Prokaryotic and Eu	ıkar	yotio	c cells	s ar	nd 1	brie	f or	n th	eir	org	anell	les, p	orinc	iples	s of
membra	ne or	ganization, membrai	ie p	rotei	ins, ex	tra	cell	lulaı	ma	trix	i, cy	tosł	celete	on sti	ructu	res,	cell
junction	and	cell adhesions, types	of	cell	divisic	on, i	mit	osis	& 1	nei	osis	, cel	l cyc	ele ar	nd me	oleci	ules
that con	trol c	ell cycle.															
UNIT I	I	TRANSPORT AC	RO	SS I	BIO M	1EN	MB	RA	NES	5					9 ho	urs	
Osmosis	s and	l reverse osmosis, i	Pass	sive	& ac	tive	e tr	ansp	oort	, po	erm	ease	s, so	odiur	n po	tass	ium
pump,C	a2+	ATPase pumps, vo	ltag	e ar	nd liga	and	ga	ted	cha	ann	els,	lys	oson	nal a	nd v	acu	olar
membra	nne A	TP dependent protor	n pu	mps	, Princ	ciple	es c	of Pa	atch	-Cl	amj	o exj	perin	nent	to sti	udy i	ion-
channels	s acti	vity; Co- transport -	sym	port	, antip	ort,	Tr	ansp	ort	ves	icle	s in	volve	ed in	Ende	ocyte	osis
and exo	cytos	is. Entry of virus and	l toy	kins	into ce	ells.											
UNIT I	Π	RECEPTORS AN	D N	101	DES O	F C	CEI	LS	SIG	NA	LL	INC	ř		9 ho	urs	
Cytosol	ic, n	clear and membran	e b	ounc	l recep	ptor	s v	vith	exa	mp	les,	aut	ocrir	ne, p	aracr	rine	and
endocrin	ne mo	odes of action, quanti	fica	tion	and c	hara	acte	eriza	tior	ı of	rec	eptc	ors.				
UNIT I	V	SIGNAL TRANSI)U(CTI	ON										9 ho	urs	
Signal a	ampli	fication, role of seco	onda	ary r	nessen	nger	(S- (cycl	ic A	M	P, i	nosi	tol tr	ri pho	ospha	ates	and
cyclic (GMP;	G proteins - role i	n si	gnal	trans	duc	tio	n, c	alci	um	ior	flu	x an	d its	role	in in	cell
signalin	g, ro	le of protein kinases	- se	erine	e – thr	eon	ine	kin	ase	s, tı	ımo	or ne	ecros	is fa	ctor	recej	ptor
families	5.																
UNIT V	/	BASICS OF CEL	LC	ULT	TURE										9 ho	urs	
Cell lin	ne, g	generation of cell	lin	es,	maint	ena	nce	of	st :	ock	c	ells,	cha	aract	eriza	tion	of
cells,mc	orpho	logical analysis tec	hnio	ques	in co	ell	cul	ture	, p	rim	ary	cul	tures	, co	ntam	inat	ion,
differen	tiatio	n, three dimensional	cul	tures	s, role	ofı	mat	rix	in c	ell g	grov	vth;	Cell	viab	ility	stud	ies:
using te	trazo	lium salts, LDH relea	ase,	Try	phan b	olue	ex	clus	ion,	etc							
LEARN	NING	RESOURCES															
Text Books		1. Darnell J, Lodis 8 th Edition,2016		l, Ba	ltimor	e D), "]	Mol	ecul	ar (Cell	Bic	logy	", W	.H.F	reen	nan;

Reference https://www.youtube.com/watch?v=uIut0vWCEg https://www.youtube.com/watch?v=UIut0vWCEg https://www.youtube.com/watch?v=UIut0vWCEg https://www.youtube.com/watch?v=RpDke-Sadzo NeGivern NPTEL https://archive.nptel.ac.in/courses/102/103/102103012/ 1 Oh, M. H., Honey, S. H., & Tax, F. E. (2020). The control of cell expansioneregive. International Journal of Molecular Sciences, 21(5), 1743. 2 McGi		
Science (Taylors Francis), 2002. 4. Sadava, D.E. "Cell Biology: Organelle Structure and Funti PanimaPublishing, 2004. 5. Rastogi, S.C. "Cell Biology" 2nd Edition, New Age International, 2002. 1. Becker W.M. et al., "The World of the Cell", Vth Edition, Pearson Educa 2003. 2. Campbell N.A., ReceeJ.B. and Simon E.J., "Essential Biology", IIIrd Edi Pearson International, 2007. 3. Alberts Bruce et al., "Essential Cell Biology", IInd Edition, Garland I (Taylor & Francis), 2004. https://www.youtube.com/watch?v=RQ-SMCmWB1s https://www.youtube.com/watch?v=JFes5I07c0 https://www.youtube.com/watch?v=J7LGmFgW44c https://www.youtube.com/watch?v=RpDke-Sadzo Reference NPTEL https://archive.nptel.ac.in/courses/102/103/102103012/ 1. Oh, M. H., Honey, S. H., & Tax, F. E. (2020). The control of cell expan: cell division, and vascular development by brassinosteroids: a histo perspective. International Journal of Molecular Sciences, 21(5), 1743. 2. MeGivern, J. G., & Ding, M. (2020). Ion channels and relevant screening approaches. SLAS DISCOVERY: Advancing the Science of I Discovery, 25(5), 413-419. 3. Zhao, Y. G., & Zhang, H. (2020). Phase separation in membrane biology interplay between membrane-bound organelles and membrane condensates. Developmental Cell, 55(1), 30-44. 4. Kanneganti, T. D. (2020). Intracellular innate immune receptors: Life in the cell. Immunological reviews, 297(1), 5.		2. Cooper G.M. and Hansman R.E., "The Cell: A Molecular Approach", 4 th Edition, ASM Press, 2007.
PanimaPublishing, 2004. 5. Rastogi, S.C. "Cell Biology" 2nd Edition, New Age International, 2002. 1. Becker W.M. et al., "The World of the Cell", Vth Edition, Pearson Educa 2003. 2. Campbell N.A., ReceeJ.B. and Simon E.J., "Essential Biology", IIIrd Edi Pearson International, 2007. 3. Alberts Bruce et al., "Essential Cell Biology", IInd Edition, Garland I (Taylor & Francis), 2004. https://www.youtube.com/watch?v=RQ-SMCmWB1s https://www.youtube.com/watch?v=JFes5I07c0 https://www.youtube.com/watch?v=J7LGmFgW44c https://www.youtube.com/watch?v=RpDke-Sadzo Reference NPTEL 1. Oh, M. H., Honey, S. H., & Tax, F. E. (2020). The control of cell expanse cell division, and vascular development by brassinosteroids: a histor perspective. International Journal of Molecular Sciences, 21(5), 1743. 2. McGivern, J. G., & Ding, M. (2020). Ion channels and relevant screening approaches. SLAS DISCOVERY: Advancing the Science of I Discovery, 25(5), 413-419. 3. Zhao, Y. G., & Zhang, H. (2020). Phase separation in membrane biology interplay between membrane-bound organelles and membrane condensates. Developmental Cell, 55(1), 30-44. 4. Kanneganti, T. D. (2020). Intracellular innate immune receptors: Life in the cell. Immunological reviews, 297(1), 5.		
Reference research/ review articles1. Becker W.M. et al., "The World of the Cell", Vth Edition, Pearson Educa 2003.Reference research/ review articles1. Becker W.M. et al., "The World of the Cell", Vth Edition, Pearson Educa 2003.Reference research/ review articles2. Campbell N.A., ReceeJ.B. and Simon E.J., "Essential Biology", IIIrd Edit Pearson International, 2007.3. Alberts Bruce et al., "Essential Cell Biology", IInd Edition, Garland H (Taylor & Francis), 2004.https://www.youtube.com/watch?v=RQ-SMCmWB1s https://www.youtube.com/watch?v=ulut0oVWCEg https://www.youtube.com/watch?v=J7LGmFgW44c https://www.youtube.com/watch?v=RpDke-SadzoReference NPTELhttps://archive.nptel.ac.in/courses/102/103/102103012/1. Oh, M. H., Honey, S. H., & Tax, F. E. (2020). The control of cell expansion cell division, and vascular development by brassinosteroids: a histor perspective. International Journal of Molecular Sciences, 21(5), 1743.2. McGivern, J. G., & Ding, M. (2020). Ion channels and relevant screening approaches. SLAS DISCOVERY: Advancing the Science of I Discovery, 25(5), 413-419.3. Zhao, Y. G., & Zhang, H. (2020). Phase separation in membrane biology interplay between membrane-bound organelles and membrane condensates. Developmental Cell, 55(1), 30-44.4. Kanneganti, T. D. (2020). Intracellular innate immune receptors: Life in the cell. Immunological reviews, 297(1), 5.		
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Signal process and read outs – signal to noise ratio – sources of noise, Enhancement of signa																	
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two dimensional PAGE, electrophoresis of nucleic acids using agarose gel, capillary electrophoresis.

LEARNING	RESOURCES
Text Books	 Skoog D.A. F., James Holler and StankyR.Crouch, "Instrumental Methods of Analysis", Cengage Learning, 2007. Willard Hobart, et al., "Instrumental Methods of Analysis", 7th Edition, CBS, 1986. Braun, Robert D, "Introduction to Instrumental Analysis", Pharma Book Syndicate, 1987. Ewing G.W., "Instrumental Methods of Chemical Analysis", 5th Edition, McGraw- Hill, 1985. Sharma D.K., "Instrumental Methods of Chemical Analysis", Analytical
Reference Books	 Sharma B.K., "Instrumental Methods of Chemical Analysis: Analytical Chemistry", Goel Publishing House, 1972. Haven Mary C., et.al., "Laboratory Instrumentation", 4thEdition, John Wiley, 1995.
Reference videos	https://youtu.be/spUNpyF58BY https://youtu.be/OiukFtC8E04 https://youtu.be/cJ9vweOnvbg https://youtu.be/8Q0VfIbhEmM https://youtu.be/dII05-g3LXY
Reference NPTEL	https://nptel.ac.in/courses/103108100
Reference research/ review articles	 Hemath, M., Mavinkere Rangappa, S., Kushvaha, V., Dhakal, H. N., & Siengchin, S. (2020). A comprehensive review on mechanical, electromagnetic radiation shielding, and thermal conductivity of fibers/inorganic fillers reinforced hybrid polymer composites. Polymer Composites, 41(10), 3940-3965. Pérez-Jiménez, A. I., Lyu, D., Lu, Z., Liu, G., & Ren, B. (2020). Surface- enhanced Raman spectroscopy: benefits, trade-offs and future developments. Chemical science, 11(18), 4563-4577. Züllig, T., & Köfeler, H. C. (2021). High resolution mass spectrometry in lipidomics. Mass spectrometry reviews, 40(3), 162-176. Murisier, A., Duivelshof, B. L., Fekete, S., Bourquin, J., Schmudlach, A., Lauber, M. A., & D'Atri, V. (2021). Towards a simple on-line coupling of ion exchange chromatography and native mass spectrometry for the detailed characterization of monoclonal antibodies. Journal of Chromatography A, 1655, 462499. Dao, T. T., Truong, D. D., Duong, L. N., Nguyen, N. N., & Nguyen, H. D. (2023). Preparation of Bacillus subtilis cell samples and generation of an SDS-PAGE. BioTechniques, 74(3), 123-129.

Course	Code		C	our	se T	itle					L		Т		Р		С			
10211B	T301	MICROB	ΙΟΙ	JOG	FY L	AB	ORA	AT(DRY	7	0		0		2		1			
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CO Nos	•		Cou	rse	Out	com	es						(1	10wl Based Dom's	on r	evise	d			
CO1	Demons laborato techniqu	•																		
CO2	identify	strate the ty techniques ganisms.																		
CO3		ustrate the working principles of microscopy an stinguish the morphology and type of microbes.													K4, S3					
CO4	Examin activity	e the effec	t of	dis dis	sinfe	ctan	ts a	and	ant	imi	croł	oial	K4, S4							
CO5		-	ecific growth rate of bacterial species in hemical conditions.											K	5, S4	4				
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CO Nos.	Course	Outcomes				Prog	gram	me O	lutco	mes	(POs	5)			S Ou	rogra pecifi itcom PSOs	c es			
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3			
CO1	regulations the lab handling o and ster	te the safety followed in oratory, f equipment rilization tiques.	Н	L	М	L	Н	Н	М	Н	М	М	-	М	Н	Н	Н			
CO2	of nutri medium a technique isolati preserv	tte the types ent broth nd identify es used for ion and vation of rganisms.	М	М	Н	L	М	М	М	L	М	М	-	М	Н	Н	Н			

CO3	Illustrate the working principles of micro scopy and distinguish the morphology and type of microbes.	Н	М	М	М	Н	М	L	М	М	Н	-	М	М	М	М
CO4	Examine the effect of disinfectants and antimicrobial activity.	М	Н	М	Н	Н	М	Н	М	М	Н	-	М	М	Н	М
CO5	Estimate the specific growth rate of bacterial species in various physiochemical conditions.	Н	Н	Н	Н	М	М	М	L	М	М	-	М	М	Н	Н

H – High; M- Medium; L- Low

LIST OF EXPERIMENTS:

- 1. Laboratory safety and sterilization techniques.
- 2. Culture Media-Types and Use; Preparation of Nutrient broth and agar
- 3. Culture Techniques, Isolation and Preservation of Cultures- Broth: flask, test tubes; Solid: Pour plates, streak plates, slants, stabs.
- 4. Quantification of Microbes: Sampling and Serial Dilution; Bacterial count in Soil TVC.
- 5. Staining techniques Simple and Gram's staining.
- 6. Effect of Disinfectants- Phenol Coefficient.
- 7. Antibiotic Sensitivity Assay.
- 8. Growth Curve in Bacteria and Yeast.
- 9. Effect of pH, Temperature, UV radiation on Growth Bacteria.
- 10. Biochemical test for identification of *E.coli*, *Bacillus*.

LEARNING RESOURCES

Reference Books	 Cappuccino J.G. and Sherman N., "Microbiology: A Laboratory Manual", 4thEdition, Addison-Wesley, 1999. Collee J.G.,<i>et al</i>, "Mackie & McCartney Practical Medical Microbiology"
DUURS	4 th Edition,Churchill Livingstone, 1996.
Virtual Lab	https://bio.libretexts.org/Courses/North_Carolina_State_University/MB352_G eneral_Microbiology_Laboratory_2021_(Lee)/01%3A_Laboratory_Safety/1.0 1%3A_Safety_Procedures_for_the_Microbiology_Laboratory https://bio.libretexts.org/Courses/North_Carolina_State_University/MB352_G eneral_Microbiology_Laboratory_2021_(Lee)/02%3A_Cultivation_of_Microb es/2.04%3A_Lab_ProceduresPrepare_solid_media_Aseptic_Technique_T- streaking https://vlab.amrita.edu/?sub=3&brch=73~=213&cnt=2 https://bio.libretexts.org/Courses/North_Carolina_State_University/MB352_G eneral_Microbiology_Laboratory_2021_(Lee)/05%3A_Enumeration_of_Bacte ria/5.03%3A_Lab_ProceduresViable_Plate_count

https://bio.libretexts.org/Learning_Objects/Laboratory_Experiments/Microbiol ogy_Labs/Book%3A_General_Microbiology_Lab_Manual_(Pakpour_and_Ho rgan)/Lab_03%3A_Simple_Negat ive_and_Gram_Stain
https://bio.libretexts.org/Bookshelves/Microbiology/Microbiology_(OpenStax) /13%3A_Control_of_Microbial_Growth/13.04%3A_Testing_the_ Effectiveness_of_Antiseptics_and_Disinfectants
https://medlineplus.gov/lab-tests/antibiotic-sensitivity-test/
https://bio.libretexts.org/Bookshelves/Microbiology/Microbiology_(Bruslind)/ 09%3A_Microbial_ Growth
https://bio.libretexts.org/Courses/Manchester_Community_College_(MCC)/Re mix_of_Openstax %3AMicrobiology_by_Parker_Schneegurt_et_al/08%3A_ Microbial_Growth/8.03%3A_The_Eff ects_of_pH_on_Microbial_Growth
https://bio.libretexts.org/Courses/North_Carolina_State_University/MB352_G eneral_Microbiology_Laboratory_2021_(Lee)/07%3A_Microbial_ Metabolism/7.01%3A_Introduction_to_Biochemi cal_Tests_Part_

Course	Code			Co	ours	e Tit	le						L]	Γ	P	0						
10211H	3T302	BIOCI	HEN	AIS	TRY	' LA	BO	RA	TO	RY			0	()	2	1						
Course C	Category	Program	n Co	re																			
Preamble	e	To learn quantitat									es b	ehin	d th	e qu	alita	tive	an						
Prerequi	site Cours	ses 10210Cl	H10.	2 - 1	Bioch	hemi	stry																
Course Outcome	upon :	successful con	nple	tion	of t	he co	ours	se, si	tude	ents	wil	l be	able	to:									
CO Nos.			Co	urse	Out	tcom	ies						Knowledge Lev (Based on revised Bloom's Taxonom										
CO1	Comp	rehend the prot	coco	l for	prej	parat	tion	of v	veak	c bu	ffer	s.	K2, S3										
CO2		ate the concent llitative and qu						tes a	and	am	ino	acid	ls K2, S3										
CO3	-	nalyse protein concentration in aqueous solution by using bectroscopic methods.														g K4, S4							
CO4	-	nalyse and identify the biomolecules using chromatograph ethods.														C K4, S4							
CO5	Evalua	ate the activity	of e	nzyı	mes	for d	liffe	rent	sub	ostra	ates				K5,	S5							
Correlati	on of COs	with POs:													1								
CO Nos.	Cours	e Outcomes				Prog	rami	me O	utco	mes	(POs	5)			S Ou	rogra pecifi utcom PSOs	c es						
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3						
	Comprehe protocol f of weak b	for preparation	Н	М	М	М	Н	_	-	Н	М	М	-	М	Н	М	N						
CO2	hydrates acids by c	the tion of carbo and amino qualitative and ve method	М	Н	Н	М	Н	М	-	М	М	Н	-	М	М	Н	E						
CO3	Analyse concentra aqueous using methods.	protein tion in solution by spectroscopic		Н	М	Н	Н	М	-	М	М	Н	-	М	Н	Н	N						
004	-	and identify olecules using graphic		Н	М	Н	Н	М	-	М	М	Н	-	М	Н	Н	N						

methods.

CO5	Evaluate the activity of enzymes for different substrates	М	Н	М	Н	Н	М	М	Н	М	М	-	М	М	Н	М
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H – High; M- Medium; L- Low

Course Content:

LIST OF EXPERIMENTS:

- 1. pH measurements and buffer preparation.
- 2. Qualitative tests for carbohydrates distinguishing reducing from non-reducing sugars and keto from aldo sugars.
- 3. Quantitative method for amino acid estimation using ninhydrin distinguishing amino from imino acid.
- 4. Quantification of sugars (Anthrone method).
- 5. Protein estimation by Biuret and Lowry's methods.
- 6. Estimation of Lipids by Zak's method.
- 7. Determination of saponification number of lipids.
- 8. Separation of amino acids Thin layer chromatography.
- 9. Quantification of nucleic acids using spectrophotometer.
- **10.** Estimate enzyme activity of alpha-amylase.

LEARNING RESOURCES

Text Books	
Reference Books	 Gupta R.C., and Bhargavan S., "Practical Biochemistry", 5th Edition, CBS Publishers and Distributors Pvt., Ltd., 2013. David T. Plummer., "Introduction of Practical Biochemistry", 2nd Edition, Mc Graw Hill, 1978.
Virtual Lab	https://chem.libretexts.org/Ancillary_Materials/Laboratory_Experiments/We t_Lab_Experiments/General_Chemistry_Labs/Online_Chemistry_Lab_Man ual/Chem_12_Experiments/05%3A_pH_Measurement_and_Its_Application s_(Experiment) https://biotech01.vlabs.ac.in/exp/analysis-of-carbohydrates/pretest.html https://vlab.amrita.edu/?sub=3&brch=63∼=156&cnt=1 https://www.studocu.com/in/document/k-l-deemed-to-be- university/biology/5-quantitative-analysis-of-carbohydrates-by-anthrone- method/75541219 https://vlab.amrita.edu/?sub=3&brch=64∼=1087&cnt=1 https://biotech01.vlabs.ac.in/exp/saponification-value-fats-oils/theory.html https://biotech01.vlabs.ac.in/exp/saponification-value-fats-oils/theory.html https://biotech01.vlabs.ac.in/exp/saponification-value-fats-oils/theory.html https://vlab.amrita.edu/?sub=3&brch=63∼=154&cnt=1 https://vlab.amrita.edu/?sub=3&brch=64∼=1342&cnt=1

Course	Code				Cou	irse	Titl	e					L	T		P	С	
10211B	T303	3 CELL BIOLOGY LABORATORY												0		2	1	
														1				
Course	Category	Progr	am	Core	е													
Preamb	le	To un Biolog		stan	d an	d pr	acti	ce t	he d	diffe	eren	t tec	hniq	ues a	used	in (Cell	
Prerequ	isite Courses	NIL																
Cours Outcon	I non cu	ccessful co	omp	letic	on of	the	coui	rse,	stuc	lent	s wi	ill be	able	e to:				
CO No	98.		Course Outcomes											(Dase loom ²	d on	revis	ed	
CO1		ry, handl	te the safety regulations followed in the handling of equipment and sterilization										K2, S3					
CO2		ent mici	15 5															
CO3	Make us and bloo		of staining methods to analyses the plant cells									;	K2, S4					
CO4		and di cules by so		•				co	mpo	oner	nts	and	l	K3, S4				
CO5		and evalu acterial sa			nun	nber	of	live	cel	ls a	nd	dead	K3, 85					
Correlat	ion of COs wit	h POs:													1			
CO Nos.	Course Out	comes				Prog	gram	me O	utco	mes	(POs)		Program Specific Outcomes (PSOs)				
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	Demonstrate t regulations for the laboratory, of equipme sterilization te	llowed in handling	М	L	-	-	Н	Н	М	Н	М	М	L	Н	Н	HL	-	
CO2	Illustrate the principles o contrast and fl microscopy to the components.	f phase uorescent	hase ccent ntify H H M M H M - M M H								-	М	Н	Н	М			
CO3	methods to an	te use of staining hods to analyses the t cells and blood M H M M H M - M M H									Н	-	М	М	Н	М		

CO4	Identify and distinguish cellular components and biomolecules by separation process	Н	М	Н	Н	М	М	Н	М	М	_	М	Н	Н	М
CO5	Analyse and evaluate the number of live cells and dead cells in bacterial sample	Н	М	М	Н	М	М	Н	М	М	-	М	Η	Н	М

H-High; M-Medium; L-Low

Course Content:

LIST OF EXPERIMENTS:

- 1. Principles of microscopy, phase contrast and fluorescent microscopy.
- 2. Identification of given plant, animal and bacterial cells and theirs components bymicroscopy.
- 3. Identification of cells in a blood smear using Leishman stain.
- 4. Giemsa staining.
- 5. Haemotoxylin Eosin Staining.
- 6. Osmosis and Tonicity.
- 7. Tryphan Blue Assay
- 8. Separation and identification of peripheral Blood mononuclear cells from blood.
- 9. Isolation of chloroplasts from spinach leaves
- 10. Staining for different stages of mitosis in Allium cepa (Onion).

LEARNING RES	OURCES
Reference Books	1. Rickwood D. and Harris J.R., "Cell Biology: Essential Techniques", John Wiley, 1996
Virtual Lab	https://openstax.org/books/microbiology/pages/2-3-instruments-of- microscopy https://www.labster.com/simulations/cell-structure https://myhematology.com/red-blood-cells/leishman-stain/ https://www.merckmillipore.com/IN/en/ivd-oem-materials-and- reagents/learning-center/giemsa- solution/r2ab.qB.aBwAAAFOqm81ISAJ,nav https://www.learnsci.com/resources/haematoxylin-eosin-h-e-stain-lab- simulation https://www.studocu.com/en-us/document/anne-arundel-community- college/fundamentals-of-biology-lab/lab-5-virtual-lab-tonicity-in-red- blood-cells/20723329 https://vlab.amrita.edu/?sub=3&brch=188∼=336&cnt=5 https://vlab.amrita.edu/?sub=3&brch=187∼=878&cnt=2 https://vlab.amrita.edu/?sub=3&brch=187∼=878&cnt=2 https://vlab.amrita.edu/?sub=3&brch=187∼=878&cnt=2

Course Cod	le	Course Title	L	Т	Р	С			
10211BT11	8	BIOCHEMISTRY	3	0	0	3			
Course Cate	gory	Program Core							
Preamble		biomol	lecule	s and	l its				
Prerequisite	rerequisite Courses NIL								
Course Outcomes	I non successful completion of the course students will be								
CO Nos.		Course Outcomes	(E	Knowledge Level (Based on revised Bloom's Taxonomy)					
CO1	Identificat thermodyr	ion of metabolic pathways and in a manic principles	ts	ł	K2				
CO2	Describe t amino acio	he structure and metabolism of nucleic acids an ls	d	ł	Χ3				
CO3	Outline th metabolism	ls	s K3						
CO4		e other biomolecules such as vitamins an s and its importance.	d	ł	Χ3				
CO5		lrugs for hormone deficiencies related variound disorders.	IS	ł	Χ3				

Correlation of COs with POs:

CO Nos.	Course Outcomes				Prog	ramı	ne O	utco	mes	(PO:	s)		-	S Ou	ograi pecifi itcom PSOs)	c es
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO2	Identification of metabolic pathways and its thermodynamic principles	м	Н		M	М							M	M	L	L
CO3	Describe the structure and metabolism of nucleic acids and amino acids		Н		М	М							М	М	L	L
CO4	Outline the different aspects of nucleic acid and lipids metabolism		Н		М	М							М	М	L	L
CO4	Utilize the other biomolecules such as vitamins and coenzymes and its importance.	Н	М	М									L	Н	М	

CO5 horr	elop drugs for none deficiencies ted various diseases disorders.		Н	Н	М	Н		М					М	М	Н	L
H – High; M	- Medium; L- Low															
Course Cont		NIT		100		мла	T	X 7				Ι		01.		
UNIT I	INTRODUCTIO and scope of bioch								ora	oni	a ah	amig		9 ho		, of
	Introduction to phy		•		-		-		-				•		•	
	ter as universal solv		č										•			
		ent.	PIII	leipi	01	VISC	osn	y, st	ITA	se t	ensi	on, a	mus	1011, 0	osmo	5818
in biological	1															
UNIT II	INTRODUCTIO													9 ho		
	nction and propert				•							•	•			
homopolysac	charides (starch and	d gl	ycog	gen)	; het	erop	poly	sacc	har	ide	s, Ca	arbol	hydra	ates,	Lip	ids:
classification	, structure, properti	es a	and	func	tion	s, A	min	no a	cid	s: c	lass	ificat	tion	and	gen	eral
properties, Pr	roteins: Primary, Se	cond	lary	, Tei	tiary	/ an	d Q	uate	rna	ry.	Nuc	leic a	acid:	stru	cture	e of
purine and py	rimidine															
UNIT III	METABOLIC PA			AYS	OF	CA	RB	он	YD]	RA	TES			9 ho	urs	
Metabolic pa	thways of Carbohyc	lrate	es - 1	Glyc	olys	is, (Gluc	coge	nesi	is, (Gluc	ogen	olys	is, T	CA	and
ETC; Metabo	lism of fatty acids, s	synt	hesis	s and	l deg	grada	atio	n of	fatt	y ao	cids.					
UNIT IV	METABOLIC PA	ATH	IW	AYS	OF	NU	CLI	EIC	AC	ID	S AN	ND		9 ho	urs	
Biosynthesis	of nucleotides, de	nov	/o a	nd s	salva	ge	path	iway	vs f	or	purii	nes a	and j	pyrir	nidiı	nes,
regulatory me	echanisms: Degradat	ion	ofn	ıclei	c aci	d by	/ exe	o ano	d en	do	nucl	eases	s. Tri	acylg	glyce	erol
and phospho	lipid biosynthesis a	nd d	legra	ıdati	on; (Cho	leste	erol	bio	syn	thesi	is an	d reg	gulat	ion	and
targets and ac	tion of cholesterol l	owe	ring	drug	gs, si	tatin	s.									
UNIT V	BIOENERGETI	CS												9 ho	urs	
Bioenergetics	- High energy com	ipou	nds,	eleo	ctron	lega	tive	pot	enti	al c	of co	mpo	unds	, res	pirat	ory
chain, ATP c	ycle, calculation of A	ATP	yie	ld dı	iring	oxi	dati	on c	f gl	ucc	ose a	nd fa	atty a	cids.		
LEARNING	RESOURCES															
	1. Nelson D.L., C McMillan Lea						-			Prin	cipl	es c	of Bio	ochei	mist	ry",
Text Books	2. Voet D.J., Vo Edition, John								Prin	cipl	les c	of Bi	ioche	emist	ry",	3 rd
	3. Murray R.K., McGraw-Hill,			Harp	er's	Illus	strat	ed E	Bioc	her	nistr	y". 2	XXV	IIth	Editi	ion,

Reference Books	 Berg J.M., Tymoczko, J.L. and Stryer, L., "Biochemistry",6th Edition, WH Freeman, 2006. Salway J.G., "Metabolism at a Glance", 2nd Edition, Blackwell Science Ltd., 2000.
Reference videos	https://youtu.be/SeOrvA9ikW8 https://youtu.be/NIvhyULL3s0 https://youtu.be/WuQS_LpNMzo https://www.youtube.com/watch?v=zpk1p1197u4 https://www.youtube.com/watch?v=1cxXwoyyOk4
Reference NPTEL	https://onlinecourses.nptel.ac.in/noc24_bt12/preview
Reference research/ review articles	 Shao, X., Fredericks, S. A., Saylor, J. R., & Bostwick, J. B. (2020). A method for determining surface tension, viscosity, and elasticity of gels via ultrasonic levitation of gel drops. The Journal of the Acoustical Society of America, 147(4), 2488-2498. Van Eker, D., Samanta, S. K., & Davis, A. P. (2020). Aqueous recognition of purine and pyrimidine bases by an anthracene-based macrocyclic receptor. Chemical Communications, 56(65), 9268-9271. Paredes-Flores, M. A., Rahimi, N., & Mohiuddin, S. S. (2024). Biochemistry, glycogenolysis. In StatPearls [Internet]. StatPearls Publishing. Long, T., Debler, E. W., & Li, X. (2022). Structural enzymology of cholesterol biosynthesis and storage. Current opinion in structural biology, 74, 102369. Seyfried, T. N., Arismendi-Morillo, G., Mukherjee, P., & Chinopoulos, C. (2020). On the origin of ATP synthesis in cancer. Iscience, 23(11).

GENETIC ENGINEERING / MOLECULAR BIOLOGY

Course	Code				Cou	rse '	Titl	e					L	Т	'	P	С			
10211B	5T104	4 MOLECULAR BIOLOGY: CONCEI AND TECHNIQUES												0		0	3			
~	~																			
Course	Category	Progra				.1		1	,	• .1		1.		1	. ,		1			
Preamb	le	To hav functio		imili	ariz	e th	e st	uaei	nt n	viin	nu	cieic	acı	as si	ructi	ure	ana			
Prerequ	isite Cours	es 10211E 10211E					0	~												
Cours Outcom	$ I / n_0 n$	successful co	mpl	etio	n of i	the c	our	se, s	tud	ents	s wi	ll be	able	to:						
CO No	s.		Course Outcomes											Knowledge Level (Based on revised Bloom's Taxonomy)						
CO1		rstand the phy ic acids	nd the physiochemical and, structural properties of cids										2	K2						
CO2		date the con- anism.	e the concepts of DNA replication and repair K2																	
CO3		onstrate the ryotic and eul			-				l er	nhai	ncei	s ir	K2							
CO4		rate the proce fictions.	ess o	of tr	ansla	ation	an	d po	ost t	ran	slat	iona			K2	,				
CO5	· ·	in the key ryotic and eul					g	ene	reş	gula	atio	n ir	1		K2					
Correlat	ion of COs	with POs:																		
CO Nos.	Course	Outcomes				Prog	ramı	me O	utco	mes	(PO	5)			S Ou	rogra pecifi utcom PSOs	ic ies			
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3			
CO1	chemical a	d the physio nd, structural of nucleic	Н	Н										Н		M				
CO2		the concepts plication and hanism.	Н	Н										H M						
CO3	Demonstra promoters enhancers prokaryotic eukaryotic Transcripti	in c and	Η	Η	Н									H M L						

CO4	Illustrate the process o translation and pos translational modifictions.		Н										Н		М	L
CO5	Explain the key mechanism of gene regulation in prokaryotic and eukaryotic cells.	М	М		Н	Н							Н		Н	
H – Hig	h; M- Medium; L- Low			•							•		•	•		
	Content:															
UNIT I	CHEMISTRY C) hou		
	tion to nucleic acids: Nu				•											
propertie	es of elements in DNA	and I	RNA	, Bi	olog	ical	sign	nific	anc	e o	f dif	ferer	nces	in Dl	NA a	and
RNA. P	rimary structure of DNA	4: C	hemi	ical	and	stru	ctur	al q	uali	ties	s of	3', 5	'-Ph	ospho	odies	ster
bond. Se	condary Structure of D	JA: V	Vats	on 8	z Cri	ck r	nod	el, C	Cha	rgat	ff's r	ule, I	X—ra	y dif	fract	ion
analysis	of DNA, Forms of DNA	A, C	onfo	rmat	iona	l va	rian	ts o	f do	oub	le he	lical	DN.	A, H	ogst	een
base pai	ring, Triple helix, Quad	ruple	heli	ix, R	lever	sibl	e de	enati	urat	ion	and	hyp	erchr	omic	effe	ect.
Tertiary	structure of DNA: DN	A su	perc	oilin	g. S	truc	ture	and	d fi	Incl	ion	of m	RNA	A, r-F	RNA	, t-
RNA. Se	econdary structures in R	NA.														
UNIT I	I DNA REPLICA	TIO	N										ç) hou	irs	
~ ·	ation of prokaryotic and	euka	ryoti	ic ch	rom	osoi	nes	DN	JA 1	repl	icati	on: N	Mese	lson	& St	ahl
Organiza								c	agm	ent	s, I	rote	omic	s of	, DI	NΔ
-	ent, bi-directional DN	A r	eplic	catio	n, (Okaz	zaki	Ira	8							N/L
experim	ent, bi-directional DN on, Fidelity of DNA repl		_						-	tio	n, Oʻ	vervi	ew o	f diff		
experim replicati		icatio	on, Ir	nhibi	tors	ofE	DNA	rep	lica						eren	ces
experime replication in prokat	on, Fidelity of DNA repl	icatio NA re	on, Ir	nhibi	tors	ofE	DNA	rep	lica						eren	ces
experime replication in prokat	on, Fidelity of DNA repl ryotic and eukaryotic DN ircle mode of replication	icatio NA re 1.	on, Ir	nhibi	tors	ofE	DNA	rep	lica				votes		èren oop a	ces
experime replication in prokat rolling c UNIT II	on, Fidelity of DNA repl ryotic and eukaryotic DN ircle mode of replication	icatio NA re n. ON	on, Ir	nhibi atior	tors 1, Te	of E lom	ONA ere	repl	licat	ion	in e	ıkary	votes	; D-lo) hou	Yeren Dop a	ces and
experime replication in prokat rolling c UNIT II Characte	on, Fidelity of DNA repl ryotic and eukaryotic DN ircle mode of replication	icatio NA re n. ON enhai	on, Ir eplication	nhibi atior	tors n, Te	of E lom es. F	NA ere 1 RNA	repl repl	licat	ion sis:	in er	ikary	votes	; D-le) hou	eren oop a urs ion a	ces and
experime replication in prokat rolling c UNIT II Characte terminat	on, Fidelity of DNA repl ryotic and eukaryotic DN ircle mode of replication II TRANSCRIPTI eristics of promoter and o	icatio IA re 1. ON enhar	on, Ir eplication	nhibi atior sequ	itors n, Te lence A syn	of E lom es. F	ONA ere 1 RNA sis,	repl repl syr	licat icat	ion sis: v of	in en Init	iation	votes <u>y</u> n, elo nthes	; D-le) hou ongat is, In	eren oop a urs ion a hibit	ces and and ors
experime replication in prokator rolling control UNIT II Character terminator of transco	on, Fidelity of DNA repl ryotic and eukaryotic DN ircle mode of replication II TRANSCRIPTI eristics of promoter and ion of RNA synthesis, Ph	icatio NA re n. ON enhai roteir	on, Ir eplication ncer ns of yotic	nhibi atior sequ RNA	itors n, Te lence A syn l euk	of E lom es. F nthe	ONA ere RNA sis, otic	repl repl syr Fide tran	licat icat nthe elity scri	ion esis v of ptic	in er Init RN/	iation A syr	votes , elo n, elo nthes conc	; D-lo) hou ongat is, In epts	eren oop a urs ion a hibit	ces and and ors NA
experime replication in prokator rolling control UNIT II Character terminator of transco world: F	on, Fidelity of DNA repl ryotic and eukaryotic DN ircle mode of replication II TRANSCRIPTI eristics of promoter and ion of RNA synthesis, Ph ription, Differences in pr	icatio NA re n. ON enhai roteir	on, Ir eplication ncer ns of yotic	nhibi atior sequ RNA	itors n, Te lence A syn l euk	of E lom es. F nthe	ONA ere RNA sis, otic	repl repl syr Fide tran	licat icat nthe elity scri	ion esis v of ptic	in er Init RN/	iation A syr	votes , elo n, elo nthes conc	; D-lo) hou ongat is, In epts	eren oop a urs ion a hibit	ces and and ors NA
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translational modifications and its importance.

UNIT V	REGULATION OF GENE EXPRESSION AND DNA REPAIR	9 hours
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Regulation of genes – replication- transcription & translation factors; Lac and trp operon; Mutation – transition- transversion- artificial & natural mutation; suppressor mutation; Repair of DNA.

LEARNING	RESOURCES
Text Books	 Friefelder David, "Molecular Biology", Narosa Publications, 1999 Weaver, Robert F., "Molecular Biology", 2ndEdition, Tata McGraw-Hill, 2003. Friefelder David and George M. Malacinski, "Essentials of Molecular Biology", 2nd Edition, Panima Publishing, 1993.
Reference Books	 Tropp Burton E., "Molecular Biology: Genes to Proteins", 3rd Edition, Jones and Bartlett, 2008. Glick B.R. and Pasternak J.J., "Molecular Biotechnology: Principles and Applications of Recombinant DNA", 4th Edition, ASM, 2010.
Reference videos	https://www.youtube.com/watch?v=GGW4ufsvQWo https://www.youtube.com/watch?v=EO2DBj3D71k https://www.youtube.com/watch?v=JhP3kHVmicw https://www.youtube.com/watch?v=nX18E81nmFs https://www.youtube.com/watch?v=yrJn-7k_5Fc
Reference NPTEL	https://onlinecourses.nptel.ac.in/noc24_bt07/preview
Reference research/ review articles	 Fariselli, P., Taccioli, C., Pagani, L., & Maritan, A. (2021). DNA sequence symmetries from randomness: the origin of the Chargaff's second parity rule. Briefings in bioinformatics, 22(2), 2172-2181. Sánchez, H., McCluskey, K., van Laar, T., van Veen, E., Asscher, F. M., Solano, B., & Dekker, N. H. (2021). DNA replication origins retain mobile licensing proteins. Nature communications, 12(1), 1908. Georgakopoulos-Soares, I., Parada, G. E., & Hemberg, M. (2022). Secondary structures in RNA synthesis, splicing and translation. Computational and structural biotechnology journal, 20, 2871- 2884. Nieuwkoop, T., Finger-Bou, M., van der Oost, J., & Claassens, N. J. (2020). The ongoing quest to crack the genetic code for protein production. Molecular cell, 80(2), 193-209. Crowther, A., Bergan-Roller, H. E., Galt, N. J., Booth, C. S., Dauer, J. T., & Helikar, T. (2021). Discovering prokaryotic gene regulation with simulations of the trp operon.

Course		Course Title													P	С			
10211B	G	GENETIC ENGINEERING											0)	0	3			
Course (Category	Progra	m (Core	,														
Course	category	The course is designed to familiarize the student with use of tools																	
Preambl	le		and techniques for the manipulation and analysis of genetic																
			material.																
Prerequ	isite Course		10211BT102 – Cell Biology 10211BT104 – Molecular biology: concepts and techniques																
		102111	511	04 -	- 1010	iecu	uri	<i><i>л</i>оп</i>	<u>igy.</u>	10	nce	pis u	nu i	ecnn	ique	3			
Cours	se Unon	successful co	omr	lotic	n of	the	cou	rso	stu	lont	C 147	ill ha	ahl	e to:					
Outcon	nes	successful co	Jinp		m 0j	inc	cou	, sc,	Sinc	ieni	5 11					T			
CO No	os.		Co	urs	e Ou	tcor	nes							now Base					
										•				loom'					
CO1	Select	the various	s n	nanip	ulati	ng	tool	s u	sed	ın	ge	netic			K3				
CO2	0	the vectors fo	r clo	oning	g and	expi	essi	on o	f gei	ne of	f int	erest			K3				
CO3		ise of cloning	met	thods	s to c	onstr	uct]	DNA	Alib	ary	for	gene			K3				
	Elucid	ng ate the use of	mod	lern 1	0010	and	tech	niau	es to	ide	ntif	v the	-						
CO4	DNA f	inger printing	g and	l seq	uenc	ing		1				-			K3				
CO5		the genetic m						ety r	egul	atio	ns i	n the			K4				
	domair	n of food, mee		ie an	a ag	ricui	lure						1						
Correlat	ion of COs w	ith POs:																	
															Program Specific				
CO Nos.	Course O	utcomes				Prog	ram	me O	utco	mes	(POs	5)	Outcomes						
			1	2	3	4	5	6	7	8	9	10	11	12	(PSOs) 1 2 3				
	Select the	e various	-	_		-					-	10			-				
CO1	manipulating	-	Н	Н										Н		Μ			
	in genetic er Apply the																+		
CO2	cloning and		Н	н	н	н	Н			Н				Н	М	Н	H		
	of gene of in																		
	Make use	0																	
CO3	methods to DNA librar		Н	Н	Н	Н			Η					M	Н	Η			
	mapping.	y for gene																	
	Elucidate t																		
CO4		ools and	TT	м	м		тт	тт	тт	11				тт	тт	т			
CO4	techniques the DNA fin		Н	M	M		H	H	H	H				H	Н	L			
	and sequenc																		
	Apply the	•																	
	modification								Н						Н	Н	Н		
CO5	biosafety reg the domain		Η	Н	Н	Н				Н			Η	М					
	Medicine	and														1			
	agriculture.																L		
H – High	n; M- Mediur	n; L- Low																	

Course Content:							
UNIT I BASICS OF GENETIC ENGINEERING	9 hours						
Overview of recombinant DNA technology and its applications. Recombinant	t DNA technology						
tools - Restriction and Modifying systems: Biological importance, Classification,							
Nomenclature, Applications in recombinant DNA technology - Cohesive ends, blunt ends,							
Isoschizomers, Neoschizomers, Star activity, Compatible cohesive ends,	DNA polymerase,						
DNA ligase, Alkaline phosphatase - Inter and intra molecular ligation, Poly	nucleotide kinase,						
Terminal transferase and Exonuclease, Linkers and adpators; Safety guideli	ne of recombinant						
DNA research.							
UNIT II CLONING VECTORS	9 hours						
Plasmid vector: Cloning site, Selection, Screening, Host range – shuttle							
compatibility, copy number regulation and TA cloning. Bacteriophage vector	r: λDNA vectors –						
Insertional and replacement vectors, in vitro packaging, Size based selection	and Spi ⁻ selection.						
Single strand DNA vectors: M13 phage vector and its applications. Com	binatorial vectors:						
Cosmid and Phagemid. Artificial chromosomes: Bacterial and yeast artificial	l chromosomes.						
UNIT III CONSTRUCTION OF LIBRARIES	9 hours						
Construction of genomic and cDNA library: Methods, Chromosomal walki	ng, Limitations in						
cDNA library construction and full-length cDNA library construction; Screen	eening of libraries						
with DNA probes and antisera; Characterization of recombinant clones by Se	outhern, Northern,						
Western - PCR analysis.							
UNIT IV TECHNIQUES USED IN GENETIC ENGINEERING	9 hours						
Polymerase Chain reaction: Principle and Steps in PCR, Types of PCR - Inv	verse PCR, Nested						
PCR, AFLP-PCR, Hot start PCR, Colony PCR, Methylation specific PCR and single cell PCR.							
Real-time PCR/qPCR and its advantages - SYBR green assay, Taqman assay, Molecular							
beacons. DNA sequencing: Maxam Gilbert's and Sanger's methods of DNA sequencing,							
Pyrosequencing, Nanopore DNA sequencing, Next generation sequencing.							
UNIT V APPLICATIONS OF GENETIC ENGINEERING	9 hours						
Site directed mutagenesis: Primer extension method, Kunkel's method and	d PCR based site-						
directed mutagenesis. Applications of genetic engineering in medicine, agriculture, creation of							
knockout animals, transgenic animals; gene silencing and gene therapy.							

LEARNING	RESOURCES
Text Books	1. Old R.W., Primrose S.B., "Principles of Gene Manipulation, An Introduction to Genetic Engineering", Blackwell Science Publications, 1993.
Reference Books	 Ansubel F.M., Brent R., Kingston R.E., and Moore D.D., "Current Protocols In Molecular Biology", Greene Publishing Associates, NY, 1988. Berger S.L., Kimmer A.R., "Methods in Enzymology", Vol. 152, Academic Press, 1987.
Reference videos	https://www.youtube.com/watch?v=i48eAyBPi2c https://www.youtube.com/watch?v=S8Z1_JwIRHM https://www.youtube.com/watch?v=a5jmdh9AnS4 https://www.youtube.com/watch?v=ONGdehkB8jU https://www.youtube.com/watch?v=J2Y_S4EkLy8
Reference NPTEL	https://onlinecourses.nptel.ac.in/noc22_bt59/preview
Reference research/ review articles	 Akram, M., Jabeen, F., Daniyal, M., Zainab, R., ul Haq, U., Adetunji, C. O., & Ogbo, A. B. (2020). Genetic engineering of novel products of health significance: Recombinant DNA technology. Functional Foods and Nutraceuticals: Bioactive Components, Formulations and Innovations, 595- 611. Cronan, J. E. (2023). Two neglected but valuable genetic tools for Escherichia coli and other bacteria: In vivo cosmid packaging and inducible plasmid replication. Molecular Microbiology, 120(6), 783-790. Ying, S. Y., Lui, H. M., Lin, S. L., & Chuong, C. M. (2024). Generation of full-length cDNA library from single human prostate cancer cells. Biotechniques, 27(3). Shirmohammadi, A., Babaloo, A., Maleki Dizaj, S., Lotfipour, F., Sharifi, S., Ghavimi, M. A., & Khezri, K. (2021). A view on polymerase chain reaction as an outstanding molecular diagnostic technique in periodontology. BioMed Research International, 2021(1), 9979948. Bezie, Y., Tilahun, T., Atnaf, M., & Taye, M. (2021). The potential applications of site-directed mutagenesis for crop improvement: A review. Journal of Crop Science and Biotechnology, 24, 229-244.

Course Code			Course Title L											Т	P		С			
10211B		DLECULAR BIOLOGY AND ENETIC ENGINEERING LABORATORY											0	2		1				
Course	Category	Dr	oar		Tora															
			Program Core To understand and have the hands on experience of techniques														ues			
Preamb		uti	utilized in molecular biology and genetic engineering																	
Prerequ	isite Course	s 10.	10211BT104 - Molecular Biology: Concepts and Techniques													5				
Cours Outcon	1/n0n	successful co	omp	letio	on of	the	coui	rse, ,	stua	lent	s wi	ill be	e able	e to:						
CO No	os.		Co	urse	Out	com	ies						(1	Based	on r	ge Level revised xonomy)				
CO1	Identit metho	fy the cellula d.	ar ai	nd g	enor	nic I	DNA	A by	pre	ecip	itati	ion		K	3, S	3				
CO2			d analyse the fragments of DNA based on veight (Gel electrophoresis)												3, S4	4				
CO3	Apply enzym	and analyse es.	DN	A fr	agm	enta	tion	s usi	ing	rest	ricti	ion	K3, S4							
CO4		•	examine DNA transformation for the K3, S5 frecombinant cells.																	
CO5 Analyse the trans PCR studies.				nsformation efficiency by SDS PAGE and K4, S5																
Correlat	ion of COs v	vith POs:																		
CO Nos. Course Outcomes				Programme Outcomes (POs)											S Ou	ogra pecifi itcom PSOs	c es			
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3			
CO1	Identify the genomic precipitation	DNA by		М	-	L	М	-	-	Н	М	L	-	Н	Н	Н	н			
CO2	the fragmer based on its weight	istinguish and analyse e fragments of DNA used on its molecula eight (Ge ectrophoresis)			М	Н	Н	М	-	М	М	Н	-	М	Н	Н	Н			
CO3	Apply an DNA fraș using enzymes.	d analyse gmentations restriction		Н	М	Н	Н	М	-	Н	М	М	-	М	Н	Н	Н			

CO4	Identify and examine DNA transformation for the development of recombinant cells.	τī	Н	Н	М	Н	М	-	н	М	Н	-	М	Н	Н	Н
CO5	AnalysethetransformationefficiencybySDSPAGEandPCRstudies.	Η	Н	М	Н	Н	М	-	М	М	Η	-	Н	Н	Н	Н

H-High; M-Medium; L-Low

Course Content:

LIST OF EXPERIMENTS:

- 1. Isolation of Genomic DNA (Bacterial cell, Animal cell and Plant cell).
- 2. Isolation of plasmid DNA.
- 3. Agarose gel electrophoresis.
- 4. Purification of DNA from agarose gel.
- 5. Restriction enzyme digestion and ligation.
- 6. Competent cell preparation (Calcium chloride method).
- 7. Transformation and screening of recombinants (Blue white selection method).
- 8. Induction and Analysis of Gene expression.
- 9. SDS PAGE analysis.
- 10. Polymerase Chain reaction (PCR).

LEARNING RESOURCES

Reference Books	 Sambrook, J and Russell D.W., "The Condensed Protocols: From Molecular Cloning: A Laboratory Manual", Cold Spring Harbor, 2006. Ansubel F.M., Brent. R., Kingston R.E. and Moore D.D., "Current Protocols in Molecular Biology", Greene Publishing Associates, 2003.
Virtual Lab	https://www.stemcell.com/protocol-for-genomic-dna-isolation-from-mouse-tail- animal-tissue-or-cultured-cells.html https://vlab.amrita.edu/?sub=3&brch=77∼=314&cnt=1 https://vlab.amrita.edu/?sub=3&brch=77∼=1375&cnt=2 https://vlab.amrita.edu/?sub=3&brch=77∼=1365&cnt=2 https://vlab.amrita.edu/?sub=3&brch=77∼=694&cnt=1 https://vlab.amrita.edu/?sub=3&brch=77∼=702&cnt=2#:~:text=Pick%20a% 20single%20bacterial%20colony,the%20growth%20of%20the%20culture. https://vlab.amrita.edu/?sub=3&brch=77∼=1107&cnt=1 https://vlab.amrita.edu/?sub=3&brch=237∼=1249&cnt=1 https://vlab.amrita.edu/?sub=3&brch=186∼=321&cnt=1

CHEMICAL ENGINEERING

Course	Code				Co	urse	Tit	le					L]	Γ	P	С
10211B	ST106		C			AL I INE				N			3	()	0	3
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Course	Category	Progra			1		1			1				<i>c</i>			1.
Preamb	le	To stud biotech										0	0 0		ctors	s use	d in
Prerequ	isite Courses	10211E 10211E 10211E	<i>ST1</i>	10 - 1	Biop	proce	ess E	Engi	neer	ring	5			nolog	<u>3</u> y		
Course Outcom	$ I / n \cap n \circ u$	ccessful con	nple	etion	of ti	he co	ours	e, st	ude	nts	will	l be c	able i	to:			
CO No	s.		Co	urse	Ou	tcon	ies							now (Base loom	d on	revis	ed
CO1		and infernent of rate				of	rea	ctio	n k	ine	tics	and	l		K2		
CO2		rate equation CSTR and P			liffe	rent	type	es of	f ide	eal r	eac	tions	5		K3		
CO3		t the mat s for single							rep	res	ent	rate	;		K3		
CO4		e of dispers					serie	es m	node	el to	tes	st the	;		K3		
CO5	Apply th	e knowledg	e oi	n dev	veloj	pmei	nt of	fnov	vel ł	oior	eac	tors.			K3		
Correlat	ion of COs w	ith POs:															
CO Nos.	Course O	utcomes				Prog	gram	me O	utco	mes	(POs	s)				rogra pecifi utcom PSOs	ic 1es
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Illustrate and basics of kinetics development equations.	reaction and		Н		Н	н							Н	Н	Н	
CO2	Develop rate for different ideal reactio CSTR and P	t types of ons (Batch,		Н		Н	н	Н						Н	Н	Н	
CO3	Construct mathematica represent rate for multiple	e equations	н	Н		Н	Н	Н						Н	Н	Н	

and		
	tank in series model II	
to te	est the performance $ \mathbf{H} \mathbf$	H H H
	on-ideal reaction.	
App CO5 on	ly the knowledge development of H H H H	Н Н Н
	el bioreactors.	
H – High; M	- Medium; L- Low	
Course Cont	ent:	
UNIT I	SCOPE OF CHEMICAL KINETICS & CHEMICAL REACTION ENGINEERING	9 hours
Broad outlin	e of chemical reactors; reaction system, chemical kinetic	s, rate equation,
Elementary a	nd non- elementary reactions. Molecularity and order, depen	dence of rate on
concentration	, temperature dependent term of a rate equation, concept of a	ctivation energy -
Arrhenius the	eory, collision theory, transition state theory. Methods to dete	ermine order of a
reaction- Inte	gral & differential method of analysis of data, Half-life method.	
UNIT II	IDEAL REACTORS	9 hours
	atch, flow, semi-batch reactors; Concept of ideal flow, space t	
	equations for single reactors: Batch reactors, Continuous stir	-
-	g flow reactors (PFR).	red tunk redetors
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UNIT III	DESIGN OF MULTIPLE REACTOR SYSTEM	
D : 0 :		9 hours
-	ngle reaction: size comparison of single reactors; multiple reactor	or systems (Mixed
flow reactors	in series and parallel connection, Plug flow reactors in se	or systems (Mixed eries and parallel
flow reactors		or systems (Mixed eries and parallel
flow reactors	in series and parallel connection, Plug flow reactors in se	or systems (Mixed eries and parallel
flow reactors connection); T	in series and parallel connection, Plug flow reactors in semultiple reactions, and qualitative analysis of product distribution	or systems (Mixed eries and parallel on. 9 hours
flow reactors connection); UNIT IV Reason for no	in series and parallel connection, Plug flow reactors in semultiple reactions, and qualitative analysis of product distribution IDEAL FLOW AND NON-IDEAL FLOW	or systems (Mixed eries and parallel on. 9 hours onship between E
flow reactors connection); r UNIT IV Reason for no and F curve,	in series and parallel connection, Plug flow reactors in semultiple reactions, and qualitative analysis of product distribution IDEAL FLOW AND NON-IDEAL FLOW on-ideality, Residence time distribution, E curve, F curve, relation	or systems (Mixed eries and parallel on. 9 hours onship between E te of aggregation-
flow reactors connection); r UNIT IV Reason for no and F curve, micro and ma	in series and parallel connection, Plug flow reactors in semultiple reactions, and qualitative analysis of product distribution IDEAL FLOW AND NON-IDEAL FLOW on-ideality, Residence time distribution, E curve, F curve, relationship between mean residence time and space time, State	or systems (Mixed eries and parallel on. 9 hours onship between E te of aggregation-
flow reactors connection); r UNIT IV Reason for no and F curve, micro and ma tanks in series	in series and parallel connection, Plug flow reactors in semultiple reactions, and qualitative analysis of product distribution IDEAL FLOW AND NON-IDEAL FLOW on-ideality, Residence time distribution, E curve, F curve, relationship between mean residence time and space time, State acro fluid, Earliness or lateness of mixing, basic models for non s model and dispersion model.	or systems (Mixed eries and parallel on. 9 hours onship between E te of aggregation- -ideal reactor like
flow reactors connection); r UNIT IV Reason for no and F curve, micro and ma tanks in series UNIT V	in series and parallel connection, Plug flow reactors in semultiple reactions, and qualitative analysis of product distribution IDEAL FLOW AND NON-IDEAL FLOW on-ideality, Residence time distribution, E curve, F curve, relationship between mean residence time and space time, State acro fluid, Earliness or lateness of mixing, basic models for non s model and dispersion model. GAS-SOLID, GAS-LIQUID REACTORS	or systems (Mixed eries and parallel on. 9 hours onship between E te of aggregation- -ideal reactor like 9 hours
flow reactors connection); r UNIT IV Reason for no and F curve, micro and ma tanks in series UNIT V G/L reactions	 in series and parallel connection, Plug flow reactors in semultiple reactions, and qualitative analysis of product distribution IDEAL FLOW AND NON-IDEAL FLOW on-ideality, Residence time distribution, E curve, F curve, relationship between mean residence time and space time, State acro fluid, Earliness or lateness of mixing, basic models for non s model and dispersion model. GAS-SOLID, GAS-LIQUID REACTORS con solid catalysis; trickle bed, slurry reactors; three phase-fluidities 	or systems (Mixed eries and parallel on. 9 hours onship between E te of aggregation- -ideal reactor like 9 hours
flow reactors connection); r UNIT IV Reason for no and F curve, micro and ma tanks in series UNIT V G/L reactions	in series and parallel connection, Plug flow reactors in semultiple reactions, and qualitative analysis of product distribution IDEAL FLOW AND NON-IDEAL FLOW on-ideality, Residence time distribution, E curve, F curve, relationship between mean residence time and space time, State acro fluid, Earliness or lateness of mixing, basic models for non s model and dispersion model. GAS-SOLID, GAS-LIQUID REACTORS	or systems (Mixed eries and parallel on. 9 hours onship between E te of aggregation- -ideal reactor like 9 hours
flow reactors connection); f UNIT IV Reason for no and F curve, micro and ma tanks in series UNIT V G/L reactions for fluid-fluid	 in series and parallel connection, Plug flow reactors in semultiple reactions, and qualitative analysis of product distribution IDEAL FLOW AND NON-IDEAL FLOW on-ideality, Residence time distribution, E curve, F curve, relationship between mean residence time and space time, State acro fluid, Earliness or lateness of mixing, basic models for non s model and dispersion model. GAS-SOLID, GAS-LIQUID REACTORS on solid catalysis; trickle bed, slurry reactors; three phase-fluidi l reactions; tank reactors. 	or systems (Mixed eries and parallel on. 9 hours onship between E te of aggregation- -ideal reactor like 9 hours
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Reference Books	 Missen R.W., Mims C.A., and Saville B.A., "Introduction to Chemical Reaction Engineering and Kinetics", John Wiley, 1999. Dawande, S.D., "Principles of Reaction Engineering", Ist Edition, Central Techno Publications, 2001.
Reference videos	https://www.youtube.com/watch?v=rCeSCjC4BjU https://www.youtube.com/watch?v=fQOzHC828aM https://www.youtube.com/watch?v=pIsGeffJGgo https://www.youtube.com/watch?v=MRe07mhFaJs https://www.youtube.com/watch?v=DLbhAS2Ww6U
Reference NPTEL	https://archive.nptel.ac.in/courses/103/106/103106116/
Reference research/ review articles	 Taylor, C. J., Pomberger, A., Felton, K. C., Grainger, R., Barecka, M., Chamberlain, T. W., & Lapkin, A. A. (2023). A brief introduction to chemical reaction optimization. Chemical Reviews, 123(6), 3089-3126. Cherkasov, N., Adams, S. J., Bainbridge, E. G., & Thornton, J. A. (2023). Continuous stirred tank reactors in fine chemical synthesis for efficient mixing, solids-handling, and rapid scale-up. Reaction Chemistry & Engineering, 8(2), 266-277. Dong, Z., Wen, Z., Zhao, F., Kuhn, S., & Noël, T. (2021). Scale-up of micro- and milli-reactors: An overview of strategies, design principles and applications. Chemical Engineering Science: X, 10, 100097. Lele, A. D., & Ju, Y. (2023). Assessment of the impact of reactor residence time distribution on non-equilibrium product selectivity of polypropylene pyrolysis using reactive molecular dynamics simulations. Fuel, 338, 127328. Alwared, A. I., & Jaber, W. S. (2020). Spiral path three phase fluidized bed reactor for treating wastewater contaminated with engine oil. Applied Water Science, 10(9), 1-11.

MASS TRANSFER OPERATIONS IN			P	С
BIOTECHNOLOGY	3	0	0	3
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Program Core				
To understand the essential concepts and va mass transfer in biotechnological industries.	arious	appli	cation	is of
10211BT104 – Principles of Chemical Engine 10211BT112– Unit Operations in Biotech Indu				
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essful completion of the course, students will be	able	to:		
Course Outcomes	(nowle Based o oom's '	on revi	sed
ate and infer the concepts of molecular diffusion luids and interphase between two phases.	1	ł	K2	
ne efficiency of distillation process on separation compounds.	1	ł	Κ4	
ne efficiency of absorption process in gas-liquid fer operations	ł	ł	Χ4	
he efficiency of absorption process in Liquid s transfer operations.	-	ł	Χ4	
e performance of adsorption process in solid	-	I	Χ4	
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Correlation of COs with POs:

CO Nos.	Course Outcomes		Programme Outcomes (POs)													m c les)
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Demonstrate and infer the concepts of molecular diffusion in solids, fluids and interphase between two phases.		М	М	М								М	Н	Н	
CO2	Analyse the efficiency of distillation process on separation of volatile compounds.	т	М	Н	Н		Н						М	Н	Н	Н
CO3	Analyse the efficiency of absorption process in gas-liquid mass transfer operations	т	М	Н	Н		Н						М	Н	Н	Н

CO4 CO4	nalyse the efficiency f absorption process in iquid-liquid mass ransfer operations.	М	Н	Н	Н
CO5 p	Dissect the erformance of dsorption process in blid-liquid systems	М	Н	Н	Н
H – High;	M- Medium; L- Low				
Course Co		1			
UNIT I	DIFFUSION AND MASS TRANSFER		hou		
Molecular	diffusion in solids, liquids and gases; Inter-phase mass transfer; th	eories	to de	term	ine
mass trans	fer coefficients; Analogies in Transport phenomenon.				
UNIT II	GAS - LIQUID OPERATIONS	9	hou	irs	
Principles	of gas absorption; Single and Multi component absorption; Absor	ption w	ith cl	hem	ical
reaction; D	esign principles of absorbers; Industrial absorption equipment; H	TU, NI	TU co	once	pts.
UNIT III	VAPOUR - LIQUID OPERATIONS	9	hou	irs	
Vapour-Li	quid equilibria; Simple, Steam and Flash Distillation; Cont	inuous	dist	illati	on;
McCabe -	Thiele & enthalpy concentration method; Industrial distillation of	equipm	ents,	ΗE	TP,
HTU and N	NTU concepts.				
UNIT IV	EXTRACTION OPERATIONS	9) hou	irs	
Liquid-Liq	uid equilibria, Staged and continuous extraction, Solid-liquid e	quilibri	a, L	each	ing
principles,	Equipment for extraction and leaching.				
UNIT V	SOLID - FLUID OPERATIONS	9) hou	irs	
Adsorption	n equilibria – Types - Batch and fixed bed adsorption; Drying – M	lechani	sm –	Dry	ing
curves - Ti	me of drying; Equipment for drying - Batch and continuous drye	ers.			
LEARNIN	NG RESOURCES				
Text Book	 Treybal R.E., "Mass Transfer Operations", 3rd Edition, M Geankoplis C.J., "Transport Processes and Unit Opera Prentice Hall of India, 2002. 	tions",	3 rd]	Editi	on,
	 Warren, L, Mc Cabe, Julian .C. Smith and Peter Harriot of Chemical Engineering", 6th Edition, McGraw Hill In New York, 2001. 				
Reference	 Coulson J.M., Richardson J.F., Backhurst J.R. and Har & Richardson's Chemical Engineering", Vol. I, 6th Ed Heinemann, Oxford, 1999. 				
Books	2. Perry's, "Handbook of Chemical Engineering", 7 th Edit 1997.	tion, M	cGra	iw H	Iill,

Reference	https://www.youtube.com/watch?v=XJSRZhY92i4 https://www.youtube.com/watch?v=dzWsPPyig1Q https://www.youtube.com/watch?v=P7PB31BQ5-s
videos	https://www.youtube.com/watch?v=07iYOd1uWL4 https://www.youtube.com/watch?v=CRlsh2XqOI4
Reference NPTEL	https://nptel.ac.in/courses/103103145
Reference research/ review articles	 Marinos-Kouris, D., & Maroulis, Z. B. (2020). Transport properties in the drying of solids. In Handbook of industrial drying (pp. 113-159). CRC Press. Wang, C., Liu, Y., Jia, Z., Zhao, W., & Wu, G. (2023). Multicomponent nanoparticles synergistic one-dimensional nanofibers as heterostructure absorbers for tunable and efficient microwave absorption. Nano-Micro Letters, 15(1), 13. Mehtari, N., Kahani, M., & Zamen, M. (2023). Energy, environmental, and economic analysis of a new configuration multi-stage flash distillation unit coupled with steam power plant. Case Studies in Thermal Engineering, 50, 103456. Bu, X., Danstan, J. K., Hassanzadeh, A., Behrad Vakylabad, A., & Chelgani, S. C. (2024). Metal extraction from ores and waste materials by ultrasound- assisted leaching-an overview. Mineral Processing and Extractive Metallurgy Review, 45(1), 28-45. Sharma, A., Khamar, D., Cullen, S., Hayden, A., & Hughes, H. (2021). Innovative drying technologies for biopharmaceuticals. International Journal of Pharmaceutics, 609, 121115.

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CO4	molar properties of various extensive thermodynamic parameters in solutions.	Н	Н	Н	Η						H	Н	Н	
	biotechnology. Analyze the partial													
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CO3	thermodynamic laws and properties of			1				1		1	1			

PHASE AND CHEMICAL REACTION UNIT V **EQUILIBRIA**

9 hours

Gibbs phase rule and its derivation for reacting and non-reacting systems; Phase equilibriacriteria-VLE Calculations - Liquid-liquid Equilibria; Chemical equilibrium constants; Homogeneous and heterogeneous reactions; Effect of Temperature- Effect of pressure-Equilibrium conversion in single and multiple reactions.

LEARNING RESOURCES

	 Bhatt, B.I. and S.M. Vora, "Stoichiometry (SI Units)", 3rd Edition, Tata McGraw- Hill, 1996. Smith J.M., Van Ness H.C., and Abbot M.M., "Introduction to Chemical
Text Books	Engineering Thermodynamics", 6 th Edition, Tata McGraw-Hill, 2003.
	3. Narayanan K.V., "A Text Book of Chemical Engineering
	Thermodynamics", PHI, 2003.
	1. Himmelblau, D.M., "Basic principles and calculations in Chemical Engineering", 6 th Edition, PHI, 2006.
Reference	2. Narayanan, K.V. and Lakshmi Kutty, "Stoichiometry and Process Calculations", PHI, 2006.
Books	3. 3. Coulson J.M., Richardson J.F., Backhurst J.R. and Harker J.M., "Coulson & Richardson's Chemical Engineering", Vol. I, 6 th Edition, Butter worth Heinemann, Oxford, 1999.
	4. Sandler S.I., "Chemical and Engineering Thermodynamics", John Wiley,1989.
	https://www.youtube.com/watch?v=UL1jmJaUkaQ
Reference	https://www.youtube.com/watch?v=QQGaLrbXGq0
videos	https://www.youtube.com/watch?v=gKDCMtuVrDs
	https://www.youtube.com/watch?v=utfxPRImBgw
	https://www.youtube.com/watch?v=J4WJCYpTYj8
Reference NPTEL	https://archive.nptel.ac.in/courses/103/103/103103165/
	1. White, C., Silva III, H., & Vorobieff, P. (2021). Investigation of mixing law efficacy for gaseous hydrodynamic simulations. Journal of
	Thermophysics and Heat Transfer, 35(1), 98-103.
	2. Heinzle, E., Dunn, I. J., Ingham, J., & Přenosil, J. E. (2021). Biological Reaction Engineering: Dynamic Modeling Fundamentals with 80 Interactive Simulation Examples. John Wiley & Sons.
Reference research/	3. Xamroyevna, M. B. (2024). THERMODYNAMICS OF LIVING SYSTEMS. Multidisciplinary Journal of Science and Technology, 4(3), 303-308.
review articles	4. Vegh, A., Korozs, J., & Kaptay, G. (2022). Extension of the Gibbs–Duhem Equation to the Partial Molar Surface Thermodynamic Properties of Solutions. Langmuir, 38(16), 4906-4912.
	5. Tran, H. N. (2022). Improper estimation of thermodynamic parameters in adsorption studies with distribution coefficient KD (qe/C e) or Freundlich constant (KF): Considerations from the derivation of dimensionless thermodynamic equilibrium constant and suggestions. Adsorption Science & Technology, 2022, 5553212.

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Properties and cl	haracterization of	f par	rticu	late,	Siz	e rec	luct	ion,	Anal	ysis	and to	echni	cal r	neth	ods
for size determ	ination of powe	ders	in	biot	ech	ind	ustr	ies-	Size	red	uction	n and	d Sc	reen	ing
equipment; Sieve	e analysis, Screen	n effe	ectiv	venes	ss, ca	ipaci	ity, 1	theor	y of	Settl	ing ar	nd See	dime	ntati	on.
Mixing – Type	es of mixers, p	owe	r n	umb	er,	pow	er	cons	umpt	ion	in m	nixing	g op	erati	on,
Biomaterials Ha	andling-Belt con	nvey	or,	Scre	ew (Conv	veyo	or, b	ucke	t ele	evator	and	l pn	euma	atic
conveyor.															
UNIT IV	FUNDAMENTA	ALS	5 OF	F HE	AT	TRA	ANS	SFEI	R				9 he	ours	
Introduction – C	Conduction – Basi	ic co	once	pts o	of co	ndu	ctio	n in :	solid	s, liq	uids	and g	gases	- O	ne-
and two-dimensi	ional heat conduct	tion	- Ci	ritica	al an	d op	tim	um iı	nsula	tion	thickr	ness.	Intro	duct	ion
to unsteady stat		Prir	ncip	les	of c	onve	ectic	on –	Eau	atior	ns of	forc	ed a	nd f	free
convection.	te heat transfer.		-						-1-						

UNIT V	RADIATION AND HEATEXCHANGERS	9 hours
Basic laws of	heat transfer by radiation – black body and gray body concept	s – solar radiations
– combined l	heat transfer coefficients by convection and radiation. Heat T	Fransfer equipment
Double pipe,	Shell & tube and Plate type heat exchanger.	
LEARNING	RESOURCES	
Text Books	 Warren L. McCabe, Julian C. Smith and Peter Harriot, ' Chemical Engineering", 7th Edition, McGraw-Hill Educar Christie Geankoplis, "Transport Process Principles and U Edition, Prentice Hall of India, 2015. Kumar K.L., "Fluid Mechanics", S Chand & Company L YunusCengel, "Heat and Mass Transfer – Fundamentals & edition, McGraw-Hill, 2015. 	tion, 2017. nit Operations", 4 th td., 2008.
Reference videos	https://www.youtube.com/watch?v=Ch6Iqog9gm8 https://www.youtube.com/watch?v=0KIj-r6hp1g https://youtu.be/npiTNdapr7w https://youtu.be/tG-PmLzx6NA https://youtu.be/z-2b6cRMF8Q	
Reference NPTEL	https://onlinecourses.nptel.ac.in/noc21_ch34/preview	
Reference research/ review articles	 Bakarji, J., Callaham, J., Brunton, S. L., & Kutz, J. N. (20) consistent learning with Buckingham Pi. Natur Science, 2(12), 834-844. Wen, X., Wang, L. P., Guo, Z., & Zhakebayev, D. B. (turbulent flow transition inside the boundary layer adja wall of natural convection flow in a cubical cavity. Inter Heat and Mass Transfer, 167, 120822. Sharma, A., Mishra, M. K., & Trivedi, A. (2023). HAZAR AND ITS CONTROL IN BULK MATERIAL HANDLI AN INTEGRATED STEEL PLANT. Akan, A. E. (2021). Determination and modeling of o thickness for thermal insulation of buildings in al Turkey. International Journal of Thermophysics, 42(4), 4 Gabir, M. M., & Alkhafaji, D. (2021, August). Compre double pipe heat exchanger techniques. In Journal of Pl Series (Vol. 1973, No. 1, p. 012013). IOP Publishing. 	e Computational (2021). Laminar to acent to isothermal national Journal of RD ASSESSMENT NG PROCESS OF optimum insulation 1 city centers of 9. chensive review on

INDUSTRIAL BIOTECHNOLOGY

Course	Code					(Cour	se T	itle						L	T		P	С	
10211B	T110			BIC	PR	OC	ESS	EN	GIN	IEE	RIN	IG			3	0		0	3	
Course	C <mark>atego</mark> r	у		Progra	m C	Core														
Preamb	le		To comprehend the expertise in developing the help of upstream applications.								bio-j	bio-products with the								
Prerequ	isite Co	urse	s	102111 102111 102111	<i>BT1</i>	08 –	Prin	ncipl	es oj	f Ch										
Cours Outcon		pon	succe	essful c	omp	oletic	on of	the	coui	rse,	stuc	lent	s w	ill be	e abl	e to:				
CO No)5.				С	ours	e Ot	itcoi	mes							Lnow (Base loom	d on	revis	ed	
CO1				and g and its				dge	or	n c	onst	truc	tior	n of	f		K2			
CO2	fo	ormu	latior	identify the suitable statistical models (medium ons) and sterilization techniques in industrial on process.								К3								
CO3				of stoic ind sub				-					-		t	К3				
CO4				ne criteria for scale-up of bioreactor systems with mechanical and mass transfer properties.								1	K4							
CO5				te selec and inl						-	-		ı ki	netic	;		K4			
Correlat	ion of C	Os v	vith P	POs:													D			
CO Nos.	Co	ırse C	Outcom	ies				Prog	ramı	me O	utco	mes ((POs	s)			S Ou	rogra pecifi itcom PSOs	ic ies	
					1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	Illustrat knowle constru ferment ancillar	dge ctior ærs	and n and		Н	Н										Н	Н	М	М	
CO2	Apply suitable models formula steriliza in ferment	tion tion	sta (m s) tech ind	tistical nedium and niques lustrial	Н	Н	Н	Н	Н	L						Н	Н	М	М	

CO3	Make use stoichiometric and to infer the pro- formation and sub- utilization in biolo systems.	oduct strate M	Н			М]	М	М	М	L	
CO4	Analyze the criteri scale-up of biore systems with response mechanical and transfer properties.	ect to M mass	Н	Н	Н	Н			М			н н н					
		alyze inetic and M	М		Н	Н			L			н н м м					
H – High	; M- Medium; L- l	Low															
Course (Contant:																
UNIT I	FERMENTA CONFIGUR			ROC FER				AND)	BA	ASIC		9) hou	irs		
Introduct	ion to bioprocess	developn	nent	; cur	rent	sce	nari	o of	f fe	rme	entatio	on in	dus	stry,	gene	eral	
requirem	ents of fermentation	on proces	ses,	type	s of	ferr	nent	tatio	n p	roc	ess: E	Batch	, fe	d ba	tch a	and	
continuo	us. Construction of	f ferment	er ar	nd ai	ncilla	aries	s, m	ain j	para	ame	eters t	o be	mc	onito	red	and	
controlle	d in fermentation p	rocesses;	prop	pertie	es of	feri	nen	ted p	proc	luct	ts.						
UNIT II	MEDIA OPT KINETICS	TIMIZAT	ΓΙΟΙ	N AI	ND S	STE	RIL	IZA	ΔTI	ON	I		9) hou	irs		
Media fo	ormulation and op	otimizatio	n-on	ne fa	ictor	at	a ti	ime	me	tho	d, Pl	acket	tt E	Burm	an	and	
Response	e surface method	lology; d	lesig	gn c	of v	ario	us	com	nme	rcia	al mo	edia	fo	r in	dust	rial	
fermenta	tions; Thermal deat	th kinetic	s of	micr	oorg	ganis	sms,	Ste	riliz	zatio	on: ba	atch a	and	cont	inuc	ous-	
air, heat a	and filter sterilization	on of liqu	id m	nedia	l.												
UNIT II	I STOICHION	IETRIC	AN	ALY	SIS								9	hou	Irs		
Stoichior	netry and kineti	cs of l	oiop	roces	sses,	St	coicł	niom	netr	y	of n	nicro	bial	re	actio	ons,	
Stoichior	netry- Mass-balanc	e equation	ons,	elem	nenta	l ba	lanc	e, d	legr	ees	of re	ducti	ion	of s	ubsti	rate	
and biom	ass, available elect	ron balan	ices,	yiel	d co	effic	eient	s of	bic	ma	ss and	d pro	duc	t for	mati	ion,	
maintena	nce coefficients en	ergetic an	alys	is of	mic	robi	al gi	owt	h ar	nd p	oroduc	ct for	mat	tion,	oxy	gen	
consump	tion and heat evolu	tion in ae	robi	c cul	lture	s, th	erm	odyı	nan	nic e	efficie	ency	ofg	grow	th.		
UNIT IV	BIOREACT	OR STR	ATE	GIF	ËS								9) hou	irs		
Types of	bioreactors-Modes	of operat	tion	ofbi	orea	ctor	- Ki	ineti	cs c	of ce	ell gro	wth	in b	atch	cult	ure	
1	s of cell growth in																

Stability analysis of bioreactor Scale up criteria for bioreactors (Constant power per Unit volume, Constant KLa, Constant mixing quality, Constant impeller tip speed, Constant momentum factor, Constant mixing rate number, Similar drop size distribution).

UNIT V

KINETICS OF MICROBIAL GROWTH AND PRODUCT FORMATION

9 hours

Phases of cell growth in batch cultures; simple unstructured kinetic models for microbial growth - Monod model, growth of filamentous organisms, product formation kinetics - Leudeking-Piret models, substrate and product inhibition on cell growth and product formation; homogeneous and heterogeneous reaction kinetics.

LEARNING RESOURCES

LEAKINING	J RESOURCES
Text Books	 Shuler M.L. and FikretKargi, "Bioprocess Engineering: Basic Concepts", 2nd Edition, Prentice Hall, 2001. Doran P., "Bioprocess Engineering Principles", 2nd Edition, Elsevier, 2012.
Reference Books	 Lydersen, Bjorn K, "Bioprocess Engineering Systems, Equipment and Facilities", John Wiley, 1994. Bailey, James E. and David F. Ollis, "Biochemical Engineering Fundamentals", 2nd Edition, McGraw Hill, 1986. Peter F. Stanbury, Stephen J. Hall and Whitaker A., "Principles of Fermentation Technology", 3rd Edition, Elsevier, 2016. Harvey W. Blanch, Douglas S. Clark, "Biochemical Engineering", Marcel DekkerInc., 2007.
Reference videos Reference	https://youtu.be/bKunpGA2r7U https://youtu.be/mUDXupn2Dhk https://youtu.be/psPAJDWzrb8 https://youtu.be/8xbYn5IatvM https://youtu.be/rab_BkiNuW0
NPTEL	https://nptel.ac.in/courses/102106053
Reference research/ review articles	 Hanifah, I. A., Primarista, N. P. V., Prasetyawan, S., Safitri, A., Adyati, T., & Srihadyastutie, A. (2022, May). The effect of variations in sugar types and fermentation time on enzyme activity and total titrated acid on eco-enzyme results of fermentation. In 7th International Conference on Biological Science (ICBS 2021) (pp. 585-589). Atlantis Press. GÜRKÖK, S. (2021). Statistical Optimization of Extracellular Thermo- Alkaline Lipase Production from Aeromonas caviae LipT51 with Response Surface Methodology. Journal of the Institute of Science and Technology, 11(3), 1770-1780. Saadat, N. P., Nies, T., Rousset, Y., & Ebenhöh, O. (2020). Thermodynamic limits and optimality of microbial growth. Entropy, 22(3), 277. Roberto, I. C., Pessoa, A., & Tonso, A. (2021). Bioreactors: Modes of Operation. In Pharmaceutical Biotechnology (pp. 157-179). CRC Press. Bohórquez, W. F., Osorio-Pascuas, O. M., Santaella, M. A., & Orjuela, A. (2020). Homogeneous and heterogeneous catalytic kinetics in the production of triethyl citrate. Industrial & Engineering Chemistry Research, 59(43), 19203-19211.

Course Code	Course Title	L	Т	Р	С
10211BT111	DOWNSTREAM PROCESSING	0	3		
Course Category	Program Core				
Preamble	To understand the process involved in the re of bioproducts	covery	and p	urifica	ation
Prerequisite Courses	10211BT115 – Analytical and Instrumentation 10211BT110 - Bioprocess Engineering	on Eng	ineerii	ıg	

Course Outcomes	Upon successful completion of the course, students will	be able to:
CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Illustrate the importance of downstream processing on separation technology and economic aspects in process design.	К3
CO2	Demonstrate the primary separation techniques using mechanical, enzymatic, chemical methods.	К3
CO3	Make use of various mass transfer operations on separation of biological products.	К3
CO4	Apply different purification techniques (chromatography and electrophoresis) for product recovery.	К3
CO5	Utilize the product formulation and polishing techniques to develop the product for industrial scale up	К3

Correlation of COs with POs:

CO Nos.	Nos. Course Outcomes		Programme Outcomes (POs)											Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Illustrate the importance of down stream processing on separation technology and economic aspects in process design.	Н	Н	Н	М								Н	Н	Н	
CO2	Demonstrate the primary separation techniques using mechanical, enzymatic, chemical methods.	Н	Н	Н	М								Н	Н	Н	

CO3	Make use of vario mass trans operations separation of biologic products.	er on H	Н	Н	М								Н	Н	Н				
CO4	Apply different purification techniques chromatography and H H H M electrophoresis) for product recovery.																		
CO5	Utilize the product formulation and																		
H – Hig	h; M- Medium; L- Lo	v								·			• 						
	Content:			FOOI															
UNIT I	DOWNSTREA					1.		1	1	• 1	1) hou		, ·			
	d importance of downs		-		-				-		-								
	lecules and bioproce		•									•		•					
Econom	ics of downstream pro	cessin	g in i	Biot	echn	olog	gy, o	cost	-cut	tting	g stra	ategi	es, ch	arac	teris	tics			
of biolog	gical mixtures, process	desig	n crit	teria	for v	ario	ous	clas	ses	of	bio-j	produ	icts.						
UNIT II	I PRIMARY SE	PARA	TIO	N T	ECH	INI	QU	ES			Mechanical, enzymatic and chemical methods of cell disruption for product release;								
							-		disr	upt	ion	for	-			ase;			
Mechani		chem	cal	met	hods	of	° ce	ell		-			prod	uct	relea				
Mechani Immobil	ical, enzymatic and	chem luid e	ical xtrac	met tion	hods evap	of oora	ce tior	ell 1, su	per	liq	uid (extra	prod ction,	uct , soli	relea d liq	uid			
Mechani Immobil	ical, enzymatic and lization, super critical on - flocculation, sed	chem luid e	ical xtrac	met tion	hods evap	of oora	ce tior	ell 1, su	per	liq	uid (extra	prod ction,	uct , soli	relea d liq	uid			
Mechani Immobil separatio	ical, enzymatic and lization, super critical : on - flocculation, sed on.	chemi Iuid e imenta	cal xtrac tion	met ction , filt	hods evaț tratic	of oora	ce tior	ell 1, su	per	liq	uid (extra	prod ction, and	uct , soli	relea d liq n ba	uid			
Mechani Immobil separatic separatic	ical, enzymatic and lization, super critical : on - flocculation, sed on.	chem luid e imenta	cal xtrac ation	met tion , filt TIO	hods evap tratic NS	of oora on, o	cent	ell (1, su arifu	per gat	liq ion	uid o sett	extra ling	prod ction, and	uct , soli foan) hou	relea d liq n ba	uid sed			
Mechani Immobil separatic separatic UNIT II Adsorpti	ical, enzymatic and lization, super critical f on - flocculation, sed on.	chem luid e imenta ΓΟΡΙ action,	ical xtrac ation E RA aqu	met tion , filt TIO	hods evap tratic NS s two	of pora on, o p-ph		ell o a, su crifu ext	gat	liq ion tior	uid o sett	extrac ling embr	prod ction, and	uct , soli foan) hou separ	relea d liq n ba irs ratio	uid sed			
Mechani Immobil separatic separatic UNIT II Adsorpti ultra filt	ical, enzymatic and lization, super critical i on - flocculation, sed on. II ENRICHMENT ion, liquid-liquid extra	chemi luid e imenta F OPI action, nosis,	ical xtrac ation ERA aqu dial	met etion , filt TIO leous ysis,	hods evap tratic NS s two pree	of pora on, o po-ph cipit	cent cent	ell o , su crifu ext	per gat trac	liq ion tior	uid o sett n, m eins	extrac ling embr	prod ction, and	uct , soli foan) hou separ	relea d liq n ba irs ratio	uid sed			
Mechani Immobil separatic separatic UNIT II Adsorpti ultra filt	ical, enzymatic and lization, super critical : on - flocculation, sed on. II ENRICHMEN ion, liquid-liquid extra ration and reverse ost gation, settling, sedim	chemi luid e imenta F OPI action, nosis, entatic	cal xtrac ution E RA aqu dial n, de	met xtion , filt TIO leous ysis, ecant	hods evap tratic NS s two pred ting a	of pora on, o po-ph cipit	cent cent	ell o , su crifu ext	per gat trac	liq ion tior	uid o sett n, m eins	extrac ling embr	prod ction, and grane iffere	uct , soli foan) hou separ	relea d liq n ba irs ration netho	uid sed			
Mechani Immobil separatic separatic UNIT II Adsorpti ultra filt Centrifu	ical, enzymatic and lization, super critical : on - flocculation, sed on. II ENRICHMEN ion, liquid-liquid extra tration and reverse ost gation, settling, sedim	chemi luid e imenta F OPH action, nosis, entatic RIFIC	ical xtrac attion CRA aqu dial n, de CAT	met ction , filt TIO teous ysis, ecant	hods evap tratic NS s two pree	of pora on, o p-ph cipit	tion cent cent ase catic mic	ell o , su rrifu ext on o erofi	per gat trac f p ltra	liq ion tior rote	uid o sett n, m eins n.	extracting embr by d	prod ction, and <u>g</u> rane i iffere	uct , soli foan) hou separ ent n	relea d liq n ba mrs ratio netho	n –			
Mechani Immobil separatic separatic UNIT II Adsorpti ultra filt Centrifu UNIT IV Chromat	ical, enzymatic and lization, super critical i on - flocculation, sed on. II ENRICHMENT ion, liquid-liquid extra tration and reverse ost gation, settling, sediment V PRODUCT PU	chemi luid e imenta F OPI action, nosis, entatic RIFIC adsor	ical xtrac ation CRA aqu dial n, de CAT ption	met etion , filt TIO neous ysis, ecant ION	hods evap tratic NS s two pred ting a	of oora on, o o-ph cipit and even	tior cent cent ase catic mic	ell of a sub- a, sub- crifu ext on o crofi	gat gat trac f p ltra se,	liq ion tior rote tior	uid o sett n, m eins n. -excl	extracting embrembre by d	prod ction, and grane iffere e, siz	uct , soli foan) hou separ ent n) hou e ex	relea d liq n ba irs ratio netho irs clusi	n – ods.			
Mechani Immobil separatic separatic UNIT II Adsorpti ultra filt Centrifu UNIT IV Chromat hydrophy	ical, enzymatic and lization, super critical : on - flocculation, sed on. II ENRICHMENT ion, liquid-liquid extra tration and reverse ost gation, settling, sediment V PRODUCT PU tographic techniques -	chemi luid e imenta F OPH action, nosis, entatic RIFIC adsorj	ical xtrac ation CRA aqu dial n, de CAT otion y a	met tion , filt reous ysis, ecant ION , TL nd	hods evap tratic NS s two pred ting a .C, r pseu	of pora on, o p-ph cipit and even do	tion cent cent ase catic mic rse j aff	ell of a sub- rifu ext on o rofi phas	per gat trac f p ltra se,	liq ion tion rote tion ion	uid o sett n, m eins n. -excl	extracting embracting by d hang	prod ction, and grane iffere e, siz phic	uct , soli foan) hou separ ent n) hou e ex tecl	relea d liq n ba urs ratio netho clusi nniqu	n – ods.			

UNIT V	PRODUCT FORMULATION AND POLISHING	9 hours
Crystallizatio	on, drying and lyophilization for final product formulation.	
LEARNING	G RESOURCES	
Text Books	 Belter P.A., Cussler E.L. and Wei-Houhu, "Bioseparatic Processing For Biotechnology, Wiley Interscience, 1988. Sivasankar B., "Bioseparations: Principles and Technique 	
Reference Books	 Jenkins R.O., "Product Recovery in Bioprocess Technology Open Learning Series, Butterworth-Heinemann, 1992. Janson J.C., and Ryden L., "Protein Purification – Principle Methods and Applications", VCH Pub., 1989. Scopes R.K., "Protein Purification – Principles and Pract 1994. 	s, High Resolution
Reference videos	https://youtu.be/Uut1cUs6GpA https://youtu.be/9f0hMYQe0 https://youtu.be/sywSp-E2Rjw https://youtu.be/qIW_VjVf3ZY https://youtu.be/qPDRS75CR2Q	
Reference NPTEL	https://archive.nptel.ac.in/courses/102/106/102106022/	
Reference research/ review articles	 Rodríguez-Sifuentes, L., Marszalek, J. E., Hernández-Cark Hernández, C. (2021). Importance of downstream pro- astaxanthin for pharmaceutical application. Frontier Engineering, 2, 601483. Alisherovna, A. M. (2023). THE STUDY OF HE SYSTEMS AND METHODS FOR THEIR SEPARAT Journal of Advance Scientific Research, 3(04), 90-96. Pérez-Rodriguez, S., Ramírez, O. T., Trujillo-Roldán, M. A N. A. (2020). Comparison of protein precipitation mo preparation prior to proteomic analysis of Chinese h homogenates. Electronic Journal of Biotechnology, 48, 86 Rana, B., & Joshi, G. K. (2023). Electrophoresis: Basic pr applications. In Basic Biotechniques for H Bioentrepreneurship (pp. 183-193). Academic Press. Butreddy, A., Dudhipala, N., Janga, K. Y., & Gadda Lyophilization of small-molecule injectables: an indust formulation development, process optimization, scale-u drug product quality attributes. Aaps Pharmscitech, 21, 1- 	cessing of natural rs in Chemical ETEROGENEOUS TON. International A., & Valdez-Cruz, ethods for sample amster ovary cell 5-94. rinciple, types, and Bioprocess and am, R. P. (2020). try perspective on up challenges, and

Course	Cod	e		Course Title										L	T	`	P	С		
10211B	T11.	3		MF	ТА	BO	LIC	EN	GIN	EE	RIN	G			3	0		0	3	
Course	Cate	gory		Progra																
Preamb	le			'o infe nprov												path	way	s for	• the	
Prerequ	isite	e Courses 10212BT144 – Advanced Biochemistry 10211BT110 – Bioprocess Engineering 10211BT105 – Genetic Engineering										_	_							
Cours Outcom		Upon s	uccess	ful co	mpl	etion	n of i	the c	cours	se, s	tud	ents	wi	ll be	able	to:				
CO No	s.	Course						tcor	nes							Lnow (Base loom	d on	revis	ed	
CO1		Identify	y the n	eed ai	nd s	cope	e of r	neta	boli	c en	gin	eeri	ng.				K3			
CO2		Constru	uct the	scher	ne c	of reg	gulat	ory	path	way	/s.						K3			
CO3		Develop the tools used in metabolic engineering.											K3							
CO4		Evaluate the strategies used in metabolic pathway manipulation.									,	K4								
CO5		Analyz various			icati	ions	of	met	abo	lic	eng	ine	erin	g in	l		K4			
Correlat	ion o	f COs w	vith PC	Ds:																
CO Nos.		Course O	outcome	8				Prog	gramı	ne O	utco	mes	(PO	s)		Program Specific Outcomes (PSOs)				
					1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	scop	tify the be of neering.	meta	and bolic												Н	Н	L		
CO2	Con	struct th latory p	e sche		Н	М	М									Н	Н	L		
CO3	in	elop the neering.	meta	used bolic		М	М		н							Н	Н	L		
		aluate the strategies				М	Н	Н	M	L	L	L				н	н	L		
CO4	used path			tion.															-	
CO4 CO5	path Ana appl meta	way ma	nipula engine	the of	Н	М	Н	Н	Н	L	L	L				Н	Н	L		

Course Conter	ıt:	
	NTRODUCTION TO METABOLIC	9 hours
Importance of	metabolic engineering; Concept of metabolic pathway	v synthesis; Central
Metabolism:	Fueling metabolism, Supply of biomass precu	rsors, Anabolism,
Anaplerosis. N	eed for pathway synthesis, Paradigm shift; Informatio	n resources; Scope
and future of m	etabolic engineering; Methods for metabolic character	ization.
UNIT II R	REGULATION OF METABOLIC PATHWAY	9 hours
Regulation of I	Enzymatic Activity, Regulation of Enzyme concentra	tion, Regulation at
whole cell leve	el, Regulation of Metabolic networks, Transport med	chanisms and their
models, Mecha	nisms and theirdynamic representation	
UNIT III T	OOLS IN METABOLIC ENGINEERING	9 hours
Metabolic flux	analysis (MFA), Methods for MFA - Metabolite	Balancing, Tracer
Experiments, M	IS and NMR in labelling measurement, Metabolic contr	rol analysis (MCA),
Determination	of Flux control coefficients, MCA of Linear and Brand	ched pathways.
UNIT IV N	IETABOLIC PATHWAY MANIPULATION	9 hours
Enhancement of	f product yield and productivity, Extension of substra	te range, Extension
of product spec	trum and novel products, Improved cellular properties,	metabolic pathway
synthesis - case	e study: lysine biosynthesis, Synthetic biology in meta	bolic engineering -
heterologous pa	athway modification yeast, genome-wide analysis and	engineering.
	PPLICATIONS OF METABOLIC	9 hours
Application of	metabolic engineering in pharmaceuticals, chemica	l bioprocess, food
technology, ag	riculture, environmental bioremediation and biomass	s conversion. Case
studies of Meta	bolic engineering: engineering of Saccharomyces crew	vices for production
of secondary r	netabolites. Enhancement of product yield (amino a	icid); Extension of
substrate range	; Extension of product spectrum and novel products (b	iopolymer).
LEARNING F	RESOURCES	
	1. Stephanopoulos G.N., Aristidou A.A., Niels Engineering: Principles and Methodologies" 1998.	, Academic Press,
Text Books	2. Sang Yup Lee and Terry Papoutsakis E., "Meta Marcel Dekker, New York, 1999.	
	3. Heinrich R., and Schuster S., "The Regu Systems", Chapman & Hall, 1996.	lation of Cellular
Reference Books	1. Eberhard O. Voit, "Computational Analysis Systems: A Practical Guide for Biochem Biologists", Cambridge University Press, 2000	ists andMolecular

	2. David Fell, "Understanding the Control of Metabolism", Portland Press, London, 1997.
Reference videos	https://youtu.be/lqlu3Xps9PM https://youtu.be/IbvCtKINz1I https://youtu.be/pNH3JbJohJk https://youtu.be/TY7NqeZz7pg https://youtu.be/M0upS8uc51A
Reference NPTEL	https://archive.nptel.ac.in/courses/102/105/102105086/
Reference research/ review articles	 Dasgupta, A., Chowdhury, N., & De, R. K. (2020). Metabolic pathway engineering: Perspectives and applications. Computer Methods and Programs in Biomedicine, 192, 105436. Johnson, R., Vishwakarma, K., Hossen, M. S., Kumar, V., Shackira, A. M., Puthur, J. T., & Hasanuzzaman, M. (2022). Potassium in plants: Growth regulation, signaling, and environmental stress tolerance. Plant Physiology and Biochemistry, 172, 56-69. Vupputuri, A., Gupta, A., & Ghosh, N. (2021). MCA-DN: Multi- path convolution leveraged attention deep network for salvageable tissue detection in ischemic stroke from multi-parametric MRI. Computers in Biology and Medicine, 136, 104724. Liu, J., Wang, X., Dai, G., Zhang, Y., & Bian, X. (2022). Microbial chassis engineering drives heterologous production of complex secondary metabolites. Biotechnology Advances, 59, 107966. Antoniewicz, M. R. (2021). A guide to metabolic flux analysis in metabolic engineering: Methods, tools and applications. Metabolic engineering, 63, 2-12.

Course Code		Course Title	L	Т	Р	С
10211BT114	Gl	REEN BIOTECHNOLOGY & POLLUTION ABATEMENT	2	0	0	2
Course Categor	ry	Program Core				
Preamble		To have insight knowledge on applications of bio sustainable environment.	otechn	ology	in cre	ating
Prerequisite Courses		10211BT101 - Microbiology				
Course Outcomes	Upo	on successful completion of the course, students w	ill be a	ble to	:	
CO Nos.		Course Outcomes	(Based	dge L on revi Taxono	sed
CO1		strate the process involved in biological wast nagement.	e	J	K2	
CO2		nonstrate the mechanism of biotransformation an catalysts.	d]	K2	
CO3		line the different forms of treating th ironmental waste with biological process.	e	J	K2	
CO4	Dev	velop the bio-products with eco-friendly nature.		I	K3	
CO5		bly the knowledge of biotechnology in protectin environment.	g]	K3	
Correlation of C	COs v	vith POs:				

00110100														1		
CO Nos.	Course Outcomes				Prog	ramı	ne O	utco	mes	(POs	5)			S Ou	ograi pecifi itcom PSOs	c ies
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Illustrate the process involved in biological waste management.		Μ	L				Н						Н		
CO2	Demonstrate the mechanism of biotransformation and biocatalysis.	М	М	L				Н	L					Н		
CO3	Outline the different forms of treating the environmental waste with biological process.	М	М	L				Н	L					Н	Н	
	Develop the bio- products with eco- friendly nature.		Μ	L				Н	L					Н	Н	М

CO5 biot	bly the knowledge of technology in tecting the ironment.	м	М	L				Н	L					Н	М	Н
H – High; M	- Medium; L- Low					I	I						I		1	
Course Con																
UNIT I	BIOLOGICAL													6 hou		
_	astewater treatment		_	-			-	-								
	advanced bioreacto		-							-					•	-
_	ing of organic re														_	
C C	on of Xenobiotic	Coi	npo	unds	; Fa	actor	rs a	iffec	ting	g b	olode	grad	ation	, m	1cro	bial
degradation of	of hydrocarbons.															
UNIT II	BIOTRANSFOR													6 hou		
Basic organi	c reaction mechan	ism-	· Co	mm	on p	oreju	idico	es a	igai	nst	enz	ymes	s, ad	vant	ages	s &
disadvantage	s of biocatalysts,	isola	ated	enz	yme	s vo	ersu	s w	hol	e c	ell	syste	ems,	bioc	catal	ytic
application, o	atalytic antibodies;	stoio	chior	metr	y.											
UNIT III	BIOREMEDIAT	[0]	N Al	ND I	BIO	RES	бто	RA	TI	DN			6	5 hou	irs	
Introduction	and types of bio	rem	edia	tion,	bic	orem	nedia	atio	1 C	f s	urfa	ce s	soil a	and	sluc	lge,
bioremediation	on of subsurface m	ater	ial, 1	In si	i <i>tu</i> a	nd	Ex-s	itu	tec	nno	logie	es, p	hytor	eme	diati	ion-
restoration of	f coal mines a case s	tudy	y. bi	orest	torati	ion:	refo	orest	tatio	on t	hrou	gh n	nicroj	prop	agati	ion,
use of mycor	rhizae in reforestatio	on, u	se of	fmic	crobe	es fo	r im	pro	ving	g so	il fei	rtility	, ref	orest	ation	n of
soils contami	nated with heavy me	etals	5.													
UNIT IV	ECO-FRIENDL	Y B	IOP	ROI	DUC	CTS							6	ó hou	irs	
Fundamental	s of composting pro	oces	s: sc	ienti	fic a	spe	cts a	and	pro	spe	cts c	of bio	ofuel	proc	ducti	ion:
bioethanol, b	iohydrogen and biod	liese	el; bi	ofer	tilize	ers a	nd t	oiop	esti	cide	es.					
UNIT V	BIOTECHNOLO PROTECTION	DGY	Y IN	EN	VIR	ON	ME	NT					(ó hou	ırs	
Current statu	s of biotechnology i	n en	viro	nme	nt pr	otec	tion	and	l its	fut	ure,	relea	ase of	f gen	netica	ally
engineered of	rganisms in the envi	ronr	nent													
LEARNING	RESOURCES															
	1. Winter J., "En 2008.															
Text Books	2. Ramalho R.S. 1977.	, "1	ntroc	iucti	on t	υW	aste	ewat	er	ı rea	atme	nt,	Acac	iemi	c Pr	ess,
	3. Bhattacharya Oxford Press,			nd R	Litu	Ban	erje	e, "	En	viro	nme	ntal	Biot	echn	olog	gy",

	4. Singh D.P. and Dwivedi S.K., "Environmental Microbiology &
	Biotechnology", New Age International Publishers, 2004.
	5. Martin Alexander, "Biodegradation and Bioremediation", 2 nd Edition, Elsevier Science & Technology, 1999.
Reference Books	 Bruce Rittmann and Perry McCarty, "Environmental Biotechnology: Principles and Applications", 2nd Edition, McGraw Hill, 2020. Pradipta K.M., "Textbook of Environmental Biotechnology", I.K. International Pvt. Ltd., 2007. Gupta O.P., "Energy Technology", Khannabooks, 2018.
Reference videos	https://youtu.be/hUOTjVm9n1E https://youtu.be/Efh5GkVbhEc https://youtu.be/Qxqg3iHTxUE https://youtu.be/LvqMMfa8ysM https://youtu.be/Xz1gTOXxeDY
Reference NPTEL	https://archive.nptel.ac.in/courses/102/105/102105088/
Reference research/ review articles	 Khan, S., Anjum, R., Raza, S. T., Bazai, N. A., & Ihtisham, M. (2022). Technologies for municipal solid waste management: Current status, challenges, and future perspectives. Chemosphere, 288, 132403. Rodrigues, R. C., Berenguer-Murcia, Á., Carballares, D., Morellon-Sterling, R., & Fernandez-Lafuente, R. (2021). Stabilization of enzymes via immobilization: Multipoint covalent attachment and other stabilization strategies. Biotechnology advances, 52, 107821. Wang, M., Chen, S., Jia, X., & Chen, L. (2021). Concept and types of bioremediation. In Handbook of bioremediation (pp. 3-8). Academic Press. Jain, A., Sarsaiya, S., Awasthi, M. K., Singh, R., Rajput, R., Mishra, U. C., & Shi, J. (2022). Bioenergy and bio-products from bio-waste and its associated modern circular economy: Current research trends, challenges, and future outlooks. Fuel, 307, 121859. Yong, J. J. J. Y., Chew, K. W., Khoo, K. S., Show, P. L., & Chang, J. S. (2021). Prospects and development of algal-bacterial biotechnology in environmental management and protection. Biotechnology advances, 47, 107684.

Course Co	de		Course Title	L		Т	Р	C			
10211BT11	17		PLANT AND ANIMAL BIOTECHNOLOGY	3	3	0	0	3			
				'							
Course Cate	egory										
Preamble		ions of	r bi	iotech	nolog	y in					
Prerequisite	e Cours	es	Higher Secondary School knowledge								
Course Outcomes	I non successful completion of the course students will be										
CO Nos.			Course Outcomes		Knowledge Leve (Based on revised Bloom's Taxonomy						
CO1	Summ growt		e the knowledge of isolation, maintenance cells.	e and]	K2				
CO2			he concepts of micromanipulation techno enic animal technology	ology]	Χ3				
CO3	Devel the sig	with	K3								
	T 14 '1'	.1	transgenie plants and plant tissues to produce	e the			-				
CO4			transgenic plants and plant tissues to produc ally valuable products.]	K3				

Correlation of COs with POs	Correlation	of CO	s with	POs:
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CO Nos.	Course Outcomes				Prog	ramı	ne O	utcoi	nes	(POs	5)			Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Summarize the knowledge of isolation, maintenance and growth of cells.	Н	L	Н	L				L	М			М	Н	Н	Н
CO2	Illustrate the concepts of micromanipulation technology and transgenic animal technology	М	L	L					L				М	L	L	М
CO3	Develop the transgenic plant by gene transfer method with the significant viral vectors.	Н	М	Н	Н	Н		L					Н	Н	М	L

CO4	plar to ther	ize the transgenic its and plant tissues produce the apeutically valuable ducts.	Н	L	L	M	M	L	L	L				Н	Н	Н	M
CO5	cult vari	te use of plant tissue ure techniques for ous cultures elopments.	Н	L	L	М	М							Н	Н	Н	L
H – Hig	h; M	- Medium; L- Low											•				•
Course	Cont	ent:															
UNIT I		ANIMAL CELL (CUI	LTU	RE									8	8 hou	irs	
Animal	cell	culture; media con	npo	sitio	n ai	nd g	row	th o	cond	litic	ons;	An	imal	cell	and	l tis	sue
preservation; Anchorage and non-anchorage dependent cell culture; Primary and secondary																	
culture; Animal cell growth characteristics and kinetics; somatic cell fusion; cell cultures as a																	
source of valuable products; organ cultures.																	
UNIT II ADVANCES IN ANIMAL CELL CULTURE 8 hours																	
Micro & macro- carrier culture; Hybridoma technology; monoclonal antibodies and their use in																	
diagnosi	is, St	em cell technology;	Cor	ncep	ts of	`tran	isgei	nic a	anin	nal	tecl	nnolo	ogy;	strate	egies	for	the
producti	ion o	f transgenic animals	and	d the	eir ir	npor	tanc	e ir	n bio	otec	hno	ology	, Ar	nimal	cloi	ning	, In
<i>vitro</i> fer	tiliza	tion technology				-										-	
UNIT I	II	PLANT CELL CU	JLT	UR	E									1	0 ho	urs	
Totipote	ency;	Plant growth regula	ator	s; R	eger	nerat	ion	and	mi	croj	oroj	baga	tion	of p	lants	clo:	nal
propaga	tion,	organogenesis, shoc	ot-tij	o an	d me	eriste	em o	culti	ıre,	har	oloi	d cu	lture.	, trip	loid	culti	ure,
		lture; Somaclonal va	-							-				-			
		, growth kinetics a										_				-	
		n Agrobacterium m				•											
		ants - herbicide resis						,		•				•, 11	ouu	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	UI
UNIT I	•	SECONDARY M												1	0 ho	urs	
		sign and operation of										a for	man				lant
-		ttegies for fermentat				-			-							-	
•		on of secondary me							•								
•		portance, Production							•			• 1			•	10013	. 01
	-					-			5,1								
UNIT V		PROCESSING O							tha	hic		00000	in d-		hou		001
-		nonitoring and contr				-					-						
	Ũ		00'	wnst	rean	u p	огосе	2881f	ıg:	ce	ntri	ruga	uon,	T11	tratic	n	and
chromat	methodologies; Overview of downstream processing: centrifugation, filtration and chromatographic techniques.																

LEARNING	RESOURCES
	1. Butterworth Heinemann Ltd., (1994) Biotol Series, In vitro Cultivation of Plant cell.
	2. Bhojwani S.S. and Razdan M.K. (1996) Plant Tissue Culture: Theory and Practice, a Revised Edition, Elsevier Science
	3. T. A. Brown, (2001) Gene Cloning and DNA Analysis: an Introduction, Blackwell Science.
Text Books	4. M. L Shuler and F. Kargi. (2002), Bioprocess Engineering, Prentice Hall Inc.
& Reference	5. A. Slater, N. Scott and M. Fowler (2003), Plant Biotechnology: the Genetic Manipulation of Plants, Oxford University Press.
Books	6. M. M. Ranga (2007), Animal Biotechnology, 3rd Revised Edition, Agrobios.
	7. Freshney. (2016) Culture of Animal Cells.
	8. Meyer, Handschel, Wiesmann (2009). Fundamentals of Tissue Engineering and Regenerative Medicine.
	9. Chawla H.S., "Introduction to Plant Biotechnology", 3 rd Edition, Science Publishers, 2009.
	10. Selected Papers from Scientific Journals, particularly Nature & Science.
	https://youtu.be/6Wdyyu-vQsU
Reference	https://youtu.be/U76L13OuBsU
videos	https://youtu.be/4EAjUK62og4
(Incos	https://youtu.be/7rI-Lyftpd0
	https://youtu.be/Pa2EUPz3vRE
Reference NPTEL	https://archive.nptel.ac.in/courses/102/103/102103016/
	1. Nix, J., Marrella, M. A., Oliver, M. A., Rhoads, M., Ealy, A. D., & Biase, F. H. (2023). Cleavage kinetics is a better indicator of embryonic developmental competency than brilliant cresyl blue staining of oocytes. Animal Reproduction Science, 248, 107174.
	2. Tsao, L. C., Force, J., & Hartman, Z. C. (2021). Mechanisms of therapeutic antitumor monoclonal antibodies. Cancer research, 81(18), 4641-4651.
Reference research/	3. Sutradhar, M., & Mandal, N. (2023). Reasons and riddance of Agrobacterium tumefaciens overgrowth in plant transformation. Transgenic Research, 32(1), 33-52.
review articles	4. Nasim, N., Sandeep, I. S., & Mohanty, S. (2022). Plant-derived natural products for drug discovery: current approaches and prospects. The Nucleus, 65(3), 399-411.
	5. Armstrong, A., Horry, K., Cui, T., Hulley, M., Turner, R., Farid, S. S., & Bracewell, D. G. (2021). Advanced control strategies for bioprocess chromatography: Challenges and opportunities for intensified processes and next generation products. Journal of Chromatography A, 1639, 461914.

Course Co	de	Course Title	L	Т	Р	С		
10211BT30	95	BIOPROCESS ENGINEERING LABORATORY	0	0	2	1		
Course Cate	egory	Program Core						
Preamble		To comprehend the principles of upstream proc in Biotechnology	essing	g techr	niques	used		
Prerequisite Courses	9	10211BT101 - Microbiology						
Course Outcomes	Upon s	uccessful completion of the course, students will b	e able	to:				
CO Nos.		Course Outcomes		(Based	edge L on rev Taxon	ised		
CO1	Examir enzyme	ne the effect of different parameters on the activity es.	of	K	3, S4			
CO2		bout the mechanism of substrate- enzyme binding a pr- enzyme binding	nd	K	3, 85			
CO3		nine the suitable parameters for higher production ry by using different optimization methods.	ict	K4, S5				
CO4	Analyz	te the immobilized enzymes and specific growth rate	te.	. K4, S5				
CO5	Discov method	er the mass transfer coefficient using differe ls	nt	K	4, S6			

Correlation of COs with POs:

CO Nos.	Course Outcomes				Prog	ramı	ne O	utcoi	mes	(POs	5)			Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Examine the effect of different parameters on the activity of enzymes.		Н	М	Н	Н	-	-	М	М	Н	-	Н	Н	М	L
CO2	Infer about the mechanism of substrate- enzyme binding and inhibitor- enzyme binding		Н	М	Н	М	-	-	M	М	Н	-	Н	Н	М	L
CO3	Determine the suitable parameters for higher product recovery by using different optimization methods.		Н	Н	Н	Н	М	М	М	М	Н	Н	Н	Н	М	L
CO4	Analyze the immobilized enzymes and specific growth rate.	н	Н	М	Н	М	-	М	М	М	Н	-	М	Н	М	L

CO5 ti	ansfer	the mas coefficier ent method	t H	Н	М	Н	М	М	Н	М	М	Н	-	Н	Н	М	L
H – High;	M- Mediu	m; L- Low															
Course Co	ntent:																
LIST OF	EXPERIM	IENTS:															
1. Enzym	e kinetics -	- Determir	ation	of N	Mich	aelis	s Me	enter	1 pa	ram	leter	rs.					
	1	ture and pI	I on	enzy	me a	nctiv	ity.										
•	e inhibition																
•		zation – G		-													
-		nal paramo		-						10d.							
		specific gr ch steriliza			•	vlon	od n	node	el.								
 7. Estima 8. Estima 						t me	thod	1									
		a – Dynam a – Sulphit			-												
10. Estima		-															
11. Estima	-																
LEARNIN	G RESO	URCES															
Reference Books	Pea 2. Star Tec 3. Bai Edir 4. Pau 201 5. Blaz	nch H.W. a	, Ha rd Ed nd O McGr ran, '	ll. S ition llis I raw-' 'Bioj	S.J. a , Els D.F., Hill, proc	and evie "Bi 201 ess E	Wh r, 20 loch 5. Engi	itako)17. emio neer	er. cal	A, Eng Prii	"Pr gine ncip	incip ering les"	oles g Fu , 2 nd	of F ndan Editi	ermo nenta on, E	entat ils", Elsev	2 nd
	https://v	ker, 2012. vlab.amrita															
Virtual Lab	https://t ochemi https://v https://v Burmar https://v univers https://v https://v univers method https://v univers	vlab.amrita pio.libretes stry)/6La vlab.amrita www.scrib n-Partial-F www.studo ity/biotech vlab.amrita www.studo ity/biotech /67179211 www.studo ity/biotech vlab.amrita	tts.or b_N .edu/ d.cor actor ocu.co nolog .edu/ .edu/ ocu.co nolog	g/Bc otes_vert n/do ial-D om/ir/ggy/gr ggy/gr ggy/gr ggy/de om/ir ggy/de	ooksł Parto =3& cum Jesig n/do rowt =3& =3& n/do n/do etern n/do	nelve :_2/6 tbrcl tbrcl ns-fd cum tbrcl tbrcl tbrcl tbrcl cum ninat	es/B 5.2% n=1% 0059 00	ioch 3A_ 77& 420 1eth dr-bi s-m 77& 17-bi of-k dr-bi of-k	emii _En sim 1/D od r-an onc sim sim r-an cla-l	istry zym =13 vave od-n =13 =11 nbee by-s	7/Su ne_k 47& Dun dkan node 48& 95& dkan sulp dkan sow	pple kinet &cnt r- el/67 &cnt kcnt r- hate r- er-co	men ics =1 -Usir 11792 =1 =1 -oxic	– ng-Pl 221 lation	acke 1-	- ett-	

Course	Code				Cou	rse [Гitle						L		Т	P)	С
10211B	T306		DOWN			M I RA			SSI	NG			0		0	2		1
Course (Catego	• v	Program	Co	re													
Preambl		5	To unde Downstr	erst	and		-	acti	ice	the	dį	iffer	ent	tech	niqu	es i	used	in
Prerequ	isite Co	ourses	1021181 1021181 1021181	7110) - B	iopr	oces	s En	igin	eeri	ng				neeri.	ng		
Cours Outcon		Ipon su	eccessful co	omp	letic	on of	the	coui	rse,	stua	lent	s w	ill be	e able	e to:			
CO No) \$.			Coı	ırse	Out	com	es						(I	nowl Based Dom's	on re	evise	h
CO1		•	the separation me				•			-			nd		K	4, S4	4	
CO2		Compar ecovery	e differen	t ce	ell d	listu	rb n	neth	ods	for	pı	rodı	ıct		K	4, S4	4	
CO3		xamine nethods	e the prote	ein	sepa	ratio	n ef	ficie	ency	v of	dif	fere	ent		K	4, S :	5	
CO4		-	uish the pr chromatog					ner	bior	nole	cul	es	by		K	4, S5	5	
CO5			proper me e of the bio				-	g (dı	yin	g) to	o in	crea	ise		K	.5, S(5	
Correlat	ion of ('Os wit	h POs															
CO Nos.		urse Out					Prog	rami	me O	utcoi	nes	(POs	5)			S Ou	rogra pecifi utcom PSOs	ic ies
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	efficien centriff microf method	ncy ugation iltratior	n separate	Н	Н	М	Н	Н	М	М	L	М	Н	-	Н	Н	М	L
CO2	Compa disturb produc	metl		Н	Н	М	Н	Н	М	-	L	М	Н	-	н	Н	М	L
CO3		ion eff	e protein iciency of ods		Н	М	Н	Н	М	М	L	М	Н	-	Н	Н	М	L

CO4	Distinguish the proteins from other bio molecules by various chromatographic methods		Н	Н	Н	Н	М	М	L	М	Н	-	Н	Н	М	L
CO5	Choose proper method of polishing (drying) to increase the value of the biological product	ц	Н	М	Н	М	М	Н	L	М	Н	-	Н	Н	М	L
H – High	; M- Medium; L- Low															
Course (Content:															
LIST OF	EXPERIMENTS:															
LEARN Reference Books	Biotechnology" 3. Janson J.C., and Methods and A	mor ion se exurific urific urific - sp ussle Biot "?, Op I Ryo pplic	ttrac catio catio catio catio ray o er E. techr Prod ben I den I catio	sulp alys tion n - i n - a dryir L. a nolog luct L.earn L., "]	on e affin gel f ng, fi gy, V Re ning VC	e pre excha ity c iltra reez Wei- Wile Seri ein F H Pu	ange hro tion e dr Hou y In ery ies, Purif ub.,	e ch mate chr ying uhu, ters in Butt ficat 198	rom ogr g (L "B cier terv ion 9.	aph atog yop Bios nce, Bio vort _ P	y graph ohiliz epara 198 proc h-Ho rinci	ation ation 8. ess einen	s –] Tec nann , Hig	hnol , 199 h Rea	ogy 02. solut	_ tion
Virtual Lab	https://chem.librete Lab_Techniques Methods/1.5G%3A https://www.assayg https://opsdiagnosti guidepart5.html https://vlab.amrita.e https://vlab.amrita.e https://www.thermode biology-learning-cea application-notes/sea https://openbiotech https://bio.libretext istry (Jakubowski	(Nic Ce genie cs.c cs.c cs.c c cs.c c cs.c c c cs.c c c c	hols ntrif om/a ?sub ner.c ?/pro ation s.ac. gyjc)/01 fugat n/soi appli appli =3& om/i tein- cha in/ez ourna oksh	%3A ion nicati icati icati icati icati nicati biol n/en biol nract xp/b il.co nelve	<u>tion-</u> <u>ons/</u> <u>n=7(</u> / <u>horogy-</u> <u>erist</u> <u>atch</u> <u>m/V</u> <u>es/B</u> :	-pro sam)&si ne/l -reso tics- -rea (OL	tocc plef im= ife-s ourc dial ctor UM	<u>Fec</u> <u>ol-fo</u> <u>nom</u> 722 <u>scie</u> <u>scie</u> <u>scie</u> <u>scie</u> <u>r/the</u> E/1	hnid or-c noge 2&c ence ibra ibra s-m eory 13/P	ell-ly eniza nt=1 e/pro ry/pi emb v.htm PAGI	vsis ution tein- rotein ranes nl E/27/	/hom biolo n-bio s.htm	oger ogy/p logy l	terin nizati rotei -	in-

Structure_and_Catalysis/03%3A_Amino_Acids_Peptides_and_Proteins/3.04%3
<u>A_Protein_Purification</u>
https://www.caframolabsolutions.com/application/homogenizing/protein-
affinity-chromatography/
https://conductscience.com/gel-filtration-chromatography-protocol/
https://ajpsonline.com/HTMLPaper.aspx?Journal=Asian%20Journal%20of%20
Research%20in%20Pharmaceutical%20Sciences;PID=2016-6-4-10

PHARMACEUTICAL & MEDICAL BIOTECHNOLOGY

Course	Code				0	Cour	se T	itle						L]	Г	P	С
10211B	T202			B	IOI	NFC	RM	AT	ICS)				2	()	2	3
Course (Catego	ry	Prog															
Preambl	e		To F crea									lica	tions	s of	biote	echn	olog	y in
Prerequ	isite C	ourses	NIL															
Cour Outcor		Upon	successfu	l cor	nple	rtion	of tl	he c	ours	se, s	tud	ent	s wil	l be i	able	to:		
CO N	os.			C	our	se O	utco	me	5						Know (Base loom	d on	revis	ed
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CO2	2	Demo algori	onstrate the ithms	e sec	luen	ce a	lignr	nen	t an	d pi	ogi	ram	ming	5		K2	2	
CO	3		lop the con		and	defi	nitic	on o	f sec	quer	nce	pati	terns	,		K3	}	
CO4	1	micro		e protein prediction structure algorithms and construction and Protein analysis using bio K3 tools.														
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CO2	Demor sequer progra algorit	nce alig mming	gnment and	Н	Н	Н	М	Н							М	Н	M	
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CO4	and	tion structure	Н	Η	Н	М	Η							H	Н	L	Н
CO5		ver the drug for is diseases by bioinformatics		Н	Н	М	Н							Н	Н	L	Н
H – Higl	h; M- N	Medium; L- Low										•					
Course	Conter	nt:															
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Introduc	tion to	the biomolecules	s (D	NA,	, RN	IA, I	Prot	eins	, Li	ipid	ls a	nd (Carbo	ohydi	rates); ge	ene,
genome,	, DNA	and Protein seque	nce,	seq	uenc	ce as	sem	ıbly,	, sec	quei	nce	con	paris	son.	Over	view	/ of
biologica	al datał	bases, nucleic acid	& p	orote	in da	ataba	ases.										
UNIT II	ſ	BIOLOGICAL	DA	ТАН	RAS	ES									9 ho	urs	
				1 / 11											/ 110	uis	
				ural	clas	sific	atio	n da	tab	ase.	Se	auer	nce fo	ormat	ts &	stora	ige.
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LEARNING RE	SOURCES
Text Books / Reference Books	 Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press. Campbell, M & Heyer, L. J. (2006), Discovering Genomics, Proteomics and Bioinformatics, Pearson Education. Oprea, T. (2005). Chemoinformatics in Drug Discovery, Volume 23. Wiley Online Library. Gasteiger, J. & Engel, T. (2003), Chemoinformatics: a Textbook, Wiley Online Library.
Reference videos	https://www.youtube.com/watch?v=qhoDiwEX8mI https://www.youtube.com/watch?v=JmKD5SnQtFE https://www.youtube.com/watch?v=jFCD8Q6qSTM https://www.youtube.com/watch?v=ipp-pNRIp4g https://www.youtube.com/watch?v=DhxD6sVQEYc
Reference NPTEL	https://archive.nptel.ac.in/courses/102/106/102106065/
Reference research/ review articles	 Abarca-Cabrera, L., Fraga-García, P., & Berensmeier, S. (2021). Bionano interactions: binding proteins, polysaccharides, lipids and nucleic acids onto magnetic nanoparticles. Biomaterials research, 25(1), 12. Dörpinghaus, J., Weil, V., Schaaf, S., & Apke, A. (2023). Sequence Analysis. In Computational Life Sciences: Data Engineering and Data Mining for Life Sciences (pp. 415-437). Cham: Springer International Publishing. Zheng, S., Wolff, G., Greenan, G., Chen, Z., Faas, F. G., Bárcena, M., & Agard, D. A. (2022). AreTomo: An integrated software package for automated marker-free, motion-corrected cryo-electron tomographic alignment and reconstruction. Journal of Structural Biology: X, 6, 100068. Xia, Z., Cui, Y., Zhang, A., Tang, T., Peng, L., Huang, C., & Liao, X. (2021). A review of parallel implementations for the Smith–Waterman algorithm. Interdisciplinary Sciences: Computational Life Sciences, 1-14. Zhang, X. M., Liang, L., Liu, L., & Tang, M. J. (2021). Graph neural networks and their current applications in bioinformatics. Frontiers in genetics, 12, 690049.

Course	Cod	le			(Cour	se T	itle						L	T	'	P	С		
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Course	Cate	gory	Progra																	
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CO No	s.	Course Outcomes											now (Base loom	d on	revis	ed				
CO1		identify	Impart the basic knowledge of immune system and to identify the fundamental characteristics of both the innate and adaptive immune systems													K2				
CO2		Describ interact	e the propo ions	ertie	es of	f an	tiger	n, ai	ntib	odie	s a	nd	their	•		K2				
CO3		Demon regulati		an	tige	n p	orese	ntin	g	cell	s	and	its	5		K2	K2			
CO4			te the mecha concept of				erse	nsiti	ivity	, au	toir	nm	unity	7		K2	K2			
CO5			various ological diag		•	al	tech	niqu	ies	fo	r	diff	erent	t	К3					
Correlat	ion (of COs w	ith POs:																	
CO Nos.		Course O	utcomes				Prog	rami	me O	utco	mes	(POs	5)		Spe Oute			rogram pecific itcomes PSOs)		
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3		
CO1	syst the chai the	wledge em and f cacteristic	ne basic of immune to identify undamental cs of both nd adaptive tems	Н	М										Н	Н				
CO2	of	antigen,	e properties antibodies eractions	М	Н	Н									Н	Н	Н			
CO3	anti	nonstrate gen pres its regul	enting cells	Н	Н	М	М				Н				Н	Н	Н	L		

CO4	hyper autoir	rate anism sensitivity, nmunity a pt of vacci	and the	Η	Н	М	М				Н				Н	Н	н	L
CO5	for	tical tecl d nological	various hniques ifferent		Н	Н	Н	Н	М		М				Н	Н	Н	Н
H – Hig	gh; M- I	Medium; L	- Low															
Course	Conte	nt:																
Course Content: UNIT I INTRODUCTION TO IMMUNE SYSTEM 9 hours																		
UNIT IINTRODUCTION TO IMMUNE SYSTEM9 hoursIntroduction to immunology; cells of the immune system: types of immune response; lymphoid																		
organs:	prima	ry and se	condary	ly	mph	oid	orga	ans;	Na	itura	ıl k	ille	r Co	ells.	Act	ivati	on	and
different	tiation	of T-cells a	and B-ce	ells;	Rec	epto	rs ar	nd S	igna	ling	g: T-	- cel	l and	d B-	cell r	recep	otors.	
UNIT I	I	ANTIGEN	N AND	AN	ТІВ	ODY	Y IN	TEI	RAC	CTI	ON				9) hou	irs	
UNIT II ANTIGEN AND ANTIBODY INTERACTION 9 hours Antibodies: structure, gene organization and functions; antigens: chemical andmolecular nature;																		
Antibod	lies: stru	ucture, gen		zati	on ai	nd fu	incti	ons;	anti	igen	s: cl	hem	ical	andı	nole	culaı	r nati	ıre;
		ucture, gen ants; B ar	e organi							•								
haptens;	; adjuv		e organi nd T-cel	ll ep	pitop	oes;	antig	geni	c de	eterr	nin	ants	on	anti	ibodi	es; a	antig	en-
haptens; antibody	; adjuv y react	ants; B ar	e organi nd T-cel	ll ep	pitop	oes;	antig	geni	c de	eterr	nin	ants	on	anti	ibodi	es; a	antig	en-
haptens; antibody	; adjuv y react	ants; B ar ions; Mor	e organi nd T-cel noclonal	ll ep an	pitop Id P	oes; olyc	antiş lona	geni 1 aı	c do ntibo	eterr odie:	nina s: J	ants prin	on ciple	anti	ibodi nd ຄ	es; a	antig catic	en-
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haptens; antibody Hybrido UNIT I Classes molecul	; adjuv y react oma tec II of MI les, Ant	ants; B ar ions; Mor hnology. ANTIGEN IC – MH	e organi nd T-cel noclonal N PROC C/HLA nting ce	ll ep an CES ger	pitop Id P SIN netic	oes; olyc GA loc	antiş lona . ND i. M	geni 1 aı PRI Ioleo	c do ntibo ESE cula	eterr odie: ZNT r sti	mina s: j AT	ants prin IOP ure	on ciple	anti es a	ibodi nd a <u>9</u> semb	es; a appli) hou ly o	antig catic 1rs f M	en- ns-
haptens; antibody Hybrido UNIT I Classes molecul	; adjuv y react oma tec II of MI les, Ant ell resp	ants; B ar ions; Mor hnology. ANTIGEN IC – MH igen preser	e organi nd T-cel noclonal N PROC C/HLA nting ce okines. MUNIT	ll ep an CES ger Ills-	pitop Id P SIN netic antig	oes; olyc G A loc gen j	antig Iona ND i. M proce	geni 1 aı PRI Ioleo essii	c do ntibo ESE cula ng a	eterr odie: ZNT. r str nd p	mina s: 1 AT: ruct	ants prin ION ure enta	on ciple	anti es a l ass ; reg	ibodi nd a <u>9</u> semb gulati	es; a appli) hou ly o	antig catic irs f M of T-	en- ns-
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haptens; antibody Hybrido UNIT I Classes molecul and B-co UNIT I Autoimn proposed	; adjuv y react oma tec II of MI les, Ant ell resp V V munity, ed mech	ants; B ar ions; Mor hnology. ANTIGEN IC – MH igen present onses; cyto AUTOIM IMMUNC Auto imr	e organi nd T-cel noclonal N PROC C/HLA nting ce okines. MUNIT DEFIC nune di r induct	Il ep an CES ger Ills- TY, Seas ion	Pitop d P SIN netic antig H NCY ses: f of A	G A loc gen J IYP	anti llona ND i. M proce ERS emic	geni 1 an PRI Iolec essiin EEN anc	c do ntibo ESE cula ng a SIT d or, ty, 7	eterr odie: CNT. r stu nd p IVI' gan	mina s: j AT ruct pres TY spee	ants prin ION ure enta ecifi nt c	on ciple and ttion ANI c au of A	anti es a l ass ; reg	ibodi nd a g semb gulati	es; a appli bout hou bout	antig catic urs f M of T urs sord	en- ns- HC cell ers, ses;
haptens; antibody Hybrido UNIT I Classes molecul and B-co UNIT I Autoimn proposed compler	; adjuv y react oma tec II of MI les, Ant ell resp V munity ed mech ment sy	ants; B ar ions; Mor hnology. ANTIGEN IC – MH igen preser onses; cyto AUTOIM IMMUNO Auto imr nanisms for	e organi nd T-cel noclonal N PROC C/HLA nting ce okines. MUNIT DDEFIC nune di r induct unosupp	Il ep an CES ger Ils- TY, CIEN seas ion	pitop d P SSIN netic antig F NCY ses: a of A sion-	G A loc gen J IYPI syste Auto - Gra	antig lona ND i. M proce ERS emic imm	geni l an PRI loled essiin EEN and unit ersu	c dantibo ESE cula ng a SIT d or ty, 7 s ho	eterr odie: ZNT/ r str nd p IVI' gan Treat st re	mina s: p AT: ruct pres TY spe tme eact	ants prin IOP ure enta ecifi nt c ion;	on ciple and tion ANI c au of A tol	anti es a l ass ; reg	ibodi nd a 9 semb gulati mun mmu nce;	es; a appli) hou ly o fon o) hou ne di aller	antig catic Irs f M of T Irs sord lisea:	en- ns- HC cell ers, ses; and
haptens; antibody Hybrido UNIT I Classes molecul and B-co UNIT I Autoimn proposed compler	; adjuv y react oma tec II of MH les, Ant ell resp V v munity, ed mech ment sy nsitivit	ants; B ar ions; Mor hnology. ANTIGEN IC – MH igen preser onses; cyto AUTOIM IMMUNO Auto imr nanisms for stem; imm y - Types	e organi nd T-cel noclonal N PROC C/HLA nting ce okines. MUNIT DDEFIC nune di r induct unosupp	Il ep an CES ger Ils- TY, CIEN seas ion	pitop d P SSIN netic antig F NCY ses: a of A sion-	G A loc gen J IYPI syste Auto - Gra	antig lona ND i. M proce ERS emic imm	geni l an PRI loled essiin EEN and unit ersu	c dantibo ESE cula ng a SIT d or ty, 7 s ho	eterr odie: ZNT/ r str nd p IVI' gan Treat st re	mina s: p AT: ruct pres TY spe tme eact	ants prin IOP ure enta ecifi nt c ion;	on ciple and tion ANI c au of A tol	anti es a l ass ; reg	ibodi nd a 9 semb gulati mun mmu nce;	es; a appli) hou ly o fon o) hou ne di aller	antig catic Irs f M of T Irs sord lisea:	en- ns- HC cell ers, ses; and
haptens; antibody Hybrido UNIT II Classes molecul and B-co UNIT I Autoimm proposed compler hyperser	; adjuv y react oma tec II of MI les, Ant ell resp V munity, ed mech ment sy nsitivity	ants; B ar ions; Mor hnology. ANTIGEN IC – MH igen preser onses; cyto AUTOIM IMMUNO Auto imr nanisms for stem; imm y - Types	e organi nd T-cel noclonal N PROC C/HLA nting ce okines. MUNIT DEFIC nune di r induct unosupp of hype	Il ep an CES ger Ills- TY, CIEI seas ion press press	Pitop d P SIN netic antig E Ses: 1 of 2 sion- nsitiv	es; olyc G A loc gen J YP Syste Auto - Gra vity;	antig lona ND i. M proce ERS emic imm	geni l an PRI loled essiin EEN and unit ersu	c dantibo ESE cula ng a SIT d or ty, 7 s ho	eterr odie: ZNT/ r str nd p IVI' gan Treat st re	mina s: p AT: ruct pres TY spe tme eact	ants prin IOP ure enta ecifi nt c ion;	on ciple and tion ANI c au of A tol	anti es a l ass ; reg	ibodi nd a gemb gulati mmun nce; ccine	es; a appli) hou ly o fon o) hou ne di aller	antig catic Irs f M of T Irs sord lisea: rgy sista	en- ns- HC cell ers, ses; and
haptens; antibody Hybrido UNIT I Classes molecul and B-co UNIT I Autoimn proposed compler hyperset and imm	; adjuv y react oma tec II of MH les, Ant ell resp V d munity, ed mech ment sy nsitivity nunizat	ants; B ar ions; Mor hnology. ANTIGEN IC – MH igen preser onses; cyto AUTOIM IMMUNC Auto imr nanisms for stem; imm y - Types ion.	e organi nd T-cel noclonal N PROC C/HLA nting ce okines. MUNIT DDEFIC nune di r induct unosupp of hype	Il ep an CES ger Ils- TY, CIEN seas ion press rser	pitop d P SIN netic antig Bes: F of A sion- nsitiv	G A loc gen j YYP syste Auto - Gra vity;	antig lona ND i. M proce emic emic imm aft vo Imm	geni l an PRI lolec essin anc unit ersu nunc	c do ntibo ESE cula ng a SIT d or ty, 7 s ho odef	eterrr odie: ZNTZ r str nd p IVI gan freat st re ficier	mina s: p ruct ores TY spe tme eact ncy	ants prin IOP ure enta ecifi nt c ion; -A	on ciple and ttion ANI c au of A tol IDS;	anti es a l ass ; reg D utoin utoin ileran ; Va	ibodi nd a semb gulati umun nce; ccino	es; a appli) hou ly o fon o) hou ne di aller es-re) hou	antig catic IIIS f M f T	en- ns- HC cell ers, ses; and nce
haptens; antibody Hybrido UNIT I Classes molecul and B-co UNIT I Autoimn proposed compler hyperset and imm	; adjuv y react oma tec II of MH les, Ant ell resp V wunity, ad mech ment sy nsitivity nunizat	ants; B ar ions; Mor hnology. ANTIGEN IC – MH igen preser onses; cyto AUTOIM IMMUNO Auto imm nanisms for stem; imm y - Types ion. IMMUNO phoresis,	e organi nd T-cel noclonal N PROC C/HLA nting ce okines. MUNIT DDEFIC nune di r induct unosupp of hype	Il ep an CES ger Ills- TY, CIEI seas ion press rrser INI R	pitop d P SIN netic antig Ses: F of A sion- nsitiv QUI	G A loc gen 1 IYP Syste Auto - Gra vity;	antig lona ND i. M proce emic emic imm aft vo Imm	geni l an PRI lolec essin anc unit ersu nunc	c do ntibo ESE cula ng a SIT d or, ty, 7 s ho odef	eterr odie: CNT. r str nd p IVI gan freat st re ficier etho	mina s: p ruct pres TY spee tme eact ncy	ants prin ION ure enta ecifi nt c ion; -A	on ciple and ttion ANI c au of A tol IDS; de	anti es a l ass ; reg D utoin utoin ileran ; Va	ibodi nd a gulati gulati nmun nce; ccino gon o	es; a appli) hou ly o fon o) hou ne di aller es-re) hou	antig catic IIIS f M f T	en- ns- HC cell ers, ses; and nce ens,

technology for the study of the immune system, Immunotherapy with genetically engineered antibodies.

LEARNING	RESOURCES
Text Books	1. Kuby J., "Immunology", WH Freeman & Co., 2000.
I EXT DOOKS	2. Roitt I., MaleBrostoff., "Immunology", Mosby Publ., 2002.
	1. Ashim K. Chakravarthy, "Immunology", TataMcGraw-Hill, 1998.
Reference Books	2. Coico Richard, "Immunology: A Short Course", 5 th Edition, John Wiley, 2003.
	3. Khan, Fahim Halim, "Elements of Immunology", Pearson Education, 2009.
	https://www.youtube.com/watch?v=xQiF2ZwI2uo
D.f	https://www.youtube.com/watch?v=GzuM_nfrXLk
Reference videos	https://www.youtube.com/watch?v=R69M7NuBNBA
videos	https://www.youtube.com/watch?v=v2najhx2PPs
	https://www.youtube.com/watch?v=ERk0hwqhyDw
Reference NPTEL	https://archive.nptel.ac.in/courses/102/105/102105083/
Reference research/ review articles	 Varadé, J., Magadán, S., & González-Fernández, Á. (2021). Human immunology and immunotherapy: main achievements and challenges. Cellular & Molecular Immunology, 18(4), 805-828. Megha, K. B., & Mohanan, P. V. (2021). Role of immunoglobulin and antibodies in disease management. International journal of biological macromolecules, 169, 28-38. Naito, T., & Okada, Y. (2022, January). HLA imputation and its application to genetic and molecular fine-mapping of the MHC region in autoimmune diseases. In Seminars in immunopathology (Vol. 44, No. 1, pp. 15-28). Berlin/Heidelberg: Springer Berlin Heidelberg. Nymark, L. S., Miller, A., & Vassall, A. (2021). Inclusion of additional unintended consequences in economic evaluation: a systematic review of immunization and tuberculosis cost-effectiveness analyses. PharmacoEconomics-open, 1-17. Ahsan, H. (2022). Monoplex and multiplex immunoassays: approval, advancements, and alternatives. Comparative clinical pathology, 31(2), 333- 345.

Course (Course Title L									Т		P	С			
10211BT	307	IMMUN)L()GY	' LA	BO	RA'	lOF	RY			0		0		2	1	
Course C	atagami	Ducanan	- C															
Course Ca Preamble		Program To unde			nd n	ract	icot	hal	็ทาทา	11100		ical	toch	iana	20			
Prerequis			rsiu	nu u	nu p	ruci	ice i	ne i		unc	nog	icui	iecni	пцие				
rerequis																		
Course Outcomes	Upon :	Upon successful completion of the course, students will b											able to:					
CO Nos.		Course Outcomes										Knowledge Level (Based on revised Bloom's Taxonomy)						
CO1		Make use of the animal handling techniques for in vivo studies.												k	K3, S	2		
CO2		y and classify					-	-	-					K	K3, S	3		
CO3		ze the antibody antitative met			tigen	inte	eract	tions	s by	qua	alita	tive		k	K4, S	4		
CO4		guish the per sytes from the			bloo	d n	nonc	onuc	lear	ce	ells	and		k	K4, S	5		
CO5		ver and loca			ide	vari	iety	of	ar	ntig	ens	by		k	K4, S	5		
Correlatio		with POs:				Prog	ramı	ne O	utco	mes	(POs	\$)	Program Specific Outcomes (PSOs)					
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1 h		of the animal echniques for idies.	Н	М	М	Н	М	М	-	Н	М	Н	-	Н	Н	Н	Н	
		nd classify the blood group.	Н	Н	М	Н	M	M	-	L	M	Н	-	Н	Н	Н	H	
CO3 a	and antige by qual	the antibody n interactions itative and ve methods.	Н	Н	Н	Н	Н	М	-	L	М	Н	-	Н	Н	Н	Н	
CO4 m	eripheral	ononuclear cells and onocytes from the		Н	М	Н	М	М	-	L	М	Н	-	Н	Н	Н	H	
	CO5 Discover and localize wide variety of antigens by immunochemical methods.			Н	Н	Н	Н	М	-	L	М	Н	_	Н	Н	Н	H	

Course Content:

LIST OF EXPERIMENTS:

- 1. Handling of animals, immunization and raising antisera.
- 2. Identification of leukocytes from blood smear by differential staining (Geimsa stain).
- 3. Separation of Peripheral Blood Mononuclear Cells (PBMC) by Ficoll –Hypaque.
- 4. Isolation of monocytes from blood.
- 5. Agglutination reaction to determine blood group.
- 6. Immunodiffusion and immunoelectrophoresis.
- 7. Enzyme Linked Immuno Sorbent Assay (ELISA).
- 8. Testing for typhoid antigens by Widal test.
- 9. Identification of T cells by T-cell rossetting using sheep RBC.
- 10. Western blotting.

LEARNING RESOURCES

Reference Books	 Roitt I, Male, Brostoff, "Immunology", Mosby Publ., 2002. Kuby J, "Immunology", 7th Edition, WH Freeman & Co., 2013. Ashim K. Chakravarthy, "Immunology", TataMcGraw-Hill, 1998. Edward A. Greenfield, Dana-Farber, "Antibodies: A Laboratory Manual", Second Edition, Cancer Institute, Cold Spring Harbour Laboratory, 2014.
Virtual Lab	https://www.sinobiological.com/resource/antibody-technical/pab-production https://www.macsenlab.com/blog/giemsa-stain-overview/ https://www.stemcell.com/isolating-mononuclear-cells-from-whole-blood-by- density-gradient-centrifugation.html https://www.reprocell.com/blog/cls/protocol-isolating-pbmcs-whole-blood https://www.medicine.mcgill.ca/physio/vlab/bloodlab/ABO_n.htm https://microbenotes.com/immunoelectrophoresis-principle-procedure-results- and-applications-advantages-and-limitations/ https://bio.libretexts.org/Bookshelves/Biotechnology/Lab_Manual%3A_Introdu ction_to_Biotechnology/01%3A_Techniques/1.17%3A_ELISA https://www.metropolisindia.com/blog/health-wellness/widal-test-introduction- principle-procedure-preparation- price#:~:text=The%20Widal%20test%20is%20an,threatening%20illnesses%20l ike%20typhoid%20fever. https://www.stemcell.com/products/brands/rosettesep-immunodensity-cell- separation.html https://vlab.amrita.edu/?sub=3&brch=187∼=1331&cnt=2

PROGRAM ELECTIVE COURSES VTR UGE 2021

INDUSTRIAL DOMAIN

Course	Code			Course Title											T		P	С	
10212B	ST101	F	TLUID M	IECHANICS AND TRANSPORT PHENOMENA										3	0		0	3	
			T																
Course	C <mark>ateg</mark> o	ory	Progra	m E	lecti	ive													
Preamb	le			To understand the basic concepts of fluid mechanics and transpor henomena and its application in biological system.															
Prerequ	isite C	102118	211BT112 – Unit Operations in Biotech Industry																
Cours Outcon		Upon suc	cessful c	omp	oletic	on of	^c the	сои	rse,	stuc	lent	ts w	ill be	e abl	e to:				
CO N					ours	e Oı	itco	mes							Inow (Base loom	d on	revis	ed	
CO1		Summari	ze the fur	ıdaı	nent	als c	of flu	uid n	necł	nani	cs.					K2			
CO2		Explain t	he proces	s in	volv	ved i	n tra	nspo	ort p	hen	om	ena				K2			
CO3		Utilize th	e momen	tun	n trai	nspo	rt of	diff	erer	nt op	bera	tion	ıs.			K3			
CO4		Develop	the know	ledg	ge al	oout	ener	gy t	rans	por	t.					K3			
CO5		Apply the system.	e concept	ts o	f tra	ansport phenomena in biological									K3				
Correlat CO Nos.		COs with ourse Outco					Prog	ramı	ne O	utcoi	mes	(POs	\$)		Progra Specif Outcon (PSOs				
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	Summ fundai mecha	nentals	the of fluid	Н	Н		Н	Н							Н	Η	Н		
CO2		in the red in t mena.	process transport	Н	Н		Н	Н							Н	Н	Н		
CO3		ze the momentum port of different			Н	Н	Н	Н							Н	Н	Н		
CO4	Develop the knowledge			Н	Н	М	Н	Н							Н	Н	Н		
CO5	Apply the concepts of			Н	Н	Н	Н	Н							Н	Η	Н		
H _ High	•• M_ N	/ledium;]	L-Low																

Course Con	tent:	
UNIT I	BASICS OF FLUID MECHANICS	9 hours
Fluid definit	ion and classification, Rheological behaviour of fluids & amp; 1	Newton's Law of
viscosity. –	Density, specific gravity, specific weight, surface tension, vap	our pressure and
viscosity. Flu	id statics-Pascal's law, Hydrostatic equilibrium, Barometric equa	ation and pressure
measuremen	t(problems),Basic equations of fluid flow – Continuity equation,	, Euler's equation
and Bernoull	i equation, Reynolds experiment; Flow through circular and non	-circular conduits
– Hagen Poi	seuille equation (no derivation).Flow past immersed bodies - c	lrag and drag co-
efficient, ap	plication of KozneyKarmen& Burke Plummer equation	n; Flow through
stagnant flui	ds - theory of Settling and Sedimentation -Equipment (cyc	clones, thickners)
Conceptual r	umerical.	
UNIT II	INTRODUCTION TO TRANSPORT PHENOMENA	9 hours
Philosophy a	and fundamentals of transport phenomena: Importance of trans	port phenomena;
analogous na	ture of transfer process; basic concepts, conservation laws, Male	aular transport of

analogous nature of transfer process; basic concepts, conservation laws. Molecular transport of momentum, Heat and mass, laws of molecular transport, Newton's law of viscosity, Fourier law of heat conduction, and Fick's law of diffusion. Transport coefficients – viscosity, thermal conductivity and mass diffusivity.

UNIT III MOMENTUM TRANSPORT

Viscosity, temperature effect on viscosity of gases and liquids, Newton's law, mechanism of momentum transport, shell balance method, pressure and velocity distributions in falling film, circular tube, annulus, slit.

UNIT IV ENERGY TRANSPORT

9 hours

9 hours

Thermal conductivity, temperature and pressure effect on thermal conductivity of gases and liquids, Fourier's law, mechanism of energy transport, shell energy balance, temperature distribution in solids and laminar flow, with electrical, nuclear, viscous, chemical heat source, heat conduction through composite walls, cylinders, spheres, fins, slits.

UNIT V TRANSPORT PHENOMENA IN MICROBIAL SYSTEM

9 hours

Unified theory of momentum, energy and mass transfer; Flow and mixing of Newtonian and non-Newtonian fluids; Gas-liquid mass transfer in microbial systems; Oxygen transfer rates; Single and multiple bubble aeration; Design of spargers and aeration equipment; Mass transfer across free surface as well as freely rising or falling bodies; Basic concept of oxygen transfer coefficient (KLa) and its measurement; Correlation of KLa with other operating variables; Factors affecting the KLa.

LEARNING	GRESOURCES
Text Books	 Bird R.B., Stewart W.E. and LighfootE.W., "Transport Phenomena", John Wiley, New York, 1960. Wilty J.R., Wilson R.W. and Wicks C.W., "Fundamentals of Momentum Heat and Mass Transfer", 5th Edition, John Wiley, New York, 2007.
Reference Books	 Christie J. Geankopolis, "Transport Processes and Separation Process Principles", 4th Edition, PrenticeHall, 2015. Shuler M.L. and FikretKargi, "Bioprocess Engineering: Basic Concepts", 2nd Edition, Prentice Hall, 2001.
Reference videos	https://youtu.be/d6N9kShpzLA https://youtu.be/m6FmA0nclM8 https://youtu.be/KM_BstD6wbI https://youtu.be/hDP6egLrsdM https://youtu.be/_517v0r6Vfg https://youtu.be/O9VL-QHpxiU
Reference NPTEL	https://archive.nptel.ac.in/courses/112/105/112105269/
Reference research/ review articles	 Patra, A. K., Nayak, M. K., & Misra, A. (2020). Viscosity of nanofluids-A Review. Int. J. Thermofluid Sci. Technol, 7(2), 070202. Junker, M. A., te Brinke, E., Compte, C. M. V., Lammertink, R. G., de Grooth, J., & de Vos, W. M. (2023). Asymmetric polyelectrolyte multilayer nanofiltration membranes: Structural characterisation via transport phenomena. Journal of Membrane Science, 681, 121718. Karmakar, A., & Acharya, S. (2021). Numerical simulation of falling film flow hydrodynamics over round horizontal tubes. International Journal of Heat and Mass Transfer, 173, 121175. Hummel, M., Müller, A., Forthuber, S., Kranzl, L., Mayr, B., & Haas, R. (2023). How cost-efficient is energy efficiency in buildings? A comparison of building shell efficiency and heating system change in the European building stock. Energy Efficiency, 16(5), 32. Deaton, K. E., de León, L. R. L., Pascual, S., & Deshusses, M. A. (2022). Critical assessment of gassing-in methods to determine mass transfer coefficient in miniature and microbioreactors with gas-liquid flow. Biochemical Engineering Journal, 187, 108655.

Course Code	Course Title	L	Т	Р	С
10212BT102	BIOENERGY	3	0	0	3
Course Category	Program Elective				
Preamble	This course introduces the basics of Bioe explain the basic and advanced con- sustainability concepts.				
Prerequisite Courses	NIL				

Course Outcomes	Upon successful completion of the course, students will be	e able to:
CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Outline the basic concepts and types of Bioenergy and their global impact.	K2
CO2	Illustrate the various Biomass conversion technologies to obtain the bio substrates	K2
CO3	Utilize the biomass feed stock to produce biofuel	K3
CO4	Develop biofuel by using microbial technology and nanotechnology concepts with higher yield.	К3
CO5	Analysis the life cycles of biofuel generators in environment for sustainability maintenance	К3

CO Nos.	CO Nos. Course Outcomes		Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
			2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	Outline the basic concepts and types of Bioenergy and their global impact.	н					Н	Н					Н	Н	Н	М	
CO2	Illustrate the various Biomass conversion technologies to obtain the bio substrates	н			Н		Н	Н	Н				Н	Н	Н	Н	
CO3	Utilize the biomass feed stock to produce biofuel	н	Н	Н	Н		Н	Н	Μ				Н	Н	Н	Н	

CO4	Develop biofuel by using microbia technology and nanotechnology concepts with highe yield.	d H	Н	М	Н		Н	M	M				Н	М	М	Н
CO5	Analysis the life cycle of biofuel generators in environment fo sustainability maintenance		Н	Н	Н	Н							Н	Н	Н	Н
H – Hig	n; M- Medium; L- Low	•														
	Content:					DO	. 7									
UNIT I								. f .			F) hou		
	tion to energy and energy														•	
Bioener	entional and renewable gy.	sour	ces,	Indi	an ai	na g	1008	al er	ierg	y s	ourc	es, 1	ssues	, Coi	ıcep	t oi
UNIT I	BIOMASS CON	IVE	RSIO	ON 1	ГЕС	HN	OL	OG	IES	,			Ģ) hou	irs	
Energy	crops: wood (Lignoc	ellulo	ose),	Mi	icrob	oial	deg	grad	atio	n,	Bio	ener	gy to	echn	olog	ies:
Thermo	chemical and biochemi	ical,	The	rmo	chen	nical	l: Ir	ncin	erat	ion	, C	ombi	ustion	i, Py	roly	sis,
Liquefac	tion, gasification, Fisch	er-Tr	opsc	h pr	oces	s foi	: liqu	uid l	oiof	uel	s, H	ydro]	lysis,	Enzy	me	and
-	rolysis, Fermentation.			1			I				•		•			
UNIT I	I BIOFUELS												ç) hou	irs	
Introduc	tion to First, Second an	d Th	ird g	gene	ratio	n bi	iofu	els,	Bic	ma	ss a	nd f	eedsto	ock f	for f	irst,
second a	and third generation bio	fuels	, de	velo	pme	nt o	f ne	w b	ion	nass	fee	dsto	cks a	nd te	echn	ical
constrain	nts, Approximate and u	ultim	ate a	inaly	/sis	of I	Bion	nass	, В	ion	nass	logi	stics	invo	lvec	l in
harvesti	ng, collecting, densificat	ion,	trans	port	and	stor	age									
UNIT I	ADVANCED B	IOEI	NER	GY	CO	NCI	ЕРТ	S					ç) hou	irs	
Advance	d bioenergy concepts,	Mic	robia	al fu	el c	ells,	wo	orkir	ng j	orin	cipl	e an	d app	olicat	tions	of
biologic	al fuel cells, Biocoal, Na	anote	chnc	ology	/ and	l its	role	in l	Bio	ene	rgy,	Adv	anced	l low	car	oon
fuels.																
UNIT V	BIOENERGY A	ND	SUS	TA	INA	BIL	ITY	ľ					9) hou	irs	
Sustaina	bility, Environmental su	stain	abili	ity, E	Bioer	herg	y &	sus	tain	abi	lity,	Life	Cycl	e An	alysi	s I:
General	understanding, Cradl	e-to-	grav	e, f	field	to	W	heel	S	con	cept	s, (Goal	and	sc	ope
determin	ation, defining LCA bo	ounda	aries	; Lif	e Cy	ycle	An	alys	is I	I, I	life	Cycl	e Inv	ento	ry, I	Life
	ation, defining LCA bo ssessment.	ounda	aries	; Lif	e C	ycle	An	alys	is I	I, I	life	Cycl	e Inv	rento	ry, I	Life

LEARNING	RESOURCES
	1. Chakraverthy A, "Biotechnology and Alternative Technologies for Utilization ofBiomass or Agricultural Wastes", Oxford & IBH publishing Co., 1989.
	2. Mital K.M, "Biogas Systems: Principles and Applications", New Age International publishers (P) Ltd., 1996.
Df	3. NijagunaB.T., "Biogas Technology", New Age International publishers (P) Ltd., 2002.
Reference Books	4. Venkata Ramana P. and Srinivas S.N, "Biomass Energy Systems", Tata EnergyResearch Institute, 1996.
	5. Tiwari G.N. and Ghosal M., "Renewable Energy Resources: Basic Principles and Applications", Narosa Publishing House, India, 2004.
	6. David M. Mousdale, "Biofuels: Biotechnology, Chemistry, and Sustainable Development', CRC Press, 2008.
	7. Gupta, Vijai Kumar, Tuohy, Maria G., "Biofuel Technologies RecentDevelopments", Springer, 2013.
	https://youtu.be/Zgp86PVXXuQ
Defenence	https://youtu.be/txRnYTzrb60
Reference videos	https://youtu.be/rjbq_Q0yEbo
viucos	https://youtu.be/bECIaInLmRw
	https://youtu.be/_iiAcuOO-Ds
Reference NPTEL	https://archive.nptel.ac.in/courses/102/104/102104057/
	1. Anca-Couce, A., Hochenauer, C., & Scharler, R. (2021). Bioenergy technologies, uses, market and future trends with Austria as a case study. Renewable and Sustainable Energy Reviews, 135, 110237.
Reference	2. Zang, G., Sun, P., Elgowainy, A. A., Bafana, A., & Wang, M. (2021). Performance and cost analysis of liquid fuel production from H2 and CO2 based on the Fischer-Tropsch process. Journal of CO2 Utilization, 46, 101459.
research/ review articles	 Wang, Y., Wang, J., Schuler, J., Hartley, D., Volk, T., & Eisenbies, M. (2020). Optimization of harvest and logistics for multiple lignocellulosic biomass feedstocks in the northeastern United States. Energy, 197, 117260.
	4. Obileke, K., Onyeaka, H., Meyer, E. L., & Nwokolo, N. (2021). Microbial fuel cells, a renewable energy technology for bio-electricity generation: A mini-review. Electrochemistry Communications, 125, 107003.
	 Calvin, K., Cowie, A., Berndes, G., Arneth, A., Cherubini, F., Portugal- Pereira, J., & Smith, P. (2021). Bioenergy for climate change mitigation: Scale and sustainability. GCB Bioenergy, 13(9), 1346-1371.

Course	Code				Cou	rse [Fitle	9					L]	[P	С		
10212B	T103	FOOD	PR	OC	ESS	ING	; TF	CH	INO	LO	G	ľ	3	0)	0	3		
	·													·		·			
Course	Category	Progra	m E	Elect	ive														
Preamb	le	To und	erst	and	the i	impo	rtan	ice d	and	teck	hniq	ues	of fo	od pr	roce	ssing	ς.		
Prerequ	isite Courses	102111	<i>3T1</i>	01 -	Micr	robic	olog	y											
Course Outcom	I non succ	Upon successful completion of the course, students will be							be a	ıble i	to:								
CO Nos	S.	Course Outcomes									(Base loom	d on	revis	ed					
CO1	Infer the properties.		onst	titue	nts	of fo	ood,	the	eir s	our	ces	and		K2					
CO2	Identify ar									·					K2				
CO3	Utilize the processing					cial r	nicr	oorg	gani	sms	s in	food		К2					
CO4	Identify the infections											food		K2					
CO5	Make use and blanch												К3						
Correlat	ion of COs wit	h POs:													r				
CO Nos.	Course Out	comes		1	1	Prog		ne O	utco						S O	rogra pecifi utcon PSOs	ic nes 5)		
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3		
CO1	Infer the constituents their source properties.	-	Н		Н	М								Н	Н	Н	М		
CO2		ntify and select the litives that aid in H d processing.			Н	L								Н	Н	Н	Н		
CO3	of 1	-			М	М								Н	Н	Н	Н		

CO4	Identify the vari food borne dises such as food infect and intoxicaticaused by f spoilage.	ases ions _H	М	М			Н	Н	Н				Н	М	М	Η
CO5	preservation (sterilization,		Н	Н	Н	Н							Н	Н	Н	Н
H – Higl	; M- Medium; L- L	ow														
Course																
UNIT I								9 ho								
		s of food – carbohydrates, lipids, proteins, water, vitamins and minerals, dietary														
	role and functional	proper	ties	in f	ood	, co	ntri	buti	on	to	orga	nole	ptic	and	text	ural
character	istics.															
UNIT II	FOOD ADDI	TIVES												9 ho	urs	
Classific	ation, intentional and	d non-in	tenti	onal	add	litiv	es, f	ùnc	tior	al 1	ole i	in fo	odpro	ocess	ing	and
preserva	ion; food colorants -	– natura	l and	l arti	ficia	al; fo	ood	flav	vors	; er	zym	les a	s foo	d pro	cess	ing
aids																
UNIT II	I MICROORG	ANISM	S AS	SSO	CIA	TE	D W		HF	00	D			9 ho	urs	
Bacteria.	yeasts and molds –	sources	s, typ	bes a	nd s	pec	ies d	of ir	npc	orta	nce i	n fo	odpro	ocess	ing	and
	ion; fermented food					•			•				1		U	
UNIT IV	FOOD BORN	F DISF	ASF	7					-					9 ho	urc	
	ation – food infection				l oth	er ty	/pes	; fo	od i	nto	xicat	ions				<u>2</u> S –
	and non-bacterial;						-						-	-		
	vegetable, fruit, meat, poultry, beverage and other food products.															
UNIT V	FOOD PRESI	ERVAT	ION	I										9 ho	urs	
Principle	s involved in the use	of steril	izati	on, p	oaste	uriz	atio	n ar	nd b	lan	ching	g, th	ermal	l deat	th cu	rve
of micro	organisms, canning;	frozen s	torag	ge-fr	eezii	ng c	hara	icter	risti	cs c	of foo	ods,	micro	obial	activ	vity
		al meth	ods o	of fo	odpr	esei	vati	on-	pic	kin	g, sa	lting	g, sun	dryi	ng.	
at low te	mperatures, tradition								_		-					
at low te	nperatures, tradition								_		-					
	ING RESOURCES								_		-					

	2. SivasankarB., "Food Processing and Preservation", Prentice-Hall of India Pvt. Ltd., New Delhi, 2002.
Reference Books	 FrazierW.C.andWesthoffD.C., "Food Microbiology", 4thEdition, McGraw- Hill Book Co., New York, 1988. JayJ.M., "Modern Food Microbiology", Cbs Pub., New Delhi, 1987.
Reference videos	2. JayJ.M., Modern Food Microbiology , Cbs Pub., New Denn, 1987. https://www.youtube.com/watch?v=OjhbTvyR-Ts https://www.youtube.com/watch?v=jSgILz https://www.youtube.com/watch?v=W81V-d36y5k&list=PL1- n1zj2ZzWtztfCAebd5ORTBRMr55dpu https://www.youtube.com/watch?v=L3pI6CISTZE https://www.youtube.com/watch?v=wWLm290vamg
Reference NPTEL	https://archive.nptel.ac.in/courses/126/105/126105011/
Reference research/ review articles	 Cuéllar, A. D., & Webber, M. E. (2010). Wasted food, wasted energy: the embedded energy in food waste in the United States. Environmental science & technology, 44(16), 6464-6469. Sowbhagya, H. B., & Chitra, V. N. (2010). Enzyme-assisted extraction of flavorings and colorants from plant materials. Critical reviews in food science and nutrition, 50(2), 146-161. Elkenany, R., Eltaysh, R., Elsayed, M., Abdel-Daim, M., & Shata, R. (2022). Characterization of multi-resistant Shigella species isolated from raw cow milk and milk products. The Journal of veterinary medical science, 84(7), 890–897. https://doi.org/10.1292/jvms.22-0018 Lorenzo, J. M., Munekata, P. E., Dominguez, R., Pateiro, M., Saraiva, J. A., & Franco, D. (2018). Main Groups of Microorganisms of Relevance for Food Safety and Stability: General Aspects and Overall Description. Innovative Technologies for Food Preservation, 53–107. https://doi.org/10.1016/B978- 0-12-811031-7.00003-0 Ferreira, S. M., Matos, L. C., & Santos, L. (2024). Harnessing the potential of chestnut shell extract to enhance fresh cheese: A sustainable approach for nutritional enrichment and shelf-life extension. Journal of Food Measurement and Characterization, 18(2), 1559-1573.

Course	Code			Cou	ırse	Titl	e						L]	[P	С	
10212B	T104	AGRICUI	JTU	RA	L B	[OT]	ECI	HN(OLO)G	Y		3	0)	0	3	
Course	Category	Program																
Preamb	e	To compr agricultur			the k	now	ledg	ge a	nd a	app	lica	tion	s of	biote	echn	ology	v in	
Prerequ Courses	isite	NIL																
Cours Outcom	$ I / n \rangle$	on successful c	omp	oletia	on oj	f the	сои	ırse,	, stu	den	its v	vill E	oe ab	le to	:			
CO No	·S.	Course Outcomes											(E	owle Based oom's	on r	evised	ł	
CO1		Understand the basic concepts of normal and hydright plant cells development for agricultural applications.									-	rid	K2					
CO2		Apply the various genetic engineering tools and metho to improve the growth and production of plant.									tho	ds	K2					
CO3	agri	ve plant grow cultural field v biomass.		-					-						K2			
CO4		bly proper plan radation of mat				-	es c	ons	erva	tio	n ai	nd		K2				
CO5		ke use of ethica elopment	al k	now	ledg	e of	GM	l fo	r ag	ricu	ıltur	al			K3			
Correlat	ion of CO	s with POs:																
CO Nos.		se Outcomes				Prog	ramı	ne O	utcoi	mes	(POs	i)				rogra pecifi utcom PSOs	c es	
		1 2 3 4 5 6 7 8 9						10	11	12	1	2	3					
CO1	concepts hybrid developn	nd the basic of normal and plant cells nent for agri pplications.	Н		L	М			L					Н	Н	М		
CO2	Apply genetic tools and improve	the various engineering d methods to the growth and on of plant.	Н	Н	М	М	М	Н	М	М				Н	Н	М	L	

CO3	Solve plant growth promotion related problems in agricultural field with organic products with microbes and biomass.		L	М	Η	Н	Н		Н	Н	Н	Н
CO4	Apply proper plan for rare species conser vation and degradation of materials by plants	Н	L	Н	Н	М	Н		Н	Н	М	Н
CO5	Make use of ethical knowledge of GM for agricultural development	М	Н	М	Н	Н	М		Н	Н	М	М
H – Higl	n; M- Medium; L- Low											

Course Content:

UNIT I INTRODUCTION

9 hours

Basic concepts of Agriculture, Role of Genetic engineering for increasing crop productivity, Agricultural Applications of Genetic Engineering, : shoot - tip - cultures, shoot - tip - grafting, viricidal compound, Protoplast isolation: culture and fusion, selection of hybrid cells and regeneration of hybrid plants, somatic hybridization, Introducing genes into pro-and eukaryotes using gene transfer methods, DNA mediated and Agrobacterium mediated transfers, microinjection, electroporation, somatic cell hybridization.

UNIT II GENETIC ENGINEERING TECHNOLOGIES IN AGRICULTURE

9 hours

9 hours

Techniques for the insertion of genes into plant cells, Ti plasmid and vectors, (i) Transgenic plants (ii) Gene cloning, Restriction Fragment Length Polymorphisms, Transposons, and Insertional mutagenesis. Molecular Farming: Plants As factories for biopharmaceuticals, Transgenic value added specialty crops, Use of antisense RNA and other technologies, Developing stress tolerant varieties, vaccine and antibody producing plants. Terminator technology, Introduction of male sterility through genetic engineering. Genetic engineering in improving nitrogen fixation in plants.

UNIT III BIOFERTILIZERS AND ORGANIC FARMING

Biofertilizer: Mass cultivation of microbial inoculants, green manuring, algalization, Azolla. Microbial products and plant health: PGPR (plant growth promoting Rhizobacteria), significance of mycorrhizae, toxin producing microbes (antibiotics, aflatoxin, and others), microbial herbicides, Organic Farming: Introduction and sustainable use of natural and bioresources, Organic standards and certification of organic produce and products, Biological control, Global initiatives and future prospects.

UNIT IV	BIODIVERSITY AND ENVIRONMENTAL PRESERVATION	9 hours
Preservation o	f rare plant species germplasm collection and conservation	n, Soil Reclamation:
Phytoremediat	ion	
UNIT V	ISSUES IN AGRICULTURE AND FOOD SECURITY	9 hours
World Food Se	curity: Causes of food insecurity, social economic issues, en	suring food security,
BIS regulation	s, GM food, GM Crops – Ethical challenges.	
LEARNING I	RESOURCES	
	 Arie Altman, "Agricultural Biotechnology', Marcel D Henry R.J., "Practical applications of Plant Molecular & Hall London, UK, 1997. Chrispeels M.J. and Sadava D.E., "Plants, 	Biology", Chapman
Reference Books	Biotechnology", 2 nd Edition, American Society of Pla and Bartlett Publishers, USA, 2003.	
	4. Lindsey K, Jones M.G.K., "Plant biotechnology In A hall, 1990.	griculture", Prentice
	5. Bhojwani S.S. and Razdan M.K., "Plant Tissue of Practice", Elsevier Science, Netherlands, 2004.	culture Theory and
	https://www.youtube.com/watch?v=ICv9o3dexrc	
	https://www.youtube.com/watch?v=Un_LA9s9y-E	
Reference videos	https://www.youtube.com/watch?v=2wStx02R_qg https://www.youtube.com/watch?v=dtKThKBq454	
viucos	https://www.youtube.com/watch?v=tLMW96vkduI	
	https://www.youtube.com/watch?v=iyT0wTEPO08	
Reference NPTEL	https://onlinecourses.nptel.ac.in/noc24_ag08/preview	
	1. Ye, R., Yang, X., & Rao, Y. (2022). Genetic Engine for Improving Crop Yield and Quality. Agron https://doi.org/10.3390/agronomy12040759	
	 Aziz, Mughair Abdul, Faical Brini, Hatem Rouz Masmoudi. "Genetically engineered crops for sustain production systems." Frontiers in Plant Science 13 (https://doi.org/10.3389/fpls.2022.1027828. 	ably enhanced food November 8, 2022).
Reference research/ review articles	 Aloo, Becky N., Vishal Tripathi, Billy A. Makumba, a "Plant growth-promoting rhizobacterial biofertilizers The past, present, and future." Frontiers in Plant Sci 16, 2022). https://doi.org/10.3389/fpls.2022.1002448. 	for crop production: ence 13 (September
	 4. "Origins of food crops connect countries worldwide." Society. Biologica Sciences/Proceedings - Royal Sciences 283, no. 1832 (June 15, 2 https://doi.org/10.1098/rspb.2016.0792. 	e .
	 Ahmad, N., Alam, Z., SK, S., & Husain, M. (202 concept, causes, Effects and Possible Solutions Humanities and Social Science, 2(1), 105-113. 	•

Course Co	de	L	Т	Р	C			
10212BT10)5	ALGAL BIOTECHNOLOGY	3	0	0	3		
Course Cate	egory	Program Elective						
Preamble		To have an in depth knowledge on the growth and development.	variou	s aspec	cts of	algal		
Prerequisite	e Courses	NIL						
Course Outcomes	Upon succ	ll be abi	le to:					
CO Nos.		Course Outcomes		Knowledge Leve (Based on revised Bloom's Taxonom				
CO1		e sterilization techniques to prepare mediur e cultivation	n for		K2			
CO2	· ·	e micronutrient enriched microalgal with protection to the second s	roper		K3			
CO3	Identify th cultivation	algae		K3				
CO4		e microalgae biomass for various indu paration and commercialization.	strial		K3			
CO5		of the microalgae to produce the biofu and marine water.	el in		K3			

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Utilize the sterilization techniques to prepare medium for micro algae cultivation	н					Н	Н					Н	Н	Н	М
CO2	Develop the micronutrient enriched microalgal with proper cultivation techniques.	н		Н	Н		Н	Н	Н				Н	Н	Н	Н
CO3	Identify the physiochemical parameters for microalgae cultivation at pilot and industrial level.	Н	Н	Н	Η	М	Н	Н	М				Н	Н	Н	Н

CO4	Utilize the microalgae piomass for various industrial product separation and commercialization.	Н		Н	Н			М	М				Н	М	М	Н
CO5	Make use of the microalgae to produce	L	Н	L	Н	Н							Н	Н	Н	Н
H – High	; M- Medium; L- Low													•		
Course C	ontent:															
UNIT I	INTRODUCTIO	ΝT	O A	LG	AE									9) hou	urs
media-ma Microalga microalga	tion and systematic, oc rrine and fresh water c al pigments–PC, PE an e. Culture methods. Me	ultu nd A asur	re n APC reme	nedia . Ph ent of	a. T <u>y</u> loto- f gro	ypes chrc wth	of omat	me ic o	dia effe	and	l ste	eriliz	ation	tech aptat	nniqu tions	ues. of
UNIT II	GROWTHANDO	CUL	TIV	'AT	ION	OF	ALC	GAI	E					9) hou	urs
methods, protein fi omega3fa UNIT III Marine an organisms strategies	the Basic cultural technic biotechnological appro- com Spirulina, race w tty acids from microalg ALGAE INBIOT and freshwater microalga s. Spirulina: Superfood in cyanobacteria. Grow Soil to different enviro	ach ay ae, e EC ae. A and th R	es fo syste enric HN(An in Med espo	or p em o hme DLC itegr licin	rodu of n ent of OGY cal ev e. U of cy	ctio nicro f mi vent V-B yanc	n of croa in t Rac	f in ae o lgao he o diat teria	leve a fro	tan ure, th r elop ind	t m vit nicr	icroa tamir onutr nt of l stre ly so	lgae. ns, m rients algae ss an il anc	Sin niner 3. e and d pro	gle als hou hig btect	cell and urs ther tion aste
UNIT IV							-				ator	.11 11a) hoi	
Biotechno Agricultu Cyanobac A Potentia Industrial	blogical applications o re. Role of Blue Gre steria to Insecticides and al Biofuel Resource, Alg Utilization of microalg	f m en I fun gal B al Fa	icroa Alga gici biodi atty	algae ae in des. esel: Acid	e. B n R Lipi : Pro ls. C	iote ice ds a cedu yand	chno Pro nd F ures obac	olog duc Fatty and teri	ical tion A A Re	R . F cids	Resp froi rces	onse m Ma for I	s of arine .abor	Micr Ric micr atory Hea	obes e Fi roalg y Stu lth.	in ield gae: idy.
UNIT V	ALGAE ASA FU) hou	
Algae Fue	el, Type, Freshwater alg	ae, N	Aari	ne al	gae,	Pro	duct	ion	, Tr	eatr	nent	proc	cess,	Appl	licati	on.
LEARNI	NG RESOURCES									_						
Text Books	 Wolfgang E., "N University Press Robert A. Ander 2005. 	, 199	94.													-
Referenc	e 1. Stevenson R.J.,	'Alg	al E	colo	gy",	Aca	aden	nic	Pres	ss,1	996					
Books	2. Robert Edward I	Lee,	"Ph	ycol	ogy'	', Ca	ambi	ridg	e U	niv	ersit	y pre	ess,20	008.		
Referenc videos	e https://www.youtub MnTsP8Aj5EDOE7		m/w	atch	?v=l	Jbx]	NCC	38x	Ey0	&li	st=I	PLgrl	PoGl	4jGd	oYf	kc

	https://www.youtube.com/watch?v=IJPfaqXbm0A
	https://www.youtube.com/watch?v=F2kSA70Ivig
	https://www.youtube.com/watch?v=bEl_a8vVVvQ
	https://www.youtube.com/watch?v=IKsYzZfXIEk
Reference NPTEL	https://onlinecourses.swayam2.ac.in/cec23_bt22/preview
Reference research/ review articles	 Kumar, P.S., Thomas, J. Seasonal distribution and population dynamics of limnic microalgae and their association with physico-chemical parameters of river Noyyal through multivariate statistical analysis. Sci Rep 9, 15021 (2019). https://doi.org/10.1038/s41598-019-51542-w Nalley, J. O., O'Donnell, D. R., & Litchman, E. (2018). Temperature effects on growth rates and fatty acid content in freshwater algae and cyanobacteria. Algal research, 35, 500-507. Dwivedi, S., & Ahmad, I. Z. (2023). Evaluation of the effect of UV-B radiation on growth, photosynthetic pigment, and antioxidant enzymes of some cyanobacteria. Environmental Research, 218, 114943. Haldar, C., Ram, R., Kumar, S., & Menna, L. L. (2018). Microalgae as a potential source of biofuels and its current advances. Examines Mar Biol Oceanogr, 2(1). Faried, M., Samer, M., Moselhy, M. A., Yousef, R. S., Ali, A. S., Ahmed, R. H., & Abdelsalam, E. M. (2024). Photobiostimulation of green microalga Chlorella sorokiniana using He–Ne red laser radiation for increasing biodiesel production. Biomass Conversion and Biorefinery, 14(1), 117-131.

Course Code					(Coui	rse T	itle						L	T		P	С	
10212E	BT106		NAN	10			CHN ICA'			Y A	ND)		3	0		0	3	
Course	Catego	orv	Progra	ım İ	Eleci	tive													
Preamb			To stud	ly th	he ad	lvan	сете	ent c	of Ne	anol	biot	ech	nolo	gy ai	nd its	app	lica	tior	
Prerequ	isite C	ourses	NIL																
Cour Outco		Upon suc	ccessful	сот	ıplet	ion c	of the	e coi	urse	, stı	ıder	its 1	will l		e able to:				
CO N	los.			С	ours	se O	utco	mes	5					(now (Base) loom	d on	revis	ed	
СО	the base	ics	of na	anote	echn	olog	gy a	nd i	ts s	ynt	hesis			K2					
CO	rate the		-								•			K2					
CO3 Extend the im													~		K2				
CO	4		ine the applications of nano devices in medical field.								K2								
CO5 Build the strong knowledge about drug delivery process with the help of nano particles.									K3										
Correlat		COs with					Prog	ramı	ne O	utcol	mes	(POs	5)	Program Specific Outcomes				ic	
001100				1	2	3	4	5	6	7	8	9	10	11	(PSOs))	
CO1	nanote	ate the ba echnology esis proces	and its	-		_	M	5	U	,		,	10		Н	Н	Н		
CO2	Demo techni	nstrate	the	Н	M	Н	Н								Н	Н	н		
	nanote	echnology																	
CO3	Exten of	*	ortance	Н	Н	Н	Н		Н	Н					Н	Н	Н	L	
CO3 CO4	Extend of biotec Outlin of na	echnology d the imp nano	oortance in ications		H H	H M	Н		н н	H L					H	H M	H H		
	Extend of biotec Outlin of na medic Build knowl delive	echnology d the imp nano hnology. te the appl ano devi al field. the edge abo ry proces help of	ortance in ications ces in strong ut drug ss with	Н	Н	М	н											L	

Course Content:		
UNIT I BA	SICS OF NANOTECHNOLOGY	9 hours
A Brief History	and development of Nanotechnology, Definition of	nanotechnology,
Nano <i>bio</i> technolog	gy v/s Bionanotechnology, Bottom-Up versus Top-De	own approaches;
Methods of synthe	esis of nanoparticles or fabrication, Surface property relatio	nship.
UNIT II ME	THODS IN NANOTECHNOLOGY	9 hours
Types of Nanoma	terials, Characterization techniques by SEM, TEM, Atomic	force microscopy,
Dynamic light sca	attering (DLS), XRD. Surface Plasmon resonance (SPR), Ra	aman shift, FTIR.
UNIT III BIO	ONANOTECHNOLOGY	9 hours
Lipid Bilayers, lip	posomes, neosomes, Polysacharides, Peptides, Nucleic acid	s, DNA scaffolds,
Enzymes, Biomol	ecular motors: linear, rotary mortors, Immunotoxins, Mem	brane transporters
and pumps; S-laye	er proteins: structure, chemistry and assembly; engineered N	Nanopores.
UNIT IV CL	INICAL APPLICATIONS OF NANODEVICES	9 hours
Artificial neurons	. Real-time nanosensors- Synthetic retinyl chips based on ba	acteriorhodopsins.
High throughput	DNA sequencing with nanocarbon tubules, Nanoparticles	for Bioanalytical
Applications; App	plications in cancer biology.	
UNIT V NA	NOPARTICLES IN DRUG DELIVER	9 hours
Delivery of Nano	particles: Brain Delivery, Ocular Drug Delivery, Gene Deli	very Systems and
Carriers in Cance	r Therapy; Natural polymers in tissue engineering applica	tions, Degradable
polymers for tiss	sue engineering, Controlled release strategies in tissue	engineering and
Nanotoxicology.		
LEARNING RE	SOURCES	
	1. David S Goodsell, "Bionanotechnology", John Wiley	& Sons 2004
Text Books	 Christof M. Niemeyer, Chad A. Mirkin, "Nanobiotechn Applications and Perspectives", 1stEdition, Wiley-VC 	nology: Concepts,
	3. Charles P. Poole Jr. and Frank J. Owens, Nanotechnology", A Wiley-Interscience publication, I	
	 Bernd Rehm, "Microbial bionanotechnology: Biologic Systems and Biopolymer-Based Nanostructures", Ta 2006. 	•
Reference Books	 Salata O.V., "Applications of nanoparticles in biolo Journal of nanobiotechnology, 2004. 	gy & medicine",
	3. Vladimir P Torchilin, "Nanoparticulates Drug Ca College Press, 2006.	arriers", Imperial
	https://youtu.be/DAOFpgocfrg	
Reference	https://youtu.be/a0G7iyz4McM	
videos	https://youtu.be/J5pWH1r3pgU	
	https://youtu.be/psJ5J0daSsk	
	https://youtu.be/wYnCYq93c9s	

Reference NPTEL	https://archive.nptel.ac.in/courses/118/107/118107015/
	 Harish, V., Ansari, M. M., Tewari, D., Gaur, M., Yadav, A. B., García-Betancourt, M. L., & Barhoum, A. (2022). Nanoparticle and nanostructure synthesis and controlled growth methods. Nanomaterials, 12(18), 3226. Patil, R. M., Deshpande, P. P., Aalhate, M., Gananadhamu, S., & Singh, D. M. (2022). And A. M.
	P. K. (2022). An Update on Sophisticated and Advanced Analytical Tools for Surface Characterization of Nanoparticles. Surfaces and Interfaces, 33, 102165. https://doi.org/10.1016/j.surfin.2022.102165.
Reference research/ review articles	 Lu, D., Wu, P., Yang, W., Wang, Y., Yang, J., Zhang, G., Wang, C., Yang, L., Zhu, L., & Sun, Z. (2023). Recent advances in lipid nanovesicles for targeted treatment of spinal cord injury. Frontiers in Bioengineering and Biotechnology, 11. https://doi.org/10.3389/fbioe.2023.1261288
	4. Ohshiro, T. (2021). Nanodevices for Biological and Medical Applications: Development of Single-Molecule Electrical Measurement Method. Applied Sciences, 12(3), 1539. https://doi.org/10.3390/app12031539
	 Mundekkad, D., & Cho, W. C. (2022). Nanoparticles in Clinical Translation for Cancer Therapy. International Journal of Molecular Sciences, 23(3). https://doi.org/10.3390/ijms23031685

Course Cod	le		Course Title	L	Т	Р	С				
10212BT10	7		FERMENTATION TECHNOLOGY	3	0	0	3				
	•										
Course Cate	gory		Program Elective								
Preamble			This course provides the importance of fermentation and its application in various fields	-							
Prerequisite	Cours	ses	s 10211BT101 – Microbiology 10211BT110 – Bioprocess Engineering								
Course Outcomes	Upor	ı succ	essful completion of the course, students will be	e able	to:						
CO Nos.			Course Outcomes	(1	Knowledge Lev (Based on revised Bloom's Taxonom						
CO1	Exter	nd the	basic idea towards fermentation processes.		K2						
CO2		-	ne Instrumentation and control involved in the process.	e	K2						
CO3	Dem produ		te the recovery and purification of fermentation	n K2							
CO4	Cons proce		the Effluent treatment involved in fermentation	n	K3						
CO5	CO5 Build the Fermentation economics involved in commercial aspect.										

CO Nos.	Course Outcomes		Programme Outcomes (POs)											Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Extend the basic idea towards fermentation processes.		L	L										М	М	
CO2	Interpret the Instrumentation and control involved in the fermentation process.		L	L									L	М	L	Н
CO3	Demonstrate the recovery and purification of fermentation products.	М	L	L									L	М		Н
CO4	Construct the Effluent treatment involved in fermentation process.		L	L									L	М	М	L

CO5 e	Build the Fermentation conomics involved in M L L M M M	L	М	L	Н
H – High;	M- Medium; L- Low				L
Course C	ontent:				
UNIT I	AN INTRODUCTION TO FERMENTATION PROCESS	9) ho	urs	
Microbial	Biomass, Microbial Enzymes, Microbial Metabolites, Recon	nbinan	t Pı	odu	cts,
Transform	ation Process, Microbial Growth, Isolation and Preservation.				
UNIT II	INSTRUMENTATION AND CONTROL	9) ho	urs	
Temperate	ire measurement and its control, Flow measurement and control,	gases a	and	liqu	ids,
pressure n	neasurement and control analysis, control system.				
UNIT III	IIIRECOVERYANDPURIFICATIONOFFERMENTATION PRODUCTS	9) ho	urs	
Microbial	Cells removal, Separation of foam, Filtration via Precipitation, E	oifferer	nt Fi	ltrat	ion
Process, G	Centrifugation, Different Centrifuge Cell Description, Recovery	metho	ds,	Solv	rent
Recovery,	Supercritical fluid Extraction, Chromatography, Membrane P	rocess	es, 1	Dryi	ng,
Crystalliz	ation, Whole Broth Processing.				
UNIT IV	EFFLUENT TREATMENT	9) ho	urs	
Strength of	of Fermentation Effluent, Treatment and Disposal, Treatment Pr				cal.
-	and Biological, Aerobic Process, Anaerobic Treatment.				
UNIT V	FERMENTATION ECONOMICS	9) ho	urs	
Introducti	on to Isolation of microorganisms of industrial interest, Strain imp	rovem	ent,	Mar	ket
				v cos	sts.
potential,	Plant and equipment, Media, air sterilization, heating and coolin	g, reco	very		
		g, reco	very		
	NG RESOURCES		-		
			-		
	 NG RESOURCES 1. Stanbury P., "Principles of Fermentation Technology', Bu 1999. 2. Haber C.C. and William Andrew, "Fermentation a Engineering Handbook", IIndEdition, 2007. 	ittuwoi und E	rthH Biocl	anm	ical
LEARNI	NG RESOURCES 1. Stanbury P., "Principles of Fermentation Technology', Bu 1999. 2. Haber C.C. and William Andrew, "Fermentation at the second secon	ittuwoi und E	rthH Biocl	anm	ian,
LEARNI	 NG RESOURCES 1. Stanbury P., "Principles of Fermentation Technology', Bu 1999. 2. Haber C.C. and William Andrew, "Fermentation a Engineering Handbook", IIndEdition, 2007. 3. Hydersen B.K., Nancy A.Dela, NelsenK.L., "Bioprocess Er Interscience, 1994. https://youtu.be/JOuGdhl_hWU 	ittuwoi und E	rthH Biocl	anm	ian,
LEARNI	 NG RESOURCES 1. Stanbury P., "Principles of Fermentation Technology', Bu 1999. 2. Haber C.C. and William Andrew, "Fermentation a Engineering Handbook", IIndEdition, 2007. 3. Hydersen B.K., Nancy A.Dela, NelsenK.L., "Bioprocess Er Interscience, 1994. https://youtu.be/JOuGdhl_hWU https://youtu.be/vSIJ8e7IpMI 	ittuwoi und E	rthH Biocl	anm	ian,
LEARNI Text Boo	 NG RESOURCES 1. Stanbury P., "Principles of Fermentation Technology', Bu 1999. 2. Haber C.C. and William Andrew, "Fermentation a Engineering Handbook", IIndEdition, 2007. 3. Hydersen B.K., Nancy A.Dela, NelsenK.L., "Bioprocess Er Interscience, 1994. https://youtu.be/JOuGdhl_hWU https://youtu.be/vSIJ8e7IpMI https://youtu.be/SnbXQTTHGs4 	ittuwoi und E	rthH Biocl	anm	ical
LEARNI Text Bool Reference	 NG RESOURCES 1. Stanbury P., "Principles of Fermentation Technology', Bu 1999. 2. Haber C.C. and William Andrew, "Fermentation a Engineering Handbook", IIndEdition, 2007. 3. Hydersen B.K., Nancy A.Dela, NelsenK.L., "Bioprocess Er Interscience, 1994. https://youtu.be/JOuGdhl_hWU https://youtu.be/vSIJ8e7IpMI 	ittuwoi und E	rthH Biocl	anm	ian,

	1. Amin, F., Bhatti, H. N., & Bilal, M. (2019). Recent advances in the production strategies of microbial pectinases—A review. International journal of biological macromolecules, 122, 1017-1026.
	2. Schmidt, F. R. (2005). Optimization and scale up of industrial fermentation processes. Applied microbiology and biotechnology, 68, 425-435.
Reference research/ review articles	 Parente, E. U. G. E. N. I. O., & Ricciardi, A. (1999). Production, recovery and purification of bacteriocins from lactic acid bacteria. Applied microbiology and biotechnology, 52, 628-638. Judd, S. J. (2016). The status of industrial and municipal effluent treatment with membrane bioreactor technology. Chemical Engineering Journal, 305, 37-45.
	 Sharma, D., Saini, A., Sharma, D., & Saini, A. (2020). Fermentation Economics and Future Prospects. Lignocellulosic Ethanol Production from a Biorefinery Perspective: Sustainable Valorization of Waste, 217-227.

Course	Code				Co	urse	Titl	e						L	Т		2	С	
10212B	ST108		PRO	DTI	EIN	EN(GIN	EEF	RIN	G				3	0	()	3	
Course	0	ory	Program E																
Preamb	le		To study an	d cl	hara	cteri	ze tl	ie pi	rote	in st	truc	tur	e wit	h its	appl	icati	on.		
Prerequ			10212BT14							-									
Courses			10212BT14	3 -	Com	iputa	ition	al B	liolo	gy:	Tec	chni	iques	s and	l App	licat	ions		
Cour Outco		Upor	n successful d	com	pleti	on o	f the	е сог	ırse,	stu	den	its v	vill b	be able to:					
CO Nos.				Co	ours	e Ou	itcor	nes						(nowl Basec oom':	l on r	evise	d	
CO	CO1 Illustrate the intusing electroma					-		ns w	vith	vari	ous	s bo	onds			K2			
CO2	2		el the prima ture of protei				•					onc	lary	К3					
CO	3		e use of basi derstand the						•		-		eins		К3				
CO4	1	Appl chara	y the spectro acters	osco	opic	met	hods	s to	stuc	ly t	he	pro	tein	in K3			K3		
CO	5		-	eering techniques to modify the proteins eal and industrial applications.									К3						
		~~~																	
Correlat	tion of (	COs v	vith POs:													D.			
CO Nos.	C	ourse (	Outcomes				Prog	ramı	ne O	utcoi	mes	(POs	5)			S Ou	ograi pecifi itcom PSOs	c es	
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	of pro bonds	teins v usi	e interaction with various ng electro diation.	Н		М									M	Н	М		
CO2	second second	dary dary ns wit	e primary, and super structure of h respective	Н		Н	Н	Н							Н	Н	Н		
CO3	structı about	ural pr stand	of basic knowledge oteins to the tertiary quaternary	Н	Н	Н		Н							Н	Н	Н		

structure.

CO4	Apply th spectroscopic method to study the protei characters	s н	М	М	L	Н	М						Н	Н	Н	L				
CO5	Utilize the engineerin techniques to modif the proteins for variou medical and industria applications.	y s H		Н	Н	Н							Н	Н	Н					
H – Hig	n; M- Medium; L- Low		•	•		•														
Course	Content:																			
UNIT I	UNIT IBONDS, ENERGIES, BUILDING BLOCKS OF PROTEINS9 hours																			
Covalent, Ionic, Hydrogen, Coordinate, hydrophobic and Vander walls interactions in protein																				
structure	. Interaction with electr	omag	neti	c rad	liatic	on (r	adic	, m	icro	, in	frare	d, vi	sible	, ultı	avio	let,				
X-ray) a	nd elucidation of protein	1 stru	ctur	e.																
UNIT II	PROTEIN ARC	HIT	ECT	TUR	E								9	hou	rs					
Primary structure: peptide mapping, peptide sequencing - automated Edman method &Protein																				
Engineer	ing and Design: Metho	ls in	prote	ein e	ngin	eeri	ng a	nd	desi	gn	– phy	/sica	l, coi	nput	atio	nal,				
-	ical and molecular tech		-		-		-			-				-						
	: Alpha, beta and loop s			Ũ		e	•	•			•	•				•				
	rnalpha, beta-turn- beta										-			•						
-	n & TIM barrel structur		- /				-		Jeta	uŋ	Jiiu, t	opor	059	iiugi	ums	, <b>u</b> p				
UNIT II	I TERTIARY ST	RUC	TUI	RE									9	hou	rs					
Predictio	n of substrate binding				y str	ucti	ire:	Do	mai	ns,	foldi	ng,	dena	turat	ion	and				
	ion, overview of metho				•							-								
	ormation of complexes,									-		-								
	CHARACTERI	ZAT	ION	OF	PR	OT	EIN	S					9	hou	rs					
UNIT IV	ectroscopy, crystallogra	phy,	spec	tros	copi	c an	d ca	lori	met	ric	meth	ods.								
				OT	ETNI	EN		JET	יחד				0	hou	rs					
	APPLICATION	S OI	f PR		LIN	EIN	GI	NE.F	кı	NG	r	UNIT VAPPLICATIONS OF PROTEIN ENGINEERING9 hoursDesign of polymeric biomaterials, nicotinic acetylcholine receptors as a model for a super								
NMR sp UNIT V												a m				per				
NMR sp UNIT V Design o		als, r	nicot	inic								a m				per				
NMR sp UNIT V Design of family o	of polymeric biomateri fligand - gated ion char	als, r	nicot	inic								a m				per				
NMR sp UNIT V Design of family o	of polymeric biomateri f ligand - gated ion char ING RESOURCES	als, r inel p	nicot prote	inic ins.	acet	ylcł	nolir	ie r	ecep	otor	s as		odel	for	a su					
NMR sp UNIT V Design of family o	of polymeric biomateri f ligand - gated ion char ING RESOURCES 1. Branden C ar GarlanPublis	als, r mel p nd To	orote	inic ins. J., "	acet	ylcł	nolir	ie r	ecep	otor	s as		odel	for	a su					

Reference Books	1. LiLiaAlberghina, "Protein engineering in industrial biotechnology", Harwood academic publication, 2003.
Reference videos	https://youtu.be/YbNKagnCwis https://youtu.be/k9mydcmkXGk https://youtu.be/9IrPVXn-x5k https://youtu.be/RZLew6Ff-JE https://youtu.be/BYW7IzqxdWQ
Reference NPTEL	https://archive.nptel.ac.in/courses/106/105/106105230/
Reference research/ review articles	<ol> <li>Ferruz, N., Schmidt, S., &amp; Höcker, B. (2021). ProteinTools: a toolkit to analyze protein structures. Nucleic acids research, 49(W1), W559-W566.</li> <li>Wakolbinger, S., Geisenhof, F. R., Winterer, F., Palmer, S., Crimmann, J. G., Watanabe, K., &amp; Weitz, R. T. (2020). Locally-triggered hydrophobic collapse induces global interface self-cleaning in van-der-Waals heterostructures at room-temperature. 2D Materials, 7(3), 035002.</li> <li>Georgakopoulos-Soares, I., Chan, C. S., Ahituv, N., &amp; Hemberg, M. (2022). High-throughput techniques enable advances in the roles of DNA and RNA secondary structures in transcriptional and post-transcriptional gene regulation. Genome biology, 23(1), 159.</li> <li>Reif, B., Ashbrook, S. E., Emsley, L., &amp; Hong, M. (2021). Solid-state NMR spectroscopy. Nature Reviews Methods Primers, 1(1), 2.</li> <li>Wittenberg, R. E., Wolfman, S. L., De Biasi, M., &amp; Dani, J. A. (2020). Nicotinic acetylcholine receptors and nicotine addiction: A brief introduction. Neuropharmacology, 177, 108256.</li> </ol>

Course Code	Course Title	L	Т	Р	С
10212BT109	PROCESS INSTRUMENTATION AND DYNAMIC CONTROL	3	0	0	3
<b>Course Category</b>	Program Elective				
Preamble	To introduce control equipment used to control of a chemical factory and to introduce the control automation and computers.				
Prerequisite Courses	10211BT110 – Bioprocess Engineering				

Course Outcomes	Upon successful completion of the course, students will b	e able to:
CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Classify instruments for the measurement of pressure, temperature, fluid flow and liquid level.	К2
CO2	Understand the dynamic behavior of bioprocesses	K2
CO3	Understand the mathematical models in biochemical engineering systems	К3
CO4	Classify biosensors and transducers used in bioprocesses	K4
CO5	Analyze stability of feedback control system.	K4

CO Nos.	Course Outcomes			Program Specific Outcomes (PSOs)												
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Classify instruments for the measurement of pressure, temperature, fluid flow and liquid level.	Н	Н	Н	Н	М							М	Н	Н	М
CO2	Understand the dynamic behavior of bioprocesses		Н	Н	Н	Н	L						М	Н	Н	М
CO3	Understand the mathematical models in biochemical engineering systems		Н	Н	Н	Н	Μ						М	Н	Н	М
CO4	Classify biosensors and transducers used in bioprocesses		Н	Н	Н	Н	М						М	Н	Н	М

H - High; M- Medium; L- Low         Course Content:         UNIT I       PROCESS INSTRUMENTATION       9 hours         Principles of measurements and classification of process control instruments, measuremer temperature, pressure, fluid flow, liquid weight and weight flow rate, viscosity and consiste pH, concentration, electrical and thermal conductivity, humidity of gases, compositio physical and chemical properties.         UNIT II       BIOPROCESSINSTRUMENTATION       9 hours         Monitoring and control of bioreactors, Biochemical Reactor Instrumentation, physichemical and bio-chemical parameters, Introduction to flow, pressure, temperature, pH, f         DO, redox and level measurements, sensors for medium and gases; Online and of monitoring.         UNIT III       MATHEMATICAL MODELS FOR BIOCHEMICAL ENGINEERING SYSTEMS       9 hours         Continuous flow tanks- mixing vessel- mixing with reaction-reversible reaction. S jacketed vessel-boiling of single component liquid-open and closed vessel-continuous be system-Batch distillation.       9 hours         UNIT IV       BIOSENSORS       9 hours         Types, Transducers in biosensors- calorimetric, optical, potentiometric / amperom conductometric / resistometric, piezoelectric, semiconductor, mechanical and mole electronics based, molecular wires and switches, development of molecular arrays as mer stores, design for a biomolecular photomic computers-information processing.       9 hours         UNIT V       INSTRUMENTATION AND CONTROL       9 hours         Physical and chemical sensors for the medium and gases	CO5	Analyze feedback system.	stability of control		Н	Н	Н	Н	М						М	Н	Н	L
UNIT IPROCESS INSTRUMENTATION9 hoursPrinciples of measurements and classification of process control instruments, measuremertemperature, pressure, fluid flow, liquid weight and weight flow rate, viscosity and consistepH, concentration, electrical and thermal conductivity, humidity of gases, compositiophysical and chemical properties.UNIT IIBIOPROCESSINSTRUMENTATIONMonitoringand control of bioreactors, Biochemical Reactor Instrumentation, physicchemical and bio-chemical parameters, Introduction to flow, pressure, temperature, pH, fDO, redox and level measurements, sensors for medium and gases; Online and ofmonitoring.UNIT IIIMATHEMATICAL MODELS FOR BIOCHEMICAL ENGINEERING SYSTEMSOntinuous flow tanks- mixing vessel- mixing with reaction-reversible reaction. Sjacketed vessel-boiling of single component liquid-open and closed vessel-continuous bosystem-Batchdistillation.UNIT IVBIOSENSORSYppes, Transducers in biosensors- calorimetric, optical, potentiometric / amperom conductometric / resistometric, piezoelectric, semiconductor, mechanical and mole electronics based, molecular wires and switches, development of molecular arrays as mer stores, design for a biomolecular photomic computers-information processing.UNIT VINSTRUMENTATION AND CONTROLPhysical and chemical sensors for the medium and gases, online and offline sensors, pro control- Concept of Cascade control, Selective control system, split range control, Feed for & Feedback control, Ratio control, Adaptive control and Inferential control. Computer t control- Basic functional elements, Computer interfaces for fermentation process and Cascade contr	H – Higl	h; M- Med	ium; L- Low	1						I							I	<u> </u>
UNIT IPROCESS INSTRUMENTATION9 hoursPrinciples of measurements and classification of process control instruments, measuremertemperature, pressure, fluid flow, liquid weight and weight flow rate, viscosity and consistepH, concentration, electrical and thermal conductivity, humidity of gases, compositiophysical and chemical properties.UNIT IIBIOPROCESSINSTRUMENTATIONMonitoringand control of bioreactors, Biochemical Reactor Instrumentation, physicchemical and bio-chemical parameters, Introduction to flow, pressure, temperature, pH, fDO, redox and level measurements, sensors for medium and gases; Online and ofmonitoring.UNIT IIIMATHEMATICAL MODELS FOR BIOCHEMICAL ENGINEERING SYSTEMSOntinuous flow tanks- mixing vessel- mixing with reaction-reversible reaction. Sjacketed vessel-boiling of single component liquid-open and closed vessel-continuous bosystem-Batchdistillation.UNIT IVBIOSENSORSYppes, Transducers in biosensors- calorimetric, optical, potentiometric / amperom conductometric / resistometric, piezoelectric, semiconductor, mechanical and mole electronics based, molecular wires and switches, development of molecular arrays as mer stores, design for a biomolecular photomic computers-information processing.UNIT VINSTRUMENTATION AND CONTROLPhysical and chemical sensors for the medium and gases, online and offline sensors, pro control- Concept of Cascade control, Selective control system, split range control, Feed for & Feedback control, Ratio control, Adaptive control and Inferential control. Computer t control- Basic functional elements, Computer interfaces for fermentation process and Cascade contr																		
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UNIT II         BIOPROCESSINSTRUMENTATION         9 hours           Monitoring and control of bioreactors, Biochemical Reactor Instrumentation, physichemical and bio-chemical parameters, Introduction to flow, pressure, temperature, pH, f         DO, redox and level measurements, sensors for medium and gases; Online and of monitoring.           UNIT III         MATHEMATICAL MODELS FOR BIOCHEMICAL ENGINEERING SYSTEMS         9 hours           Continuous flow tanks- mixing vessel- mixing with reaction-reversible reaction. S jacketed vessel-boiling of single component liquid-open and closed vessel-continuous bot system-Batch distillation.         9 hours           UNIT IV         BIOSENSORS         9 hours           Types, Transducers in biosensors- calorimetric, optical, potentiometric / amperomic conductometric / resistometric, piezoelectric, semiconductor, mechanical and mole electronics based, molecular wires and switches, development of molecular arrays as met stores, design for a biomolecular photomic computers-information processing.         9 hours           UNIT V         INSTRUMENTATION AND CONTROL         9 hours           Physical and chemical sensors for the medium and gases, online and offline sensors, procontrol-Concept of Cascade control, Selective control system, split range control, Feed for & Feedback control, Ratio control, Adaptive control and Inferential control. Computer & control-Basic functional elements, Computer interfaces for fermentation process and Case					erma	al co	ondu	ctiv	ity,	hun	nidi	ty o	of g	ases,	con	iposi	tion	by
Monitoring and control of bioreactors, Biochemical Reactor Instrumentation, physichemical and bio-chemical parameters, Introduction to flow, pressure, temperature, pH, f         DO, redox and level measurements, sensors for medium and gases; Online and of monitoring.         UNIT III       MATHEMATICAL MODELS FOR BIOCHEMICAL ENGINEERING SYSTEMS       9 hours         Continuous flow tanks- mixing vessel- mixing with reaction-reversible reaction. S jacketed vessel-boiling of single component liquid-open and closed vessel-continuous bot system-Batch distillation.       9 hours         UNIT IV       BIOSENSORS       9 hours         Types, Transducers in biosensors- calorimetric, optical, potentiometric / amperomic conductometric / resistometric, piezoelectric, semiconductor, mechanical and mole electronics based, molecular wires and switches, development of molecular arrays as meristores, design for a biomolecular photomic computers-information processing.       9 hours         Physical and chemical sensors for the medium and gases, online and offline sensors, precontrol- Concept of Cascade control, Selective control system, split range control, Feed for & Feedback control, Ratio control, Adaptive control and Inferential control. Computer be control- Basic functional elements, Computer interfaces for fermentation process and Case	physical	and chemi	ical properties	•														
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UNIT V       INSTRUMENTATION AND CONTROL       9 hours         Physical and chemical sensors for the medium and gases, online and offline sensors, procontrol- Concept of Cascade control, Selective control system, split range control, Feed for & Feedback control, Ratio control, Adaptive control and Inferential control. Computer to control- Basic functional elements, Computer interfaces for fermentation process and Castana Ca	electroni	ics based, 1	molecular wire	es ai	nd sv	witch	nes, o	deve	elopi	nen	t of	mc	olecu	ılar a	rrays	s as 1	nem	ory
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& Feedback control, Ratio control, Adaptive control and Inferential control. Computer b control– Basic functional elements, Computer interfaces for fermentation process and Cas	Physical	and chem	ical sensors fo	or th	e m	ediu	m ar	nd g	ases	, on	line	an	d of	fline	sens	sors,	proc	ess
control-Basic functional elements, Computer interfaces for fermentation process and Cas	control-	Concept of	f Cascade cont	rol,	Sele	ctive	e con	trol	syst	em,	spl	it ra	inge	cont	rol, F	Feed	forw	ard
	& Feedb	back contro	ol, Ratio contr	ol, /	Adap	otive	con	trol	and	Inf	erer	tial	con	trol.	Con	npute	er ba	sed
control of metabolism.	control-	Basic fund	ctional elemen	ts, C	Comj	puter	inte	erfac	es f	or f	erm	enta	ation	n proo	cess	and (	Casc	ade
	control c	of metaboli	sm.															

LEARNING R	ESOURCES
	<ol> <li>Coughnowr and Koppel, "Process Systems Analysis and Control", McGraw-Hill, New York, 1986.</li> <li>Control and Control a</li></ol>
Text Books	<ol> <li>George Stephanopolous, "Chemical Process Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 1990.</li> </ol>
	3. Luben W.L., "Process Modelling Simulation and Control for Chemical Engineers", McGraw Hill International, New York, 1990.
	1. Ekman D.P., "Industrial Instrumentation", Wiley, 1978.
	2. Shulerand Kargi, "Bioprocess Engineering, Prentice Hall, 2002.
Reference Books	3. Bailey and Ollis, "Biochemical engineering fundamentals", McGraw Hill, 2003.
	4. Tarun K Ghosh, "Biotechnology and bioprocess engineering: Proceedings, VII international biotechnology symposium, Delhi, 2004.
	https://youtu.be/DUsSWd4ZRUo
Reference	https://youtu.be/FNRUzG9EVuc
videos	https://youtu.be/A7Gb7sF4sjk
	https://youtu.be/6Y5FDMw65O4
	https://youtu.be/z7_g7euL2nE
Reference NPTEL	https://archive.nptel.ac.in/courses/103/105/103105064/
Reference research/ review articles	<ol> <li>Salehi, F., &amp; Inanloodoghouz, M. (2024). Modeling the effect of ultrasound on viscosity, consistency coefficient, and flow behavior index of different concentrations of xanthan gum. Journal of food science and technology (Iran), 21(146), 158-168.</li> <li>Wei, Y., Cheng, G., Ho, H. P., Ho, Y. P., &amp; Yong, K. T. (2020). Thermodynamic perspectives on liquid–liquid droplet reactors for biochemical applications. Chemical Society Reviews, 49(18), 6555-6567.</li> <li>Dallinger, D., Gutmann, B., &amp; Kappe, C. O. (2020). The concept of chemical generators: on-site on-demand production of hazardous reagents in continuous flow. Accounts of chemical research, 53(7), 1330-1341.</li> <li>Polat, E. O., Cetin, M. M., Tabak, A. F., Bilget Güven, E., Uysal, B. Ö., Arsan, T., &amp; Gül, S. B. (2022). Transducer technologies for biosensors and their wearable applications. Biosensors, 12(6), 385.</li> <li>Alarcon, C., &amp; Shene, C. (2021). Fermentation 4.0, a case study on computer vision, soft sensor, connectivity, and control applied to the fermentation of a thraustochytrid. Computers in Industry, 128, 103431.</li> </ol>

Course	Code				Сот	urse	Titl	e						L	Т	]	P	С	
10212B	ST110		BIOREACTOR DESIGN AND INSTRUMENTATION CONTROL									3	0		0	3			
Course	Categor	v	Program E	leci	tive														
Preamb			To underst	ana	l var				-					et, pr	incip	oles i	nvol	lved	
Prerequ Courses			<i>in their fun</i> 10211BT1 10211BT1	12 -	- Un	it Op	perat	tions	s in	Bioi	tech			У					
Cou Outco		Upo	on successfu	ıl co	ompl	etio	n of	the	cou	rse,	stu	den	ets w	ill be	e able	e to:			
CON	Nos.			С	our	se O	utco	Knowledge Level (Based on revised Bloom's Taxonomy)											
CO	01	Out	line the oper	ratio	onal	proc	edui			K2									
CO	02		nonstrate the					mb	ols ı	used	l in	P&	IDs	K2					
CO3 Construct and phenomena.				scale	e-up	the	bior	eact	port	K3									
CO	94		mine and c lelling	lass	ify	the	Bior	K4											
СО	95	Inte desi	rpret the re gn of bic ogical produ	orea	ctors	fo	or in	ndus	stria	lly	im	por	tant			K5			
Correlat	ion of C										1								
CO Nos.			utcomes	Programme Outcomes (POs)												Program Specific Outcome (PSOs)			
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	Outline procedu bioreac	ires	operational for	Н	Н	Н	Н	М							М	Н	Н	М	
CO2	used in	P& P&I	the I symbols Ds for the lant design.	Н	Н	Н	Н								M	Н	Н	М	
CO3	the bi	oreac	nd scale-up ctors with enomena.	Н	Н	Н	Н								М	Н	Н	М	
CO4	the B	iorea	nd classify ctor with odelling	Н	Н	Н	Н								М	Н	Н	М	

CO5	optimizat for the bioreacto industrial biologica	rs for ly important l products, and secondary	HI	н	Н								М	Н	Н	L
H – Higł	n; M- Med	lium; L- Low	1 1													
Course	Content:															
UNIT I	IN	TRODUCTIO	ON TO	) BIO	REA	СТО	OR	DE	SIG	N			9	hou	rs	
Basics an	nd importa	nce of bioreac	tors -	Guidel	ines	for b	oiore	eact	or d	esig	gn- N	Mech	nanic	al as	pect	s of
bioreacto	or design-	Requirements	for co	nstruc	tion	of a l	bior	eact	or-	Dev	velo	pmei	nt of	bior	eacto	ors-
Instrume	ntation to	control a biore	eactor-	Com	non	oper	atio	ns o	f bi	orea	actor	r				
UNIT II	DI	ESIGN CRITI	ERIA	AND	SCA	LE-	UP						9	hou	rs	
Design c	riteria for	airlift, bubble	colur	nn, an	d ch	emos	stat	bioı	eact	tors	, po	wer	requ	irem	ents	for
Newtoni	an/non-Ne	ewtonian broth	is and	gasse	d flu	iids,	Bic	orea	ctor	sca	ale-u	ip ba	ased	on c	const	ant
		n per volume (		-								-				
-	-	eactor perform														
		dia and biorea				-	-					-	-			-
				nocure	un a	even	-pin		mat		it u	unu	onny	, 511	<i></i> , ]	,
and Tem	perature.															
and Tem		RANSPORT	PHEN	OME	NΔ	ANI	) 5	CA	LEI	ΤP	OF					
and Tem	TH	RANSPORT		OME	NA	ANI	D S	CA	LEU	UP	OF		9	hou	rs	
UNIT II	I TH BI		S													o of
UNIT II Transpor	I TF BI Thenom	OREACTOR	<b>S</b> tors- F	Parame	eters	influ	ienc	ing	trar	sfe	r op	erati	ons-	Scal	le-up	
UNIT II Transpor bioreacto	I TF BI Thenom	OREACTOR ena in bioreac a of scale-up-	<b>S</b> tors- F	Parame	eters	influ	ienc	ing	trar	sfe	r op	erati	ons-	Scal	le-up	
UNIT II Transpor bioreacto	I TH BI et phenom prs-Criteri tion of me	OREACTOR ena in bioreac a of scale-up-	S tors- F Scale	Parame e-up m	eters netho	influ ds-	ienc Ger	ing Ieral	trar lizeo	isfe 1 aj	r op	erati	ons- es to	Scal	le-up e-up	
UNIT II Transpor bioreacto combina UNIT IN	I TH BI et phenom prs-Criteri tion of me V IN	OREACTOR ena in bioreac a of scale-up- thods.	S tors- F Scale MODE	Parame e-up m ELLIN	eters netho	influ ds- <b>PF R</b>	ienc Ger EA	ing Ieral	trar lized	isfe 1 aj	r op opro	erati ache	ons- es to 9	Scal scal	le-up e-up rs	in
UNIT II Transpor bioreacto combina UNIT IN Bioreacto	I TH BI The phenom prs-Criteri tion of me V IN or modell	OREACTOR ena in bioreac a of scale-up- ethods. DUSTRIAL M	S tors- F Scale MODE ferme	Parame e-up m ELLIN enter, t	eters netho IG O he c	influ ds- <b>OF R</b> hemo	Ger Ger EA osta	ing t, th	tran lized	isfe 1 aj 5 ed 1	r op opro oatcl	h fer	ons- es to 9 ment	Scal scal <b>hou</b> ter, l	le-up le-up <b>rs</b>	ass
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(chemo), fed batch fermentation (fedbat), kinetics of enzyme action (mmkinet), repeated fed

batch culture (repfed), lineweaver-burk plot (lineweav), steady-state chemostat (chemosta), variable volume fermentation (varvol and varvold), penicillin fermentation using elemental balancing (penferm), fluidized bed recycle reactor (fbr).

LEARNING	RESOURCES
Text Books	<ol> <li>Brownell L.E. and Young E.H., "Process Equipment Design", Wiley India Pvt. Ltd., 2015.</li> <li>Dunn J., Heinzle E., Ingham J., Pfenosil J.E., "Biological Reaction Engineering: Dynamic Modelling Fundamentals with Simulation Examples", Wiley, 2003.</li> <li>Bailey J.E. and OllisD.F., "Biochemical Engineering Fundamentals", McGraw Hill, 2010.</li> <li>Joshi M.V. and MahajaniV.V., "Process Equipment Design", MacMillan Company of India Ltd., 2009.</li> <li>Atkinson B. and Mavituna F., "Biochemical Engineering and Biotechnology Handbook", 2nd Edition, McGraw Hill, 1993.</li> <li>Sinnott R.K., "Chemical Engineering Series: An Introduction to Chemical Engineering Dasign", Maxwall, Maamillan Bargamon, Bublishing</li> </ol>
Reference Books	<ul> <li>Engineering Design", Maxwell Macmillan Pergamon Publishing Corporation, 2005.</li> <li>McCabe W.L. and Smith J.C., "Unit Operations in Chemical Engineering", McGraw-Hill, 1976.</li> <li>Stanbury P.F., Whitaker A. and Hall S.J., "Principles of Fermentation Technology", 2ndEdition, 1997.</li> <li>Vogel H.C., "Fermentation and Biochemical Engineering Handbook: Principles, Process design, and Equipment", Noyes Publications, 1983.</li> <li>Shule and Kargi, "Bioprocess Engineering", Prentice Hall, Second Indian Reprint, 2004.</li> <li>Harvey W. Blanch and Duoglas S. Clark, "Biochemical Engineering", Marcel Dekker Inc., 1997.</li> <li>Pauline Doran, "Bioprocess Engineering Principles", Academic Press, 2012.</li> </ul>
Reference videos	https://youtu.be/azdVSr7DBlg https://youtu.be/jj92shxeFeU https://youtu.be/7zhA4s0QI6U?list=PL1A176s4- oBlXPqB7uzUzfkmZhMpIsrdS https://youtu.be/XApUZukvbmQ https://youtu.be/fuM13fVk0CA
Reference NPTEL	https://archive.nptel.ac.in/courses/102/106/102106086/
Reference research/ review articles	<ol> <li>Mitra, S., &amp; Murthy, G. S. (2022). Bioreactor control systems in the biopharmaceutical industry: A critical perspective. Systems Microbiology and Biomanufacturing, 1-22.</li> <li>Amani, A., Balcázar, N., Naseri, A., &amp; Rigola, J. (2020). A numerical approach for non-Newtonian two-phase flows using a conservative level- set method. Chemical Engineering Journal, 385, 123896.</li> <li>Khairnar, S. V., Pagare, P., Thakre, A., Nambiar, A. R., Junnuthula, V., Abraham, M. C., &amp; Dyawanapelly, S. (2022). Review on the scale-up</li> </ol>

methods for the preparation of solid lipid nanoparticles. Pharmaceutics, 14(9), 1886.
4. Maluta, F., Paglianti, A., & Montante, G. (2021). Two-fluids RANS predictions of gas cavities, power consumption, mixing time and oxygen transfer rate in an aerated fermenter scale-down stirred with multiple impellers. Biochemical Engineering Journal, 166, 107867.
<ol> <li>Marcoline, F. V., Furth, J., Nayak, S., Grabe, M., &amp; Macey, R. I. (2022). Berkeley Madonna Version 10–A simulation package for solving mathematical models. CPT: pharmacometrics &amp; systems pharmacology, 11(3), 290-301.</li> </ol>
6. Todros, S., Spadoni, S., Maghin, E., Piccoli, M., & Pavan, P. G. (2021). A novel bioreactor for the mechanical stimulation of clinically relevant scaffolds for muscle tissue engineering purposes. Processes, 9(3), 474.

Course Code	Course Title	L	Т	Р	С
10212BT111	VALORISATION	3	0	0	3
Course Category	Program Elective				
Preamble	This course enables the student to become conversion of waste material to valuable pro- high value products from waste is an importa-	oducts	or ex	tracti	on of
Prerequisite Courses	s NIL				

Course Outcomes	Upon successful completion of the course, students will	be able to:
CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Understand the basic concepts in transformation of biomass to valuable product.	K2
CO2	Comprehend about the chemical, thermal and thermos chemical methods for conversion of biological material	K2
CO3	Utilize the biomass to produce Biofertilizer and Biofuels	К3
CO4	Planning for Valorization with respect to environmental factors and economical factors	К3
CO5	Solve the biomass accumulation issue by degradation technology and recovering processes.	К3

CO Nos.	Course Outcomes		Programme Outcomes (POs)											Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the basic concepts in trans formation of biomass to valuable product.	Н	М				Н	Н	Н				М	Н	М	L
CO2	Comprehend about the chemical, thermal and thermos chemical methods for conversion of biological material		Н	Н	М		Н	Н	M				М	Н	Н	М
CO3	Utilize the biomass to produce Biofertilizer and Biofuels	Н	М	Н	М		L	М	Н				М	Н	Н	
CO4	PlanningforValorizationwithrespecttoenvironmentalfactorsand economic factors	Н		Н	Н		М	М	L			Н	М	Н	Н	М

	nulation issue by dation technology recovering	Н		М	М	Η		М					М	Н	Н	L
H – High; M-	Aedium; L- Low															
Course Conte	nt:															
UNIT I	INTRODUCTIO	N											9	hou	rs	
	th concept, Role of		liotec	hno	logy	, in	was	ste t	o v	veal	lth.	Unde				ste
	rgy concepts, phy													-		
	(bio- transformatio								-		-					
	tives, shaping divid				<i>,</i> 3	epa	ano	/11 a1	na F	Juii	neat	.1011 (		<i>J</i> -1110	iccu	103,
UNIT II	WASTE TO WE	AL	TH	ГЕС	CHN	OL	OG	IES					9	hou	rs	
Waste to energ	y technologies: The	rma	al (Di	rect	con	ıbus	stion	and	l In	cine	eratio	on), 7	Therr	no-c	hem	ical
(Torrefaction,	Plasma treatment,	Gas	sifica	tion	and	l Py	roly	vsis)	an	d B	sioch	nemio	cal (	Com	posti	ing,
Ethanol fermer	ntation and Anaerob	oic l	Diges	stior	ı),Fl	ow	cher	nist	ry p	orin	ciple	es.	,		•	U,
UNIT III	CONVERSION T	ГЕС	CHN	OL	OG]	IES	AN	D					9	hou	rs	
Microbial bio	degradation of wast	e, B	Biofer	rtiliz	zer, l	Biof	uels	, Bi	0 0	il, E	Bioga	as.				
UNIT IV	ECONOMIC FA	СТ	ORS	5 OI	F VA	LC	RIS	SAT	<b>OI</b>	N			9	hou	rs	
GM Biotechn	ology and Valoriz	zatio	on, l	Intro	oduc	tion	to	ge	ne	ma	nipu	lated	l En	viro	nmei	ntal
biotechnology.	applications, Fact	tors	und	erly	ing	Val	oriz	atio	n f	ron	ı us	ed n	atura	l res	sour	ces,
Market dynam	ics of Valorization,	Mi	nima	l wa	aste j	poli	cies									
UNIT V	EMERGENT TE	CH	INO	LO	GIE	S							9	hou	rs	
Plasma techn	ology, Torrefactio	n,	Land	dfill	ga	s r	ecov	very	, F	roc	lucts	fro	m	Incin	erati	ion,
Lignocellulosi	c degradation.															
LEARNING	RESOURCES															
Reference Books	<ol> <li>Robert Gumis Hensel, "Biom for banana pro 2017.</li> <li>MirjamKnocka perspective of biotechnology</li> </ol>	nass oces aert	wast ssing , So the	te-to in phie ec	o-ene Uga eMar onor	ergy nda niga nic	val ", B rt, va	oris liote Sofi alori	atio chr ieCa zati	n te nolo atto	echno gy 1 ird, of	ologi for B Will ge	es: a liofue lyVe ne	revi els, rstra man	ew c 10 (1 ete,	ase 11), "A
Reference videos	https://youtu.be/w https://youtu.be/Z https://youtu.be/L https://youtu.be/E	H90 vqN	D3Cp /Mfa	ofW 18ys	<u>rs</u> M											

	https://youtu.be/fFsXsUA0704
Reference NPTEL	https://nptel.ac.in/courses/126105023
Reference research/	<ol> <li>Corrêa, P. S., Morais Júnior, W. G., Martins, A. A., Caetano, N. S., &amp; Mata, T. M. (2020). Microalgae biomolecules: Extraction, separation and purification methods. Processes, 9(1), 10.</li> <li>Oliveira, M., Ramos, A., Ismail, T. M., Monteiro, E., &amp; Rouboa, A. (2022). A review on plasma gasification of solid residues: recent advances and developments. Energies, 15(4), 1475.</li> <li>Ru, J., Huo, Y., &amp; Yang, Y. (2020). Microbial degradation and valorization</li> </ol>
review	of plastic wastes. Frontiers in Microbiology, 11, 507487.
articles	4. Sharma, M., Usmani, Z., Gupta, V. K., & Bhat, R. (2021). Valorization of fruits and vegetable wastes and by-products to produce natural pigments. Critical Reviews in Biotechnology, 41(4), 535-563.
	5. Domonkos, M., Tichá, P., Trejbal, J., & Demo, P. (2021). Applications of cold atmospheric pressure plasma technology in medicine, agriculture and food industry. Applied Sciences, 11(11), 4809.

<b>Course</b> Coc	le		Course Title	L	Т	Р	С							
10212BT11	2	E	NVIRONMENTAL BIOTECHNOLOGY	3	0	0	3							
<b>Course Cate</b>	gory		Program Elective											
Preamble			To study the basic concepts and emergent trends and techniques in Environmental Biotechnology.											
Prerequisite Courses			10211BT114 – Green Biotechnology & Pollu	tion A	batem	ent								
Course Outcomes	Upon sı	icce	essful completion of the course, students will be	e able	to:									
CO Nos.			Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)										
CO1			te the basic dynamics of the Environment and ntal pollution.	nd K2										
CO2	Illustrat treatmen		he implications of Biological wastewater	•	ŀ	K2								
CO3			rious types and management methods involved ste management.		K2									
CO4	e importance of air pollution in Environmental.	al K3												
CO5			nd apply the various concepts in current and nvironmental biotechnology.		ŀ	<b>K</b> 4								

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
			2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Demonstrate the basic dynamics of the Environment and Environmental pollution.	н	Н		Н	Н		Н	Н				Н	Н	Н	М
CO2	Illustrate the implications of Biological wastewater treatment.	ц		Н	М	M		М	Н				Н	Н	Н	L
CO3	Infer the various types and management methods involved in Solid waste management.	Н	Н	L	Н	L	Н	М	Н				Н	Н	Н	М

CO4	of a Envir	fy the important ir pollution conmental ective.	nce in H	М	L	Н	М	Н	Н	M				Н	Н	Н	М
Analyze and apply the various concepts in CO5       Analyze and apply the various concepts in current and emergent H       L       M       L       H       L       M       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H <td></td>																	
H – High; M- Medium; L- Low																	
~	~ .																
Course	Conte						NINA	EN	TAI	r							
UNIT I		INTRODUCT BIOTECHNC			AN VI	IKU	INIVI	EIN	IAI	L				9	) hou	irs	
Introduc	tion t	o Environmer	nt, Ec	osyst	em	and	В	iodi	vers	sity	co	once	ots;	Intro	oduct	tion	to
Environ	mental	Pollution, type	s of Po	lluta	nts;	Intro	duc	tion	to l	Mic	rob	ial d	egrad	latio	n and	l dec	ay,
Bioreme	diation	technologies	and th	eir 1	role	in e	envii	ronr	nent	tal	pro	tectio	on a	nd c	onse	rvati	on,
Introduc	tion to	modern wastes	s such a	ıs E-	Was	te.											
UNIT II	[	BIOLOGICA	L WA	STE	WA	TER	R TF	REA	ТМ	IEN	T			9	) hou	irs	
UNIT II     BIOLOGICAL WASTEWATER TREATMENT     9 hours																	
Introduction to Water and Wastewater treatment, Principles and Microbiology of Water and Wastewater treatment, Aerobic and Anaerobic wastewater treatment, Types and operation of																	
								-									
Wastewa	ater tre		ic and	Anae	erobi	c wa	astev	wate	er tr	eatr	nen	t, Ty	pes	and	opera	atior	n of
Wastewa	ater tre and	atment, Aerobi anaerobic dige	ic and	Anae	erobi	c wa	astev	wate	er tr	eatr	nen	t, Ty	pes	and	opera	atior	n of
Wastewa aerobic	ater tre and nated e	atment, Aerobi anaerobic dige	ic and esters	Anae used	erobi l in	c wa wa	astev istev	wate	er tr	eatr	nen	t, Ty	pes	and orem	opera	atior tion	n of
Wastewa aerobic contamin UNIT II	ater tre and nated e	atment, Aerobi anaerobic dige ffluents.	ic and esters FE MA	Anae used	erobi l in GEN	c wa wa IEN	astev istev	wate	ertro ert:	eatr reat	men	t, Ty nt,	/pes Phyte	and orem	opera ediat hou	atior tion <b>Irs</b>	of of
Wastewa aerobic contamin UNIT II Introduc	ater tre and nated e II tion to	atment, Aerobi anaerobic dige ffluents. SOLID WAST	ic and esters FE MA Princij	Anae used NA	erobi l in GEN of s	c wa wa <b>1EN</b> olid	astev istev T was	wate wate	er tro r tr mar	eatr reat		t, Ty nt, 1	/pes Phyte	and orem 9 s and	opera ediat hou d de	atior tion <b>Irs</b> sign	of of
Wastewa aerobic contamin UNIT II Introduc	ater tre and nated e II tion to s, Intro	atment, Aerobi anaerobic dige ffluents. SOLID WAST solid waste,	ic and esters FE MA Princij posting	Anae used NA oles g tech	erobi I in GEN of s	c wa wa 1EN olid	astev istev T was s, Bi	wate wate ste	er tro r tr mar	eatr reat		t, Ty nt, 1	/pes Phyte	and orem 9 s an solid	opera ediat hou d de	ation tion <b>Irs</b> sign	of of
Wastewa aerobic contamin UNIT II Introduc Landfills UNIT IV	ater tre and nated e II tion to s, Intro	atment, Aerobi anaerobic dige ffluents. SOLID WAST o solid waste, duction to com	ic and esters FE MA Princij posting	Anae used NA oles g tech MAN	erobi l in GEN of s mole	c wa wa 1EN olid ogies EMI	astev stev T was s, Bi	wate wate ste	er tr r t mar ergy	eatr reat nage	men tme: eme cov	t, Ty nt, 1 nt, 1 ery f	/pes Phyte Fype From	and orem 9 s and solid 9	opera ediat <b>hou</b> d de l was <b>hou</b>	ation tion <b>Irs</b> sign ste.	of of of
Wastewa aerobic contamin UNIT II Introduc Landfills UNIT IV Introduc	ater tre and nated e II	atment, Aerobi anaerobic dige ffluents. SOLID WAST solid waste, duction to com	ic and esters Princip posting FION I Role o	Anae used NA oles g tech MAN f aer	GEN of s nnolo	c wa wa 1EN olid ogies EMI s and	astev stev T wa: s, Bi ENI d dr	wate wate ste foen	er tro r t: mar ergy et nu	eatr reat nage y re-	men tme eme cov	t, Ty nt, 1 nt, 1 ery f	/pes Phyte Fype from	and orem 9 s and solid 9 of co	opera ediat <b>hou</b> d de was <b>hou</b> ntrol	ation tion <b>Irs</b> sign ste. <b>Irs</b> Illing	n of of of air
Wastewa aerobic contamin UNIT II Introduc Landfills UNIT IV Introduc pollutior	ater tre and nated e II fion to s, Intro V fion to n by b	atment, Aerobianaerobic dige ffluents. SOLID WAST solid waste, duction to com AIR POLLUT air pollution,	ic and esters Princip posting FION I Role o Odour	Anae used NA oles g tech MAN f aer	GEN of s nnolo	c wa wa 1EN olid ogies EMI s and	astev stev T wa: s, Bi ENI d dr	wate wate ste foen	er tro r t: mar ergy et nu	eatr reat nage y re-	men tme eme cov	t, Ty nt, 1 nt, 1 ery f	/pes Phyte Fype from	and orem 9 s and solid 9 of co	opera ediat <b>hou</b> d de was <b>hou</b> ntrol	ation tion <b>Irs</b> sign ste. <b>Irs</b> Illing	n of of of air
Wastewa aerobic contamin UNIT II Introduc Landfills UNIT IV Introduc pollutior	ater tre and nated e II   tion to s, Intro V   tion to n by b ns in hu	atment, Aerobianaerobic dige ffluents. SOLID WAST solid waste, duction to com <u>AIR POLLUT</u> air pollution, iotechnology, 0	ic and esters FE MA Princip posting FION I Role o Odour tock.	Anae used NA0 bles g tech MAN f aer cont	GEN of s nnold AG osol	c wa wa IEN olid EMI s and s and	astev Istev T was s, Bi ENI d dr	wate wate ste oen r ople olog	er tro r tr mar ergy et nu gical	eatr reat nage / re- ucle	eme cov	t, Ty nt, 1 nt, 1 ery f	/pes Phyte Fype from	and orem 9 s and solid 9 of co trol o	opera ediat <b>hou</b> d de was <b>hou</b> ntrol	ation tion rsign tte. Irs Iling r bo	n of of of air
Wastewa aerobic contamin UNIT II Introduc Landfills UNIT IV Introduc pollutior pathoger	ater tre and nated e II tion to s, Intro V tion to n by b ns in hu	atment, Aerobianaerobic dige ffluents. SOLID WAST solid waste, duction to com AIR POLLUT air pollution, iotechnology, o uman and livest MAJOR CON	ic and esters FE MA Princip posting FION I Role o Odour tock.	Anae used NAM bles g tech MAN f aer cont	erobi I in GEN of s Innold IAG osol I col u	c wa wa IEN olid ogies EMI s and using	astev Istev T was s, Bi ENI d dr g bio	wate wate ste oople olog	er tro r t: mar ergy et m gical	eatr reat nage / re- Lucle	men tme eme cov ei, N etho	t, Ty nt, 1 nt, 1 ery f Methods,	/pes Phyte Fype Fype Cont	and orem 9 s and solid 9 of co trol o	opera ediat hou d de was hou ntrol of ai	ation tion rs ling r bo	n of of of air
Wastewa aerobic contamin UNIT II Introduc Landfills UNIT IV Introduc pollutior pathoger UNIT V Introduc	ater trea and nated e II	atment, Aerobi anaerobic dige ffluents. SOLID WAST o solid waste, duction to com AIR POLLUT air pollution, iotechnology, o uman and livest MAJOR CON BIOTECHNO	ic and esters Princip posting FION I Role o Odour tock. CEPT DLOG 1 Gene	Anae used NA bles g tech MAN f aer cont r S IN Y tics,	GEN of s nnold AG osol rol u Fac	c wa wa olid ogies EMI s and using VIR	T wa: s, Bi ENT d dr g bio	wate wate ste oople olog	er tro r tr mar ergy et nu gical	eatr reat nage / re- ucle m CAL	eme cov ei, N etho	t, Ty nt, nt, ery f Methods, of g	/pes Phyta Fype rom Cont eneti	and orem 9 s an solid 9 of co trol o	opera ediat <b>) hou</b> d de l was <b>) hou</b> ntrol of ai	ation tion <b>Irs</b> sign tte. <b>Irs</b> lling r bo	n of of of air rne
Wastewa aerobic contamin UNIT II Introduc Landfills UNIT IV Introduc pollution pathogen UNIT V Introduc organism	ater trea and nated e II	atment, Aerobianaerobic dige ffluents. SOLID WAST solid waste, duction to com AIR POLLUT air pollution, iotechnology, fuman and livest MAJOR CON BIOTECHNO Environmenta	TE MA Princip posting FION I Role o Odour tock. ICEPT DLOG I Gene Direct a	Anae used NAU bles g tech MAN f aer cont r S IN Y utics, and I	GEN of s nnold AG osol rol u Fac ndire	c wa wa olid ogies EMI s and using VIR tors ect n	T wa: 3, Bi ENT d dr g bio RON	wate wate ste ooen C oople olog	er tro r t: mar ergy et nu gical cNT	eatr reat nage / re- ucle m CAL elea of	men tme: eme cov ei, N etho ase Bio	t, Ty nt, 1 nt, 1 ery f Methods, of g oxid	/pes Phyta Type rom Ods o Cont eneti ation	and orem 9 s an solid 9 of co trol o 9 cally , Bic	opera ediat <b>) hou</b> d de l was <b>) hou</b> ntrol of ai	ation tion rsign tte. Iling r bo urs tinee	of of of air rne
Wastewa aerobic contamin UNIT II Introduc Landfills UNIT IV Introduc pollution pathogen UNIT V Introduc organism Bioleach	ater trea and nated e II	atment, Aerobianaerobic dige ffluents. SOLID WAST solid waste, duction to com AIR POLLUT air pollution, iotechnology, o uman and livest MAJOR CON BIOTECHNO Environmenta environment, I	TE MA Princip posting FION I Role o Odour tock. ICEPT DLOG 1 Gene Direct a	Anae used NAU bles g tech MAN f aer cont Y S IN Y utics, and I tion t	GEN of s mold AG osol rol u Fac ndira	c wa wa olid ogies EMI s and using VIR tors ect n etag	T wa: 3, Bi ENI d dr g bid RON	wate wate ste oople olog IMF	er tro r t: mar ergy et m gical cNT	eatr reat nage / re- ucle m CAL elea of	men tme: eme cov ei, N etho ase Bio	t, Ty nt, 1 nt, 1 ery f Methods, of g oxid	/pes Phyta Type rom Ods o Cont eneti ation	and orem 9 s an solid 9 of co trol o 9 cally , Bic	opera ediat <b>) hou</b> d de l was <b>) hou</b> ntrol of ai	ation tion rsign tte. Iling r bo urs tinee	of of of air rne

LEARNING	RESOURCES
Text Books	<ol> <li>Rittmann B. and McCarty P., "Environmental Biotechnology: Principles and Applications", McGraw-Hill, 2006.</li> <li>Bhattacharya B.C. and Ritu Banerjee, "Environmental Biotechnology", Oxford Press, 2007.</li> </ol>
Reference Books	<ol> <li>Scargg A., "Environmental Biotechnology", Longman, 1999.</li> <li>Wainwright M., "An Introduction to Environmental Biotechnology", Kluwer Academic Press, 1999.</li> <li>Singh D.P. and Dwivedi S.K., "Environmental Microbiology &amp; Biotechnology", New Age International Publishers, 2004.</li> </ol>
Reference videos	https://youtu.be/FHyrZASHCck https://youtu.be/oD5tb6pSCSc https://youtu.be/94Qqzbz7hZE https://youtu.be/5QxrZz6QYFI https://youtu.be/iFkY5Ltl9Gk
Reference NPTEL	https://archive.nptel.ac.in/courses/102/105/102105088/
Reference research/ review articles	<ol> <li>Díaz, S., &amp; Malhi, Y. (2022). Biodiversity: Concepts, patterns, trends, and perspectives. Annual Review of Environment and Resources, 47, 31-63.</li> <li>Kumar, V. (2021). Phytoremediation of distillery effluent: current progress, challenges, and future opportunities. Bioremediation for Environmental Sustainability, 349-374.</li> <li>Ochieng, R., Gebremedhin, A., &amp; Sarker, S. (2022). Integration of waste to bioenergy conversion systems: a critical review. Energies, 15(7), 2697.</li> <li>Quintana, Á. R., Seseña, S., Garzón, A., &amp; Arias, R. (2020). Factors affecting levels of airborne bacteria in dairy farms: A review. Animals, 10(3), 526.</li> <li>Pekkala, S. (2023). Fecal metagenomics and metabolomics identifying microbial signatures in non-alcoholic fatty liver disease. International Journal of Molecular Sciences, 24(5), 4855.</li> </ol>

Course C	ode			<b>Course Title</b>	L	Т	Р	C					
10212BT	113			ZYME TECHNOLOGY AND BIOTRANSFORMATION	3	0	0	3					
Course Ca	tegory	P	rogra	um Elective									
Preamble			To have insight knowledge about the applications of enzymes and biotransformation.										
Prerequisite Courses			10212BT144 – Advanced Biochemistry										
Course Outcomes	Upon s	uccessfi	ful co	mpletion of the course, students will l	e able	to:							
CO Nos.				Course Outcomes	(	nowle Based oom's	on revi	ised					
CO1	Classif	y the dif	fferen	t types of enzymes.		]	K2						
CO2		the sing and inl		nd multi-substrate reactions in enzyr on.	ne	]	K2						
CO3				es and techniques involved in enzyr lization for its application in biosenso		]	K3						
CO4	Select a	and char	racter	ize the enzymes from different source	5.	]	K3						
CO5	Experir applica		ith er	nzymatic biotransformation for vario	us	К3							
	1												
Correlatio	Correlation of COs with POs:												
CO Nos. Course Outcomes				Programme Outcomes (POs)		Program Specific Outcomes (PSOs)							

CO Nos.	Course Outcomes				Specific Outcomes (PSOs)											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Classify the different types of enzymes.	М		М									М	Н	М	
CO2	Relate the single and multi-substrate reactions in enzyme kinetics and inhibition.	н	Н	Н	Н	Н							Н	Н	Н	
CO3	Utilize the principles and techniques involved in enzyme kinetics and immobilization for its application in biosensors.	Н	Н	Н	Н	Н							Н	Н	Н	Н
CO4	Select and characterize the enzymes from different sources.	Н	Н	Н	Н	Н							Н	Н	Н	Н

CO5			with for	Н	Н	Н	Н	Н		М	н				Н	Н	Н	Н
H – High	; M- N	<b>Iedium; L-</b> L	ow															
Course C																		
UNIT I		INTRODUC														) hou		
		f enzymes; M					•				1						U	
of enzyme	e subs	trate complex	forn	nati	on; s	spec	ificit	y of	enz	zym	e ac	ction	n; pr	incip	oles c	of cat	alys	is –
collision t	theory	, transition sta	te th	eor	y; rc	ole of	f ent	ropy	/ in	cata	lysi	s.						
UNIT II		KINETICS (	OF E	NZ	YM	ES .	ACT	[0]	N						9	) hou	irs	
Kinetics of	of sing	gle substrate 1	eacti	ions	s; es	tima	tion	of l	Mic	helis	s –	Me	nten	para	mete	ers, t	urnc	over
number; t	types of	of inhibition	& m	ode	ls –	subs	trate	, pro	oduc	et. A	llo	ster	ic re	gula	tion	of e	nzyn	nes,
Koshland	l, Ném	ethy, Filmer a	and N	Лоп	od (	Chan	geux	k W	yma	n m	ode	els, j	pH a	nd te	empe	eratu	re ef	fect
on enzym	nes & c	leactivation k	ineti	cs.														
UNIT III	[	ENZYME IN	AMO	)BI	LIZ	AT	ION	AN	DB	SIO	SEN	NSC	DRS		9	) hou	irs	
Physical a	and ch	emical techni	ques	for	enz	yme	imn	nobi	lizat	tion	— a	dso	rptio	n, m	atrix	entr	apm	ent,
encapsula	ation, c	cross-linking,	cova	len	t bin	ding	g etc.	, - e	xan	nple	s, a	dva	ntag	es an	nd dis	sadva	antag	ges;
Introduction to Biosensors - design of enzyme electrodes and their application as biosensors in												s in						
industry, I	health	care and envi	ronm	ent														
UNIT IV	7	ENZYMES I	FRO	M	NAT	TUR	ALS	SOU	RC	ES					9	) hou	irs	
Productio	on and	purification o	f cru	de e	enzy	me e	extra	cts f	rom	pla	nt, a	anir	nal a	nd m	nicro	bials	sour	ces;
methods i	in chai	racterization o	of enz	zym	les; d	leve	lopn	nent	ofe	enzy	ma	tic a	assay	vs.				
UNIT V		BIOTRANS	FOR	MA	ATI	ON A	APP	LIC	CAT	ION	NS (	OF			ç	) hou	ırs	
Hydrolyti		ENZYMES er bond, Ami	de F	Ino	vide	s. Ni	trile	s. R	edu	ctio	n re	acti	ons	ald	ehvd	es k	Cetor	nes
		1 reactions $-$ ,		•											•			
		nzymes, Cata				-	ame	Syn	unes	515-	CSU	.15,	ann	ac, p	epin	ic, iv	IUUI	licu
			lytic	am		105.												
IFARNI	ING R	ESOURCES																
		1. Trevor Pa		: "F	Enzv	mes'	". IIr	nd E	ditio	on. I	Hor	woo	od Pi	ıblis	hing	Ltd	200	7.
Text Boo		<ol> <li>Faber K, ' 2000.</li> </ol>			-										•			
Doform		<ol> <li>Harvey W Dekker In</li> </ol>				ougl	as S	. Cl	ark,	"Bi	och	em	ical	Engi	neer	ing",	Ma	rcel
Referenc Books		2. James M.						-		-								_
		3. James. E Fundamer											Bioch	nemi	cal	Engi	ineeı	ring

	4. Wiseman, "Enzyme Biotechnology", Ellis Horwood Pub., 1995.
Reference videos	https://youtu.be/s2Y-S3V0pLY https://youtu.be/mJecSUWeoTc https://youtu.be/_379SFo_jFo https://youtu.be/IXPrRSBxx6E https://youtu.be/l_WuC4vpTsY
Reference NPTEL	https://archive.nptel.ac.in/courses/102/103/102103097/
Reference research/ review articles	<ol> <li>Jha, R., Pal, R., Chakraborty, D., &amp; Chattaraj, P. K. (2023). Principles of Catalysis. In Metal Phosphates and Phosphonates: Fundamental to Advanced Emerging Applications (pp. 95-113). Cham: Springer International Publishing.</li> <li>Srinivasan, B. (2022). A guide to the Michaelis–Menten equation: steady state and beyond. The FEBS journal, 289(20), 6086-6098.</li> <li>Bollella, P., &amp; Katz, E. (2020). Enzyme-based biosensors: tackling electron transfer issues. Sensors, 20(12), 3517.</li> <li>Kim, S. B., Koo, J., Yoon, J., Hourlier-Fargette, A., Lee, B., Chen, S., &amp; Rogers, J. A. (2020). Soft, skin-interfaced microfluidic systems with integrated enzymatic assays for measuring the concentration of ammonia and ethanol in sweat. Lab on a Chip, 20(1), 84-92.</li> <li>Lubberink, M., Finnigan, W., &amp; Flitsch, S. L. (2023). Biocatalytic amide bond formation. Green Chemistry, 25(8), 2958-2970.</li> </ol>

Course	Code				(	Cour	·se T	itle						L	T	•	P	С		
10212B	ST114			SYI	NTH	<b>IET</b>	IC B	BIO	LOO	GΥ				3	0		0	3		
Course	Catego	ry	Progr	ram	Elec	ctive														
Preamb	le		To ha synth																	
Prerequ	isite C	ourses	1021 1021							0,		onc	epts	and Techniques						
Cour Outco		Upon	successful	con	ıplei	tion	of th	е со	ourse	e, st	ude	nts	will	be al	ble to	o:				
CO N	los.			С	ours	e O	utco	mes						Knowledge Level (Based on revised Bloom's Taxonomy)						
СО	1		ain the Str aryotic and						and	reg	gula	tior	n in	K2						
CO	2		narize the mbinant Dl				me gy	char	nism	S	unc	lerly	ying		К2					
CO	3		the comp in structure		iona	l toc	ols to	stu	dy tl	ne g	eno	me	and			K3				
CO	4	Make chara	of and			tatio conti			conc an			for in			K3					
CO:	5		lop suitabl Ds according								sti	udy	the			К3				
Correlat	ion of (	COs w	ith POs:																	
CO Nos.	C	ourse Oi	utcomes				Prog	ramı	ne O	utco	mes	(POs	5)			Program Specific Outcomes (PSOs)				
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3		
CO1	Explai concer Biolog	ots of	ts of Synthetic			Н									M	Н	Н			
CO2	variou underl	iment with the us mechanisms lying nbinant DNA													М	Н	Н			
CO3	Make molec Genor design	ne an	use of the llar basis of le and Protein			Н	Н	Н	L	L					М	Н	L	L		
CO4	metho		e specific volved in ology.		L	Н	М	L							М	М	М	М		

CO5 a	xamine the advanced ad emergent concepts H H H H H H Synthetic Biology.	L	L	Н				Н	Н	М	М
H – High;	M- Medium; L- Low										
Course Co											
UNIT I	INTRODUCTION TO SYNTHETIC								) hou		
Covalent,	onic, Hydrogen, Coordinate, hydrophobio	and	Va	nder	wa	ills i	ntera	action	ns in	pro	tein
structure.	nteraction with electromagnetic radiation	radio	o, m	icro	, in	frare	d, vi	sible	e, ulti	ravio	olet,
X-ray) and	elucidation of protein structure.										
UNIT II	RECOMBINANT DNA TECHNOL	)G7	7					C	) hor	irs	
	piotechnological methods - Cloning, Muta			Svr	the	sis o	fnu				NA
	etermination, Gene delivery vectors, Plas	-		-							
sequence of	etermination, Gene denvery vectors, Plas	nic e	хпа	cuo	n, c	Jeno	mics	and	PIO	eom	ics.
UNIT III	GENOME AND PROTEIN DESIGN	I						9	) hou	irs	
Introductio	n to gene assembly and protein mode	lling	, С	RIS	PR	-Cas	9 cc	ompl	ex,	direc	cted
evolution,	alternative splicing, Methods and use	s of	f D	NA	se	quer	icing	g, co	ompu	itatio	onal
modelling	Basic theoretical and computational mode	lling	<u>y</u>								
UNIT IV	-				00	<b>X</b> 7					
	SPECIFIC METHODS OF SYNTH								) hou		.1
	s and basic principles of methodologies				•			0.			
concept of	physical DNA composition, PoPs and RiP	s - tr	ansc	ript	iona	al sta	ındaı	rds fo	or fu	nctio	onal
DNA com	position, Designing biological system fro	n Bi	ioBr	icks	, iC	<b>JEM</b>	Reg	gistry	, Bi	olog	ical
part charac	terization and quality control.										
UNIT V	ADANCED CONCEPTS IN SYNTH	ЕТІ	C B	IOI	0	GY		g	) hoi	irs	
	Biology in GMO's, Metabolic Engineering,						facto				nce
•	sensing and environmental impact of S		·					-			
	0	•		•		U		0	,		UL
(Multiplex	Automated Genomic Engineering), Ethica	l cha	aller	iges	01	Synt	netic	: B10	logy	•	
LEARNI	G RESOURCES										
LEARNI	G RESOURCES           1. Paul S. Freemont, Richard I. Kir           Edition, Imperial College Press, 20	•	"Sy	nthe	tic	Bio	logy	- A	Pri	mer'	',1 ^s
Reference	1. Paul S. Freemont, Richard I. Kit	12.	2				0.				
	<ol> <li>Paul S. Freemont, Richard I. Kit Edition, Imperial College Press, 20</li> <li>Huimin Zhao, "Synthetic Biolog</li> </ol>	12. y: T hison s for	ools n II Eng	s ar I, H gine	id 4 ami erin	Appl Ilton 1g Bi	icati O.	ons" Smit gical	, 1 st h an	Edit d Ci	ion raig
Reference	<ol> <li>Paul S. Freemont, Richard I. Kir Edition, Imperial College Press, 20</li> <li>Huimin Zhao, "Synthetic Biolog Academic Press, 2013.</li> <li>Daniel G. Gibson, Clyde A. Hutc Venter J., "Synthetic Biology: Too</li> </ol>	12. y: T hison s for	ools n II Eng	s ar I, H gine	id 4 ami erin	Appl Ilton 1g Bi	icati O.	ons" Smit gical	, 1 st h an	Edit d Ci	ion raig
Reference Books Reference	<ol> <li>Paul S. Freemont, Richard I. Kir Edition, Imperial College Press, 20</li> <li>Huimin Zhao, "Synthetic Biolog Academic Press, 2013.</li> <li>Daniel G. Gibson, Clyde A. Hutc Venter J., "Synthetic Biology: Too Cold Spring Harbor Perspectives in</li> </ol>	12. y: T hison s for	ools n II Eng	s ar I, H gine	id 4 ami erin	Appl Ilton 1g Bi	icati O.	ons" Smit gical	, 1 st h an	Edit d Ci	ion raig
Reference Books	<ol> <li>Paul S. Freemont, Richard I. Kir Edition, Imperial College Press, 20</li> <li>Huimin Zhao, "Synthetic Biolog Academic Press, 2013.</li> <li>Daniel G. Gibson, Clyde A. Hutc Venter J., "Synthetic Biology: Too Cold Spring Harbor Perspectives in <u>https://youtu.be/YbNKagnCwis</u></li> </ol>	12. y: T hison s for	ools n II Eng	s ar I, H gine	id 4 ami erin	Appl Ilton 1g Bi	icati O.	ons" Smit gical	, 1 st h an	Edit d Ci	ion raig

	https://youtu.be/rD5uNAMbDaQ?list=PLuJ9u3pztP-
	30JKJERK_Ts5H6yc7zHWsi
Reference NPTEL	https://nptel.ac.in/courses/102106102
Reference research/ review articles	<ol> <li>Ou, X., Chen, X., Xu, X., Xie, L., Chen, X., Hong, Z., &amp; Yang, H. (2021). Recent development in x-ray imaging technology: Future and challenges. Research.</li> <li>Badua, C. L. D., Baldo, K. A. T., &amp; Medina, P. M. B. (2021). Genomic and proteomic mutation landscapes of SARS-CoV-2. Journal of medical virology, 93(3), 1702-1721.</li> <li>Hu, T., Chitnis, N., Monos, D., &amp; Dinh, A. (2021). Next-generation sequencing technologies: An overview. Human Immunology, 82(11), 801- 811.</li> <li>Radde, N., Mortensen, G. A., Bhat, D., Shah, S., Clements, J. J., Leonard, S. P., &amp; Barrick, J. E. (2024). Measuring the burden of hundreds of BioBricks defines an evolutionary limit on constructability in synthetic biology. bioRxiv</li> <li>Wannier, T. M., Ciaccia, P. N., Ellington, A. D., Filsinger, G. T., Isaacs, F. J., Javanmardi, K., &amp; Church, G. M. (2021). Recombineering and MAGE. Nature Reviews Methods Primers, 1(1), 7</li> </ol>

# **MEDICAL DOMAIN**

Course	Code			(	Cour	se T	itle						L	T		P	С		
10212B	T115		С	ANC	CER	BIC	)L(	)G\	l				3	0		0	3		
Course	Category	Progra	m E	Elect	ive														
Preamb	le	To crea from th detection	ie fi	ında	men	tal p	rinc	ciple	es to										
Prerequ	isite Cours	es 102111 102111							ogy:	Со	nce	pts a	nd T	Techn	ique	S			
Cours Outcom	I/non	successful co	mpl	etio	n of	the c	cour	se, s	stud	ents	s wi	ll be	able	to:					
CO No	s.		Co	ourse	e Ou	tcon	nes							Knowledge Level (Based on revised Bloom's Taxonomy)					
CO1		ate and dia points in cano	-			regu	ılati	ons	of	ce	11 0	cycle	;	K2					
CO2		rehend the v s regulatory n				of	Caro	cino	gen	ic r	nate	erials		K2					
CO3	-	in different s inderstanding	5												K3				
CO4		dentify the cause of cancer stimulation at Metastasis stage nd its regulatory proteins									;	K.3							
CO5			e proper therapy for different types of cancer to their markers and proteins									•	К3						
Correlat	ion of COs	with POs:																	
CO Nos.	Course	Outcomes				Prog	ramı	me O	utco	mes	(POs	s)		Progran Specific Outcome (PSOs)					
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3		
CO1	the regulat	nd diagnosis ions of cell ckpoints in s		М										Н	Н	М			
CO2	Compreher various Carcinogen and its mechanism	types of ic materials regulatory	Н		М	М	L						Н	Н	Н	Н			
CO3		ferent stages based on its level ing		М	Н	L							Н	М	Н	Н			

CO4       Identify the cause of cancer stimulation at Metastasis stage and its regulatory proteins       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H										
CO5       therapy for different types of cancer according to their markers and proteins       H       H       M       H       L       M       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H       H <td< td=""></td<>										
Course Content:         UNIT I       INTRODUCTION TO CANCER BIOLOGY       9 hours         Nomenclature, Historical perspective, regulation of cell cycle, check points, Basic mechanism of cancer, Signal molecules, signal transduction, mutations that cause changes in signa molecules, Modulation of cell cycle, receptors, oncogenesis, diagnostic tools for screening an early detection. Different forms of cancer.       9 hours         UNIT II       PRINCIPLES OF CARCINOGENESIS       9 hours         Theory of Carcinogenesis, Metabolism of carcinogenesis, Physical and Chemica Carcinogenesis, Radiation carcinogenesis, ionizing and non-ionization radiation effects CYP450 reductase mechanism, Retroviruses-RSV life cycle and role in cancer, Identificatio of carcinogens with long term and short term bioassays, other methods.         UNIT III       MOLECULAR BASIS OF CANCER BIOLOGY       9 hours         Principles of molecular cell biology of cancer - Differentiation, local invasion, Metastasis										
UNIT IINTRODUCTION TO CANCER BIOLOGY9 hoursNomenclature, Historical perspective, regulation of cell cycle, check points, Basic mechanism of cancer, Signal molecules, signal transduction, mutations that cause changes in signa molecules, Modulation of cell cycle, receptors, oncogenesis, diagnostic tools for screening an early detection. Different forms of cancer.9 hoursUNIT IIPRINCIPLES OF CARCINOGENESIS9 hoursTheory ofCarcinogenesis, Metabolism of carcinogenesis, Physical and Chemica Carcinogenesis, Radiation carcinogenesis, ionizing and non-ionization radiation effects CYP450 reductase mechanism, Retroviruses-RSV life cycle and role in cancer, Identificatio of carcinogenes with long term and short term bioassays, other methods.9 hoursUNIT IIIMOLECULAR BASIS OF CANCER BIOLOGY9 hoursPrinciples of molecular cell biology of cancer - Differentiation, local invasion, Metastasis9										
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Principles of molecular cell biology of cancer - Differentiation, local invasion, Metastasis										
Pathways of spread, Progression of Tumor, Signal targets and cancer, Identification, activation										
and detection of Oncogenes, activation of kinases, growth factors related to transformation										
Telomerases										
UNIT IV CANCER METASTASIS, ONCOGENES, 9 hours										
Introduction to Metastasis and cascade, Invasion-three step theory, Heterogeneity of metastati										
phenotype, Proteinases and tumor cell invasion, Introduction to oncogenes and oncoproteins										
tumor suppression genes - p53 genes, activation, evasion of apoptosis, DNA repair defects and										
instability of genes in cancer cells, chromosomal changes, gene amplification, molecular profil										
of cancer cells.										
UI CAILCEI CEIIS.										
UNIT V CANCER THERAPY 9 hours										
UNIT V CANCER THERAPY 9 hours										

LEARNING	RESOURCES
Reference Books	<ol> <li>Weinberg R.A., "The Biology of Cancer", Garland Science, 2007.</li> <li>Ian F.Tannock, Richard P. Hill, Robert G. Bristow and Lea Harrington, "The Basic Sciences of Oncology, 4thEdition, McGraw-Hill, 2005.</li> <li>PelengarisS. and Khan M., "The Molecular Biology of Cancer", Wiley Blackwell Publishing, USA, 2006.</li> <li>Margaret A. Knowles and Peter T. Selvo, "An introduction to cellular and molecular biology of cancer", Oxford Medical publication, 1991.</li> </ol>
Reference videos	https://www.youtube.com/watch?v=46Xh7OFkkCE https://www.youtube.com/watch?v=NO0eKiIUcBg https://www.youtube.com/watch?v=8fwmSnkdY8Q https://www.youtube.com/watch?v=bdWRZd19swg https://www.youtube.com/watch?v=-6j0e_1ZC60
Reference NPTEL	https://nptel.ac.in/courses/102106025
Reference research/ review articles	<ol> <li>Huang, Z., Xie, N., Illes, P., Di Virgilio, F., Ulrich, H., Semyanov, A., &amp; Tang, Y. (2021). From purines to purinergic signalling: molecular functions and human diseases. Signal transduction and targeted therapy, 6(1), 162.</li> <li>Stading, R., Gastelum, G., Chu, C., Jiang, W., &amp; Moorthy, B. (2021, November). Molecular mechanisms of pulmonary carcinogenesis by polycyclic aromatic hydrocarbons (PAHs): Implications for human lung cancer. In Seminars in cancer biology (Vol. 76, pp. 3-16). Academic Press.</li> <li>Schulz, W. A. (2023). Molecular biology of human cancers. Springer Nature Switzerland AG.</li> <li>Schiller, J. T., &amp; Lowy, D. R. (2021). An introduction to virus infections and human cancer. Viruses and human cancer: from basic science to clinical prevention, 1-11.</li> <li>Gavas, S., Quazi, S., &amp; Karpiński, T. M. (2021). Nanoparticles for cancer therapy: current progress and challenges. Nanoscale research letters, 16(1), 173.</li> </ol>

Course Category       Program Elective         To introduce the molecular basis and factors behind pathogeness and the various strategies designed to study, diagnose and tree pathogenesis.         Presequisite Courses       10211BT101 – Microbiology	Course Code	Course Title	L	Т	Р	С						
Preamble       To introduce the molecular basis and factors behind pathogeness and the various strategies designed to study, diagnose and tree pathogenesis.         Prerequisite Courses       10211BT101 – Microbiology	10212BT116	MOLECULAR PATHOGENESIS	3	0	0	3						
Preamble       To introduce the molecular basis and factors behind pathogeness and the various strategies designed to study, diagnose and tree pathogenesis.         Prerequisite Courses       10211BT101 – Microbiology												
Preamble       and the various strategies designed to study, diagnose and tree pathogenesis.         Prerequisite Courses       10211BT101 – Microbiology	<b>Course Category</b>	Program Elective										
Prerequisite Courses	Preamble	To introduce the molecular basis and factors behind pathogenesis and the various strategies designed to study, diagnose and treat pathogenesis.										
10211D1110 - Immunology and Immunolechnology	Prerequisite Courses	10211BT101 – Microbiology 10211BT116 - Immunology and Immunotechnology										

vledge Level ed on revised 1's Taxonomy)
K2
K2
K3
K3
К3

CO Nos.	Course Outcomes	Programme Outcomes (POs)													Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	Explain the historical background of molecular pathogenesis and basic mechanisms.	тт	М										Н	Н	М		
CO2	Comprehend the inter actions mechanism of pathogens toward host organism and resistance development.		Н										Н	Н	Н		
CO3	Identify the molecular mechanisms of various Enteric pathogens for disease causing in human.		М		L								Н	Н	Н		

CO4 lev	ike use of molecular el experiments to derstand host hogen interactions	н	Н	М	Н	Н							Н	Н	Н	M
CO5 CO5	velop the diagnosis d prevention tools for tious pathogenic fections.	н	Н	М	Н	L	Н						Н	Н	Н	L
H – High; N	I- Medium; L- Low															
<u> </u>																
Course Con UNIT I	INTRODUCTIO		O M	IOL	ECI	JLA	R							9 ho	urs	
Historical	background, Introd		on	to	infec	ctiou	IS	dise	ase	s,	Con	cept	s of	vi	ruler	nce,
pathogenicity, commensalism, symbiosis, opportunism, parasitism; Significance of the																
discovery of Microscope in pathogenesis, Significant contributions of Louis Pasteur, Robert																
Koch postulates, Microbial toxins - discovery, assays, underlying mechanisms of bacterial																
Koch postulates, Microbial toxins - discovery, assays, underlying mechanisms of bacterial colonization and infection.																
colonization and infection.         UNIT II       HOST DEFENSE AGAINST PATHOGENS, STRATEGIES       9 hours																
Basic comp	onents and nature of p	oatho	ogen	esis,	Hos	st de	fens	se m	lech	ani	sms	- Ski	in, M	ucos	a, Ci	ilia,
Secretions,	Physical movements,	limi	tatio	on of	free	e iro	n, a	ntin	nicr	obia	al co	mpo	unds,	mec	chan	ism
of killing b	humoral and cellula	r de	fens	e me	cha	nisn	ıs, r	esis	tano	ce c	leve	lopm	ent ii	ı pat	hoge	ens,
Pathogenic	adaptations.															
UNIT III	MECHANISM IN	N M	OLI	ECU	LA	R P.	ATI	100	GEI	NES	SIS			9 ho	urs	
Underlying	mechanisms of Mol	lecul	ar p	atho	gen	esis,	Ro	ole o	of l	Mol	ecul	ar g	enetio	cs ar	nd g	ene
regulation in	virulence of pathoge	ens, I	nflu	ence	ofli	ifest	yle	fact	ors	onv	virul	ence	, Clin	ical	featı	ires
and molecu	lar mechanism of p	atho	gen	esis:	Ent	eric	pa	thog	gens	- E	Enter	opat	hogei	nic (	EPE	EC),
Enteroinvas	ive (EIEC), Enteroag	gres	sive	E.co	li (E	EAE	C),S	Shig	ella	, Sa	ılmo	nella	ı, Der	mate	ophy	tes,
Candidiasis	Plasmodium - Life c	ycle	, Ma	alaria	a, dit	ffere	ent s	tage	es o	f In	flue	nza v	virus.			
UNIT IV	EXPERIMENTA INTERACTIONS		STU.	DIE	<b>S O</b>	Nł	105	<b>5T</b> ]	PA'	ГH	OGI	EN		9 ho	urs	
Assays for Virulence, Principles of Adherence, Invasion, Cytopathic effects; Tests in																
identifying	virulence factors, at	ttenu	atec	l mi	ıtant	s, N	Aole	ecul	ar o	cha	racte	erizat	ion o	of vi	irule	nce
factors, Signal transduction and host responses.																
	PATHOGEN DL	UNIT VPATHOGEN DIAGNOSIS AND CONTROL METHODS9 hours											9 ho			
UNIT V																
		Dia	gno	sis ı	ising	g Vi	irule	ence	fa	cto	rs, I	mmı				sed

Western blotting, Bioinformatics/whole genome analysis for pathogen diagnosis, Vaccines -Types, applications, advantages and disadvantages, Cocktail vaccines, New therapeutic strategies based on recent findings on molecular pathogenesis of pathogens.

LEARNING RE	SOURCES
Text Books	
Reference Books	<ol> <li>Iglewski B.H. and Clark V.L., "Molecular basis of Bacterial Pathogenesis", Academic Press, 1990.</li> <li>Eduardo A. Groisman, "Principles of Bacterial Pathogenesis", Academic Press, 2001.</li> <li>Peter Williams, Julian Ketley and George Salmond, "Methods in Microbiology: Bacterial Pathogenesis", Academic Press, 1998.</li> <li>Brenda B. Wilson, Abigail A. Salyers, Dixie D. Witt and Malcolm E. Winkler, "Bacterial Pathogenesis", 3rdEdition, ASM press, 2011.</li> </ol>
Reference videos	https://www.youtube.com/watch?v=_2vTa4P6Tbg https://www.youtube.com/watch?v=X6wrFMvK804 https://www.youtube.com/watch?v=oaqwrJ-SZGE https://www.youtube.com/watch?v=XvlY0zvKbm4 https://www.youtube.com/watch?v=SwNXNFBIGKc
Reference NPTEL	https://nptel.ac.in/courses/102106025
Reference research/ review articles	<ol> <li>Milgroom, M. G. (2023). The Germ Theory Paradigm. In Biology of Infectious Disease: From Molecules to Ecosystems (pp. 9-22). Cham: Springer International Publishing.</li> <li>Iannacone, M., &amp; Guidotti, L. G. (2022). Immunobiology and pathogenesis of hepatitis B virus infection. Nature Reviews Immunology, 22(1), 19-32.</li> <li>Alfinete, N. W., Bolukaoto, J. Y., Heine, L., Potgieter, N., &amp; Barnard, T. G. (2022). Virulence and phylogenetic analysis of enteric pathogenic Escherichia coli isolated from children with diarrhoea in South Africa. International Journal of Infectious Diseases, 114, 226-232.</li> <li>Ahmadi, M., Ranjbar, R., Behzadi, P., &amp; Mohammadian, T. (2022). Virulence factors, antibiotic resistance patterns, and molecular types of clinical isolates of Klebsiella Pneumoniae. Expert Review of Anti- infective Therapy, 20(3), 463-472.</li> <li>Sanya, D. R. A., Onésime, D., Vizzarro, G., &amp; Jacquier, N. (2023). Recent advances in therapeutic targets identification and development of treatment strategies towards Pseudomonas aeruginosa infections. BMC microbiology, 23(1), 86.</li> </ol>

Course	Code	BIOPHARMACEUTICAL											L	1	[	P	С		
10212B	ST117		BIC		ARI ECH				CAI	_1			3	0	)	0	3		
		1																	
Course	Category	Progra																	
Preamb	le	To und medicii				-	evel	орт	nent	pro	oces	ss fo	r th	e pre	epar	atior	ı of		
Prerequ	isite Courses	NIL																	
Cours Outcom	I / non su	ccessful co	mpl	etio	n of i	the c	our.	se, s	tud	ents	wi.	ll be!	able	to:					
CO No	<b>S.</b>	<b>Course Outcomes</b> tand the various types of therapeutic agents used i											Knowledge Level (Based on revised Bloom's Taxonomy)						
CO1		derstand the various types of therapeutic agents used rmaceutical industry, their use and regulatory aspects													K2	*			
CO2		ucidate the drug metabolism involving the physic emical properties and pharmacokinetics of drugs.													K2	,			
CO3		mical properties and pharmacokinetics of drugs. nonstrate the different types of reaction proc olved in bulk drug manufacture.												K2					
CO4		ne analytic techniques		metl	nods	in	drug	g m	anu	fact	ture	and		К3					
CO5		the varions and the transformed structure the second structure of the second s												К3					
	·																		
Correlat	ion of COs wit	h POs:													1		1		
CO Nos.	Course Out	comes				Prog	rami	me O	utco	mes	(POs	i)				rogra pecif utcon PSOs	ic 1es		
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3		
CO1	types of the agents us pharmaceutica	nd the various f therapeutic used in utical their use and M M									М	Н	М						
CO2	metabolism	-chemical and	Н	Н	Н	Н	Н							Н	Н	Н			

CO3	Demonstrate the different types o reaction process involved in bulk drug manufacture.	f s H	Н	Н	Н	Н							Н	Н	Н	Н
CO4	Apply the analytica methods in drug manufacture and packing techniques.	Вн	Н	Н	Н	Н							Н	Н	Н	Н
CO5	Identify the various pharmaceutical products, curren medicines and thei applications in therapeutic and diagnostic fields.	t r H	Н	Н	Н	Н		М	Н				Н	Н	Н	Н
H – Hig	ı; M- Medium; L- Low															
	Content:															
UNIT I	INTRODUCTIO													9 ho		
Develop	ment of Drug and Pharr	nacei	ıtica	l Ind	lustr	y, ty	pes	of t	her	ape	utic	agen	its an	d the	eir u	ses;
economi	cs and regulatory aspect	s.														
UNIT II	DRUG METABO	DLIS	M A	ND	PH	ARI	MA	<b>CO</b> ]	KIN	NE ]	FICS	5		9 ho	urs	
Drug me	etabolism – physico ch	emica	al pr	rincij	ples,	rad	ioac	ctivi	ty -	- pl	narm	nacoł	cineti	ics-a	ction	of
drugs on	human bodies.															
	I MANUFACTUR		OF	D	RUG	FS,	PI	RO	CES	<b>5S</b>	Aľ	ND		9 ho	urs	
UNIT II	APPLICATIONS			nna i	n hu	lk d	lrug	ma	nuf	actu	ire a	nd p	roces	sses.	Spe	cial
	g manufacturers, Type	of re	actio	JIIS I	n ou	in u	$\mathcal{C}$				ne a	T	1000			
Bulk dru				5115 1	n ou	iik u	U				ne a	1	1000			
Bulk dru	ng manufacturers, Type nent for bulk drug manu	actu	re.											9 ho	urs	
Bulk dru requirem UNIT I	ng manufacturers, Type nent for bulk drug manu	factur ING	re. PR	INC	IPL	ES			ggi							olet
Bulk dru requirem UNIT IV Compres	ig manufacturers, Type ient for bulk drug manu: MANUFACTUR	factur ING ation	re. <b>PR</b> -dry	INC gra	IPL nula	ES tion	or	slu		ng-	direo	et co	ompro	essio	n-ta	
Bulk dru requirem UNIT IV Compres presses,	ig manufacturers, Type ient for bulk drug manu MANUFACTUR issed table, wet granula	Tactur ING ation osules	re. PR -dry s, su	INC gra ıstaiı	IPL nula ned	ES tion actio	or on o	slu	ige	ng- for	direc ms-j	et co	ompro ntal s	essio solut	n-tal	oral
Bulk dru requirem UNIT I Compres presses, liquids-i	ig manufacturers, Type ient for bulk drug manu MANUFACTUR issed table, wet granula coating of tablets, cap	factur ING ation sules	re. PRI -dry s, su oplic	INC gra istain ation	<b>IPL</b> nula ned ns, P	ES tion action rese	or on o	slu dosa tion	ige , an	ng- for aly	direo ms-j tical	et co parer met	ompro ntal s hods	essio solut and	n-tal ion-o test	oral for
Bulk dru requirem UNIT IV Compress presses, liquids-i various o	ag manufacturers, Type ent for bulk drug manu MANUFACTUR sed table, wet granula coating of tablets, cap njections-ointment-topic lrug and pharmaceutical	factur ING ation sules al ap s, pa	re. PR -dry s, su oplic ckin	INC gra istain ation g-pa	IPL nula ned ns, P ckin	ES tion action rese g teo	or on o	slu dosa tion	ige , an	ng- for aly	direo ms-j tical	et co parer met	omprontal s hods geme	essio solut and ent, C	n-tal ion-o test GMP	oral for
Bulk dru requirem UNIT IV Compress presses, liquids-i various o UNIT V	ig manufacturers, Type ient for bulk drug manufacturers, Type MANUFACTUR issed table, wet granufacturers coating of tablets, cap njections-ointment-topic drug and pharmaceutical PHARMACEUT	Tactur ING ation sules al ap s, pa	re. PRI -dry s, su oplic ckin L PI	INC gra istain ation g-pa <b>ROD</b>	IPL nula ned ns, P ckin	ES tion action rese g teo TS	or on o crvat	slu dosa tion	ige , an s, q	ng- for aly	direc ms-j tical	et co parer met Iana	omprontal s hods geme	essio solut and ent, C 9 ho	n-tal ion-o test GMP <b>urs</b>	oral for
Bulk dru requirem UNIT I Compres presses, liquids-i various d UNIT V Theraper	ig manufacturers, Type inent for bulk drug manufacturers, Type MANUFACTUR issed table, wet granufacturers coating of tablets, cap injections-ointment-topic drug and pharmaceutical PHARMACEUT attic categories such as	Tactur ING ation sules al ap s, pa ICA vitar	re. PRI -dry s, su oplic ckin L PI	INC gra istain ation g-pa <b>ROD</b>	IPL nula ned ns, P ckin	ES tion action rese g teo TS	or on o crvat	slu dosa tion	ige , an s, q	ng- for aly	direc ms-j tical	et co parer met Iana	omprontal s hods geme	essio solut and ent, C 9 ho	n-tal ion-o test GMP <b>urs</b>	oral for
Bulk dru requirem UNIT I Compres presses, liquids-i various d UNIT V Theraper	ig manufacturers, Type ient for bulk drug manufacturers, Type MANUFACTUR issed table, wet granufacturers coating of tablets, cap njections-ointment-topic drug and pharmaceutical PHARMACEUT	Tactur ING ation sules al ap s, pa ICA vitar	re. PRI -dry s, su oplic ckin L PI	INC gra istain ation g-pa <b>ROD</b>	IPL nula ned ns, P ckin	ES tion action rese g teo TS	or on o crvat	slu dosa tion	ige , an s, q	ng- for aly	direc ms-j tical	et co parer met Iana	omprontal s hods geme	essio solut and ent, C 9 ho	n-tal ion-o test GMP <b>urs</b>	oral for
Bulk dru requirem UNIT IV Compress presses, liquids-i various d UNIT V Theraper Antibiot	ig manufacturers, Type inent for bulk drug manufacturers, Type MANUFACTUR issed table, wet granufacturers coating of tablets, cap injections-ointment-topic drug and pharmaceutical PHARMACEUT attic categories such as	Tactur ING ation sules al ap s, pa ICA vitar	re. PRI -dry s, su oplic ckin L PI	INC gra istain ation g-pa <b>ROD</b>	IPL nula ned ns, P ckin	ES tion action rese g teo TS	or on o crvat	slu dosa tion	ige , an s, q	ng- for aly	direc ms-j tical	et co parer met Iana	omprontal s hods geme	essio solut and ent, C 9 ho	n-tal ion-o test GMP <b>urs</b>	oral for

	2. Shayne Cox Gad,"Pharmaceutical Manufacturing Handbook", John Wiley
	&Sons, Inc., 2008.
	3. Bernd Meibohm, "Pharmacokinetics and Pharmacodynamics of biotech drugs", Wiley-VCH, 2006.
Reference Books	<ol> <li>Leon Lachman, "Theory and Practice of Industrial Pharmacy", 3rdEdition, Lea and Febiger, 1986.</li> <li>Remington, "Pharmaceutical Sciences", 17thEdition, Mark Publishing &amp; co, 1985.</li> </ol>
Reference videos	https://www.youtube.com/watch?v=FPLzzuwZyMo https://www.youtube.com/watch?v=qvucMHUVZA4 https://www.youtube.com/watch?v=u0uIEC-shAI https://www.youtube.com/watch?v=bGwR_7BqXfA https://www.youtube.com/watch?v=EITMeiMgsG8
Reference NPTEL	https://archive.nptel.ac.in/courses/102/107/102107028/
Reference research/ review articles	<ol> <li>Sharma, D., Patel, P., &amp; Shah, M. (2023). A comprehensive study on Industry 4.0 in the pharmaceutical industry for sustainable development. Environmental Science and Pollution Research, 30(39), 90088-90098.</li> <li>Yadav, U., &amp; Bhatted, S. K. (2023). A comparative analysis of Vamana and Shamana Chikitsa in prediabetes management: A randomized clinical trial. Journal of Ayurveda and Integrative Medicine, 14(5), 100764.</li> <li>Panchal, K., Katke, S., Dash, S. K., Gaur, A., Shinde, A., Saha, N., &amp; Chaurasiya, A. (2023). An expanding horizon of complex injectable products: Development and regulatory considerations. Drug Delivery and Translational Research, 13(2), 433-472.</li> <li>Gozdzialski, L., Wallace, B., &amp; Hore, D. (2023). Point-of-care community drug checking technologies: an insider look at the scientific principles and practical considerations. Harm Reduction Journal, 20(1), 39.</li> <li>Kiruba, J., Justin Thenmozhi, A., Jayalakshmi, M., &amp; Arockia Jeya Yasmi Prabha, E. (2023). Role of Vitamins in Alzheimer's Disease. In Nutraceuticals for Alzheimer's Disease: A Promising Therapeutic Approach (pp. 27-42). Singapore: Springer Nature Singapore.</li> </ol>

Course Code	e	Course Title	L	Т	Р	С			
10212BT118		STEM CELL TECHNOLOGY	3	0	0	3			
<b>Course Categ</b>	ory	Program Elective							
Preamble		To study the unique properties of stem cell wit to understand its application in the treatment			cation	and			
Prerequisite (	Courses	NIL							
Course Outcomes	Upon su	ccessful completion of the course, students will l	oe abl	e to:					
CO Nos.		<b>Course Outcomes</b>	(	Knowledge Level (Based on revised Bloom's Taxonomy)					
CO1	Outline stem cel	the properties, classification and preservation o	f	]	K2				
CO2		nend the source and characterization of huma ic stem cell.	n	]	K2				
CO3	CO3 Identify and study about the properties of different type of adult stem cell.								
CO4		e of the hematopoietic stem cells for bone repai ue engineering tools	wair K3						
CO5 Identify cell tech		the solution for various diseases by using ster nology.	n K3						

CO Nos.	Course Outcomes	Programme Outcomes (POs)										Program Specific Outcomes (PSOs)				
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Outline the properties, classification and preservation of stem cell	Н		Н									M	Н	М	
CO2	Comprehend the source and characterization of human embryonic stem cell.	Н											Н	Н	М	
CO3	Identify and study about the properties of different types of adult stem cell.												Н	Н	М	
CO4	Make use of the hematopoietic stem cells for bone repair with tissue engineering tools	Н	М	Н	Н	Н	М		Н				Н	Н	Н	М

CO5 vari	ntify the solution for ous diseases by ng stem cell mology.	нн	Н	Н	Н	М	Н	Н				Н	Н	Н	L
H – High; M	- Medium; L- Low														
Course Con	tent:	TO 6'	TEN		ТТ (	c							) hou		
	em Cells -Unique						cell	s _	di	ffere	ntiat				on
_	pluripotency, self – r														
-	em cells – preservatio				1 501	1 1	ene	w ui	CI	u551	licat		proc		5 111
UNIT II	HUMAN EMBRY	ONIC	STE	MC	CEL	L						Ģ	) hou	irs	
Stem cells a	and their development	ntal po	otenti	al. 1	n v	itro	fer	tiliz	atic	n-cu	ılturi	ing o	of er	nbry	os-
blastocyst-in	ner cell mass-isolat	ion a	nd g	grow	ring	ES	c c	ells	in	lab	ld	entif	icati	on a	and
characterizat	ion of human ES cells	-Cloni	ng ar	nd co	ontro	olled	l dif	fere	ntia	tion	ofh	uma	n em	bryo	nic
stem cells. A	pplications of Embryo	onic ste	em ce	ells.	Ethi	cal	issu	es a	nd	regu	latio	ns.			
UNIT III	HUMAN ADULT												) hou		
Somatic stem	cells-test for identific	eation of	ofad	ult st	em	cells	s- ad	lult	sten	n cel	l dif	feren	tiatio	on-tr	ans
differentiatio	n-plasticity-different	ypes o	fadu	lt ste	em c	ells-	-live	er st	em	cells	-ske	letal	muse	cle st	em
cells-bone m	arrow derived stem ce	ells.													
UNIT IV	STEM CELLS IN	TISSU	E E	NGI	NE	ERI	NG					9	) hou	irs	
Haematopoie	tic Stem Cells-Grow	th fact	ors a	nd t	he r	egul	latic	on c	f ha	aema	atopo	oietic	ster	n ce	lls-
clinical appli	cations of haematopo	oietic s	tem	cells	s. M	eser	nchy	ma	l ste	em c	ells	and	their	role	e in
bone tissue e	ngineering-bone repai	r. Ster	n cel	l bas	ed g	gene	the	rapy	/ an	d be	nefit	s to	huma	an.	
UNIT V	APPLICATIONS	OF ST	EM	CEI	L							Ģ	) hou	irs	
Therapeutic	applications-Parkinso	ns dise	ease,	Can	cer	sten	1 ce	-11 –	Ne	ural	sten	n cel	l for	cen	tral
nervous syste	em repair – Spinal cor	d injur	y – u	ise o	f ES	C to	o tre	at h	eart	t dise	ease	– Bu	rns a	and s	kin
ulcers - Orth	nopaedic applications	of ste	m ce	11 -	Insu	lin-j	proc	luci	ng	Cells	s De	rivec	l fro	m St	em
Cells: A Pote	ential Treatment for D	iabetes	5.												
LEARNING	RESOURCES														
Text Books	<ol> <li>Potten C.S., "Sta 2. Robert Lanza, "J</li> </ol>							logy	,",",	Acad	lemi	c Pre	ss, 2	009.	
	1. AriffBongso, Er Scientific, 2011.														
Reference Books	<ol> <li>Daniel R. Mars Press, 2001.</li> </ol>	hak, "	Stem	cell	bio	olog	y,"	Col	d S	prin	g Ha	arbor	· Lat	orat	ory
DUUKS	3. Peter Quesenbe 1998.	rry, "S	Stem	cell	bic	olog	y ai	nd	Gen	e T	heraj	ру,"	Wile	ey-L	iss,

Reference videos	https://www.youtube.com/watch?v=evH0I7Coc54 https://www.youtube.com/watch?v=gxAVnoarveE https://www.youtube.com/watch?v=fp5H3SslskQ https://www.youtube.com/watch?v=ca3H2vemYXo
Reference NPTEL	https://www.youtube.com/watch?v=o7dDKMOMYWk https://nptel.ac.in/courses/102106036
Reference research/ review articles	<ol> <li>Das, M., &amp; Sloan, A. J. (2023). Stem cell sources from human biological waste material: a role for the umbilical cord and dental pulp stem cells for regenerative medicine. Human Cell, 36(4), 1312-1325.</li> <li>Abel, A., &amp; Sozen, B. (2023). Shifting early embryology paradigms: Applications of stem cell-based embryo models in bioengineering. Current Opinion in Genetics &amp; Development, 81, 102069.</li> <li>Tkemaladze, J. (2023). Reduction, proliferation, and differentiation defects of stem cells over time: a consequence of selective accumulation of old centrioles in the stem cells?. Molecular Biology Reports, 50(3), 2751-2761.</li> <li>Plakhova, N., Panagopoulos, V., Vandyke, K., Zannettino, A. C., &amp; Mrozik, K. M. (2023). Mesenchymal stromal cell senescence in haematological malignancies. Cancer and Metastasis Reviews, 42(1), 277-296.</li> <li>Wu, B., Shi, X., Jiang, M., &amp; Liu, H. (2023). Cross-talk between cancer stem cells and immune cells: potential therapeutic targets in the tumor immune microenvironment. Molecular Cancer, 22(1), 38.</li> </ol>

Course Code		Course Title	L	Т	Р	С							
10212BT119		<b>BIOSENSOR AND INSTRUMENTATION</b>	3	0	0	3							
					1								
Course Catego	ry	Program Elective											
Preamble		To understand the importance of sensors in biol	ogical j	field.									
Prerequisite Courses		10212BT144 – Advanced Biochemistry 10211BT106 - Analytical and Instrumentation Engineering											
Course Outcomes	Upo	on successful completion of the course, students w	ill be a	be able to:									
CO Nos.		<b>Course Outcomes</b>		Knowledge Level (Based on revised Bloom's Taxonomy)									
CO1	· ·	lain the application of biomolecules in sensinitications.	g	ł	K2								
CO2		te use of chromophores and fluorophore the struct enzyme based fiberoptic biosensors.	0	ł	Χ3								
CO3	to c	ly the biochemical and electrochemical mechanism levelop biosensors and oligonucleotide sensitive trodes.											
CO4		te use of chromophores and fluorophore to struct enzyme based fiberoptic biosensors.	0	КЗ									
CO5	Iden	tify the metals and minerals by using biosensors.		K3									

CO Nos.	Course Outcomes				Prog	ramı	ne O	utcoi	nes	(POs	5)			Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Explain the application of biomolecules in sensing applications.	Η	Н	Н	Н								Н	Н	М	L
CO2	Make use of chromo phores and fluorophore to construct enzyme based fiberoptic biosensors.		Н	М	Н		Η						Н	Н	Н	
CO3	Apply the biochemical and electrochemical mechanism to develop biosensors and oligonucleotide sensitive electrodes.		Н	Н	Н	Η	Н	М					М	М	М	Н

CO4 fluo cons	te use of mophores and rophore to struct enzyme based roptic biosensors.		Η	M	Η		Η						Η	Н	Н	
CO5 min	tify the metals and erals by using ensors.		Н	Н	Н	Н	Н	Н	L				М	Н	Н	L
H – High; M-	Medium; L- Low															
Course Cont	onti															
UNIT I	INTRODUCTIO	NT	O B	IOS	ENS	SOR	S						C	) hou	irs	
Introduction	to protein/enzy			sed		nsor		npei	om	etri	c	enzy			ctroc	les-
characteristic	s- enzyme activity							-				•		mun	oass	ay–
	c enzyme electrodes											•				•
-	trodes– solid-state p								-			1				
UNIT II	ENZYME BASE													) hou	ire	
	c immune biosenso				-		tech	niaı	les.	Pr	incir	ole a				ent
	nobilized enzymes							-			-					
solution.	5											5				
UNIT III	<b>TECHNIQUES I</b>	N B	IOS	ENS	SOR	S							9	) hou	irs	
Materials use	d in sensing techniq	ues	and	their	· che	mis	try,	ty	ype	<b>5</b> O	f tra	nsdu	cer.	Fibe	er oj	ptic
biosensors-O	ptical biosensors b	asec	l on	co	mpe	titiv	e b	indi	ng.	El	ectro	on c	ondu	cting	g ree	dox
polymer in en	zyme based biosens	ors.	Hyb	oridiz	zatio	n at	olig	onu	cleo	otid	e ser	nsitiv	e ele	ctroc	les v	vith
hybridization	sensitivity-hybridiz	zatio	n co	ndit	ions-	– hy	brid	izat	ion	kin	etics	5.				
UNIT IV	FIBER OPTIC B	IOS	SEN	SOR	S								9	) hou	irs	
Enzyme base	d non-mediated fib	er o	ptic	bios	sense	ors 1	towa	ards	det	tect	ion (	of ch	rom	opho	res	and
flurophore. I	Bioluminescence an	id c	hem	ilum	ines	cen	ce ł	base	d f	ibeı	r op	ticse	nsors	s, an	alyt	ical
potential of lu	minescent reactions	s and	l its	appl	icati	ons.										
UNIT V	IONS SPECIFIC	BI	OSE	NSC	ORS								ç	) hou	irs	
Determination	n of metal ions– fluo	ores	cent	aryl	sulf	onar	nide	es fo	or zi	nc	detei	mina	ation	- ren	nova	l of
zinc from car	bonic anhydrase– de	etern	nina	tion	of zi	nc u	ising	g rea	ıger	nt ap	pro	ach–	dete	rmin	atio	1 of
copper and ot	her ions.															
LEARNING	RESOURCES											_	_			
Text Books	1. Copper J.M. an												•			
Reference	2. BrianEggins, " BlumL.J.andCould												· ·			
Books	DekkerInc., 1991.			,	2100	.~115		11	• IP	<b></b>	110/ 1	rrn <b>c</b>		,	171U	

Reference videos	https://www.youtube.com/watch?v=9IVmGDgVFdQhttps://www.youtube.com/watch?v=Cm6IKECsWpAhttps://www.youtube.com/watch?v=9ZvJr3kzM8Mhttps://www.youtube.com/watch?v=GNE81hbCggQhttps://www.youtube.com/watch?v=6Ti83oO2ml4
Reference NPTEL	https://nptel.ac.in/courses/115107122
Reference research/ review articles	<ol> <li>Barhoum, A., Altintas, Z., Devi, K. S., &amp; Forster, R. J. (2023). Electrochemiluminescence biosensors for detection of cancer biomarkers in biofluids: Principles, opportunities, and challenges. Nano Today, 50, 101874.</li> <li>Lu, J., Zhuang, X., Wei, H., Liu, R., Ji, W., Yu, P., &amp; Mao, L. (2024). Enzymatic Galvanic Redox Potentiometry for In Vivo Biosensing. Analytical Chemistry.</li> <li>Singh, A. K., Mittal, S., Das, M., Saharia, A., &amp; Tiwari, M. (2023). Optical biosensors: A decade in review. Alexandria Engineering Journal, 67, 673- 691.</li> <li>Selvolini, G., &amp; Marrazza, G. (2023). Sensor principles and basic designs. In Fundamentals of Sensor Technology (pp. 17-43). Woodhead Publishing.</li> <li>Rubino, A., &amp; Queirós, R. (2023). Electrochemical determination of heavy metal ions applying screen-printed electrodes based sensors. A review on water and environmental samples analysis. Talanta Open, 100203.</li> </ol>

Course	Code			Course Title											Т	]	2	С
10212B	T120	BIOMATERIALS										3	0	(	)	3		
Course Category Program Elective																		
Preambl	le			ourse will give a broad view towards various types of biomaterials, perties, manufacturing methods and its applications.														als,
Prerequ Courses	isite		10211BT10	2 –	Cell	Bio	logy											
	Course OutcomesUpon successful completion of the course, students will be able to:																	
CO N	05.			Ca	ours	e Ou	itcor	nes						(	nowl Based oom':	l on r	evise	d
CO1	_		erstand the naterials	e	phy	siocł	nemi	cal	p	rope	ertie	es	of			K2		
CO2	2		y the Metalli cal application		nd Co	eram	ic bi	oma	ateri	als f	forv	vari	ous			K2		
CO3	3	Make use of biopolymers for various industrial K2																
CO4	ŀ	Select the biomaterials according to the mechanisms and regularities of tissues replacement.																
CO5	5		Develop and identify the toxicity and blood compatibility of implantable biomaterials								ood	K3						
	1													1				
Correlat	ion of (	COs v	vith POs:													1		
CO Nos.	с	ourse (	Dutcomes		Programme Outcomes (POs)										Program Specific Outcomes (PSOs)			
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1		cal p	the physio roperties of s	М		М									Н	Н	М	
CO2	Ceran	nic l variou		Н	М	М									Н	Н	Н	
CO3	· •	ymer	use of s for various oplications.	Н	М	М									Н	Н	Н	L
	accord mecha	ling misms rities	of tissues		Н	Н	М								Н	Н	М	L

CO5 com impl	elop and identify toxicity and blood patibility of antable naterials	Н	Н	Н	М			Н					H H M L				
H – High; M-	Medium; L- Low			1				1							1	1 1	
Course Cont	ent:																
UNIT I	UNIT I INTRODUCTION TO BIOMATERIALS 9 hours																
Introduction to biomaterials, Physical and chemical properties, biomaterial performance											nce,						
response to in	response to implants, blood compatibility, Nanoscale phenomena.																
UNIT II	METALLIC ANI	) C	ERA	MI	СM	[AT	ERI	[AL	S				9	hou	rs		
Different imp	lants - Stainless stee	ls, c	obal	t-ba	sed a	alloy	vs, T	'itan	iun	1-ba	ised	alloy	/s, sh	ape 1	nem	ory	
alloy, cerami	c implant, nanostru	ctur	ed r	neta	llic i	impl	ants	s, bi	ode	gra	dabl	e or	bior	esou	rcea	ble,	
•	mics, nanostructure									•							
UNIT III	POLYMERIC IN	IPL	AN	ТМ	ATI	ERI	ALS	5					9	hou	rs		
Polymer as b	biomaterials, Polymo	eriz	atio	ı, pı	roper	rties	of	pol	yme	ers,	bio	degra	adabl	e po	olym	ers,	
Introduction b	oio polymers: Collag	gen,	Elas	stin a	and c	chiti	n, M	ledi	cal	Тех	tiles	5.					
UNIT IV	TISSUE REPLA	CEN	MEN	I TI	MPI	LAN	ITS						9	hou	rs		
Soft tissue r	eplacements, Percu	tan	eous	and	d sk	in	imp	lant	s, '	Vas	cula	r gr	afts,	harc	t tis	sue	
replacement I	mplants, tissue scaff	old	ing a	and e	engir	neer	ing 1	usin	g N	anc	o bio	mate	erials	•			
UNIT V	<b>TESTING OF BI</b>	OM	[AT	ERI	ALS	5							9	hou	rs		
sensitization,	Biocompatibility, blood compatibility and tissue compatibility tests, Toxicity tests sensitization, carcinogenicity, <i>In vitro</i> and <i>In vivo testing</i> ; Sterilization of implants and devices Effects of sterilization.																
LEARNING	RESOURCES																
Text Books	<ol> <li>Sujata V. Bhatt, "Biomaterials", Second Edition, Narosa Publishing House 2005.</li> <li>Sreeram Ramakrishna, Murugan Ramalingam, Sampath Kumar T.S., and Winston O. Soboyejo, "Biomaterials: A Nano Approach", CRC Press</li> </ol>									and							
	2010.																
Reference videos	https://www.youtu https://www.youtu https://www.youtu https://www.youtu	<u>be.c</u> <u>be.c</u> <u>be.c</u>	com/ com/ com/	'wato 'wato 'wato	ch?v ch?v ch?v	=k_ =QE =og	ftHr 3Ds. 4BL	nW AR2 .TX	EH1 2Dv Jv-c	<u>m8</u> v6g o							
Reference NPTEL	https://www.youtu https://nptel.ac.in/c						aP)		<u>U-S</u>								

	<ol> <li>Deng, J., &amp; Gao, C. (2023). An introduction to scaffolds, biomaterial surfaces, and stem cells. In Polymeric Biomaterials for Tissue Regeneration: From Surface/Interface Design to 3D Constructs (pp. 1-38). Singapore: Springer Nature Singapore.</li> </ol>
	<ol> <li>Que, Y., Zhang, Z., Zhang, Y., Li, X., Chen, L., Chen, P., &amp; Chang, J. (2023). Silicate ions as soluble form of bioactive ceramics alleviate aortic aneurysm and dissection. Bioactive materials, 25, 716-731.</li> </ol>
Reference research/ review articles	3. Pires, P. C., Mascarenhas-Melo, F., Pedrosa, K., Lopes, D., Lopes, J., Macário-Soares, A., & Paiva-Santos, A. C. (2023). Polymer-based biomaterials for pharmaceutical and biomedical applications: A focus on topical drug administration. European Polymer Journal, 187, 111868.
	4. Bienz, S. P., Vaquette, C., Ioannidis, A., Hämmerle, C. H., Jung, R. E., Ivanovski, S., & Thoma, D. S. (2023). Tissue integration and biodegradation of soft tissue substitutes with and without compression: an experimental study in the rat. Clinical Oral Investigations, 27(1), 313-328.
	<ol> <li>Colaço, R., &amp; Serro, A. P. (2024). Sterilization methods. In Hydrogels for Tissue Engineering and Regenerative Medicine (pp. 139-159). Academic Press.</li> </ol>

Course	Code				0	Cour	se T	itle						L	1		P	С	
10212B	T121		BIO	OCHIPS AND MICROARRAY TECHNOLOGIES											0		0	3	
~	~		1_																
Course Category Program Elective														. 7					
Preambl	PreambleTo know the essential concepts of biochips and microarra major applications in medical field.										ay ı	vith							
Prerequ	Prerequisite Courses10212BT143 - Computational Biology: Techniques										and.	Appl	icati	ions					
Cour Outcor		Upon successful completion of the course, students will be a										be ab	ole to	:					
CO N	os.			C	ours	se O	utco	mes	5						(Base	d on	ge Level 1 revised axonomy)		
COI	l		erstand the ction mechar			g pı	rinci	ples	of	bi	och	ips	and			K2			
CO2	2		elop Acquisi for various				-	tec	hniq	lues	wi	th n	nicro			K3			
CO3	3	Utilize different computational tools and statistical frame work to Analysis the Microarray Data K3																	
CO4	1	Analyse the DNA biomolecules in computing and k4																	
COS	5	Examine the biochips for molecular diagnostics, pharmaco genomics, drug discovery and epidemiology applications.							K4	K4									
Correlat	ion of (		with POs.																
CO Nos.		Programme Outcomes (POs)							S Ou	Program Specific Outcomes (PSOs)									
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1		ng pi ps an	the rinciples of d detection		М											Н	M		
CO2	with	nalysis micro	Acquisition s techniques array for lications.	ц	М	L										Н	М		
CO3		utation ical fra sis	different nal tools and ame work to the Data		Н	М	L	L	Η						М	М	М		

DNA co designin	· -			-	-		DN	<b>А</b> , Е	lec	trica	l ar	alog	gies fo	or bio	olog	ical
Introduc DNA c	· -	ube,	com	putir	ig w	ith I	DNA	4, E	lec	trica	l ar	alog	gies fo	or bio	olog	ical
Introduc	omputing – Introduction	designing DNA shapes, DNA cube, computing with DNA, Electrical analogies for biological														
	Introduction, Junctions, other shapes, Biochips and large scale structures; Strand algebras for DNA computing – Introduction; Discussion of Robinson and Kallenbach's methods for													-		
UNIT I			, Bio	ochir	os an	d la	rge	sca	le s	truc	ture	s; S				foi
	V DNA COMPUTI	NG												9 ho	ure	
Network	-			-				2				J				
	osition algorithm; Onl					•					•			-		
	tion, Mathematical mo						NA	M	icro	arra	y c	lata				lue
UNIT I	II GENOME SIGN		PRO	CES	SIN	G								9 ho	urs	
-	tion); Bioinformatics to									`			-	,		
	al models for RNA hyb	-		-		-						-				
	oarrays; Microarray dat		-			-			•							
Megacne technology for fluid microarrays, Microarray labels, Microarray scanners, Microarray robotics; Microfluidics systems; Chips and Mass Spectrometry; Electrical detection methods																
UNIT II         BIOCHIPS AND MICROARRAY CONSTRUCTION         9 hours           Magache technology for fluid microarrays         Microarray labels         Microarray scanners         Microarray								rav								
and Analysis, Detection of differential gene expression; Pathway analysis tools and Data validation; Limitations of biochip technology.																
Biochip versus gel based methods; Microarray Data analysis: Introduction, Image Acquisition																
	rays, Oligonucleotide, o			e					•		Ũ			•	•	
Basics of Biochips and Microarray Technology; Types of Biochips - DNA Microarrays, Protein																
UNIT IINTRODUCTION9 hours																
Course	Content:															
	, ,															
miology applications.																
	genomics, dru discovery and epid	-														
CO5	diagnostics, pharmac	м	Н	М	М	М	L	L	L				М	Н	Н	L
	Examine the biochip for molecula															
	computing an bimolecular device	t												11	11	
CO4	Analyse the DNA biomolecules i		H	M	Η	Н	H	H					H	Н	Н	

discovery development and drug delivery; Microarray in Differential expression analysis in cancer, Tumor classification and prognosis; genetic disease monitoring, forensics.

IFADNING	GRESOURCES
	J NEBUURUED
Text Books	
DUOKS	
Reference Books	<ol> <li>Isaac S. Kohane, Alvin Kho, Atul J. Butte., "Microarrays for an Integrative Genomics (Computational Molecular Biology)", 1st edition, MIT Press, 2002.</li> <li>Helen C. Causton, John Quackenbush, Alvis Brazma., "Microarray Gene Expression Data Analysis: A Beginner's Guide", 1st edition, Wiley- Blackwell, 2003.</li> <li>Sorin Draghici, "Data Analysis Tools for DNA Microarrays", Har/Cdr Re edition, Chapman &amp; Hall/CRC, 2003.</li> <li>DNA Computing: 15th International Meeting on DNA Computing, DNA 15, Fayetteville, AR, USA, June 8-11, 2009, Springer, 2009.</li> <li>Grigorenko E., "DNA Arrays: Technology and Experimental Strategies", Vth Edition, CRC Press, 2002.</li> <li>Wan-Li Xing and Jing Cheng., "Biochips: Technology and Applications", Springer, 2003.</li> </ol>
Reference videos	https://www.youtube.com/watch?v=k_1YSdmBmo0 https://www.youtube.com/watch?v=0ws2WX1IyhM https://www.youtube.com/watch?v=nSlhCaJKhjY https://www.youtube.com/watch?v=UTOspULanZ0 https://www.youtube.com/watch?v=kX70WLM9nHA&t=37s
Reference NPTEL	https://nptel.ac.in/courses/102101054
Reference research/ review articles	<ol> <li>Kuru, C. İ., Ulucan-Karnak, F., &amp; Akgöl, S. (2023). Lab-on-a-chip sensors: recent trends and future applications. Fundamentals of Sensor Technology, 65-98.</li> <li>Chen, X., Yao, C., &amp; Li, Z. (2023). Microarray-based chemical sensors and biosensors: Fundamentals and food safety applications. TrAC Trends in Analytical Chemistry, 158, 116785.</li> <li>Pantic, I., Paunovic, J., Cumic, J., Valjarevic, S., Petroianu, G. A., &amp; Corridon, P. R. (2023). Artificial neural networks in contemporary toxicology research. Chemico-Biological Interactions, 369, 110269.</li> <li>Meng, X., O'Hare, D., &amp; Ladame, S. (2023). Surface immobilization strategies for the development of electrochemical nucleic acid sensors. Biosensors and Bioelectronics, 115440.</li> <li>Akinnuwesi, B. A., Olayanju, K. A., Aribisala, B. S., Fashoto, S. G., Mbunge, E., Okpeku, M., &amp; Owate, P. (2023). Application of support vector machine algorithm for early differential diagnosis of prostate cancer. Data Science and Management, 6(1), 1-12.</li> </ol>

Course	Code				С	ours	se Ti	itle						L		Τ	P	С		
10212B	T122		PL	AN	T B	ΙΟΤ	ECI	INC	OLC	)GY	[			3		0	0	3		
		·																		
Course	Catego	ry	Progra	am Ì	Elect	tive														
Preamb	le		To stu biotect				cells	s wit	th it.	s fui	ncti	ons	and	app	licat	ions	in p	lant		
Prerequ	isite Co	ourses	10211 10211							0,		nce	pts a	nd T	Techn	ique	25			
Cours Outcom		pon su	accessful co	mple	etion	n of t	he co	ours	e, si	tude	ents	wil	l be d	able	to:					
CO No	s.			Co	urse	Out	tcom	ies						(	now Base oom'	d on i	revise	ed		
CO1			and the basi ction at mol				tals o	of pl	ant	cell	s, s	truc	ture			K2				
CO2			about genes fixation pr	gula	tory	me	cha	nisı	n of		K2									
CO3			the transge ificant viral				with			K2										
CO4			he transgen e products.	ic p	lants	s to p	ally			K3										
CO5			se of plant developme	f plant tissue culture techniques for various lopments.												K3				
Correlat	ion of (	COs w	ith POs:																	
CO Nos.	Co	ourse O	utcomes	Programme Outcomes (POs)												rogra pecifi utcom PSOs	ic 1es			
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3		
CO1	fundan cells,	nental strue	the basic s of plant cture and molecular	Н											Н	Н	М			
CO2	involv	ed and nism	out genes l regulatory of nitrogen ess.	п	М										Н	Н	М			
CO3		by ge d v cant	transgenic ne transfer with the viral	Н	М	Н	Н	Н		L					Н	Н	М	L		

CO4 plant thera	the transgenic s to produce the peutically valuable H L L M M L L L	Н	Н	Н	М									
CO5 cultur vario	e use of plant tissue re techniques for H I I M M	Н	Н	Н	L									
H – High; M-	Medium; L- Low													
Course Conte	nt:													
UNIT I	PLANT GENETIC MATERIAL		9 ho	ours										
Genetic Mater	ial Of Plant Cells – Nucleosome Structure and Its Biological S	ignif	icand	e; Ji	ınk									
And Repeat	Sequences; Outline Of Transcription and Translation.	Chlo	ropla	ist	and									
mitochondria g	genome.		-											
UNIT II	RUBISCO AND NITROGEN FIXATION	9 hours												
Rubisco synth	esis and assembly, Nitrogen fixation: Nitrogenase Activity,	ity, Nod Genes, Nif												
Genes, Bactero	Genes, Bacteroids.													
UNIT III	II GENE TRANSFER MECHANISM 9 hours													
Gene transfer r	nechanism - Direct and Indirect methods, Agrobacterium media	ted g	ene t	rans	fer,									
Viral Vectors:	Gemini Virus, Cauliflower Mosaic Virus, Viral Vectors and Its	s Ben	efits	•										
UNIT IV	APPLICATIONS OF TRANSGENIC PLANTS	ļ	) hou	ırs										
Production of	transgenic plants for herbicide resistance, Insect resistance and	l stre	ss to	lerar	nce.									
Plants as biore	actors, Plant derived vaccines-edible vaccines, Plantibodies, I	Reco	mbin	ant	and									
subunit vaccin	es.													
UNIT V	PLANT TISSUE CULTURE TECHNOLOGY	9	) hoi	ırs										
Outline of plan	nt tissue culture, Plant tissue culture media, Types of cultures	, Cal	lus c	ultu	res,									
Cell and suspe	nsion cultures, Single cell clones, Protoplast culture and somat	ic hy	bridi	zatic	n.									
LEARNING	RESOURCES													
	1. Chawla H.S., "Introduction to Plant Biotechnology", 3 rd Publishers, 2009.	Edit	ion,	Scie	nce									
Text Books	2. Gamburg O.L. and Philips G.C., "Plant Tissue & fundamental Methods", Narosa Publications, 1995.													
					gy:									
		etics:	Pri	ncip	les,									
	<ol> <li>Adrian Slator, Nigel W. Scott and Mark R. Fowler, "Plant Biotechnology the genetic manipulation of plants", Oxford University Press, 2008.</li> <li>Stewart Jr. C.N., "Plant Biotechnology and Genetics: Principles Techniques and Applications" Wiley-Interscience, 2008.</li> </ol>													
Reference Books	<ol> <li>Techniques and Applications" Wiley-Interscience, 2008.</li> <li>HeldtH.W., "Plant Biochemistry &amp; Molecular Biology", O Press, 1997.</li> </ol>	Oxfor	d Un	iver	sity									

Reference videos	https://www.youtube.com/watch?v=2vqpZqitVGA https://www.youtube.com/watch?v=1G3HM715HIo https://www.youtube.com/watch?v=08Q-MVeNeTU https://www.youtube.com/watch?v=kZIYkYNpnP0 https://www.youtube.com/watch?v=kK5jj1_iGM4
Reference NPTEL	https://archive.nptel.ac.in/courses/102/103/102103016/
Reference research/ review articles	<ol> <li>Gilbert, C., &amp; Maumus, F. (2023). Sidestepping Darwin: horizontal gene transfer from plants to insects. Current Opinion in Insect Science, 101035.</li> <li>Rydzy, M., Kolesiński, P., Szczepaniak, A., &amp; Grzyb, J. (2023). DnaK and DnaJ proteins from Hsp70/40 family are involved in Rubisco biosynthesis in Synechocystis sp. PCC6803 and sustain the enzyme assembly in a heterologous system. BMC Plant Biology, 23(1), 109.</li> <li>Farzanehpour, M., Miri, A., Alvanegh, A. G., &amp; Gouvarchinghaleh, H. E. (2023). Viral Vectors, Exosomes, and Vexosomes: Potential armamentarium for delivering CRISPR/Cas to cancer cells. Biochemical Pharmacology, 115555.</li> <li>Majumder, S., Datta, K., &amp; Datta, S. K. (2024). Pyramided transgenic jute (Corchorus capsularis) with biotic stress resistance and herbicide tolerance. Industrial Crops and Products, 208, 117776.</li> <li>Mackowska, K., Stelmach-Wityk, K., &amp; Grzebelus, E. (2023). Early selection of carrot somatic hybrids: a promising tool for species with high regenerative ability. Plant Methods, 19(1), 104.</li> </ol>

Course Co	de	Course Tit	Course Title								
10212BT1	23	ANIMAL BIOTECH	INOLOGY	3	0	0	3				
<b>Course Cat</b>	egory	Program Elective									
Preamble		To provide the fundamend diseases and thera micromanipulation and	py and the k	nowled		tails o ibout	of the the				
Prerequisit	e Cours	10211BT105 – Genetic 10211BT116 - Immunol		hnolog	v						
Course Outcomes	Upon s	ccessful completion of the co	urse, students will b	be able	to:						
CO Nos.		Course Outcom		Knowledge Leve (Based on revised Bloom's Taxonomy							
CO1	Summa growth	ze the knowledge of isolat f cells.	ion, maintenance a	ind	]	K2					
CO2	Relate	e concept of Animal Disease	and its Diagnosis		]	K2					
CO3	Unders	nd the Diagnosis of the anin	nal Diseases		]	K3					
CO4		the concepts of micromat genic animal technology	gy	КЗ							
CO5	Apply animal	e transgenic techniques to p	ansgenic techniques to produce the transgenic								

# **Correlation of COs with POs:**

CO Nos.	Course Outcomes		Programme Outcomes (POs)													m c ies )
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Summarize the knowledge of isolation, maintenance and growth of cells.	Н	L	Н	L				L	М			M	Н	Н	Н
CO2	Relate the concept of Animal Disease and its Diagnosis		L	М					L				М	Н	Н	н
CO3	Understand the Diagnosis of the animal Diseases		Н	Н		M			M			М	М	Н	L	L
CO4	Illustrate the concepts of micromanipulation technology and transgenic animal technology	М	L	L					L				М	L	L	М

CO5	Apply the transgenic techniques to produce the transgenic animal			Н		Η		М		L		М				М
H – High	; M- Medium; L- Low															
~	~															
Course			<u> </u>					~			-		0			
UNIT I	INTRODUCTIO											d	-	hour		4:0
	ion to basic tissue cult			•				•								
	ell cultures, their mainte			-						• •				-	-	
	continuous flow culture				ed cu	ltur	es; s	som	atic	ce	ll fus	sion;	cell	cultu	res a	1S 8
source of	valuable products; orga	n cu	ilture	es.												
UNIT II	DISEASE AND D												-	houi		
Bacterial	and viral diseases in	anin	nals;	mo	nocle	nal	ant	ibo	dies	an	d th	eir ı	ise i	n dia	agno	sis
molecula	r diagnostic techniques l	ike l	PCR,	, in-s	situ h	ybr	idiza	atio	n; n	orth	nern	and s	south	ern b	olotti	ng
RFLP.																
UNIT II	I THERAPY AND	DIA	GN	OSI	S FO	R	ANI	MA	LS				9	houi	rs	
Recombi	nant cytokines and the	eir u	ise i	n th	e tre	eatn	nent	of	an	ima	l in	fection	ons;	mon	oclo	ma
antibodie	s in therapy- VACCIN	ES-	Com	mor	n vira	ıl, t	oacte	erial	an	d p	arasi	tic d	liseas	ses a	ffect	inį
animals-	Live vaccines, killed va	accir	nes- (	Conj	ugat	e va	accir	ies-	An	ti I	dioty	pic	vacc	ine-	Subi	ıni
vaccines	Recombinant vaccines	- D	NA v	acc	ines.											
UNIT IV	, MICROMANIPU FERTILIZATIO						ITR	RO					9	hou	rs	
What is r	nicromanipulation techn	olog	gy; ec	quip	ment	's u	sed i	in n	nicr	oma	anipı	ılatic	on; ei	nrich	men	t o
x and y l	pearing sperms from ser	nen	samp	oles	of ar	ima	als; a	artif	icia	ıl ir	isem	inati	on a	nd ge	erm	cel
manipula	tions; In vitro fertilizatio	on te	chno	ology	in v	itro	mat	ura	tion	of	оосу	vtes,	cultu	re of	in v	itro
fertilized	embryos, embryo clon	ing-	qua	adrip	paren	tal	hyb	rid,	nu	clea	ır tra	nspl	antat	tion	(Dol	ly)
embryon	ic stem cells.															
UNIT V	TRANSGENIC A	NIN	ЛАL	S									9	houi	rs	
Concepts	of transgenic animal te	chn	ology	y; sti	rateg	ies	for t	he j	proc	luc	tion	of tra	ansg	enic	anin	ıal
and their	importance in biotech	nolo	ogy;	sten	n cel	1 c	ultur	res	in 1	the	proc	lucti	on o	f tra	nsge	ni
animals.																

LEARNING	G RESOURCES
Text Books	<ol> <li>Freshney R.I., "Culture of Animal Cells: A Manual of Basic Techniques and Specialized Applications", 6thEdition, John Wiley &amp; Sons, 2010.</li> <li>Ramadass P, Meera Rani S., "Text Book of Animal Biotechnology", Akshara Printers, 1997</li> </ol>
Reference Books	<ol> <li>Ranga M.M., "AnimalBiotechnology" Agrobios India Limited, 2002.</li> <li>Portner, R., "Animal Cell Biotechnology: Methods and Protocols", 2nd Edition, Humana Press, 2007.</li> <li>Masters J.R.W., "Animal Cell Culture: Practical Approach", Oxford University Press, 2000.</li> </ol>
Reference videos	https://www.youtube.com/watch?v=RpDke-Sadzo https://www.youtube.com/watch?v=oNwjMD5C29A https://www.youtube.com/watch?v=meX_OhC2qjE https://www.youtube.com/watch?v=dtJ-fBt1TaQ https://www.youtube.com/watch?v=RzYhcXjksKc
Reference NPTEL	https://archive.nptel.ac.in/content/storage2/courses/102103045/module1/lec1/5. html
Reference research/ review articles	<ol> <li>Yamanaka, K., Haraguchi, Y., Takahashi, H., Kawashima, I., &amp; Shimizu, T. (2023). Development of serum-free and grain-derived-nutrient-free medium using microalga-derived nutrients and mammalian cell-secreted growth factors for sustainable cultured meat production. Scientific Reports, 13(1), 498.</li> <li>Yehia, N., Salem, H. M., Mahmmod, Y., Said, D., Samir, M., Mawgod, S. A.,  &amp; Zanaty, A. M. (2023). Common viral and bacterial avian respiratory infections: an updated review. Poultry science, 102(5), 102553.</li> <li>Zhao, K., Li, X., Lei, B., Han, Y., An, T., Zhang, W., &amp; Yuan, W. (2023). Recombinant porcine Interferon-α and Interleukin-2 fusion protein (rPoIFNα+ IL-2) shows potent anti-pseudorabies virus activity in vitro and in vivo. Veterinary Microbiology, 279, 109678.</li> <li>Liu, Y., Yin, Q., Luo, Y., Huang, Z., Cheng, Q., Zhang, W., &amp; Ma, Z. (2023). Manipulation with sound and vibration: A review on the micromanipulation system based on sub-MHz acoustic waves. Ultrasonics Sonochemistry, 106441.</li> <li>Shakweer, W. M. E., Krivoruchko, A. Y., Dessouki, S. M., &amp; Khattab, A. A. (2023). A review of transgenic animal techniques and their applications. Journal of Genetic Engineering and Biotechnology, 21(1), 55.</li> </ol>

Course	Course Code 10212BT124					Course Title TISSUE ENGINEERING											P	С		
10212B	T124		]	<b>FIS</b>	SUE	EN	GIN	[EE]	RIN	G				3	0		0	3		
Course	Categoi	ſy	Program Ele	ectiv	'e															
Preamb	le		This course organization clinically rel	an	d st	rateg	gies .													
Prerequ Courses			NIL																	
Course Outcom	1/n	on s	successful con	ıple	tion	of th	he co	ours	e, st	ude	nts	will	be a	ıble i	to:					
CO No:	s.			Co	urse	Out	tcom	nes							now (Base loom ⁹	d on	revis	ed		
CO1			y the differen ering and prac						als a	ppli	ed	in t	issue	K2						
CO2			arize the cellu cess of cell gi			actio	ons a	nd c	ellu	lar	Sig	nali	ng in	K2						
CO3			ate the non-c , and provide					and	-		K2									
CO4			nine the Mea function and				of co	like	;		K3									
CO5			the different ering and prac						ls aj	ppli	ed i	in t	issue	;	К3					
Correlat	ion of C	COs	with POs:																	
CO Nos.	Co	urse	Outcomes	Programme Outcomes (POs)												S Ou	rogra pecifi itcom PSOs	ic 1es		
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3		
CO1	types applied engine	of l ering	he different biomaterials in tissue g and pplications.	Н	L	Н	L				L	М			М	Н	Н	Н		
CO2	Interac cellula	tion r Sig	e the cellular s and gnaling in the cell growth	L	L	М					L				М	Н	Н	Н		
CO3	the tis and p	r co sue rovi	the non- omponent of and organs, de essential affolding		Н	Н		М			М			М	М	Н	L	L		

	Measurement of c	ke M	L	L					L				М	L	L	М
	11	als ue M nd		Н		Н		М		L		М				М
H – High	; M- Medium; L- Lov	W														
Course (																
UNIT I	INTRODUCT		~ 44				<u> </u>							) hot		
	ion to tissue enginee	-				-		-				-				
organizat	ion and Components,	Tissue	e typ	es, I	Home	eost	asis	in l	nigł	ly	proli	fic ti	ssue	s and	l Tis	sue
repair. A	ngiogenesis.															
UNIT II	CELL INTER	ACTI	ONS	AN	D C	ELI	L SI	[GN	AL	IN	G		9	hou	irs	
UNIT IICELL INTERACTIONS AND CELL SIGNALING9 hoursCell differentiation, Cell migration – underlying biochemical process. Cell division, Cell death,														ath,		
Cell differentiation, Cell migration – underlying biochemical process. Cell division, Cell death, apoptosis. Cellular Interactions– soluble signals, types of growth factors and chemokines,														nes.		
	nd receiving a signal,			-		• •			-							
e	, Malfunctions in solu	•	-		Snar	,	0510	iicu	105	por	1303,	5010		10.00	II Iuv	
				_												
UNIT II														hou		
-	pes and tissue com	-			-											
Modified	ECM, Malfunctions	s in E	CM	sig	nalir	ıg.	Dire	ect	Cel	1-C	ell c	onta	ict, I	Resp	onse	to
mechanic	al stimuli.															
UNIT IV	BASICS OF T	ISSUE	CE	LL	CUI	JTU	RE						9	) hou	irs	
Measurer	nent of cell characte	ristics-	– ce	11 m	orph	olog	gy,	cell	nu	mb	er ai	nd v	iabili	ty, c	cell-	fate
processes	, cell motility, cell fu	inction	. Ce	ll an	d tis	sue	cult	ture	- t	ype	s of	tissu	e cul	ture.	me	dia,
	•								•	•				,		,
•	vironment and maint					,	,	- <b>F</b>								
culture er	nvironment and maint			aati				ED		r			0			
culture en	APPLICATIO	NS OI	F TI								<b>10</b> C			hou		
culture en UNIT V Biomater	APPLICATIO	NS OI ering, 2	F TI Appl	icati	on o	of ti	ssue				ng a	nd i				kin,
culture en UNIT V Biomater	APPLICATIO	NS OI ering, 2	F TI Appl	icati	on o	of ti	ssue				ng a	nd i				kin,
culture en UNIT V Biomater	APPLICATIO	NS OI ering, 2	F TI Appl	icati	on o	of ti	ssue				ng a	nd i				cin,
culture en UNIT V Biomaten Artificial	APPLICATIO	NS OI ering, 2	F TI Appl	icati	on o	of ti	ssue				ng a	nd i				cin,
culture en UNIT V Biomaten Artificial	APPLICATIO ials in tissue enginee blood vessels, Regen ING RESOURCES 1. Bernhard O Publishers	NS OI ering, 2 eration	TI: Appl	icati oone	on o	of ti scle	ssue	e en	gin	eeri			n Ar	tifici	al sl	-

Reference Books	1. Mao J.J., Vunjak-Novakovic G., <i>et al.</i> , (Eds), "Translational Approaches in Tissue Engineering &Regenrative Medicine", Artech House, INC Publications, 2008.
Reference videos	https://www.youtube.com/watch?v=PlEb50m7v_k https://www.youtube.com/watch?v=-dbRterutHY https://www.youtube.com/watch?v=i5tR3csCWYo https://www.youtube.com/watch?v=x7HVw1Va4qs https://www.youtube.com/watch?v=EYmLEw3ilqo
Reference NPTEL	https://archive.nptel.ac.in/courses/102/106/102106081/
Reference research/ review articles	<ol> <li>Jadav, M., Pooja, D., Adams, D. J., &amp; Kulhari, H. (2023). Advances in xanthan gum-based systems for the delivery of therapeutic agents. Pharmaceutics, 15(2), 402.</li> <li>Vasudevan, J., Jiang, K., Fernandez, J. G., &amp; Lim, C. T. (2023). Extracellular matrix mechanobiology in cancer cell migration. Acta Biomaterialia, 163, 351-364.</li> <li>Saraswathibhatla, A., Indana, D., &amp; Chaudhuri, O. (2023). Cell–extracellular matrix mechanotransduction in 3D. Nature Reviews Molecular Cell Biology, 24(7), 495-516.</li> <li>Khan, T. A., Saleem, M., &amp; Fariduddin, Q. (2023). Melatonin influences stomatal behavior, root morphology, cell viability, photosynthetic responses, fruit yield, and fruit quality of tomato plants exposed to salt stress. Journal of Plant Growth Regulation, 42(4), 2408-2432.</li> <li>Wang, Y., Wang, Z., &amp; Dong, Y. (2023). Collagen-based biomaterials for tissue engineering. ACS Biomaterials Science &amp; Engineering, 9(3), 1132- 1150.</li> </ol>

Course	Code				C	our	se T	itle						L	]	Γ	P	С	
10212B	ST125		HERB	AL		D P GIN				MI	CA	L		3		)	0	3	
Course	Categ	ory	Progra	m E	Elect	ive													
Preamb		·	To stu metabo charac	dy olite	and s f	una from	th	e	plar				ces	-			cona sola		
Prerequ	isite (	Courses	NIL																
Cours Outcor		Upon suc	ccessful c	omp	oleti	on oj	fthe	сои	rse,	stu	den	ts u	ill b	e abl	e to:				
CO No	08.			Co	urse	Ou	tcon	nes						(I	owl Based om's	on r	evise	d	
CO1		Summari isolation		liffe	erent	typ	es (	of a	ılka	loid	s a	nd	its	К2					
CO2		Utilize ar its structu						sed	К3										
CO3	5	Utilize ar its structu							sed			K3							
CO4	ŀ	Develop marine an	-		-	ing	med	of			K3								
CO5	;	Make use calculatio			-			-				lyti	cal	К3					
Correlat	ion of	COs with	POs:																
CO Nos.		Course Outco					Prog	ramı	ne O	utco	mes	(POs	5)			S O	rogra pecif utcon PSOs	ic 1es	
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	differ alkalo	21	ent types of ids and its				L				L	M			М	Н	Н	Н	
CO2	the alkalo struct		L	L	М					L				М	Н	Н	Н		
CO3	the Stero struct		Н	Н	Н		М			М			М	М	Н	L	L		

CO4 usi	velop the drugs by ng medicinal npounds of marine l plant sources												М	М	М	М
CO5 chi ana to est	ike use omatography hniques alytical calculati for phytocompo- imations. <b>I- Medium; L- Lo</b>	und		Н		Н		М		L		М			М	М
11 – 111gii, iv	I- MCulum, L- L(	, , , , , , , , , , , , , , , , , , ,														
Course Cor	itent:															
UNIT I	INTRODUCT	ION TO	) PI	HYT	OC	HEN	MIS	TR	Y					9 ho	urs	
Introduction	to alkaloids, clas	ssificati	on, p	ohys	ical,	che	mic	al a	nd g	gene	eral 1	meth	ods	for i	solat	ion
of alkaloids	–Phenyl alkyl am	ine alka	loid	s.												
UNIT II		SYNTHESIS OF HERBAL- PHYTO CONSTITUENTS –I9 hoursbladringOutputconstructionStructuringDiparingStructuringDiparingDiparingDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStructuringDiparingStruc														
Alkaloids:		hedrine, Quinine, Strychynine, Piperine, Berberine, Taxol, Vinca alkoloids,														ids,
Glycosides:	Digitoxin, Glycy	rrhizin,	Sent	nosic	les, l	Baco	osid	es, (	Que	rciti	n.					
UNIT III	SYNTHESIS CONSTITUE			L- I	PHY	то							9	hou	rs	
Steroids: H	lecogenin, gugg	ulostero	one	and	W	itha	noli	des-	C	Cour	narir	1: U	Jmbo	ellife	rone	; -
Terpenoids:	Cucurbitacins.															
UNIT IV	NATURAL PH	RODUC	CTS	AS 1	MEI	DIC	INE	2					9	hou	rs	
Marine Dru	gs, cardiovascula	r, cytot	oxic	or	antic	anc	er, a	antir	nic	robi	als,	anti-	infla	mma	atory	<i>k</i>
marine toxir	s;Antibiotics, def	inition,	clas	sific	ation	ı, na	tura	l sou	urce	es ar	nd th	erap	eutic	indi	catio	ons.
UNIT V	ANALYTICA	L MET	HO	DS I	N P	HY	ГО	СНІ	EM	IST	RY		9	hou	rs	
Chromatogr	aphy techniques-	Paper-T	Thin	Laye	er- G	iC- (	GCN	MS-	UV	-IR-	HPI	LC-H	IPTL	-C –	NM	R.
LEARNIN	G RESOURCES															
Text Books	<ol> <li>Harbone J.B., "Phytochemical Method A guide to modern techniques of plant analysis", Third edition ,Chapman and Hall, 2005.</li> <li>Trease and Evans, 'Pharmacognosy",16th Edition, Elsevier, New York, 2009.</li> <li>Dewick P.M., "Medicinal Natural products – a biosynthetic approach", John Wiley &amp; Sons 2009</li> </ol>												09.			
Reference Books	<ol> <li>Sarker S. D Product Iso</li> <li>Bruneton J Interceptt L</li> </ol>	<ol> <li>Dewick P.M., "Medicinal Natural products – a biosynthetic approach", John Wiley &amp; Sons, 2009.</li> <li>Sarker S. D., Latif Z. and Gray A.I., "Methods in Biotechnology -Natural Product Isolation", Second Edition, Humana Press, 2006.</li> <li>Bruneton J, "Pharmacognosy&amp; Phytochemistry of Medicinal Plants", Interceptt Ltd., New York.</li> </ol>														
	3. Jarald E.E Phytochemi														sy a	and

	4. Jean Bruneton, "Pharmacognosy, Phytochemistry, Medicinal plants", English edition, Levoisier Publishing, Paris, 1995.
Reference videos	https://www.youtube.com/watch?v=aLfabuFo7qo https://www.youtube.com/watch?v=6ZCnbCrYlJo https://www.youtube.com/watch?v=nVEopYV7dK4 https://www.youtube.com/watch?v=3wvwtv4sAPA https://www.youtube.com/watch?v=ByJ6lzD2Vbg
Reference NPTEL	https://nptel.ac.in/courses/102105342
Reference research/ review articles	<ol> <li>Faisal, S., Badshah, S. L., Kubra, B., Emwas, A. H., &amp; Jaremko, M. (2023). Alkaloids as potential antivirals. A comprehensive review. Natural Products and Bioprospecting, 13(1), 4.</li> <li>Liu, W., Tang, X., Fan, C., He, G., Wang, X., Liang, X., &amp; Bao, X. (2023). Chemical constituents, pharmacological action, antitumor application, and toxicity of strychnine semen from Strychnons pierriana AW Hill.: a review. Journal of Ethnopharmacology, 116748.</li> <li>Bai, B., Liu, C., Zhang, C., He, X., Wang, H., Peng, W., &amp; Zheng, C. (2023). Trichoderma species from plant and soil: An excellent resource for biosynthesis of terpenoids with versatile bioactivities. Journal of advanced research, 49, 81-102.</li> <li>Hu, D., Jin, Y., Hou, X., Zhu, Y., Chen, D., Tai, J., &amp; Lu, Y. (2023). Application of marine natural products against Alzheimer's disease: past, present and future. Marine Drugs, 21(1), 43.</li> <li>Demyanovich, R. J. (2024). High energy dissipation rates from the impingement of free paper-thin sheets of liquids: Determination of the volume of the energy dissipation zone. Chemical Engineering Science, 294, 120128.</li> </ol>

Course	Code				C	ours	e Ti	tle						L	T	<u> </u>	P	С	
10212B	ST126		ME		-	, GE DTE				<b>N</b> E	)			3	0		0	3	
<u> </u>	<u>a</u> .		D		-11														
Course	Catego	ory	Progra						1				, ,		,				
Preamb	le		To kno proteoi									nvo	lved	in ti	he ge	enon	ics	ana	
Prerequ	isite C	ourses	10211BT108 - Molecular Biology: Concepts and Techniques 10211BT112 – Genetic Engineering																
Cours Outcom		Upon succ	essful co	mpl	etio	n of	the c	cour	se, s	stud	ents	wi.	ll be	able	to:				
CO No			Course Outcomes												Knowledge Level (Based on revised Bloom's Taxonomy)				
CO1		Summarize of prokary					nd o	rgar	niza	tion	ofg	geno	omes			K2			
CO2	Ι	llustrate th	ne physical mapping techniques.													K2			
CO3		Develop th							-		•					K3			
CO4		Construct proteomic			tanc	e of	f te	chni	que	s i	nvo	lve	d in	L	К3				
CO5	1	Apply the	knowled	ge o	of pr	oteo	mics	for	pro	tein	pro	ofili	ng.			K3			
Correlat CO Nos.		COs with					Prog	rami	ne O	utco	mes	(POs	\$)		Program Specific Outcomes (PSOs)				
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	struct organ genon	narize the ure ization nes of prol ukaryotes.	and of	L											Н	L	L		
CO2		ate the principal state ing technic		L											Н	L		M	
CO3	on va	op the kno arious tec omics.		M	L	L	L								М	М			
CO4				М	L	L	L								Н	М			
CO5		the know mics for ing.	•		L	L	L								Н	М			
H – Higł	n; M- I	Medium; I	L- Low																

Course Conte	nt:									
UNIT I	OVERVIEW OF GENOMES OF BACTERIA, ARCHAEA ANDEUKARYOTA	9 hours								
Genome organ	ization of prokaryotes and eukaryotes, Gene structure of B	acteria, Archaea and								
Eukaryotes, H	uman genome project, Introduction to functional and compa	rative genomics.								
UNIT II	PHYSICAL MAPPING TECHNIQUES	9 hours								
Cytogenetic m	apping, Radiation hybrid mapping, Fish-STS mapping, SN	VP mapping, Optical								
mapping. Top	down and bottom up approach, Linking and jumping of a	clones, Gap closure,								
Pooling strategies, Automation in Genome sequencing-Next Generation Sequencing.										
UNIT III	FUNCTIONAL GENOMICS	9 hours								
Gene finding,	Annotation of genome - experimental and computational	approach. ORF and								
functional pr	ediction, Subtractive DNA library screening, Different	ential display and								
representational difference analysis, SAGE.										
UNIT IV	PROTEOMICS TECHNIQUES	9 hours								
Protein level	estimation-Edman protein microsequencing, Protein	cleavage, 2D gel								
electrophoresis	s, metabolic labelling. Detection of proteins on SDS gels.	Mass spectrometry								
principles of N	MALDITOF, Fourier Transform Ion Cyclotron Resonance	Mass Spectrometer,								
	Analyzer, Tandem MS, Peptide mass fingerprinting.	-								
UNIT V	PROTEIN PROFILING	9 hours								
	ional modification, Protein-protein interactions, Gly									
Phosphoprotei	•	coprotoni unurysis,								
	in unury 515.									
	DESOUDCES									
LEAKINING	RESOURCES 1. Twyman R.M. and PrimroseS.B., "Principle of Ge	nome Analysis and								
Text Books	Genomics", Wiley Blackwell Publications, 2007.	inome rinaryons and								
TCAT DOOKS	2. Brown T.A., "Introduction to Genetic: A molecular Science, Taylor and Francis, 2012.	Approach", Garland								
Reference	1. Liebler, "Introduction to Proteomics", Humana Press,	2002								
Books	<ol> <li>Veenstra T.W. andTates III Jr, "Proteomics for Bio Wiley Publications, 2006.</li> </ol>	ological Discovery",								
	https://www.youtube.com/watch?v=mg6tXQaiBaI									
Reference	https://www.youtube.com/watch?v=KXn533DTrsM									
videos	https://www.youtube.com/watch?v=D-Ljd5Uex0s https://www.youtube.com/watch?v=k2ie0sWZKkc									
	https://www.youtube.com/watch?v=5h3JGVlwR_8									
Reference NPTEL	https://nptel.ac.in/courses/102101072									
Reference research/	<ol> <li>Shine, M., Gordon, J., Schärfen, L., Zigackova, Neugebauer, K. M. (2024). Co-transcriptional gene reg and prokaryotes. Nature Reviews Molecular Cell Biology</li> </ol>	ulation in eukaryotes								

review articles	<ol> <li>Puebla-Aparicio, M., Ascencio-Elizondo, C., Vieira, M., Amorim, M. C. P., Duarte, R., &amp; Fonseca, P. J. (2024). Characterization of the fish acoustic communities in a Mozambican tropical coral reef. Marine Ecology Progress Series, 727, 143-158.</li> </ol>
	<ol> <li>Lang, B. F., Beck, N., Prince, S., Sarrasin, M., Rioux, P., &amp; Burger, G. (2023). Mitochondrial genome annotation with MFannot: a critical analysis of gene identification and gene model prediction. Frontiers in Plant Science, 14, 1222186.</li> </ol>
	4. Gosset-Erard, C., Aubriet, F., Leize-Wagner, E., François, Y. N., & Chaimbault, P. (2023). Hyphenation of Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS) with separation methods: The art of compromises and the possible-A review. Talanta, 257, 124324.
	5. Lee, J. M., Hammarén, H. M., Savitski, M. M., & Baek, S. H. (2023). Control of protein stability by post-translational modifications. Nature Communications, 14(1), 201.

Course Code				Course Title												Т		P	С
10212B	T127	'			С	ellul	ar E	ngir	ieer	ing					3	0		0	3
Course (	Categ	ory		Program Elective															
Preamb	<i>To know more about the techniques involved in the Cellular</i> <i>Engineering for medical applications.</i> 10211BT108 - Molecular Biology: Concepts and Techniques																		
Prerequ	0211E 151B1							gy:	Сог	ісер	ots ai	ıd To	echn	iques	5				
			1																
Cours Outcom		Upor	n success	ful co	mpl	etio	n of	the c	cour	se, s	tud	ents	s wil	ll be	able	to:			
CO No	os.			Course Outcomes											Knowledge Level (Based on revised Bloom's Taxonomy)				
C01		Sum orgai		the basic structure and functions of cellular													K2		
CO2		Illust mecł	trate M nanical p	lathen ropert				delir	ng	to	ex	plai	n	the			K2		
CO3		Mod mode	el the ad els.	heren	t ce	ll w	ith tl	herm	ody	nan	nic a	and	kin	etic	К3				
CO4		Ident moti	tify the on.	impo	rtan	ce (	of n	noled	cula	r m	otoi	s f	or	cell		K3			
CO5		Mak	e use of	cell re	cep	tor n	nedi	ated	sigr	alin	g p	roce	ess.				K3		
	•		:4 D(	<u> </u>															
Correlat	10n 01	i COs	s with PC	Ds:													Pı	rogra	
CO Nos.		Course	e Outcome	8	Programme Outcomes (POs)												Specific Outcomes (PSOs)		
					1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	struc	ture	the the and functions organs		L											Н	L	L	
CO2	Illust mode	trate eling nanica	Mathem to explai al prop	n the	L	Н	Н	М	М	L						Н	L	L	M
CO3	with	th	e adheren ermodyr c models	amic	М	L	L	L	Н	Н						М	М	L	
CO4	of m		ne impor lar moto n.		М	L	L	L	Н	М						Н	М	М	
CO5	Mak recep signa		cell liated		L	L	L	М	М						Н	М	L		
H – Higł	n; M-	Medi	ium; L- I	Low				-	•			-	I					-	-
ii – mgi	1, 11-	wicu	ium, L-																

Course Con	tent:								
UNIT I	CELLULAR STRUCTURE, ORGANIZATION, AND FUNCTION	9 hours							
Cellular stru	ctures and organizations: Membrane, the nucleus, organelles,	cytoskeleton, and							
ECM. Cellul	ar functions and their control: Proteins and enzymes, DNA, RNA	A, and recombinant							
DNA Techno	ology.								
UNIT II	CELLULAR ENGINEERING	9 hours							
The cell as a	an engineering system: Mathematical modeling of calcium tra	nsient. Mechanical							
properties of cells: Experiments and Analyses.									
UNIT III	CELL ADHESION	9 hours							
Cell adhesic	on: Adhesion molecules, Intercellular and interfacial forces	, Mechanical and							
thermodynar	nic models, Kinetic and transport models.								
UNIT IV	CELL LOCOMOTION	9 hours							
Cell locomot	tion: Molecular motors, Forces generated by a cell and a moto	r molecule, Forces							
generated by	a cell and a motor molecule, Models of cell locomotion.								
UNIT V	<b>RECEPTOR-MEDIATED PROCESSES IN CELL</b>	9 hours							
Other receptor	or-mediated processes: Binding, trafficking, and signaling. Effe	ects of physical							
(e.g. shear st	ress, strain), chemical (e.g. cytokines, growth factors), and elec	trical stimuli on							
cell function	, emphasizing topics on gene regulation and signal transduction	processes.							
LEARNING	G RESOURCES								
Text Books	<ol> <li>Gibson, L. J., and M. F. Ashby. Cellular Solids: Structure a ed. Cambridge University Press, 1997. ISBN: 9780521495</li> <li><i>Essential Cell Biology (3rd edition)</i></li> <li>Alberts et al., Garland Science (2009).</li> </ol>	*							
Reference Books	1. Gibson, L. J., M. F. Ashby, and B. A. Harley. <i>Cellular M</i> and Medicine. Cambridge University Press, 2010. ISBN:								
Reference videos	Reference       https://www.youtube.com/watch?v=URUJD5NEXC8         https://www.youtube.com/watch?v=KMF3QwoT5c8         https://www.youtube.com/watch?v=LIM8i1L foc6L1								
Reference NPTEL	https://nptel.ac.in/courses/102106036								
Reference research/ review articles	<ol> <li>Kanchanawong, P., &amp; Calderwood, D. A. (2023). Organ and mechanoregulation of integrin-mediated cell–ECM Reviews Molecular Cell Biology, 24(2), 142-161.</li> <li>Jędrzejewska-Szmek, J., Dorman, D. B., &amp; Blackwell, K. time and space for calcium control of neuron activity. neurobiology, 83, 102804.</li> </ol>	adhesions. Nature T. (2023). Making							

3.	Ahmad, T., Rehman, L. M., Al-Nuaimi, R., de Levay, J. P. B. B.,
	Thankamony, R., Mubashir, M., & Lai, Z. (2023). Thermodynamics and
	kinetic analysis of membrane: Challenges and perspectives. Chemosphere,
	139430.
4.	Lu, W., & Gelfand, V. I. (2023). Go with the flow-bulk transport by molecular motors. Journal of cell science, 136(5), jcs260300.
5.	Zhang, L., Wei, X., Wang, Z., Liu, P., Hou, Y., Xu, Y., & Zhang, C. (2023).
	NF-kB activation enhances STING signaling by altering microtubule-
	mediated STING trafficking. Cell Reports, 42(3).

Course	Cod	e		Course Title													P	С		
10212B	T128	8		BIOPRINTING											0		0	3		
<u> </u>	<u>a</u>		2	-	,															
Course (	Categ	gory	Program					-												
Preamb	le		Course manufa		-								-	intin	ig its	s pro	oper	ties,		
Prerequisite Courses         Biomaterials Engineering																				
Course Outcom		Upon t	the successful	coi	mple	tion	of th	he co	ours	e, si	tude	ents	will	be a	ble t	<i>o:</i>				
CO No	s.			Course Outcomes												Knowledge Level (Based on revised Bloom's Taxonomy)				
CO1		Illustra Bio pri	· · · ·	e basic principles and introduction pertaining to g												K2				
CO2			stand the bas sis and chara				s in	volv	ed	in 1	Bio	mat	erial			K2				
CO3		Identif	y the Biocom	pati	ibilit	y of	Bio	mate	erial	ls.						K3				
CO4		Model	the scaffolds	wit	th so	ft hy	drog	gel r	nate	rial	5					K3				
CO5		Build lithogr	the knowle aphy	dge	in	tiss	sue	eng	inee	ring	; a	nd	soft		К3					
<u> </u>																				
Correlat	10n 0	f COs	with POs:													P	roara	m		
CO Nos.		Course	Outcomes				Prog	ramı	ne O	utcoi	nes	(PO	5)	Program Specific Outcomes (PSOs)				ic 1es		
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3		
CO1	intro	ciples	the basic and n pertaining ting	L											Н	L	M			
CO2	princ Bion	ciples nateria	l the basic involved in l synthesis terization.	L					L	М					Н	L	Н			
CO3	Iden Bioc Bion	tify ompati nateria	2	М	L	L	L									М				
CO4	Mod with mate			Μ	L	L	L									М				
CO5	CO5 Build the knowledge tissue engineering a soft lithography					L	L									М				
H – High Course (			ım; L- Low																	

Turkur 1. C	INTRODUCTION TO BIOPRINTING	9 hours									
Introduction to Bioprinting: Types of Bioprinting: Prebioprintig, Bioprinting and Post											
Bioprinting,	Applications of Bioprinting in Transplantation, Biofilms a	and Environmental									
remediation.											
UNIT II	INTRODUCTION TO BIOMATERIALS	9 hours									
Introduction	to Biomaterials: Synthesis, Characterization and functional pr	operties of organic									
and inorganic	biomaterials-Natural biopolymers, synthetic polymers, and	soft materials with									
additional treatment of metals and ceramics.											
UNIT III BIOCOMPATIBILITY OF BIOMATERIALS 9 hours											
Biocompatibi	lity of Biomaterials, blood compatibility and tissue compatib	ility tests, Toxicity									
tests, sensitiz	ation, carcinogenicity of synthesized biomaterials.										
UNIT IV	9 hours										
Bioprinting &	be Biofabrication- Fabrication of scaffolds often used in tissue	e engineering, drug									
delivery, and	l some medical devices. FDM (filament deposition meth	nods) to 3D print									
thermoplastic	materials and molds for casting soft hydrogel materials.										
UNIT V	CELLULAR AND TISSUE ENGINEERING	9 hours									
Tissue Engin	Tissue Engineering-cellular and tissue engineering, physical, mechanical, and chemical										
manipulation	to direct cell and tissue function. cell culture, immunofluore										
-											
-	to direct cell and tissue function. cell culture, immunofluore										
lithography, v	to direct cell and tissue function. cell culture, immunofluore										
lithography, v	to direct cell and tissue function. cell culture, immunofluore variable stiffness substrates, and the application.	scent imaging, soft									
lithography, v	to direct cell and tissue function. cell culture, immunofluore variable stiffness substrates, and the application. <b>RESOURCES</b> 1. Bronzino, J. D. (2000). The Biomedical Engineering Ha	scent imaging, soft undbook. Germany:									
lithography, v	to direct cell and tissue function. cell culture, immunofluore variable stiffness substrates, and the application. <b>RESOURCES</b> 1. Bronzino, J. D. (2000). The Biomedical Engineering Ha CRC Press.	scent imaging, soft									
lithography, v	<ul> <li>to direct cell and tissue function. cell culture, immunofluore variable stiffness substrates, and the application.</li> <li><b>RESOURCES</b> <ol> <li>Bronzino, J. D. (2000). The Biomedical Engineering Ha CRC Press.</li> <li>Artificial Organs. (2009). Netherlands: Springer London.</li> <li>Miller, G. E. (2006). Artificial Organs. United States: Model</li> </ol> </li> </ul>	scent imaging, soft undbook. Germany: organ & Claypool ons, J. E. (2004).									
lithography, v	<ul> <li>to direct cell and tissue function. cell culture, immunofluore variable stiffness substrates, and the application.</li> <li><b>RESOURCES</b> <ol> <li>Bronzino, J. D. (2000). The Biomedical Engineering Ha CRC Press.</li> <li>Artificial Organs. (2009). Netherlands: Springer London.</li> <li>Miller, G. E. (2006). Artificial Organs. United States: Mo Publishers.</li> <li>Schoen, F. J., Ratner, B. D., Hoffman, A. S., Leme Biomaterials Science: An Introduction to Materia Netherlands: Elsevier Science.</li> </ol> </li> <li>https://www.youtube.com/watch?v=uHbn7wLN_3k</li> </ul>	scent imaging, soft undbook. Germany: organ & Claypool ons, J. E. (2004).									
lithography, v LEARNING Text Books	<ul> <li>to direct cell and tissue function. cell culture, immunofluore /ariable stiffness substrates, and the application.</li> <li><b>RESOURCES</b> <ol> <li>Bronzino, J. D. (2000). The Biomedical Engineering Ha CRC Press.</li> <li>Artificial Organs. (2009). Netherlands: Springer London.</li> <li>Miller, G. E. (2006). Artificial Organs. United States: Mo Publishers.</li> <li>Schoen, F. J., Ratner, B. D., Hoffman, A. S., Leme Biomaterials Science: An Introduction to Materia Netherlands: Elsevier Science.</li> </ol> </li> <li>https://www.youtube.com/watch?v=uHbn7wLN_3k https://www.youtube.com/watch?v=XqFSlG6WKO0&amp;t=1s</li> </ul>	scent imaging, soft undbook. Germany: organ & Claypool ons, J. E. (2004).									
lithography, v	<ul> <li>to direct cell and tissue function. cell culture, immunofluore variable stiffness substrates, and the application.</li> <li><b>RESOURCES</b> <ol> <li>Bronzino, J. D. (2000). The Biomedical Engineering Ha CRC Press.</li> <li>Artificial Organs. (2009). Netherlands: Springer London.</li> <li>Miller, G. E. (2006). Artificial Organs. United States: Mo Publishers.</li> <li>Schoen, F. J., Ratner, B. D., Hoffman, A. S., Lem Biomaterials Science: An Introduction to Materia. Netherlands: Elsevier Science.</li> </ol> </li> <li>https://www.youtube.com/watch?v=uHbn7wLN_3k https://www.youtube.com/watch?v=XqFSlG6WKO0&amp;t=1s https://www.youtube.com/watch?v=Xf0LMCgol-U</li> </ul>	scent imaging, soft undbook. Germany: organ & Claypool ons, J. E. (2004).									
lithography, v LEARNING Text Books Reference	<ul> <li>to direct cell and tissue function. cell culture, immunofluore /ariable stiffness substrates, and the application.</li> <li><b>RESOURCES</b> <ol> <li>Bronzino, J. D. (2000). The Biomedical Engineering Ha CRC Press.</li> <li>Artificial Organs. (2009). Netherlands: Springer London.</li> <li>Miller, G. E. (2006). Artificial Organs. United States: Mo Publishers.</li> <li>Schoen, F. J., Ratner, B. D., Hoffman, A. S., Leme Biomaterials Science: An Introduction to Materia Netherlands: Elsevier Science.</li> </ol> </li> <li>https://www.youtube.com/watch?v=uHbn7wLN_3k https://www.youtube.com/watch?v=XqFSlG6WKO0&amp;t=1s</li> </ul>	scent imaging, soft undbook. Germany: organ & Claypool ons, J. E. (2004).									

		Karvinen, J., & Kellomäki, M. (2023). Design aspects and characterization of hydrogel-based bioinks for extrusion-based bioprinting. Bioprinting, e00274. Kim, H. S., Kumbar, S. G., & Nukavarapu, S. P. (2023). Amorphous silica fiber matrix biomaterials: An analysis of material synthesis and characterization for tissue engineering. Bioactive Materials, 19, 155-166.
Reference research/ review articles	3.	Chong, W. J., Shen, S., Li, Y., Trinchi, A., Simunec, D. P., Kyratzis, I. L., & Wen, C. (2023). Biodegradable PLA-ZnO nanocomposite biomaterials with antibacterial properties, tissue engineering viability, and enhanced biocompatibility. Smart Materials in Manufacturing, 1, 100004.
		Suamte, L., Tirkey, A., Barman, J., & Babu, P. J. (2023). Various manufacturing methods and ideal properties of scaffolds for tissue engineering applications. Smart Materials in Manufacturing, 1, 100011. Marin, E. (2023). Forged to heal: The role of metallic cellular solids in bone tissue engineering. Materials Today Bio, 23, 100777.

Course Co	de	<b>Course Title</b>	L	Т	Р	С		
10212BT1	29	AUGMENTED AND VIRTUAL REALITY	3	0	0	3		
Course Cat	egory							
Preamble		gaming a	and en	tertainii	ng to			
Prerequisit	e Courses							
Course Outcomes	Upon succ	essful completion of the course, student	s will be a	ble to:				
CO Nos.		<b>Course Outcomes</b>		Knowledge Level (Based on revised Bloom's Taxonomy)				
CO1		d the concept of augmented and virtua and Techniques	l reality	K2				
CO2	Discuss t approaches	he different perceptions of AR as	nd VR		K2			
CO3	Explain th real-time U	e AR and VR features and Interfaces	towards		K2			
CO4	Describe t environme	he concept of AR/VR modelling in d nt	lifferent		K2			
CO5	Build an A user end.	AR/VR model for validation and testing	ng with		K3			
Correlation	of COs wit	h POs:						

CO Nos.	Course Outcomes		Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	Understand the concept of augmented and virtual reality principles and Techniques		L			Н	М	L					Н	L	М		
CO2	Discuss the different perceptions of AR and VR approaches		М	Н	L	М	Н						Н	L			
CO3	Explain the AR and VR features and Interfaces towards real-time Use cases		L	L	L	М	Н						Н	М			
CO4	Describe the concept of AR/VR modelling in different environment		L	L	L	Н	Н						M	М			
CO5	Build an AR/VR model for validation and testing with user end.		L	L	L	Н	Н						L	М			

H – High; M-	Medium; L- Low								
<u> </u>									
Course Cont	INTRODUCTION	9 hours							
	eality, Virtual Reality, Head Mounted Displays, Visu								
e	Visual World, Light and Optics, Tracking of Cam	•							
Healthcare ap		era and ricad for assisting							
UNIT II	PERCEPTIONS	9 hours							
Physiology o	f Perception, Cutaneous Senses, Pain, Olfaction, G	ustation, Auditory System,							
Auditory Loc	alization, Speech, Visual System, Object Perception, N	Iotion Detection, Depth and							
Size Percepti	on, psychophysical methods for computing perceptual	thresholds							
UNIT III	VIRTUAL REALITY	9 hours							
Defining Virt	ual Reality, History of VR, Human Physiology and P								
Virtual Reali	ty Experience, Virtual Reality System, Interface to	the Virtual World-Input &							
output- Visu	al, Aural & Haptic Displays, Applications of Vir	tual Reality in Biological							
application –	Drug Discovery, Protein structures and Chemical Bor	nding structures.							
UNIT IV	HAPTIC PERCEPTION	9 hours							
Kinesthetic a	nd Tactile Senses, Haptic Perception, Haptic Modelin	g and Rendering of Virtual							
Environment	Haptics for AR/VR. Human Factors in Virtual	l Reality, Case study on							
Construction	of Geographic Virtual World.								
UNIT V	DESIGN THINKING	9 hours							
Design Thin	king Process, Context Modeling, Ideation and S	toryboarding, Prototyping,							
Evaluation of	Interaction and Experience, User Feedback								
LEARNING	RESOURCES								
	1. Virtual Reality, Steven M. LaValle, Cambridge V	•							
	2. <i>GJ Kim</i> , "Designing VR Systems: The Structured								
l ext Books	<b>Text Books</b> 3. <i>D.A. Bowman</i> et al., "3D User Interfaces: Theory and Practice", Addison								
	<ul> <li>3. D.A. Bowman et al., SD Oser Interfaces: Theory Wesley.</li> <li>4. John Vince, "Virtual Reality Systems", Pearson 1</li> </ul>								
	<ul> <li>Wesley.</li> <li><i>John Vince</i>, "Virtual Reality Systems", Pearson 1</li> <li>Burdea, Grigore C and Philippe Coiffet, "Virtual</li> </ul>	Ed.							
Reference	<ul> <li>Wesley.</li> <li><i>John Vince</i>, "Virtual Reality Systems", Pearson 1</li> <li>Burdea, Grigore C and Philippe Coiffet, "Virtual Wiley Interscience, India, 2003.</li> </ul>	Ed. Reality Technology",							
Reference Books	<ul> <li>Wesley.</li> <li><i>John Vince</i>, "Virtual Reality Systems", Pearson 1</li> <li>Burdea, Grigore C and Philippe Coiffet, "Virtual</li> </ul>	Ed. Reality Technology",							
	<ul> <li>Wesley.</li> <li>John Vince, "Virtual Reality Systems", Pearson 1</li> <li>Burdea, Grigore C and Philippe Coiffet, "Virtual Wiley Interscience, India, 2003.</li> <li>Oliver Bimber and Ramesh Raskar, "Spatial Aug</li> </ul>	Ed. Reality Technology",							
	<ul> <li>Wesley.</li> <li>John Vince, "Virtual Reality Systems", Pearson I</li> <li>Burdea, Grigore C and Philippe Coiffet, "Virtual Wiley Interscience, India, 2003.</li> <li>Oliver Bimber and Ramesh Raskar, "Spatial Aug Real and Virtual Worlds", 2005.</li> <li>https://www.youtube.com/watch?v=vz0UUVDt2ps https://www.youtube.com/watch?v=udzhuFz3HKw&amp;</li> </ul>	Ed. Reality Technology", gmented Reality: Meging							
Books	<ul> <li>Wesley.</li> <li>John Vince, "Virtual Reality Systems", Pearson 1</li> <li>Burdea, Grigore C and Philippe Coiffet, "Virtual Wiley Interscience, India, 2003.</li> <li>Oliver Bimber and Ramesh Raskar, "Spatial Aug Real and Virtual Worlds", 2005.</li> <li>https://www.youtube.com/watch?v=vz0UUVDt2ps</li> </ul>	Ed. Reality Technology", gmented Reality: Meging							

	https://www.youtube.com/watch?v=6wJ9Aakddng
Reference NPTEL	https://archive.nptel.ac.in/courses/121/106/121106013/
Reference research/ review articles	<ol> <li>Al-Ansi, A. M., Jaboob, M., Garad, A., &amp; Al-Ansi, A. (2023). Analyzing augmented reality (AR) and virtual reality (VR) recent development in education. Social Sciences &amp; Humanities Open, 8(1), 100532.</li> <li>Jayakumar, S., Maniglia, M., Guan, Z., Green, C. S., &amp; Seitz, A. R. (2024). PLFest: A New Platform for Accessible, Reproducible, and Open Perceptual Learning Research. Journal of Cognitive Enhancement, 1-12.</li> <li>Li, D., Zhu, L., Wu, Q., Chen, Y., Wu, G., &amp; Zhang, H. (2023). Identification of binding sites for Tartary buckwheat protein-phenols covalent complex and alterations in protein structure and antioxidant properties. International Journal of Biological Macromolecules, 233, 123436.</li> <li>Schöne, B., Kisker, J., Lange, L., Gruber, T., Sylvester, S., &amp; Osinsky, R. (2023). The reality of virtual reality. Frontiers in Psychology, 14, 1093014.</li> </ol>
	<ol> <li>Daggubati, L. S. Designing Digital Payment Experiences: The Crucial Role of User-Centered Design and Effective User Feedback Integration.</li> </ol>

Course	Code				C	our	se Ti	itle						L	T		P	С			
10212B	T130		PRF		CISION AGRICULTURAL BIOTECHNOLOGY										0		0	3			
Course Category Program Electiv																					
Preamb	wide an in-depth exploration of the principles, technologies, and lications of precision agriculture.																				
Prerequ	isite (	Courses	NIL																		
Cours Outcon		Upon su	uccessful c	omp	oletio	on of	^c the	сои	rse,	stuc	deni	ts w	vill be	e abl	e to:						
CO No	os.			Co	ourse	e Ou	tcon	nes						(	now Basec oom'	l on r	evise	ed			
CO1			and basic n agricult		cepts	s, his	story	and	l bas	sic p	orac	tice	s of			K2					
CO2			the soil a								Ū					K3					
CO3		Utilize applicat		natics tools for Precision Agriculture										К3							
CO4	CO4 Develop electronic development						es and imagery tools for agricultural										К3				
CO5		Model strategie	the Green es	nhou	ıse	with	lat	est	tecl	nnol	logi	es	and	К3							
Correlat	ion of	COs wit	h POs																		
CO Nos.		Course Out		Programme Outcomes (POs)										Program Specific Outcomes (PSOs)				c ies			
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3			
CO1	conce basic	rstand epts, his pract sion agrie		Н	Н										Н	Н	L				
CO2			il and soil r farming	Н	Н	М	Н	М	L						Н	L	Н				
CO3	tools		formatics sion Agri ations	Н	М	L	L	М	М						Н	М	М				
CO4	agrici	1	lectronics tools for	Н	М	М	Н	L	L						Н	М	М				
CO5	with		reenhouse hnologies		Н	М	М	Н	М						Н	М	L				

H – High; M- Medium; L- Low

Course Content:	
UNIT I PRECISION AGRICULTURE	9 hours
Precision agriculture: concepts and techniques; their issues and concerns for	r Indian agriculture;
Historic Perspectives of Precision Agriculture. Laser leveling, mechanized	direct seed sowing;
seedling and sapling transplanting, mapping of soils and plant attributes	, site specific input
application, weed management, insect pests and disease management,	Good Agricultural
Practices in precision farming, yield mapping in horticultural crops. Peat	moss and mixtures,
rock wool and other inert media for soilless culture, nutrient film technique	(NFT)/ hydroponics.
UNIT II CULTIVATION TECHNIQUES	9 hours
Growing media, soil culture, Selection Criteria for soil media, soil	pasteurization. Soil
Variability and Soil Mapping - Factors affecting soil variability, Digital so	oil data and sources,
Correlating soil data to other crop production data. Proximate Sensors: mea	sure soil parameters
- N status and soil pH. Crop discrimination and Yield monitoring, soil	mapping; fertilizer
recommendation using geospatial technologies	
UNIT III GEOINFORAMTICS	9 hours
Geoinformatics- definition, concepts, tool and techniques; their use in Pr	ecision Agriculture.
Spatial data and their management in GIS; Geodesy and its basic principle	s; Image processing
and interpretation; Global positioning system (GPS), components and it	s functions; System
Simulation- Concepts and principles, Introduction to crop Simulation.	STCR approach for
precision agriculture; Agricultural GIS software programs. Mobile	GIS/GPS software
programs. Principles and applications of mapping data in precision agr	iculture, GIS, GPS
sensors, drones, data acquisition and management. Yield Maps. Applicat	tions of Big Data in
Precision Agriculture. Variable Rate Technology (VRT) - Grid Sampl	ing, VRT Seeding
Planter Unit Controllers, Variable Hybrid/Variety Planting, VRT Pesticide	es, Spray Boom and
Nozzle Control, Automatic Boom Leveling.	
UNIT IV SENSORS	9 hours
Electronic systems and Signal processing: Communications data netwo	ork for tractors and
machinery for agriculture applications. Remote sensing basics- Application	tions in agriculture,
correlating imagery to other crop production data, Remote sensing dat	a sources. Sensors-
Sensing Platforms-Satellite, UAV, Aerial, Proximal, The Electromagnet	ic Spectrum, Active
vs. Passive Remote Sensing, Spectral, Spatial, and Temporal Resolution,	Soil Sensors, Crop
Sensors, Weather Sensors	
UNIT V GREEN HOUSE TECHNOLOGY	9 hours
Green house technology - Introduction, Types of Green Houses; Plant resp	onse to Greenhouse

Green house technology - Introduction, Types of Green Houses; Plant response to Greenhouse environment, planning and design of greenhouses, Design criteria of green house for cooling and heating purposes. Green house equipments, materials of construction for traditional and low-cost greenhouses. Design and construction of green houses., Greenhouse heating – necessity, components, methods, design of heating system. Root media –types – soil and soil less media, composition, estimation, preparation and disinfection, bed preparation. Irrigation requirement, fertilizer management, cultivation, harvesting and post harvest techniques; Typical applications. Problems/constraints of greenhouse cultivation and future strategies.

LEARNING	RESOURCES
Text Books	<ol> <li>Singh Brahma and Balraj Singh. 2014. Advances in protected cultivation, New India Publishing Company.</li> <li>Sharma P. 2007. Precision Farming. Daya Publishing House New Delhi.</li> <li>Ghosh Arupratan, Green house Technology, the future concept of Horticulture, Kalyani Publishers, Ludhiana.</li> <li>Tiwari G.N., Green house Technology for Controlled Environment, Narosa Pub. House Pvt. Ltd., New Delhi</li> </ol>
Reference videos	https://www.youtube.com/watch?v=WhAfZhFxHTs https://www.youtube.com/watch?v=yEejDAwu4RE https://www.youtube.com/watch?v=6ct7uDKHEj8 https://www.youtube.com/watch?v=Tl1YkbdcEgU https://www.youtube.com/watch?v=8APpeti82hw
Reference NPTEL	https://onlinecourses.nptel.ac.in/noc24_bt30/preview
Reference research/ review articles	<ol> <li>Ahmad, U., &amp; Sharma, L. (2023). A review of best management practices for potato crop using precision agricultural technologies. Smart Agricultural Technology, 100220.</li> <li>Mwangi, R. W., Mustafa, M., Kappel, N., Csambalik, L., &amp; Szabó, A. (2024). Practical applications of spent mushroom compost in cultivation and disease control of selected vegetables species. Journal of Material Cycles and Waste Management, 1-16.</li> <li>Saranya, T., Deisy, C., Sridevi, S., &amp; Anbananthen, K. S. M. (2023). A comparative study of deep learning and Internet of Things for precision agriculture. Engineering Applications of Artificial Intelligence, 122, 106034.</li> <li>El-Hageen, H. M., Alatwi, A. M., &amp; Zaki Rashed, A. N. (2024). High-speed signal processing and wide band optical semiconductor amplifier in the optical communication systems. Journal of Optical Communications, 44(s1), s1277-s1284.</li> <li>Al-Naemi, S., &amp; Al-Otoom, A. (2023). Smart sustainable greenhouses utilizing microcontroller and IOT in the GCC countries; energy requirements &amp; economical analyses study for a concept model in the state of Qatar. Results in Engineering, 17, 100889.</li> </ol>

Course			С	ours	se Ti	tle						L	]	[	P	С			
10212B	T143			COMPUTATIONAL BIOLOGY: ECHNIQUES AND APPLICATIONS										2	0	)	2	3	
			1																
Course (		Program Core																	
Proombio					This course enables the Biotechnologist to make sense of immense amounts of Biologicaldata through computational tools.														
Prerequ				ance eculo				-		ots ai	nd T	echn	ique.	5					
Cour Outcor		Upon su	ccessful o	com	plet	ion c	of the	e coi	urse,	, stu	der	its v	vill b	e ab	le to	:			
CO N					utco							B	now (Base loom	d on	revis	ed			
COI			biologic formatio							erent	t da	ta ł	bases			K2			
CO2			the similar the similar the similar the similar the second	similarity between multiple sequences by prithms.										К3					
CO3			nterpret and assess the different molecular phylogenetic tree arrangement										К3						
CO4				structure and functions of protein for drug lgorithms											К3				
CO5			the Pl ons in bi			ind	PY	THO	ON	pr	ogr	am	ning			K3			
Correlat	ion of C	Os with	POs:																
CO Nos.	Cor	irse Outco	omes	Programme Outcomes (POs)										Program Specific Outcomes (PSOs)			c ies		
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	sequent differen bioinfor	es by t data b	ases and	Η	Η	Н	M	Η							M		Н		
CO2	between	ify the similarity een multiple ences by different			Н	Н	М	Н							М	Н	M		
CO3	assess	the ar sequ enetic	pret and different ences in tree		Η	Н	М	Η							Н	Н	М		

CO4	Identify the structure H H H M H and functions of protein for drug discovery algorithms	Н	Н	L	Н							
CO5	Illustrate the PERL and H H H M H M H PYTHON programming applications in biology.	Н	Н	L	Н							
H – Hig	n; M- Medium; L- Low											
	Comme Constants											
Course Content:												
UNIT I	BIOLOGICAL DATABASES		9 ho									
	Introduction to bioinformatics, biological databases and their growth. Types of Biological data-											
Genomi	e DNA, cDNA, rDNA, ESTs, GSSs; Primary Databases -Nuc	leotic	le se	eque	nce							
	s-GenBank, EMBL, DDBJ, Protein Sequence Databases- UniP											
TrEMBL, Swiss-Prot, UniProt Archive-UniParc, UniProt Reference Clusters-UniRef, UniProt												
Metagenomic and Environmental Sequences UniMES. Literature Databases- PubMed, PLos,												
BioMed	Central; Secondary databases.											
UNIT I	SEQUENCE ANALYSIS	9 hours										
Basic concepts of sequence similarity, identity and homology, definitions of homologues,												
ortholog	ues, paralogues and xenologues. Scoring matrices: basic concept of	a sco	ring	mat	rix,							
Matrices	for nucleic acid and proteins sequences, PAM and BLOSUM series,	matri	x de	rivat	tion							
methods	and principles. Pairwise sequence alignment - Basic concepts of seq	uenc	e alig	gnm	ent,							
gap per	alties, Needleman and Wunsch, Smith and Waterman algorith	ms f	òr p	oairv	vise							
alignme	nts and application in Nucleic acid and protein sequences align	nmen	ts. N	Ault	iple							
sequence	e alignments (MSA) – The need for MSA.											
UNIT II	I FILE FORMATS, SEQUENCE PATTERNS AND PROFILES		9 ho	urs								
Sequenc	e file formats – GenBank, FASTA, ALN/ClustalW2, PIR; Basic conc	ept ar	nd de	finit	tion							
of sequence patterns, motifs and profiles, various types of pattern representations viz.												
consensus, regular expression (Prosite-type) and sequence profiles; Sequence similarity based												
consensu	search engines (BLAST and FASTA); Pattern based search using MeMe and PRATT); Motif-											
	ngines (BLAST and FASTA); Pattern based search using MeMe and	based search using ScanProsite and eMOTIF; Profile-based database searches using PSI-										
search e			usi	ng F	PSI-							
search e based se			usi	ng F	PSI-							
search e based se	earch using ScanProsite and eMOTIF; Profile-based database sea and HMMer.	rches	usii 9 ho	0	PSI-							
search ea based so BLAST UNIT I	earch using ScanProsite and eMOTIF; Profile-based database sea and HMMer.	rches	9 ho	urs								
search er based se BLAST UNIT I Phyloge	earch using ScanProsite and eMOTIF; Profile-based database sea and HMMer. <b>PHYLOGENETIC ANALYSIS AND HMM</b>	rches s of F	<b>9 ho</b> Phylo	urs ogen	etic							

gene finding, and Multiple sequence alignment by HMM method.

Machine learning techniques: Artificial Neural Networks in protein secondary structure prediction, Bioinformatics approaches for drug discovery, Applications of informatics techniques in proteomics: Peptide mass fingerprinting. Protein Secondary structure and tertiary structure prediction methods, Homology modeling, *abinitio* approaches, Threading, Critical Assessment of Structure Prediction.

## LABORATORY EXPERIMENTS:

- 1. Different sequence formats such as FASTA, PIR, EMBL, PDB, etc. Different sequence databases, retrieval of sequences from those databases and different ways to store the sequences.
- 2. Use of BLAST on line server to retrieve sequences from a database, Develop a program based on BLAST algorithm to carry out database search.
- 3. Find the gene sequences of Mouse origin similar to U80226.
- 4. Determine the number of entries in SWISSPROT for Serinekinase in monkey.
- 5. Use EBI (European Bioinformatics Institute) Needle sequence alignment tool to align above two sequences and compare your result with that of Needle tool.
- 6. Collect the any two protein sequences (CAA80512, AAA29341) from the enterz database and align the sequences with each other and report the pair wise score using CLUSTALW.
- 7. Perform the local alignment and global alignment between the following sequences and score the sequences with the compositional substitution matrix BLOSUM62.
- 8. Retrieve and analyze the secondary structures of any one proteinsusing protein secondary structure prediction server.

LEARNING I	RESOURCES
	1. Mount D.W., "Bioinformatics: Genome and Sequence Analysis", Cold Spring Harbor Laboratory Press, New York, 2001.
	2. Ian Korf Mark and Josaph, "BLAST", Oreilly Publisher, 2003.
Text Books	3. Durbin R., Eddy S., Krogh A. and Mitchison G., "Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids", Cambridge University Press, 2002.
Text Books	4. Baxevanis A.D. andOuletteB.F.F., "Bioinformatics – A practical guide to the Analysis of Genes and Proteins", Willey International publishers, 2002.
	5. Bishop M.J. and Rawlings C.J., "DNA and Protein Sequence Analysis - A Practical Approach", Oxford University Press, 1996.
	6. Pevsner J., "Bioinformatics and Functional Genomics", Cold Spring Harbor Laboratory Press, New York, 2002.
Reference Books	1. Setubal J. and Meidanis J., Introduction to Computational Molecular Biology, PWS Publishing Co, 1997.
	http://hmmer.org/.
	https://blast.ncbi.nlm.nih.gov/Blast.cgi
Online	https://www.genome.jp/tools-bin/clustalw
resources	http://meme-suite.org/
	http://evolution.genetics.washington.edu/phylip.html
	https://www.rcsb.org/

	http://www.ncbi.nlm.nih.gov/education/tutorials/									
	http://www.ncbi.nlm.nih.gov/books/NBK143764/									
	https://www.youtube.com/watch?v=JmKD5SnQtFE									
Reference	https://www.youtube.com/watch?v=iqAmkNSu3oI									
videos	https://www.youtube.com/watch?v=KdKqZ6AuDCc									
viucos	https://www.youtube.com/watch?v=mzxS0m-RA6s									
	https://www.youtube.com/watch?v=hMdbSiVUw6w									
Reference NPTEL	https://archive.nptel.ac.in/courses/102/106/102106068/									
	<ol> <li>Song, E., Ang, L., Park, J. Y., Jun, E. Y., Kim, K. H., Jun, J., &amp; Lee, M. S. (2021). A scoping review on biomedical journal peer review guides for reviewers. PLoS One, 16(5), e0251440.</li> </ol>									
Reference	2. Ranwez, V., & Chantret, N. N. (2020). Strengths and limits of multiple sequence alignment and filtering methods. Phylogenetics in the genomic era, 2-2.									
research/ review articles	3. Jin, X., Liao, Q., Wei, H., Zhang, J., & Liu, B. (2021). SMI-BLAST: a novel supervised search framework based on PSI-BLAST for protein remote homology detection. Bioinformatics, 37(7), 913-920.									
	4. Khodaei, A., Feizi-Derakhshi, M. R., & Mozaffari-Tazehkand, B. (2021). A Markov chain-based feature extraction method for classification and identification of cancerous DNA sequences. BioImpacts: BI, 11(2), 87.									
	5. Pearce, R., & Zhang, Y. (2021). Toward the solution of the protein structure prediction problem. Journal of Biological Chemistry, 297(1).									

Course Co	de			L	Т	Р	С								
10212BT14	44		ADVA	NCED BIC	3	0	0	3							
Course Cat	egory		Program Core												
Preamble			To comprehend the knowledge of biochemistry and explains the processes happening at the cellular and molecular level.												
Prerequisit	e Course	es	10210CH	[102 - Bioch	emistry										
Course Outcomes	I non successful completion of the course students will be able to														
CO Nos.			С	ourse Outco	omes		(I	Knowledge Level (Based on revised Bloom's Taxonomy)							
CO1	Identifi princip		on of metab	oolic pathwa	ys and its tł	nermodynami	c	K2							
CO2	Describ amino a			and metabo	olism of nuc	eleic acids an	d	K3							
CO3	Outline metabo		different	aspects of	nucleic ac	id and lipid	S	K3							
CO4	Utilize coenzy		d	K3											
CO5			ugs for h l disorders		iciencies re	elated variou	S	К3							

# **Correlation of COs with POs:**

CO Nos.	Course Outcomes				Prog	ramı	ne O	utcoi	mes	(POs		Program Specific Outcomes (PSOs)				
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO2	Identification of metabolic pathways and its thermodynamic principles		Н		М	M							М	М	L	L
CO3	Describe the structure and metabolism of nucleic acids and amino acids		Н		М	М							М	М	L	L
CO4	Outline the different aspects of nucleic acid and lipids metabolism		Н		М	М							М	М	L	L
CO4	Utilize the other biomolecules such as vitamins and coenzymes and its importance.	Н	М	М									L	Н	М	

CO5 Devel relate and d	e deficiencies arious diseases		Н	Н	М	Н		Μ					М	М	Н	L
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#### H – High; M- Medium; L- Low

#### **Course Content:**

# UNIT I INTERMEDIARY METABOLISM AND BIOENERGETICS

## 9 hours

Overview of carbohydrate metabolism (Glycolysis, TCA, gluconeogenesis and Pentose phosphate shunt). Overview of intermediary metabolism: Interconnections and regulation of metabolic pathways. Bioenergetics - High energy compounds, electronegative potential of compounds, respiratory chain, ATP cycle, calculation of ATP yield during oxidation of glucose and fatty acids.

## UNIT II AMINO ACIDS METABOLISM AND PROTEIN TRANSPORT

#### 9 hours

Metabolism concepts-Nitrogen metabolism and urea cycle, Biosynthesis of six essential amino acids (Met, Thr, Lys, Ile, Val, Leu) and aromatic amino acids- Metabolic disorders associated with chain and aromatic amino acid degradation. Protein targeting, signal sequence, SRP pathway, secretion; Folding, Chaperons and targeting of organelle proteins, Protein degradation, ubiquitination, receptor-mediated endocytosis, turnover.

## UNIT III METABOLISM OF NUCLEIC ACIDS AND LIPIDS

# 9 hours

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

# UNIT IV VITAMINS AND COENZYMES

## 9 hours

Fat Soluble Vitamins, provitamins (A, D, E and K). Structure, physiological significance and deficiency symptoms. Water soluble vitamins, structure, coenzyme role and deficiency symptoms. Thiamine, riboflavin, pyridoxine, niacin, folic acid, biotin and Vitamin B12. Recommended dietary intake. Coenzymes: Their role in metabolic pathways: NAD, FAD, TPP, PLP, carboxybiotin.

## UNIT V HORMONES

## 9 hours

Importance of Hormones. Chemical classification of hormones. Peptide hormonevasopressin, protein hormone- insulin. Lipid and phospholipid derived hormones- prostaglandin and phospholipids. Steroid hormones-testosterone, estrogen, cortisol. Monoamines: thyroxine,

adrenaline. Mechanism of action of steroid and peptide hormones, Hormonal disorders-Diabetes, Thyroid disorders, hypercholesterolemia and its role in cardiovascular disease.

LEARNING	RESOURCES									
	1. Nelson D.L., Cox M.M., & Lehninger A.L., "Principles of Biochemistry", McMillan Learning, New York, USA, 2014									
Text Books	<ol> <li>Voet D.J., Voet J.G. and Pratt C.W., "Principles of Biochemistry", 3rd Edition, John Wiley &amp; Sons Inc., 2008.</li> </ol>									
	3. Murray R.K., et al., "Harper's Illustrated Biochemistry". XXVIIth Edition, McGraw-Hill, 2006.									
Reference	1. Berg J.M., Tymoczko, J.L. and Stryer, L., "Biochemistry",6 th Edition, WH Freeman, 2006.									
Books	<ol> <li>Salway J.G., "Metabolism at a Glance", 2nd Edition, Blackwell Science Ltd., 2000.</li> </ol>									
	https://www.youtube.com/watch?v=QX6vKCWPqBM									
Reference videos	https://www.youtube.com/watch?v=0M-B2dOfcUo									
	https://www.youtube.com/watch?v=4GFKdLy2fOE									
	https://www.youtube.com/watch?v=9MNReWZQQbw									
	https://www.youtube.com/watch?v=-SPRPkLoKp8									
Reference NPTEL	https://archive.nptel.ac.in/courses/104/104/104104066/									
Reference research/ review articles	<ol> <li>Shao, X., Fredericks, S. A., Saylor, J. R., &amp; Bostwick, J. B. (2020). A method for determining surface tension, viscosity, and elasticity of gels via ultrasonic levitation of gel drops. The Journal of the Acoustical Society of America, 147(4), 2488-2498.</li> <li>Van Eker, D., Samanta, S. K., &amp; Davis, A. P. (2020). Aqueous recognition of purine and pyrimidine bases by an anthracene-based macrocyclic receptor. Chemical Communications, 56(65), 9268-9271.</li> <li>Paredes-Flores, M. A., Rahimi, N., &amp; Mohiuddin, S. S. (2024). Biochemistry, glycogenolysis. In StatPearls [Internet]. StatPearls Publishing.</li> <li>Long, T., Debler, E. W., &amp; Li, X. (2022). Structural enzymology of cholesterol biosynthesis and storage. Current opinion in structural biology, 74, 102369.</li> <li>Seyfried, T. N., Arismendi-Morillo, G., Mukherjee, P., &amp; Chinopoulos, C. (2020). On the origin of ATP synthesis in cancer. Iscience, 23(11).</li> </ol>									

# FOOD BIOTECHNOLOGY DOMAIN

Course Code				Coi	irse	Title	e						L	Т	I	2	С				
10212BT131			RINCIPLES			JNC ICA			LF	00	D A	ND		3	0		0	3			
Course (	Catego	ry	Program E	lect	ive																
Preambl	le		To know me developmen			v			· · · · · · · · · · · · · · · · · · ·								also	th			
Prerequi Courses	isite		Nil																		
Cours Outcon		Upon	successful c	omp	letio	on of	the	coui	rse,	stuc	lents	s wi	ll be	e able	e to:						
CO Nos.			Co	urse	e Ou	tcon	nes						Knowledge Level (Based on revised Bloom's Taxonomy)								
CO1 Outline the typ and its regulate				of nutraceutical and functional foods issues												K2					
CO2 Relate deficiencie					of essential nutrients to diseases.											K2					
					s in product developments of l functional foods										К3						
			fy the inter ssing and sto					ronn	nent	al i	facto	ors	on	К3							
CO5			the metho ent forms	ds	to p	oroce	ess f	nto	К3												
Correlat	ion of (	⁷ Os w	vith POs:																		
CO Nos.			Dutcomes				Prog	ramr	ne O	utcoi	mes (l	POs)	1			Program Specific Outcomes (PSOs)					
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3			
CO1	nutrace	eutica onal fo	oods and its	Μ	Н	М	L								Н		М				
CO2		al n	ciencies of utrients to			М									Н		М				
CO3	produc of Nu	ld the steps in duct developments Nutraceuticals and ctional foods				М		Н							Н	М					

Н

М

L L M

Н

Н

Identify the interactions of environmental factors on processing and storage of foods

CO4

CO5 App food form	s into different		Н			L					Н	М		
H – High; M-	Medium; L- Low			1								I		1 1
Course Conte	ent:													
UNIT I	INTRODUCTIO											) hou		
	o functional foods, in	•		•										
foods active i	ingredients, health	benefits	s, Recent	t dev	elop	me	nt a	nd	adva	ances	s in	the a	areas	s of
functional foo	ds. Marketing and r	regulato	ory issues	for t	func	tion	al f	ood	ls.					
UNIT II	NUTRITIONAL	VALU	E OF F	UNC	TIC	NA	Lŀ	FOC	ODS		9	) hou	irs	
Therapeutic n	utrition & formulat	ion of	special d	lietar	y fo	ods	; R.	elat	ion o	of fo	od a	nd d	iseas	ses;
Deficiencies	of essential nutries	nts; As	ssessmen	t of	nut	ritic	onal	st	atus	& ]	RDA	, Et	ffect	of
processing on	nutrients.													
UNIT III	FORMULATION	N OF F	UNCTI	ONA	LF	00	DS				ç	) hou	irs	
individual ad ingredients/co	mpounds used in ctive compound o mpounds, develop mpounds as well	or pat	ient/cons	umer	r, h	nealt	th-b	ene	fittir	ng l	level	of	act	tive
UNIT IV	ROLE IN HEAL	TH AN	ND DISE	ASE	S						9	) hou	irs	
Functional fo	ods and immune of	compet	ence; ro	le ar	nd u	se	in c	obe	sity	and	nerv	/ous	syst	tem
disorders, Fun	ctional foods and nu	itraceut	ticals wit	h attr	ibut	es to	o co	ntro	ol cai	rdiov	vascu	ılar d	isea	ses,
cancer, ageing	5.													
UNIT V	PROCESSING O	OF FUN	CTION	AL I	FOC	DDS	5				ç	) hou	irs	
Processing of	Functional Foods	in var	ious forr	ns o	f po	wd	ers,	be	verag	ges,	snac	ks; s	stabi	lity
consideration,	limitation, precaut	tion to	retain b	ioact	ive	con	npo	und	ls. E	ffect	s of	pro	cessi	ing,
storage and in	teractions of various	s enviro	onmental	facto	ors c	on th	ie p	otei	ntials	s of s	such	food	s.	
LEARNING	RESOURCES													
Text Books	<ol> <li>Shi J.(Ed) 2000 Technologies</li> <li>Wildman, Rol CRC, 2006.</li> </ol>	CRC.			0									C
Reference Books	Functional Foods Analysis for Funct	•								•			hods	of

Reference videos	https://www.youtube.com/watch?v=svS6I09JORQ https://www.youtube.com/watch?v=C2WgjlotVMQ https://www.youtube.com/watch?v=qNTYqOt04rE https://www.youtube.com/watch?v=9G1wWUjkyz8 https://www.youtube.com/watch?v=0Ss_fguPoc4
Reference NPTEL	https://archive.nptel.ac.in/courses/126/105/126105015/
Reference research/ review articles	<ol> <li>Díaz, L. D., Fernández-Ruiz, V., &amp; Cámara, M. (2020). An international regulatory review of food health-related claims in functional food products labeling. Journal of Functional Foods, 68, 103896.</li> <li>Gómez, I., Janardhanan, R., Ibañez, F. C., &amp; Beriain, M. J. (2020). The effects of processing and preservation technologies on meat quality: Sensory and nutritional aspects. Foods, 9(10), 1416.</li> <li>Alongi, M., &amp; Anese, M. (2021). Re-thinking functional food development through a holistic approach. Journal of Functional Foods, 81, 104466.</li> <li>Khalaf, A. T., Wei, Y., Alneamah, S. J. A., Al-Shawi, S. G., Kadir, S. Y. A., Zainol, J., &amp; Liu, X. (2021). What is new in the preventive and therapeutic role of dairy products as nutraceuticals and functional foods?. BioMed research international, 2021(1), 8823222.</li> <li>Perfilova, O. V., Akishin, D. V., Vinnitskaya, V. F., Danilin, S. I., &amp; Olikainen, O. V. (2020, August). Use of vegetable and fruit powder in the production technology of functional food snacks. In IOP Conference Series: Earth and Environmental Science (Vol. 548, No. 8, p. 082071). IOP Publishing.</li> </ol>

<b>Course Co</b>	de	<b>Course Title</b>	L	Т	Р	С						
10212BT1	32	NUTRACEUTICALS	3	0	0	3						
<b>Course Cat</b>	egory	Program Elective										
Preamble		Provides knowledge in newly emerging area of nutraceuticals with respect to the types, mechanisms of action, manufacture of selected nutraceuticals, product development, clinical testing and toxicity aspects.										
Prerequisit												
Course Outcomes	Upon su	ccessful completion of the course, students will be a	able t	0:								
CO Nos.		Course Outcomes	Knowledge Leve (Based on revised Bloom's Taxonomy									
CO1	CO1 Define history and basis of nutraceuticals in relation to various factors											
CO2	Understa	nd concepts of nutritional assessment and indices		ŀ	K2							
CO3	Comprel in medic	nend nutritional disorders and role of nutraceuticals ine		ł	٢3							
CO4	Understa	nd applications of metabolites in medicine and		I	<b>Z</b> 2							

	in medicine	
CO4	Understand applications of metabolites in medicine and treatment	K3
CO5	Apply knowledge of nutraceutical production and formulation as functional foods	К3

CO Nos.	Course Outcomes	es Programme Outcomes (POs)								Program Specific Outcomes (PSOs)						
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Define history and basis of nutraceuticals in relation to various factors		L	М									Н	L	М	
CO2	Understand concepts of nutritional assessment and indices		L	L	L								Н		М	
CO3	Comprehend nutritional disorders and role of nutraceuticals in medicine		М	Н		L							М	М	М	
CO4	Understand applications of metabolites in medicine and treatment	Н	М	L			М		М				Н	Н		Н

CO5 pro form	ply knowledge of raceutical duction and nulation as ctional foods	М	L	Н									Н	М		
H – High; M	- Medium; L- Low															
<b>Course Con</b>	tent:															
UNIT I	INTRODUCTIO													) hou		
History, defi	nition, classification	and	sou	rce o	of nu	trac	euti	cals	, ba	sis	ofc	laim	s for	a coi	npoi	und
as a nutrace	eutical, benefits of	nutr	aceu	itical	s, ro	ole	of 1	nutra	ace	utic	als	in N	1edic	ine,	Hun	nan
physiology,	genetics, food techno	ology	y, ch	emis	stry a	and	nutr	itior	ı, so	cope	e and	l ava	ilabi	lity i	nvol	ved
in the indust	ry, Indian and global	sce	nario	э.												
UNIT II	NUTRITIONAL	AN	ALY	SIS									9	) hou	irs	
Food compo	nents based on nutrit	iona	al va	lue,	nutri	ition	al a	sses	sm	ent	of ca	arbol				eins
-	commended dietary												•	-		
	e, nitrogen balance, p							•							•	
•	ate (BMR), Body M				•		Ì									
	ence to nutraceutical			,	,,	unit		antae		291				(52)		• • • • • • •
•	1		usti y													
UNIT III	DIETARY FOOD				1 6 1		• , •		1					) hou		1
	onsible for nutritiona															
· •	ogens, lectins, enzyr									• •						
	itritional factors, nu															,
• •	, hypercholesteroler		,		-											
dietary supp	olements in prevent	ion	and	tre	atme	ent o	of c	canc	er,	ob	esity	an an	d str	ess,	role	of
nutraceutical	s and functional for	ods	in p	ediat	rics,	ger	iatri	ics,	spo	rts,	pre	gnar	icy a	nd la	ctati	ion,
functional fo	od as remedies.															
UNIT IV	PLANT AND AN	IM	AL I	MET	<b>TAB</b>	OLI	TE	S					ç	) hou	irs	
Plant secon	dary metabolites,	clas	sific	atio	n ai	nd	sub	-clas	ssif	icat	ion	-alk	aloid	ls, p	ohen	ols,
Terpenoids.	Animal metabolite	s -	chi	itin,	chit	tosa	n, g	gluc	osa	mir	ie, i	chon	droit	in s	ulph	ate,
polysacchari	des of animal origin,	, use	es an	ıd ap	plica	atior	ns ir	n pre	ever	ntiv	e me	edici	ne an	id tre	atm	ent,
Concept of p	rebiotics and probio	tics,	syn	bioti	cs fo	or m	aint	aini	ng g	300	d he	alth,	alga	e as a	a sou	irce
	fatty acids, antioxid		•							-			-			
UNIT V	INDUSTRIAL PI OF NUTRACEU'				N A	ND	FO	RM	IUI	LAT	T <b>IO</b> I	N	ç	) hou	irs	

Industrial production of nutraceuticals, formulation of functional foods containing nutraceuticals, manufacturing aspects of nutraceuticals (lycopene, isoflavonoids, prebiotics and

probiotics, glucosamine, phytosterols etc), preferences and globalization on selection of nutraceutical products, identification and estimation of health benefits of selected nutraceuticals, quality evaluation of foods containing nutraceuticals, packaging and labeling of functional foods, toxicology and bioavailability, use of animal models, pre-clinical and clinical trials involved.

LEARNING	RESOURCES
<b>Text Books</b>	
	1. Handbook of nutraceuticals and functional foods by Robert E C. Wildman, CRC/Taylor&Francis
	2. Handbook of nutraceuticals Vol I by Yahwant Vishnupant Pathak, CRC press.2009
	3. Handbook of nutraceuticals Vol II by Yahwant Vishnupant Pathak, CRC press,2011
D.C.	4. Handbook of Prebiotics, Glenn R. Gibson, Marcel Roberfroid, CRC press, 2008.
Reference Books	5. Swaminathan M., Essentials of Food and Nutrition, 2nd Ed, 1985, Ganesh and Co.
	6. Dietary Supplements: Toxicology and Clinical Pharmacology. Humana Press. Gibson GR & William CM. 2000.
	7. Dietary Supplements. 2nd Ed. Pharmaceutical Press. Campbell JE & Summers JL. 2004.
	8. Bioprocesses and Biotechnology for Nutraceuticals. Chapman & Hall. Robert EC. 2006.
	9. Handbook of Nutraceuticals and Functional Foods. 2nd Ed. Wildman.
	https://www.youtube.com/watch?v=h8uV5I_N8w4
Reference	https://www.youtube.com/watch?v=ojhdTFmkY1c
videos	https://www.youtube.com/watch?v=Ua-dLw2nFs4
videos	https://www.youtube.com/watch?v=_NNtgHmD5BU
	https://www.youtube.com/watch?v=K3L3DMkfyc8
Reference NPTEL	https://archive.nptel.ac.in/courses/126/105/126105015/
	1. Nutrition in Health and Disease 17th Edition; Anderson, Dibble, Turkki, Mitchell, Rynbergen J.B. Lippincott Company, 1982
Reference research/	2. Dietary Supplements of Plant Origin, M. Maffei (Ed.), Taylor & Francis, 2003.
review articles	3. Bioprocesses and Biotechnology for Functional Foods and Nutraceuticals, Jean – Richard Neeser & J. Bruce German, Marcel Dekker, Inc., 2004.
	Nutraceuticals in health and disease prevention, Klaus Krämer, Peter-Paul Hoppe, Lester Packer

Course	Code		Course Title										]	Г	Р	С			
10212B	ST133	FOOD		RESERVATION, PACKAGING TECHNOLOGIES										(	)	0	3		
Course	Category	Progra	ım E	Elect	ive														
Preamb		To pro	vide	an a	adeq	uate	kno	wle	dge	ofp	orin	ciple	s of j	food	pres	erva	tior		
		and pa	cka	ging															
Prerequ	isite Cours	es NIL																	
Cours Outcon	I nn	Upon successful completion of the course, students will be												able to:					
CO No	os.		Co	Course Outcomes											ledg d on 's Ta	revis	ed		
CO1		ates the diffe					1								K2				
CO2		stand the fur ration	ndan	nent	als o	f fo	od pi	rese	rva	tion	thr	ough			K2				
CO3	Identi	fy the purpos	se ar	nd pi	rincij	ples	of fo	ood	pac	kag	ing				K2				
CO4	Expla packa		e o	of different materials used in food											K2				
CO5 Develop food packaging technologies for different foods												K3							
CO Nos.	Course	Outcomes				Prog	gramı	ne O	utco	mes	(POs	5)			S Ou	rogra pecif utcon PSOs	ic 1es		
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3		
CO1		the different of food n		L			M							Н	Н	M			
CO2	Understand fundamenta preservatio dehydration	als of food n through	т	Н	L									Н	Н	L			
CO3		entify the purpose d principles of food												Н	Н				
CO4	different m	plain the nature of ferent materials used food packaging			L		M							Н	М	Н			
	CO5 Develop food packaging technologies for different foods				М			L						Н		Н			
CO5	packaging	technologies	Η		111			_											
	packaging	technologies t foods	Η																

UNIT I DIFFERENT MODES OF FOOD PRESERVATION	9 hours										
Introduction of preservation, Preservation methods: thermal and other non	-thermal methods,										
microbiological additives, and pulsed electric or magnetic fields. High	temperature, low										
temperature, drying, radiation, chemical preservatives, bio-preservatives, h	urdle technology,										
active packaging. Preservation by fermentation - Curing, Pickling and Smo	king, Chilling and										
Freezing, Properties of frozen foods. Food preservation and handling including fresh fruits and											
vegetables, grains and pulses, fish, red meat, and milk.											
UNIT II FOOD PRESERVATION THROUGH DEHYDRATION	9 hours										
Water activity and moisture absorption isotherms, Psychometric chart, Dehy	dration and drying										
of foods, drying curve and drying time calculation, Enthalpy change during	g freezing, Plank's										
equation for freezing time, Cold storage and Refrigeration load, Refrigeration	n cycle, Cryogenic										
freezing and IQF Different types of dryers: Conductive, convective and com	bined, IMF foods,										
Osmotic dehydration. food preservatives of microbial origin.											
UNIT III ADVANCED TECHNIQUES OF PACKAGING	9 hours										
Packaging of foods, requirement, importance and scope. Factors affecting	shelf life of food										
material during storage, spoilage agents with environmental factors. Contr	ol of the spoilage										
agents. Functions of packaging - packaging materials, risks associated w	ith potential food										
contamination, Interpret packaging standards and regulations in food pac	kaging materials.										
Aseptic packaging. Retort processing. Packaging systems, types: flexible an	d rigid; retail and										
bulk; levels of packaging; special solutions and packaging machines, ter	chnical packaging										
systems and data management packaging systems.Nutritional labeling on packaging	ackages, CAS and										
MAP, shrink and cling packaging, vacuum and gas packaging; Factors affect	cting the choice of										
packaging materials, Disposal and recycle of packaging waste. Print	ng and labeling,										
Lamination.											
UNIT IV MATERIALS FOR FOOD PACKAGING	9 hours										
Different types of packaging materials, their key properties and applications.	Different types of										
polymers used in food packaging and their barrier properties. Metal cans, m	anufacture of two										
polymers used in food packaging and their barrier properties. Metal cans, m piece and three-piece cans. Canning of food products, Classifications and											
	structure of cans,										

blow molding, injection molding. Glass containers, types of glass used in food packaging. Paper and paper board packaging, paper and paper board manufacture process. Relative advantages and disadvantages of different packaging materials.

#### TESTING METHODS FOR PACKAGING MATERIALS

UNIT V

Testing methods for flexible materials, rigid materials and semi rigid materials; Tests for paper (thickness, bursting strength, breaking length, stiffness, tear resistance, folding endurance, ply bond test, surface oil absorption test, etc.), plastic film and laminates (thickness, tensile strength, gloss, haze, burning test to identify polymer, etc.), aluminium foil (thickness, pin holes, etc.), glass containers (visual defects, colour, dimensions, impact strength, etc.), metal containers (pressure test, product compatibility, etc.).

LEARNING	RESOURCES
Text Books	<ol> <li>Robertson, G. L. 2005. Food Packaging: Principles and Practice. Second Edition. Taylor and Francis Pub</li> <li>Coles, R., McDowell, D., Kirwan, M.J. 2003. Food Packaging Technology. Blackwell Publishing Co.</li> </ol>
	3. Gosby, N.T. 2001. Food Packaging Materials. Applied Science Publication
Reference	1. Mahadevia, M., Gowramma, R.V. 2007. Food Packaging Materials. Tata McGraw Hill
Books	2. Robertson, G. L. 2001. Food Packaging and Shelf life: A Practical Guide. Narendra Publishing House.
	3. John, P.J. 2008. A Handbook on Food Packaging Narendra Publishing House
Reference videos	https://www.youtube.com/watch?v=NJBj0ArTcQA https://www.youtube.com/watch?v=b33hd8TO7ws https://www.youtube.com/watch?v=HCH_cVKJ51A https://www.youtube.com/watch?v=ToHIfshAt3g https://www.youtube.com/watch?v=f3JTA0YN3Hk
Reference NPTEL	https://nptel.ac.in/courses/126105015
Reference research/ review articles	<ol> <li>Xiong, Y. L. (2023). The storage and preservation of meat: I—Thermal technologies. In Lawrie's meat science (pp. 219-244). Woodhead publishing.</li> <li>Figura, L. O., &amp; Teixeira, A. A. (2023). Water activity. In Food Physics: Physical Properties-Measurement and Applications (pp. 1-57). Cham: Springer International Publishing.</li> <li>Jagoda, S. U. M., Gamage, J. R., &amp; Karunathilake, H. P. (2023). Environmentally sustainable plastic food packaging: A holistic life cycle thinking approach for design decisions. Journal of Cleaner Production, 400, 136680.</li> <li>Agarwal, A., Shaida, B., Rastogi, M., &amp; Singh, N. B. (2023). Food packaging materials with special reference to biopolymers-properties and applications. Chemistry Africa, 6(1), 117-144.</li> <li>Chen, Z., Qiao, J., Yang, X., Sun, Y., &amp; Sun, D. (2023). A review of grouting materials for pouring semi-flexible pavement: Materials, design and performance. Construction and Building Materials, 379, 131235.</li> </ol>

Course Cod	le		<b>Course Title</b>	L	T	Р	С	
10212BT13	4	MAR	NE BIOTECHNOLOGY AND AQUACULTURE	3	0	0	3	
<b>Course Cate</b>	gory	Program	n Elective					
Preamble		-	vide an adequate knowledge of the and aquaculture resources.	wealth	and	benefi	ts of	
Prerequisite	Courses	NIL						
Course Outcomes	Upon suc	ccessful c	ompletion of the course, students will	be able	e to:			
CO Nos.	Knowledge Level (Based on revised loom's Taxonomy)							
CO1	Outline t marine s		y, biochemicals, and food chain in t	he	K2			
CO2			e organisms and its importance in s d the importance of marine organisms		K2			
CO3	marine	about th system. e measure	1 1		]	K2		
CO4			ine pharmacology with the help ands produced from marine flora an		]	К2		
CO5		he know	ledge in aquaculture technology f 1s	or	]	K3		
Correlation of	of COs wit	h POs:						
			Progr	am				

CO Nos.	Course Outcomes				Prog	ramı	ne O	utco	mes	(POs	5)			Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Outline the history, biochemicals, and food chain in the marine system.	н											M	Н	М	
CO2	Illustrate about the organisms and its importance in sea water.	Н		Н	М								М	Н	Н	
CO3	Explain about the remediation and correction in the marine system. acquire to problems faced and the protective measures.	Н	М	Н	М								М	Н	Н	

CO4	help compou	cology with the of medicinal	н	Н	Н	Н	L						м н н				
CO5	in	the knowledge aquaculture ogy for various ions			М	М	Н							М	Н	Н	L
H – Hig	n; M- Me	dium; L- Low															
Course Content:         UNIT I       INTRODUCTION TO MARINE ENVIRONMENT       9 hours																	
UNIT I															9 ho		<i>.</i>
	ceans ans seas – ocean currents – physical and chemical properties of sea water – abiotic ic factors of the sea – ecological divisions of the sea – history of marine biology –																
				-				f th	e se	ea –	- hi	story	of	marir	ne bi	olog	gy –
bioecoch	emical c	ycles – food cha	in a	nd f	ood	web.	•										
UNIT II		MARINE EN BIOTECHNO				NTA	L								9 ho	urs	
Phytopla	nktons –	- zooplantons –	ne	kton	s –	bent	hos	- 1	mari	ine	ma	mma	als –	- mai	rine	alga	e –
mangrov	es – cora	l reefs – deep se	ea ar	nima	ls ar	nd ac	lapta	ation	n – i	nte	rtid	al zo	ne –	faun	a an	d flo	ra.
UNIT II	I	MARINE PH	AR	MAG	COL	.OG	Y							(	9 ho	urs	
Marine p	ollution	– biology indica	tors	(ma	rine	mici	ro, a	lgae	e) – 1	bio	deg	radat	tion	& bic	orem	edia	tion
– marine	fouling	and corrosion. I	Prot	ectic	on m	etho	ds a	gaiı	nst f	oul	ing	and	corr	rosion	1. Re	ed tio	des:
causative	e factors	and effects on th	ne or	rgan	isms	of n	nari	ne e	nvir	onr	nen	t.					
UNIT I	V	AQUACULT	URI	E TF	ЕСН	NOI	LOC	GΥ						(	9 ho	urs	
Medicin	al compo	und from marin	e flo	ora a	nd f	auna	ı — n	nari	ne t	oxi	ns (	tetro	doto	xins,	con	otox	ins,
and ciguateratoxins), antiviral, antimicrobial agents, antioxidants, collagen, gelatin, heparin,																	
chitosan, omega 3 fatty acids and carotinoids.																	
UNIT V COASTAL AQUACULTURE 9 hours																	
Important of coastal aquaculture – marine fishery resources – common fishing crafts and gears																	
	1.	1															
– aquafa	rm desigi	n and construction	on.														

LEARNING RE	SOURCES
Text Books	1. FingermanM. and Nagabhushanam MaryR.,"Recent advances in marine biotechnology", volume 3 & 2, Frances Thomson.
Reference Books	<ol> <li>Le Gal Y., Ulber, R, "Marine Biotechnology I: Advances in Biochemical Engineering/Biotechnology", Springer-Verlag Berlin Heidelberg, 2005.</li> <li>Attaway D.H. and Zaborsky O.R., "Marine Biotechnology: Volume I, Pharmaceuticals and Bioactive Natural Products", New York: Plenum. 1993.</li> </ol>
Reference videos	https://www.youtube.com/watch?v=AhkNDCe98U0 https://www.youtube.com/watch?v=nvSM9A-qW8w https://www.youtube.com/watch?v=yDBU1Dq5JTc https://www.youtube.com/watch?v=wVcIGaBZW1A https://www.youtube.com/watch?v=YGaFNZzjCXI
Reference NPTEL	https://archive.nptel.ac.in/courses/126/105/126105022/
Reference research/ review articles	<ol> <li>Morrow, R., Fu, L. L., Rio, M. H., Ray, R., Prandi, P., Le Traon, P. Y., &amp; Benveniste, J. (2023). Ocean circulation from space. Surveys in Geophysics, 44(5), 1243-1286.</li> <li>Wang, L., Liu, J., Bao, Z., Ma, X., Shen, H., Chen, J., &amp; Xie, P. (2024). Predictable shifts in diversity and ecosystem function in phytoplankton and zooplankton communities along thermocline stratification intensity continua. Science of the Total Environment, 912, 168981.</li> <li>Chen, J., Li, P., Wang, X., &amp; Yi, K. (2023). Above management: Scale development and empirical testing for public opinion monitoring of marine pollution. Marine Pollution Bulletin, 192, 114953.</li> <li>Nugraha, A. S., Firli, L. N., Rani, D. M., Hidayatiningsih, A., Lestari, N. D., Wongso, H., &amp; Keller, P. A. (2023). Indonesian marine and its medicinal contribution. Natural Products and Bioprospecting, 13(1), 38.</li> <li>Wang, M., Mao, D., Xiao, X., Song, K., Jia, M., Ren, C., &amp; Wang, Z. (2023). Interannual changes of coastal aquaculture ponds in China at 10-m spatial resolution during 2016–2021. Remote Sensing of Environment, 284, 113347.</li> </ol>

Course	Code				Co	ours	e Tit	tle						L	Т	I		С		
10212B	T135		FOOI	OOD SAFETY, QUALITY AND REGULATION										3	0	(	)	3		
~	~																			
Course	Categor	y	0	gram Elective																
Preample				p provide an adequate knowledge to learn food safety and quality uditing programme.																
Prerequ Courses	Prerequisite Courses Nil																			
Course																				
Outco		Upoi	n successfu	l co	mple	etion	of t	he c	our.	se, s	tud	ents	s will	l be d	able	to:				
CO Nos.				C	Cour	se O	utco	ome	S					(	nowl Basec oom'	l on r	evise	ed		
СО	91		pute diffennical and													K2				
CO	CO2 Acquaint know			ledg	ge or	n foo	d sa	К2												
CO	3	Iden	tify the qua	lity	attri	ibute	s of	foo	d							K3				
CO	94		elop Pre-l agement sy	Requisite program on food plant vstem										К3						
CO	95		pute aware dia and the	eness on regulatory and statutory bodies world												K3				
Correlat	ion of C	Os wi	th POs:													1				
CO Nos.	Cou	ırse Ou	tcomes		Programme Outcomes (POs)									Spe Out				ogram pecific atcomes PSOs)		
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3		
CO1	Comput of for physical biologic industry service	ood l, che al	Н	М	Н				М						Н					
CO2	· ^	nt knowledge on fety surveillance				М											М			
CO3	Identify attribute	y the quality tes of food									L		_		M			Н		
CO4	program	lop Pre-Requisite am on food plant gement system				Н			М						М					

CO5 Compute awareness on regulatory and statutory bodies in India and the world M	М	Н	М				
H – High; M- Medium; L- Low							
Course Content:							
UNIT I FOOD SAFETY AND SECURITY		hours					
Introduction to food safety and security, Factors contributing to physical, chemical and							
biological contamination in food chain, prevention and control of							
Regulation of food sanitation, personal hygiene-food handlers, cleaning co	-	ls, sanita	tion				
methods, waste disposal strategy (solid and liquid waste) and pest control							
UNIT II FOOD SAFETY SURVEILLANCE	9	) hours					
Food Adulteration, Food Additives, Food Packaging & labeling. Sanita	tion in v	varehous	ing,				
storage, shipping, receiving, containers and packaging materials. Cleani	ng and I	Disinfect	ion,				
ISO 22000 - Importance and Implementation. Requirements Specific	to Foo	d Testin	ıg –				
Physical and Chemical Parameters, Requirements Specific to Food T	Festing -	– Biolog	gical				
Parameters, General Topics: Related to Food Testing Laboratories.							
UNIT III FOOD QUALITY SYSTEM	9	) hours					
Various Quality attributes of food, Instrumental, chemical and microl	bial Qua	lity con	trol.				
Sensory evaluation of food and statistical analysis - Descriptive testing ar	nd Produ	ct Match	ing.				
Water quality and other utilities. Laboratory Quality Management Systems	ystem:O	verview	and				
Requirements of ISO 17025, Food Bioterrorism Acts. Food inspection	and Foo	d Law, I	Risk				
assessment - microbial risk assessment, dose response and exposure resp	onse mo	odelling,	risk				
management, implementation of food surveillance system to monitor	or food	safety,	risk				
communication							
UNIT IV PRE-REQUISITE PROGRAM	9	) hours					
Good Manufacturing Practices - Personal hygiene - occupational	health	and sa	fety				
specification, Food Plant Sanitation Management - Plant facilitie	s const	ruction	and				
maintenance - exterior of the building- interior of the building- e	quipmer	nts. Stor	age,				
transportation, traceability, recalling procedures, training.							
UNIT V FOOD SAFETY REGULATIONS	9	) hours					
Indian and global regulations: International Agencies in Food Regu	lation:	Food Co	odex				
Alimentarius: Codex India - Role of Codex Contact point, National Codex contact point							
(NCCP), National Codex Committee of India – ToR, Functions, Shad	ow Con	nmittees	etc.				
Various aspects and relation with domestic laws; FAO, WHO, WTO. FA							

Cooperation programmes, Bio-security in Food and Agriculture, World Health Organization (WHO), World Animal Health Organization (OIE), International Plant Protection Convention (IPPC).

LEARNING F	RESOURCES
Text Books	<ol> <li>Handbook of food toxicology by S. S. Deshpande, 2002</li> <li>The food safety information handbook by Cynthia A. Robert, 2009</li> <li>Nutritional and safety aspects of food processing by Tannenbaum SR, Marcel Dekker Inc., New York 1979</li> </ol>
Reference Books	1. Microbiological safety of Food by Hobbs BC, 1973
Reference videos	https://www.youtube.com/watch?v=0J2Qv_72Xzo https://www.youtube.com/watch?v=rkuInbWL_pI https://www.youtube.com/watch?v=yxlC-ffnfrY https://www.youtube.com/watch?v=ZvmMMDRQoyw https://www.youtube.com/watch?v=_mcsYYbhEhE
Reference NPTEL	https://nptel.ac.in/courses/126105336
Reference research/ review articles	<ol> <li>Kiran, V., Harini, K., Thirumalai, A., Girigoswami, K., &amp; Girigoswami, A. (2024). Nanotechnology's Role in Ensuring Food Safety and Security. Biocatalysis and Agricultural Biotechnology, 103220.</li> <li>Glykas, M. (2024). Quality management implementation maturity assessment in the food industry: glykas quality compass assessment on ISO 22000. International Journal of Productivity and Quality Management, 41(3), 289-336.</li> <li>Chen, L., Ning, F., Zhao, L., Ming, H., Zhang, J., Yu, W., &amp; Luo, L. (2023). Quality assessment of royal jelly based on physicochemical properties and flavor profiles using HS-SPME-GC/MS combined with electronic nose and electronic tongue analyses. Food Chemistry, 403, 134392.</li> <li>Overbosch, P., &amp; Blanchard, S. (2023). Principles and systems for quality and food safety management. In Food Safety Management (pp. 497-512). Academic Press.</li> <li>Choudhury, A., Singh, P. A., Bajwa, N., Dash, S., &amp; Bisht, P. (2023). Pharmacovigilance of herbal medicines: Concerns and future prospects. Journal of Ethnopharmacology, 116383.</li> </ol>

Course	Code			<b>Course Title</b>											L	T		P	С	
10212B	T136			S	STORAGE ENGINEERING											0		0	3	
Course (	Catego	ory	P	Program Elective																
					o acquire knowledge about the different storage techniques and torage design structures.															
Prerequ	isite C	ourse	s A	/IL																
Cours Outcon		Upon	succes	sful c	omp	oletio	on oj	f the	сои	rse,	stu	den	ts n	ill be	e abl	e to:				
CO No	DS.				C	ours	e Oı	itcoi	mes							now (Base) loom	d on i	revis	ed	
CO1		Outlin	ne the s	scope	and	imp	orta	nce o	of st	torag	ge ei	ngir	neer	ring.			K2			
CO2			ate the strespo							torag	ge a	and	tel	l the			K2			
CO3			the de														K3			
CO4		Plan t	he met	hods	ls and ways to store foods											K3				
CO5		Make	use of	the re	egul	atio	ns in	volv	ed i	n ste	orag	ge					K3			
Correlat	ion of	COs w	vith PC	)s:																
CO Nos.	C	ourse O	Outcome	8	Programme Outcomes (POs)										Program Specific Outcomes (PSOs)				c les	
					1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	impor		scope of st		М		Н									Н	L			
CO2	Illustr	ate th ges to the nsible	ne pos storag			М	Н									Н	L	Н		
CO3	1		desig ctures.	n of	М		Н	М								Н		М		
CO4		the methods and s to store foods			Н	М	Н									Н	Н	М		
CO5	Make regula storag	gulations involved in					Н			М		Н				Н	Н	Н	М	
H – Higł	n; M- N	Mediui	<b>m; L-</b> ]	Low																

Course Content:									
UNIT I	INTRODUCTION TO STORAGE ENGINEERING	9 hours							
Introduction,	Scope and Importance of Food and Grain storage, Methods a	and factors for Safe							
and scientific	c storage, Site selection for storage facilities, Overview of Pr	e and post Storage							
operations; (	cleaning, drying), Control measures to prevent spoilage during	storage, Inspection							
and Quality o	control of stored foods.								
UNIT II	DAMAGES TO STORAGE	9 hours							
Direct damag	ges, Indirect damages during storage, Biotic and Abiotic Fac	tors for spoilage in							
storage (moi	sture, temperature, humidity, respiration loss, heat of resp	iration, sprouting),							
destructive agents (rodents, birds, insects, etc.), Sources of infestation and control measures.									
UNIT III	DESIGN OF STORAGE STRUCTURES	9 hours							
Introduction	to food storage structures and facilities, Principles of Grain stor	rage loads, pressure							
and capacitie	s, Considerations in choice of storage structures, Functional an	nd structural design							
of grain stor	age structures, Modern and large scale storage: Bulk storage,	Warehouses; Silos							
(deep, shallow), Design aspects of Silos (Janseens equations).									
UNIT IV	STORAGE OF FOODS	9 hours							
Factors invo	lved in Storage of Perishables, Conditions for storage of p	erishable products,							
Principles of	Controlled and modified atmospheric storage, control of temp	erature and relative							
humidity, Hy	pobaric storage, Cold storage, evaporative cooling storage, fu	inctional, structural							
and thermal of	design of cold stores.								
UNIT V	<b>REGULATIONS INVOLVED IN STORAGE</b>	9 hours							
Regulations	and Quality control of storage structures, National and In	nternational market							
regulations in	n Storage specifications, BIS specifications, Centralized and de	ecentralized storage							
facilities, Ov	erview of logistics and supply control from storage facilities.								
LEARNING	RESOURCES								
	1. G. Boumans. 1985. Grain Handling and Storage. Elsevier	Science Publishers,							
	Amsterdam, The Netherlands. 2. C.W. Hall. 1980. Drying and Storage of Agricultural	Crops The AVI							
	Publishing Company, Inc., Westport, Connecticut, USA.	l'eleps. The rivi							
Text	3. Donald B. Brooker, F.W. Bakker-Arkema, Carl W. Hall								
Books	Storage of Grains and Oilseeds. The AVI Publishin Westport, Connecticut, USA.	ng Company, Inc.,							
	4. P.H. Pandey. 2014. Principles and Practices of Agricult	ural Structures and							
	Environmental Control. Kalyani Publishers, Ludhiana.								
	5. Myer Kutz. 2007. Handbook of Farm, Dairy, and Food M Andrew, Inc., Norwich, NY, USA.	Aachinery. William							
Reference	1. A.M. Michael and T.P. Ojha. 2004. Principal of Agricu	Iltural Engineering							
Books	Vol. I. Jain Brothers, New Delhi.	·····							

	2. L.W. Newbaver and H.B. Walker. 2003. Farm Buildings Design. Prentice-
	Hall Inc., New Jersey, USA.
	3. Jayas D.S., White N.D.G., Muir, W.E. 1994. Stored Grain Ecosystems.
	Marcel Dekker, New York.
	<b>4.</b> J. Whitaker. 2002. Agricultural Buildings and Structures. Reston Publishing
	Home, Reston, Virgenia, USA.
	https://www.youtube.com/watch?v=TNGno8H2Tzg
DC	https://www.youtube.com/watch?v=6jmSg4kiIuw
Reference	https://www.youtube.com/watch?v=BggCZHQ77Uc
videos	https://www.youtube.com/watch?v=N4vSFEd1MY8
	https://www.youtube.com/watch?v=CiEy9GmmFdM
Reference	
NPTEL	https://nptel.ac.in/courses/126105015
Reference research/ review articles	<ol> <li>Navaid, H. B., Emadi, H., &amp; Watson, M. (2023). A comprehensive literature review on the challenges associated with underground hydrogen storage. International Journal of Hydrogen Energy, 48(28), 10603-10635.</li> <li>Taher, H., San Martino, S., Abadia, M. B., &amp; Bartosik, R. E. (2023). Respiration of barley seeds (Hordeum vulgare L.) under different storage conditions. Journal of Stored Products Research, 104, 102178.</li> <li>Kolli, V. S., Garg, S., &amp; Shirkole, S. S. (2023). Silos and bins. In Transporting Operations of Food Materials Within Food Factories (pp. 61-93). Woodhead Publishing.</li> <li>Abbas, H., Zhao, L., Gong, X., &amp; Faiz, N. (2023). The perishable products case to achieve sustainable food quality and safety goals implementing on- field sustainable supply chain model. Socio-Economic Planning Sciences, 87, 101562.</li> <li>Lin, C., Burggräf, P., Liu, L., Adlon, T., Mueller, K., Beyer, M., &amp; Wang, F. (2023). Deep-Dive analysis of the latest Lithium-Ion battery safety testing standards and regulations in Germany and China. Renewable and Sustainable Energy Reviews, 173, 113077.</li> </ol>

# **OPEN ELECTIVE COURSES**

Course Co	de	<b>Course Title</b>	L	Т	Р	С							
10213BT1	01	BIOCHIPS	3	0	0	3							
Course Cat	egory	Open Elective											
Preamble		To know the essential concepts of biochips major applications in medical field.	To know the essential concepts of biochips and microarray with major applications in medical field.										
Prerequisit	e Courses	NIL											
Course Outcomes	Upon suc	ccessful completion of the course, students will be	able t	0:									
CO Nos.		<b>Course Outcomes</b>	(	Knowledge Level (Based on revised Bloom's Taxonomy)									
CO1	Understa mechanis	nd the working principles of biochips and detection m	n	]	K2								
CO2	Develop array for	0	K3										
CO3	Identify the use of DNA biomolecules in computing and bimolecular device with nanoelectronics												
CO4	Develop biochips.	the commercial and market strategies involved i	n	]	K3								
CO5		the biochips for molecular diagnostics, pharmace, drug discovery and epidemiology applications.	0	]	K3								

CO Nos.	Course Outcomes	Programme Outcomes (POs)											Program Specific Outcomes (PSOs)			
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the working principles of biochips and detection mechanism	Η		Η	Н								Η	Н	М	
CO2	Develop Acquisition and analysis techniques with micro array for various applications.	Η	Η	М	М		М						Н	Н	Н	
CO3	Identify the use of DNA biomolecules in computing and bimolecular device with nanoelectronics	Η	Η	Μ	L	L	Η						М	М	М	
CO4	Develop the commercial and market strategies involved in biochips.		Η	Μ	Η	Н	Η	Η					Η	Н	Н	

for dia CO5 gen dis epi	discovery and epidemiology applications.							L		
H – High; N	I- Medium; L- Low						1			
Course Cor										
UNIT I	INTRODUC							) hou		
	Biochips; Types	_			-					-
Oligonucleo	tide, cDNA and ge	enomic micro	oarrays,	Integra	ted bioch	ip sys	stem;	mic	croar	ray
scanners./he	aders, microarray rol	botics; micro	fluidics	systems	s, chips and	d mass	s spec	etron	netry	•
UNIT II	CONSTRUC	CTION OF I	BIOCHI	PS			9	) hou	irs	
Biochips ass	ays, combination of	nicroarray ar	nd bioser	nsor tecl	hnology, b	iochip	vers	us ge	el-ba	sed
methods, pr	ocess flow for prod	uction and a	nalysis o	of a chi	p, standar	dizati	on of	f mic	roar	ray
analysis, bio	informatics and mic	croarrays, eva	aluation	of conv	ventional 1	nicroa	array	tech	nolo	gy.
Electrical de	tection methods for	microarrays,	SERS (S	Surface-	Enhanced	Rama	an sp	ectro	scop	y)-
based micro	arrays.									
UNIT III	GENOME COMPUTIN		ROCES	SING	AND D	NA	9	) hou	irs	
Genome sig	nal processing: Introc	luction, Math	ematica	l model	s and Mod	eling l	DNA	Mic	roarr	ay;
DNA Comp	uting: Introduction,	Junctions, of	her shap	bes, Bio	ochips and	large	scal	e str	uctu	res;
Strand algeb	ras used in DNA con	nputing.								
UNIT IV	COMMERC	CIAL ASPEC	CTS OF	BIOC	HIPS		9	) hou	irs	
Markets for	biochip technolog	ies, commer	cial sup	port fo	r the dev	elopm	nent (	of b	iochi	ips,
government support for biochip development, business strategies and patent issues.										
UNIT V APPLICATIONS OF BIOCHIPS 9 hours										
Application of microarray technology in drug discovery development and drug delivery, use of										
DNA chip technology for drug safety, use of microchips for drug delivery, use of biochips in										
health care,	se of microarray in t	forensics, Lir	nitations	ofbiod	chip techno	ology.				

LEARNING RE	SOURCES
	1. Isaac S. Kohane, Alvin Kho, Atul J. Butte., "Microarrays for an Integrative Genomics (Computational Molecular Biology)", 1 st edition, MIT Press, 2002.
	<ol> <li>Helen C. Causton, John Quackenbush, Alvis Brazma., "Microarray Gene Expression Data Analysis: A Beginner's Guide", 1st edition, Wiley- Blackwell, 2003.</li> <li>Sorin Draghici, "Data Analysis Tools for DNA Microarrays", Har/Cdr</li> </ol>
Text Books	<ul> <li>Re edition, Chapman &amp; Hall/CRC, 2003.</li> <li>4. DNA Computing: 15th International Meeting on DNA Computing, DNA</li> </ul>
	15, Fayetteville, AR, USA, June 8-11, 2009, Springer, 2009.
	5. Grigorenko E., "DNA Arrays: Technology and Experimental Strategies", Vth Edition, CRC Press, 2002.
	<b>6.</b> Wan-Li Xing and Jing Cheng., "Biochips: Technology and Applications", Springer, 2003.
Reference Books	
Reference videos	https://www.youtube.com/watch?v=208pMhKoQeo https://www.youtube.com/watch?v=g8Qav3vIv9s https://www.youtube.com/watch?v=vefBhhjodpE https://www.youtube.com/watch?v=-EO5fmz0tts https://www.youtube.com/watch?v=HZ8f0F2RMuo
Reference NPTEL	https://nptel.ac.in/courses/112104029
Reference research/ review articles	<ol> <li>Kuru, C. İ., Ulucan-Karnak, F., &amp; Akgöl, S. (2023). Lab-on-a-chip sensors: recent trends and future applications. Fundamentals of Sensor Technology, 65-98.</li> <li>Chen, X., Yao, C., &amp; Li, Z. (2023). Microarray-based chemical sensors and biosensors: Fundamentals and food safety applications. TrAC Trends in Analytical Chemistry, 158, 116785.</li> <li>Pantic, I., Paunovic, J., Cumic, J., Valjarevic, S., Petroianu, G. A., &amp; Corridon, P. R. (2023). Artificial neural networks in contemporary toxicology research. Chemico-Biological Interactions, 369, 110269.</li> <li>Meng, X., O'Hare, D., &amp; Ladame, S. (2023). Surface immobilization strategies for the development of electrochemical nucleic acid sensors. Biosensors and Bioelectronics, 115440.</li> <li>Akinnuwesi, B. A., Olayanju, K. A., Aribisala, B. S., Fashoto, S. G., Mbunge, E., Okpeku, M., &amp; Owate, P. (2023). Application of support vector machine algorithm for early differential diagnosis of prostate cancer. Data Science and Management, 6(1), 1-12.</li> </ol>

Course	Code			С	ours	se Ti	itle						L	]	Γ	P	С		
10213B	ST102			BI	OSE	NSC	ORS						3	0	)	0	3		
Course	Category	Open l	Eleci	tive															
Preamb	le	recogn	This course helps to understand the use of biomolecues as recognition elements for detection of a particular analyte and the use of biological elements such as proteins in place of silicon chips.																
Prerequ	isite Cou	rses NIL																	
Cours Outcon	I n	Upon successful completion of the course, students will be ab									able to:								
CO No	<b>)</b> \$.	Course Outcomes									(Dase loom	d on	revis	ed					
CO1		Explain the application of biomolecules applications.								in	ser	nsing	5		K2				
CO2		lerstand principsensors and imp						ons	of t	the	imr	nune	K2						
CO3	dev	bly the biochen elop biosens etrodes.		l and an		ctroc olig						m to sitive			K2				
CO4		ke use of chro yme based fibe	-					opho	ore t	:o c	ons	truct	ţ	К3					
CO5	Ana	lyze the metals	s and	l mi	neral	ls by	usi	ng b	oiose	enso	ors.		K4						
Correlat	tion of CC	os with POs:																	
CO Nos.		se Outcomes				Prog	gram	me O	utcol	mes	(POs	\$)	Prog Spec Outco (PS0				cific		
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3		
CO1	of bio	the application molecules in opplications.	Н	Н	Н	Н								Н	Н	M	L		
CO2	Understa behind t	nd principle ne functions of une biosensors immobilized	H	Н	Н	Н		M	М					Н	Н	Н	L		
CO3	and e mechani biosenso oligonuc		н	Н	Н	Н	Н	Н	М					М	М	М	Н		

CO4	chromophores a:		Н	М	Н		Н						Н	Н	Н	
CO5	Apply the biosens tools for agricultur pharmaceuticals a drug indust applications	re, nd M	Н	Н	Н	Н	Н	Н	L				М	Н	Н	L
H – Hig	h; M- Medium; L- Lov	N														
	Content:		) <b>D</b> I				0							0.1		
UNIT I										1		<u> </u>		9 ho		
	ons, biological inspira							-		-					-	
-	tion event: Catalytic, S	-		-		•										
	ell sensing – bacteria,	yeast,	man	nma	lian	cell	, Ge	enera	atio	n of	Bio	osens	sor; l	Biom	nolec	ule
Immobi	lization Techniques.															
UNIT I	<b>BASIC DESIG</b>	N ANE	) TR	RAN	SDI	JCE	R							9 ho	urs	
Conside	rations calibration, dyn	amic R	lang	e, si	gnal	to n	oise	e, se	nsit	ivity	, se	lectiv	vity,	Inter	fere	nce
Recogni	tion/Transduction men	nbrane	pro	otein	ser	isor	s: io	on (	char	nnel	s, T	ypes	s of	Trar	nsduo	cer,
Optical;	Fiber Optic, FET, Imp	edance	e, Pie	ezoe	lectr	ic; (	Cant	ilev	er							
UNIT I	II DETECTION N	метн	ODS	S										9 ho	urs	
Fluoresc	ence Spectroscopy, U	V-Vis	Abs	orpt	ion a	and	Em	issic	on,	Surf	ace	Plas	mon	Res	onar	ice,
Magneti	c labeling, Electrocher	nical D	etec	tion												
UNIT I	V APPLICATION	NS OF	BIC	)SE	NSC	RS								9 ho	urs	
D:	ors and diabetes manag	ement,	Mic	rofa	bric	ated	bio	sens	ors	and	poi	nt-of	-care	e diag	gnos	tics
Biosens			1	linic	ala	nalv	vsis:	Sı	ırfa	ce	plas	mon	res	onan	ce	and
	, Noninvasive biosen	isors i	n cl	mit	ui u	licel										
systems	, Noninvasive biosen ent wave biosensors, B										-	s.				
systems	ent wave biosensors, B	iosenso	or in	can	cer a	and ]	HIV	ear	ly c		-	s.		9 ho	urs	
systems, evanesco UNIT V	ent wave biosensors, B	iosenso NS OF	or in NA	can NO	cer a	and ]	HIV RIAI	ear	ly c	liagi	nosi					cle,
systems, evanesco UNIT V Nano M	ent wave biosensors, B APPLICATION BIOSENSORS	iosenso <b>NS OF</b> Carbo	or in NA n ba	can NOI	cer a MAT Nar	rer rer	HIV RIAI /late	ear L <b>S I</b>	ly c N M	liagi	nosis	de ai	nd na	ano p	parti	
systems, evanesco UNIT V Nano M	ent wave biosensors, B APPLICATION BIOSENSORS laterials in biosensors; n dots, Role of nano	iosenso <b>NS OF</b> Carbo	or in NA n ba	can NOI	cer a MAT Nar	rer rer	HIV RIAI /late	ear L <b>S I</b>	ly c N M	liagi	nosis	de ai	nd na	ano p	parti	
systems, evanesco UNIT V Nano M Quantur Fabricat	ent wave biosensors, B APPLICATION BIOSENSORS laterials in biosensors; n dots, Role of nano ion.	iosenso <b>NS OF</b> Carbo	or in NA n ba	can NOI	cer a MAT Nar	rer rer	HIV RIAI /late	ear L <b>S I</b>	ly c N M	liagi	nosis	de ai	nd na	ano p	parti	
systems, evanesce UNIT V Nano M Quantur Fabricat	ent wave biosensors, B APPLICATION BIOSENSORS laterials in biosensors; n dots, Role of nano ion.	iosenso <b>NS OF</b> Carbo	or in NA n ba	can NOI	cer a MAT Nar	rer rer	HIV RIAI /late	ear L <b>S I</b>	ly c N M	liagi	nosis	de ai	nd na	ano p	parti	
systems, evanesco UNIT V Nano M Quantur Fabricat	ent wave biosensors, B APPLICATION BIOSENSORS [aterials in biosensors; n dots, Role of nano ion.	iosenso NS OF Carbo materi	or in NA n ba al ir	can NOI ased 1 Sig	cer a	TER 10 N An	HIV RIAI Mate	ear LS I rial, ficat	ly c N Mi	etal s, D		de an	nd na and	ano p Tra	partio	cer

	<ol> <li>Mohammed Zourob, "Recognition Receptors in Biosensors", 1st Edition, Springer-Verlag, New York.</li> <li>ZviLiron, "Novel Approaches in Biosensors and Rapid Diagnostic Assays", 1st Edition, Springer US, 2001.</li> </ol>
Reference	https://www.youtube.com/watch?v=9SF_8LP2xKM https://www.youtube.com/watch?v=4PvOLVzHV3g&list=PLkqcnysg6e- tdd24uyfDKlaC0vyFbkNdF
videos	https://www.youtube.com/watch?v=ER6YIeYjluY&list=PLkqcnysg6e- tdd24uyfDKlaC0vyFbkNdF&index=3 https://www.youtube.com/watch?v=IY0PswHQS9k https://www.youtube.com/watch?v=0-PvA1Sl4WE
Reference NPTEL	https://nptel.ac.in/courses/115107122
	1. Barhoum, A., Altintas, Z., Devi, K. S., & Forster, R. J. (2023). Electrochemiluminescence biosensors for detection of cancer biomarkers in biofluids: Principles, opportunities, and challenges. Nano Today, 50, 101874.
Reference	2. Lu, J., Zhuang, X., Wei, H., Liu, R., Ji, W., Yu, P., & Mao, L. (2024). Enzymatic Galvanic Redox Potentiometry for In Vivo Biosensing. Analytical Chemistry.
research/ review articles	3. Singh, A. K., Mittal, S., Das, M., Saharia, A., & Tiwari, M. (2023). Optical biosensors: A decade in review. Alexandria Engineering Journal, 67, 673-691.
	4. Selvolini, G., & Marrazza, G. (2023). Sensor principles and basic designs. In Fundamentals of Sensor Technology (pp. 17-43). Woodhead Publishing.
	5. Rubino, A., & Queirós, R. (2023). Electrochemical determination of heavy metal ions applying screen-printed electrodes based sensors. A review on water and environmental samples analysis. Talanta Open, 100203.

Course Co	de	Course Title	L	Т	Р	С				
10213BT10		BIOMATERIALS ENGINEERING	3	0	0	3				
			-		-	-				
Course Cat	egory	Open Elective								
Preamble		This Course will give a broad view towa biomaterials, its properties, manufacturin applications.				v				
Prerequisite	Prerequisite Courses NIL									
Course Outcomes	Upon suce	cessful completion of the course, students will be	able	to:						
CO Nos.		Course Outcomes	(1	nowle Based o oom's '	on revi	sed				
CO1	Understan	d the physiochemical properties of Biomaterials	K2							
CO2		Metallic and Ceramic biomaterials for various oplications	К3							
CO3		ł	ζ3							
CO4		biomaterials according to the mechanisms and as of friction and wear.	К3							
CO5		and identify the degradation and Corrosion stics of biomaterials		ł	κ3					

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
CO1 d CO2 d f cO3 t		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the physio chemical properties of Biomaterials			М									Н	Н	М	
CO2	Apply the Metallic and Ceramic biomaterials for various medical applications	н	М	М									Н	Н	Н	
CO3	Make use of biopolymers for various industrial applications.		М	М									Н	Н	Н	L
CO4	Select the biomaterials according to the mechanisms and regularities of friction and wear.	Н	Н	Н	М								Н	Н	М	L

CO5 Co cha	velop and identify degradation and rrosion H H H M H materials H H H M	H H M L
H – High; M	I- Medium; L- Low	
Course Con	tent:	
UNIT I	BIOMATERIALS	9 hours
Introduction	to Biomaterials, Physical and Chemical properties, perform	nance, response to
implants, blo	ood compatibility, Nanoscale phenomena.	
UNIT II	METALLIC AND CERAMIC BIOMATERIALS	9 hours
Different im	plants - Stainless steels, cobalt-based alloys, Titanium-based all	oys, shape memory
alloy, ceram	nic implant, nanostructured metallic implants, biodegradable	or bioresorbable,
bioactive cer	ramics, nanostructured bio ceramics.	
UNIT III	POLYMERIC BIOMATERIALS	9 hours
Polymer as	biomaterials, Polymerization, properties of polymers, biodeg	gradable polymers,
Introduction	bio polymers: Collagen, Elastin and chitin, Medical Textiles.	
UNIT IV	FAILURE AND TRIBOLOGY OF BIOMATERIALS	9 hours
Failure and	Tribology of Biomaterials: Deformation Mechanics, Fra	acture Mechanics,
Classificatio	n of Fracture, Brittle to Ductile Transition of Biomaterials, T	oughness Analysis
of Biomateri	als.	
UNIT V	DEGRADATION AND CORROSION OF BIOMATERIALS	9 hours
Degradation	and Corrosion of Biomaterials: Surface Properties, Degradation	on of Biomaterials,
Corrosion of	Biomaterials, Methods of Corrosion Testing, Biocompatibility	of Implants.
LEARNING	G RESOURCES	
Text Books	1. Sujata V. Bhatt, "Biomaterials", Second Edition, Narosa 2005.	Publishing House,
Reference Books	<ol> <li>Sreeram Ramakrishna, Murugan Ramalingam, Sampath Winston O. Soboyejo, "Biomaterials: A Nano Appro 2010.</li> </ol>	,
Reference videos	https://www.youtube.com/watch?v=-jw8osY5QJM https://www.youtube.com/watch?v=k_ftHmWEHm8 https://www.youtube.com/watch?v=BYW7IzqxdWQ https://www.youtube.com/watch?v=Oq7Q-Xf2jGg https://www.youtube.com/watch?v=iALmpZHTXx4	

1 Dang I	
and sterSurfaceNature2.Que, Y(2023).aneurysReferenceresearch/reviewarticles4.Bienz,Ivanovsof soft tin the ra5.Colaço,	<ul> <li>, &amp; Gao, C. (2023). An introduction to scaffolds, biomaterial surfaces, m cells. In Polymeric Biomaterials for Tissue Regeneration: From /Interface Design to 3D Constructs (pp. 1-38). Singapore: Springer Singapore.</li> <li>, Zhang, Z., Zhang, Y., Li, X., Chen, L., Chen, P., &amp; Chang, J. Silicate ions as soluble form of bioactive ceramics alleviate aortic m and dissection. Bioactive materials, 25, 716-731.</li> <li>P. C., Mascarenhas-Melo, F., Pedrosa, K., Lopes, D., Lopes, J., o-Soares, A., &amp; Paiva-Santos, A. C. (2023). Polymer-based rials for pharmaceutical and biomedical applications: A focus on drug administration. European Polymer Journal, 187, 111868.</li> <li>S. P., Vaquette, C., Ioannidis, A., Hämmerle, C. H., Jung, R. E., ki, S., &amp; Thoma, D. S. (2023). Tissue integration and biodegradation issue substitutes with and without compression: an experimental study tt. Clinical Oral Investigations, 27(1), 313-328.</li> <li>R., &amp; Serro, A. P. (2024). Sterilization methods. In Hydrogels for Engineering and Regenerative Medicine (pp. 139-159). Academic</li> </ul>

Course Code		Course Title		L	Т	Р	С
10213BT104	BIO-INS	PIRED DESIGN: PRINCIPLES AN PRACTICE	ND	3	0	0	3
<b>Course Category</b>	7	Open Elective					
PreambleThis course introduces and explains the opportunities available in engineering de					princi	iples	and
Prerequisite Cou	irses	NIL					
Course Outcomes	Upon succ	essful completion of the course, studen	ts will	be a	ble to:		
CO Nos.	Know on	ı revi	e Leve sed Bloc konomy	om's	ased		

CO1	Relate the nature based biological systems to engineering designs.	K2
CO2	Understand the structural and functional properties of bio composites	K2
CO3	Develop the biosensors and navigators from the working principle of natural biosystems	К3
CO4	Make use of natural design to design the engineering tools	К3
CO5	Utilize the biological concepts to identify various computational and industrial tools	К3

CO Nos.	Course Outcomes		Programme Outcomes (POs)											Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Relate the nature based biological systems to engineering designs.			М			L						Н	М	Н	L
CO2	Understand the structural and functional properties of bio composites	н		М			Η						Н	Н	Н	
CO3	Develop the biosensors and navigators from the working principle of natural biosystems	ц	Н	Н	М		М						Н	Н	Н	
CO4	Make use of natural design to design the engineering tools		М	Н	Н		М						Н	Н	Н	Н

CO5 con	ize the biological cepts to identify ous computational industrial tools H H H H H		Н	Н	Н	М			
H – High; M	- Medium; L- Low								
Course Con									
UNIT I	INTRODUCTION TO BIOLOGICAL SYSTEM			hou					
	to biological systems, Biological systems and in								
Design base	d adaptations in biological systems, Observation	n of Nat	ture base	ed d	esigr	1 —			
principles an	d methods, Application of bio inspired design for en	igineers.							
UNIT II	BIOMIMETICS		9	hou	rs				
Introduction	to Biomimetics, Elements of Biological design a	us seen i	n nature	, Fu	nctio	nal			
rationale of	bio inspired design, Studies on structural, functi	onal pro	perties o	of bio	olog	ical			
material (skeletal structure, muscular structure, exoskeletons, plants and tree structure - Tree									
trunks, Bamboo), Bio composites and Biomaterials.									
UNIT III	BIOLOGICAL SYSTEMS OF PERCEPTION NAVIGATION	N AND	9	hou	rs				
Perception -	spatial awareness and biological sensors in nature, G	ait, move	ment and	lloco	omot	tion			
from Biolog	y, Bio-optics, Bio-photonics, Navigational meth	ods four	nd in na	ture	– ł	oird			
migration,	Energy conservation in organisms – hiberr	ation,	fat/nutrie	nt	stora	ige,			
•	ion networks in nature.					0			
UNIT IV	BIO- INSPIRED DESIGN FOR ENGINEERS		9 hou	rs					
Introduction	to Advanced concepts in Bio- inspired design for	r enginee	ers, Sym	bioti	c liv	ring			
structures an	d design, Nanostructures in nature – Gecko grip, S	hark skir	n; Integra	ted 1	netw	ork			
across large	listances – termite mounds, root network, Mycelial	mats.							
UNIT V	CASE STUDIES		9 hou	rs					
Existing bio	inspired designs used by engineers, Case studie	s of aest	thetic V/	's fu	nctio	nal			
designs from	n nature, Applications in robotics, Bio- inspired	d Comp	utational	tecł	nniqu	les,			
Concepts of	green building and Industrial ecology, activity on bi	o inspire	d design.						
LEARNING	RESOURCES								
Text Books	1. Maria G. Trotta, "Bio-inspired Design Methodo Information Science 1(1), 2011.	logy", In	ternation	al Jo	urna	l of			
Reference	<ol> <li>Yoseph Bar-Cohen, "Biomimetics: Nature-Ba 2016.</li> </ol>	ised Inno	ovation",	CRO	C Pro	ess,			
Books	2. Ashok K.G., Daniel A. McAdams, and Ro inspired designs: computational methods and to								

	<ol> <li>Lakhtakia A. and Martin-Palma R.J., "Engineered biomimicry", Elsevier, 2013.</li> <li>Reich Y., "A critical review of General Design Theory", Research in Engineering Design, 7 (1) 1-18, 1995.</li> </ol>
Reference videos	https://www.youtube.com/watch?v=vWSsNi5uFVY https://www.youtube.com/watch?v=wvAXzlHpSs8 https://www.youtube.com/watch?v=jmxiMZ67VZs https://www.youtube.com/watch?v=iMtXqTmfta0 https://www.youtube.com/watch?v=Ezd4AcC3uZ4
Reference NPTEL	https://nptel.ac.in/courses/127106231
Reference research/ review articles	<ol> <li>Martinez, A., DeJong, J., Akin, I., Aleali, A., Arson, C., Atkinson, J., &amp; Zheng, J. (2022). Bio-inspired geotechnical engineering: principles, current work, opportunities and challenges. Géotechnique, 72(8), 687-705.</li> <li>Tang, T. C., An, B., Huang, Y., Vasikaran, S., Wang, Y., Jiang, X., &amp; Zhong, C. (2021). Materials design by synthetic biology. Nature Reviews Materials, 6(4), 332-350.</li> <li>Yue, X., Tao, T. H., &amp; Jiang, J. (2022, January). Visualized Drug Release Silk Patch Using Thermal Nanoimprinting of Pdms Template. In 2022 IEEE 35th International Conference on Micro Electro Mechanical Systems Conference (MEMS) (pp. 21-24). IEEE.</li> <li>Göçerler, H., Gachot, C., Grützmacher, P. G., &amp; Eder, S. J. (2023). Skin as an interface: Understanding the synergy of dermatology, biomimetics and tribology. Tribology and Materials, 2(3), 128-153.</li> <li>Molina, D., Poyatos, J., Ser, J. D., García, S., Hussain, A., &amp; Herrera, F. (2020). Comprehensive taxonomies of nature-and bio-inspired optimization: Inspiration versus algorithmic behavior, critical analysis recommendations. Cognitive Computation, 12, 897-939.</li> </ol>

Course Code			<b>Course Title</b>										L	Т	Р		С
10213BT105 ENGIN				EERING ADVANCES IN FOO PRESERVATION									2	0	0		2
Course	Category	Ope	n El	lecti	ve												
Preamb	le	knov	This course will give a broad view towards fundamental knowledge of modern food preservation techniques and the equipment used.														
Prerequ	isite Cours	es NIL															
Course Outcom s		uccessful com	ple	tion	of th	ne co	urse	e, sti	ıder	its v	vill	be a	ble t	<i>o:</i>			
CO Nos	s.	Course Outcomes											evel 's Ta				
CO1		Understand the principles of heat and mass transfer in food processing											K2				
CO2		Implementing the proper canning technology in food preservation								K3							
CO3	Apply of foods	Apply different thermal technologies to preserve the foods								K3							
CO4	Apply foods	Apply the chemicals and antibiotics to preserve the foods								K2							
CO5		Design the proper food packaging materials for food transport							K3								
Correlat	ion of COs	with POs:															
CO Nos.	Course	Outcomes	Programme Outcomes								(POs	)		Program Specific Outcomes (PSOs)			
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1		of heat and sfer in food	Н	Н	М			М						Н	Н	Н	
CO2	Implement proper technology preservatio	canning in food		М	М	М		Н						Н	М	Н	н
CO3	technologi preserve th	e foods	Н	Н	М			Н						Н	Н	Н	M
CO4	Apply the and ant preserve th	e chemicals ibiotics to le foods	Н	Н	Н	Н		Н						М	М	Н	

CO5 p	Design the proper food ackaging materials for bod transport	Н	Н	Н	Н		М						Н	Н	М	М	
H – High; M- Medium; L- Low																	
Course Co																	
UNIT I	INTRODUCTION													ours			
Introductio	n to food preservation	1 —	Obje	ectiv	es ai	nd n	node	ern	tecł	nniq	lues	in fo	ood p	orese	rvati	ion.	
Transport	phenomena with respec	et to	foo	ds; F	acto	ors a	ffect	ting	hea	it ai	nd m	lass t	ransi	fer; S	Study	y of	
heat transf	er and its application in	the	des	ign o	of the	erma	al pr	oce	sses	an	d fre	ezing	g. Pa	steur	izati	ion.	
UNIT II	CANNING TECHN	IOI	JOG	Y									9 h	ours	6		
Preservatio	on principle of canning	of	food	iter	ns, t	hern	nal p	proc	essi	ing	food	ls, N	ewei	met	hods	s of	
thermal pr	ocessing; application	of	infra	a-red	l mi	crov	vave	es; (	ohn	nic	heat	ing;	pres	erva	tion	by	
concentrat	ion and dehydration; os	smo	tic n	netho	ods.	Des	ign o	ofm	ode	ern	Canr	ning	macl	nines			
UNIT III	NIT III DRYING AND REFRIGERATION TECHNOLOGY								9 h	ours	5						
Water activ	vity of food and its sigr	nific	ance	in f	ood	pres	erva	tior	n; de	ehy	drati	on ai	nd dr	ying	of f	ood	
items; IM	F; Low temperature 1	ores	erva	tion:	col	d st	torag	ge,	free	zin	g. D	Desig	n pa	irame	eters	of	
different ty	pes of dryers; freezin	g aı	nd c	old s	stora	.ge.	Free	eze	dryi	ing,	IQI	F; Re	efrige	eratio	on lo	oad,	
design of f	reezers and cold storag	ges n	nach	ines	•	-			-	-			-				
UNIT IV	NON-THERMAL	ГЕС	CHN	OL	OGY	ľ							9 h	ours	5		
Super Crit	ical Technology for Pre-	eser	vatio	on - (	Cher	nica	ıl pr	eser	vati	ives	, pre	eserv	ation	by i	oniz	ing	
radiations,	ultrasonics, high pre	ssur	e, f	erme	entat	ion,	cur	ing,	, pi	ckli	ing,	smo	king	, me	mbr	ane	
technology	. Modern Hurdle techr	nolo	gy. /	Antił	oioti	cs, l	actic	e aci	d b	acte	eria.						
UNIT V	FOOD PACKAGIN	NG '	ГЕС	CHN	OL	) JGY	Y					9 hours					
Basic pac	kaging materials, type							ging	; m	ach	ine	desi	gn, 1	etort	po	uch	
packing, P	reservation of foods by	lov	v ten	npera	ature	es Co	onsi	dera	itioi	ns r	elatii	ng to	stor	age d	of fo	ods	
	perature, controlled and			-								-		-			
LEARNIN	IG RESOURCES																
Text Books	1. KyzlinkV., "Princ Elsevier Press, 1	-		Foo	d Pr	eser	vatio	on (	Dev	velo	pme	ents i	n Fo	od S	cien	ce),	
Referenc e Books	1. SivasankarB., "I 2002.	Food	l Pro	oces	sing	anc	l Pro	eser	vati	on'	', Pr	entic	e H	all o	f In	dia,	
C DUUKS	2. Singh M.K., "Fo	od I	Prese	ervat	ion"	, Di	scov	ery	Pul	olis	hing	, 200	7.				
Referenc	https://www.youtube xItIeO3LJaFQnhdx	e.co	m/w	atch'	?v=d	lJXs	T6g	JXg	30&	list	=PL	AY9	8libo	βFHc	wL3	3H-	
e videos	https://www.youtube									U							
	https://www.youtube	2.CO	n/w	atch	∶v=b	033h	að I	0/1	NS								

Referenc	https://www.youtube.com/watch?v=0RCsmoqRGBY&list=PLbRMhDVUMngd Syw7OUHJJNYPfo_p4Ysln&index=20 https://www.youtube.com/watch?v=VZ0ke71IXZE&list=PLAY98libqFHqk2qN GnFS8zmgBXh-ZNyBw
e NPTEL	https://nptel.ac.in/courses/126103017
Referenc e research/ review articles	<ol> <li>Yu, T., Niu, L., &amp; Iwahashi, H. (2020). High-pressure carbon dioxide used for pasteurization in food industry. Food Engineering Reviews, 12(3), 364-380.</li> <li>Kutlu, N. (2022). Optimization of ohmic heating-assisted osmotic dehydration as a pretreatment for microwave drying of quince. Food Science and Technology International, 28(1), 60-71.</li> <li>Noriega-Juárez, A. D., Rubio-Carrillo, J. D., de Lourdes García-Magaña, M., González-Aguilar, G. A., Meza-Espinoza, L., Chacón-López, M. A., &amp; Montalvo-González, E. (2024). Comparison of individual quick freezing and traditional slow freezing on physicochemical, nutritional and antioxidant changes of four mango varieties harvested in two ripening stages. Food Chemistry Advances, 4, 100590.</li> <li>Kaveh, S., Hashemi, S. M. B., Abedi, E., Amiri, M. J., &amp; Conte, F. L. (2023). Bio-preservation of meat and fermented meat products by lactic acid bacteria strains and their antibacterial metabolites. Sustainability, 15(13), 10154.</li> <li>Latos-Brozio, M., &amp; Masek, A. (2020). The application of natural food colorants as indicator substances in intelligent biodegradable packaging materials. Food and Chemical Toxicology, 135, 110975.</li> </ol>

Specialization Food and Precision Agriculture

Course Co	de	Course Title	L	Т	Р	С							
10212BT13	31	PRINCIPLES OF FUNCTIONAL FOOD AND APPLICATIONS	3	0	0	3							
Course Cat	egory	Program Elective											
Preamble		To know more about functional foods and its nutritional values, also the development of functional foods and its processing methods.											
Prerequisite	e Courses	NIL	NIL										
Course Outcomes	Upon successful completion of the course students will be able to:												
CO Nos.		(	Knowledge Level (Based on revised Bloom's Taxonomy)										
CO1	Outline th its regulate	1	]	K2									
CO2	Relate def		K2										
CO3	Build the and functi	S	К3										
CO4	-	the interactions of environmental factors or g and storage of foods	1	]	K3								
CO5	t	К3											

CO Nos.	Course Outcomes	Programme Outcomes (POs)											Program Specific Outcomes (PSOs)			
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Outline the types of nutraceutical and functional foods and its regulatory issues				L			L					Н	Н	М	
CO2	Relate deficiencies of essential nutrients to diseases.			L	L		L	L					Н	Н	М	
CO3	Build the steps in product developments of Nutraceuticals and functional foods			М		М	L	L					Н	М	L	
CO4	Identify the interactions of environmental factors on processing and storage of foods	н	М	М	L				М				М	М	L	Н

App	ly the methods to						
CO5 proce	ess functional M I I I	М	М				
food form	s into different						
	Medium; L- Low						
Course Conte	ent:	I					
UNIT I	INTRODUCTION TO FUNCTIONAL FOODS		) hou				
Introduction to	o functional foods, importance, history, definition, classification	on, list o	of fu	nctio	nal		
foods active i	ngredients, health benefits, Recent development and advan	ces in	the a	areas	of		
functional foo	ds. Marketing and regulatory issues for functional foods.						
UNIT II	NUTRITIONAL VALUE OF FUNCTIONAL FOODS	9	) hou	irs	-		
Therapeutic n	utrition & formulation of special dietary foods; Relation of	food a	nd d	iseas	ses;		
Deficiencies	of essential nutrients; Assessment of nutritional status &	k RDA	, Et	ffect	of		
processing on	nutrients.						
UNIT III	FORMULATION OF FUNCTIONAL FOODS	9	) hou	irs			
Steps in produ	tet developments of functional foods, formulation of function	al food	s coi	ntain	ing		
nutraceuticals	- stability and analytical issues. selections, optimal stability of	conditio	ons o	fact	ive		
ingredients/co	mpounds used in the developments, selections of approp	oriate p	orodu	icts	for		
individual ac	ctive compound or patient/consumer, health-benefitting	level	of	act	tive		
ingredients/co	mpounds, developments of base formulae and formulae	conta	ining	act	ive		
ingredients/co	mpounds as well						
UNIT IV	ROLE IN HEALTH AND DISEASES	9	) hou	irs			
Functional fo	ods and immune competence; role and use in obesity ar	nd nerv	ous/	syst	em		
disorders, Fun	ctional foods and nutraceuticals with attributes to control card	iovascu	lar d	iseas	ses,		
cancer, ageing	<u>.</u>						
UNIT V	PROCESSING OF FUNCTIONAL FOODS	9	) hou	irs			
Processing of	Functional Foods in various forms of powders, beverage	s, snac	ks; s	stabi	lity		
consideration,	limitation, precaution to retain bioactive compounds. Effe	ects of	pro	cessi	ng,		
storage and interactions of various environmental factors on the potentials of such foods.							
LEARNING	RESOURCES						
	1. Shi J.(Ed) 2006. Functional Food Ingredients and Nutrace	euticals	: Pro	cess	ing		
Text Books	Technologies CRC.	Ennatio		Faad	1~"		
	2. Wildman, Robert "Handbook of Nutraceuticals and I CRC, 2006.	r unctio	mal	r000	15.		
					C		
Reference Books	Functional Foods by R. Chadwick, S. Henson, B. Moseley Analysis for Functional Foods and Nutraceuticals by W. Jef			hods	of		

Reference NPTEL	https://archive.nptel.ac.in/courses/126/105/126105015/
Reference research/ review articles	<ol> <li>Díaz, L. D., Fernández-Ruiz, V., &amp; Cámara, M. (2020). An international regulatory review of food health-related claims in functional food products labeling. Journal of Functional Foods, 68, 103896.</li> <li>Gómez, I., Janardhanan, R., Ibañez, F. C., &amp; Beriain, M. J. (2020). The effects of processing and preservation technologies on meat quality: Sensory and nutritional aspects. Foods, 9(10), 1416.</li> <li>Alongi, M., &amp; Anese, M. (2021). Re-thinking functional food development through a holistic approach. Journal of Functional Foods, 81, 104466.</li> <li>Khalaf, A. T., Wei, Y., Alneamah, S. J. A., Al-Shawi, S. G., Kadir, S. Y. A., Zainol, J., &amp; Liu, X. (2021). What is new in the preventive and therapeutic role of dairy products as nutraceuticals and functional foods?. BioMed research international, 2021(1), 8823222.</li> <li>Perfilova, O. V., Akishin, D. V., Vinnitskaya, V. F., Danilin, S. I., &amp; Olikainen, O. V. (2020, August). Use of vegetable and fruit powder in the production technology of functional food snacks. In IOP Conference Series: Earth and Environmental Science (Vol. 548, No. 8, p. 082071). IOP Publishing.</li> </ol>

Course	Code		Course Title									L	ſ		P	С	
10212B	ST132		NUTRACEUTICALS										3	0		0	3
Course	Category	Progra	Program Elective														
Preamb	le	ovides knowledge in newly emerging area of nutraceuticals with spect to the types, mechanisms of action, manufacture of selected traceuticals, product development, clinical testing and toxicity pects.															
Prerequ	isite Cours	es NIL															
	T																
Cours Outcom	I / non	successful cor	nple	etion	of t	he co	ours	e, st	ude	nts	wil	l be d	ıble	to:			
CO No	s.		Co	urse	Out	tcon	ies							now Base loom'	d on	revis	ed
CO1		history and s factors	ba	sis c	of nu	ıtrac	euti	cals	in	rel	atio	n to			K2		
CO2	Unders	Understand concepts of nutrition							nt a	nd	indi	ces			K2		
CO3	-	Comprehend nutritional disorders and role of nutraceuticals in medicine K2															
CO4		Develop the product with metabolites for various in medicinal and treatment purpose K3															
CO5		Apply knowledge formulation as func				ge of nutraceutical production and actional foods									K3		
													I				
Correlat	ion of COs	with POs:															
CO Nos.	Course	Outcomes	Programme Outcomes (POs)										Program Specific Outcome (PSOs)			c es	
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	of nutrac			L	М									Н	L	М	
CO2	Understand nutritional and indices				L	L								Н		М	
CO3	disorders	omprehend nutritional sorders and role of atraceuticals in edicine			Н		L							М	М	М	
CO4	with meta various ir	nedicine Develop the product vith metabolites for arious in medicinal nd treatment purpose			L			М		М				Н	Н		Н

CO5	Apply knowledge of nutraceutical production and formulation as functional foods	M	L	Н									Н	М		
H – Higl	H – High; M- Medium; L- Low															

### **Course Content:**

## UNIT I INTRODUCTION

History, definition, classification and source of nutraceuticals, basis of claims for a compound as a nutraceutical, benefits of nutraceuticals, role of nutraceuticals in Medicine, Human physiology, genetics, food technology, chemistry and nutrition, scope and availability involved in the industry, Indian and global scenario.

### UNIT II NUTRITIONAL ANALYSIS

### 9 hours

9 hours

Food components based on nutritional value, nutritional assessment of carbohydrates, proteins and fats, recommended dietary intake, recommended daily allowance (RDA), acceptable dietary intake, nitrogen balance, protein efficiency ratio (PER), basics of energy balance - Basal Metabolic Rate (BMR), Body Mass Index (BMI) and Standard Dynamic Action (SDA) with special reference to nutraceutical industry

UNIT III	DIETARY FOODS	9 hours
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Factors responsible for nutritional disorders: Malnutrition, undernutrition and anti-nutritional factors (cyanogens, lectins, enzyme inhibitors, phytoallexins and phytates), types of metabolic disorders, nutritional factors, nutraceuticals for prevention and treatment (diabetes mellitus, hypertension, hypercholesterolemia, etc), concept of antioxidants - use of antioxidants as dietary supplements in prevention and treatment of cancer, obesity and stress, role of nutraceuticals and functional foods in pediatrics, geriatrics, sports, pregnancy and lactation, functional food as remedies.

### UNIT IV PLANT AND ANIMAL METABOLITES

#### 9 hours

Plant secondary metabolites, classification and sub-classification -alkaloids, phenols, Terpenoids. Animal metabolites - chitin, chitosan, glucosamine, chondroitin sulphate, polysaccharides of animal origin, uses and applications in preventive medicine and treatment, Concept of prebiotics and probiotics, synbiotics for maintaining good health, algae as a source of omega - 3 fatty acids, antioxidants and minerals - extraction and enrichment.

# UNIT VINDUSTRIAL PRODUCTION AND FORMUALTION<br/>OF NUTRACEUTICALS9 hours

Industrial production of nutraceuticals, formulation of functional foods containing nutraceuticals, manufacturing aspects of nutraceuticals (lycopene, isoflavonoids, prebiotics and

probiotics, glucosamine, phytosterols etc), preferences and globalization on selection of nutraceutical products, identification and estimation of health benefits of selected nutraceuticals, quality evaluation of foods containing nutraceuticals, packaging and labeling of functional foods, toxicology and bioavailability, use of animal models, pre-clinical and clinical trials involved.

LEARNING	RESOURCES
Text Books	
Reference Books	<ol> <li>Handbook of nutraceuticals and functional foods by Robert E C. Wildman, CRC/Taylor&amp;Francis</li> <li>Handbook of nutraceuticals Vol I by Yahwant Vishnupant Pathak, CRC press.2009</li> <li>Handbook of nutraceuticals Vol II by Yahwant Vishnupant Pathak, CRC press,2011</li> <li>Handbook of Prebiotics, Glenn R. Gibson, Marcel Roberfroid, CRC press, 2008.</li> <li>Swaminathan M., Essentials of Food and Nutrition, 2nd Ed, 1985, Ganesh and Co.</li> <li>Dietary Supplements: Toxicology and Clinical Pharmacology. Humana Press. Gibson GR &amp; William CM. 2000.</li> <li>Dietary Supplements. 2nd Ed. Pharmaceutical Press. Campbell JE &amp; Summers JL. 2004.</li> <li>Bioprocesses and Biotechnology for Nutraceuticals. Chapman &amp; Hall. Robert EC. 2006.</li> <li>Handbook of Nutraceuticals and Functional Foods. 2nd Ed. Wildman.</li> <li>Nutrition in Health and Disease 17th Edition; Anderson, Dibble, Turkki, Mitchell, Rynbergen J.B. Lippincott Company, 1982</li> <li>Dietary Supplements of Plant Origin, M. Maffei (Ed.), Taylor &amp; Francis, 2003.</li> <li>Bioprocesses and Biotechnology for Functional Foods and Nutraceuticals, Jean – Richard Neeser &amp; J. Bruce German, Marcel Dekker, Inc., 2004.</li> <li>Nutraceuticals in health and disease prevention, Klaus Krämer, Peter-Paul Hoppe, Lester Packer</li> <li>Nutraceutical beverages Chemistry, Nutrition and health Effects, Shahidi and Weerasinghe (Ed.), American Chemical Society, 2004.</li> <li>Functional Foods: Principles and Technology, M. Guo, CRC press, 2009.</li> </ol>
	https://www.youtube.com/watch?v=h8uV5I_N8w4
	https://www.youtube.com/watch?v=ojhdTFmkY1c
Reference	https://www.youtube.com/watch?v=Ua-dLw2nFs4
videos	https://www.youtube.com/watch?v=_NNtgHmD5BU
	https://www.youtube.com/watch?v=K3L3DMkfyc8
Reference NPTEL	https://archive.nptel.ac.in/courses/126/105/126105015/

	1. Kaur, M., Bhatia, S., Gupta, U., Decker, E., Tak, Y., Bali, M., & Bala, S. (2023). Microalgal bioactive metabolites as promising implements in nutraceuticals and pharmaceuticals: inspiring therapy for health benefits. Phytochemistry Reviews, 22(4), 903-933.
Reference research/ review articles	<ol> <li>Chauhan, A. S., Patel, A. K., Nimker, V., Singhania, R. R., Chen, C. W., Patel, A. K., &amp; Dong, C. D. (2024). Biorefining of essential polyunsaturated fatty acids from microbial sources: current updates and prospects. Systems Microbiology and Biomanufacturing, 4(2), 425-447.</li> <li>Duraiswamy, A., Sneha A, N. M., Jebakani K, S., Selvaraj, S., Pramitha J, L., Selvaraj, R., &amp; Kumar P, R. (2023). Genetic manipulation of anti- nutritional factors in major crops for a sustainable diet in future. Frontiers in plant science, 13, 1070398.</li> </ol>
	<ol> <li>Roy, S., &amp; Dhaneshwar, S. (2023). Role of prebiotics, probiotics, and synbiotics in management of inflammatory bowel disease: Current perspectives. World Journal of Gastroenterology, 29(14), 2078.</li> <li>Udayan, A., Pandey, A. K., Sirohi, R., Sreekumar, N., Sang, B. I., Sim, S. J.,</li> </ol>
	& Pandey, A. (2023). Production of microalgae with high lipid content and their potential as sources of nutraceuticals. Phytochemistry Reviews, 22(4), 833-860.

<b>Course Co</b>	de		Course Title	L	Т	Р	С									
10212BT13	33	F	OOD PRESERVATION, PACKAGING TECHNOLOGIES	3	0	0	3									
Course Cat	egory		Program Elective													
Preamble			To provide an adequate knowledge of principle and packaging	p provide an adequate knowledge of principles of food preservation ad packaging												
Prerequisite Courses NIL																
Course OutcomesUpon successful completion of the course, students will be able to:																
CO Nos. Course Outcomes (Base							ledge Level d on revised 's Taxonomy)									
CO1	Illustr	lustrates the different modes of food preservation K2														
CO2		Understand the fundamentals of food preservation through K2														
CO3	Identi	Identify the purpose and principles of food packaging K2														
CO4	Explain the nature of different materials used in food K2															
CO5	Develop food packaging technologies for different foods K3															
Correlation	of COs	s with	POs:													
						D										

	Correlation	of	COs	with	POs:
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CO Nos.	Course Outcomes		Programme Outcomes (POs)											Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Illustrates the different modes of food preservation		L			М							Н	Н	Μ	
CO2	Understand the fundamentals of food preservation through dehydration		Н	L									Н	Н	L	
CO3	Identify the purpose and principles of food packaging												Н	Н		
CO4	Explain the nature of different materials used in food packaging		Н	L		М							Н	М	Н	
CO5	Develop food packaging technologies for different foods			М			L						Н		Н	
H – High; M- Medium; L- Low																

Course Conte	Course Content:							
UNIT I         DIFFERENT MODES OF FOOD PRESERVATION         9 hours								
Introduction of preservation, Preservation methods: thermal and other non-thermal methods,								
microbiological additives, and pulsed electric or magnetic fields. High temperature, low								
temperature, d	temperature, drying, radiation, chemical preservatives, bio-preservatives, hurdle technology,							
active packaging	active packaging. Preservation by fermentation - Curing, Pickling and Smoking, Chilling and							
Freezing, Properties of frozen foods. Food preservation and handling including fresh fruits and								
vegetables, gra	ins and pulses, fish, red meat, and milk.							

### UNIT II FOOD PRESERVATION THROUGH DEHYDRATION

9 hours

Water activity and moisture absorption isotherms, Psychometric chart, Dehydration and drying of foods, drying curve and drying time calculation, Enthalpy change during freezing, Plank's equation for freezing time, Cold storage and Refrigeration load, Refrigeration cycle, Cryogenic freezing and IQF Different types of dryers: Conductive, convective and combined, IMF foods, Osmotic dehydration. food preservatives of microbial origin.

UNIT III ADVANCED TECHNIQUES OF PACKAGING

9 hours

Packaging of foods, requirement, importance and scope. Factors affecting shelf life of food material during storage, spoilage agents with environmental factors. Control of the spoilage agents. Functions of packaging - packaging materials, risks associated with potential food contamination, Interpret packaging standards and regulations in food packaging materials. Aseptic packaging. Retort processing.Packaging systems, types: flexible and rigid; retail and bulk; levels of packaging; special solutions and packaging machines, technical packaging systems and data management packaging systems.Nutritional labeling on packages, CAS and MAP, shrink and cling packaging, vacuum and gas packaging; Factors affecting the choice of packaging materials, Disposal and recycle of packaging waste. Printing and labeling, Lamination.

Different types of packaging materials, their key properties and applications. Different types of polymers used in food packaging and their barrier properties. Metal cans, manufacture of two piece and three-piece cans. Canning of food products, Classifications and structure of cans, corrosion, Lacquering. Manufacture of plastic packaging materials, profile extrusion, blown film/ sheet extrusion, blow molding, extrusion blow molding, injection blow molding, stretch blow molding, injection molding. Glass containers, types of glass used in food packaging. Paper and paper board packaging, paper and paper board manufacture process. Relative advantages and disadvantages of different packaging materials.

# UNIT V TESTING METHODS FOR PACKAGING MATERIALS

Testing methods for flexible materials, rigid materials and semi rigid materials; Tests for paper (thickness, bursting strength, breaking length, stiffness, tear resistance, folding endurance, ply bond test, surface oil absorption test, etc.), plastic film and laminates (thickness, tensile strength, gloss, haze, burning test to identify polymer, etc.), aluminium foil (thickness, pin holes, etc.), glass containers (visual defects, colour, dimensions, impact strength, etc.), metal containers (pressure test, product compatibility, etc.).

LEARNING	RESOURCES							
	1. Robertson, G. L. 2005. Food Packaging: Principles and Practice. Second Edition. Taylor and Francis Pub							
Text Books	2. Coles, R., McDowell, D., Kirwan, M.J. 2003. Food Packaging Technolog Blackwell Publishing Co.							
	3. Gosby, N.T. 2001. Food Packaging Materials. Applied Science Publication							
	1. Mahadevia, M., Gowramma, R.V. 2007. Food Packaging Materials. Tata McGraw Hill							
Reference Books	<ol> <li>Robertson, G. L. 2001. Food Packaging and Shelf life: A Practical Guide Narendra Publishing House.</li> </ol>							
	3. John, P.J. 2008. A Handbook on Food Packaging Narendra Publishing House							
	https://www.youtube.com/watch?v=NJBj0ArTcQA							
DC	https://www.youtube.com/watch?v=b33hd8TO7ws							
Reference videos	https://www.youtube.com/watch?v=HCH_cVKJ51A							
VIUCUS	https://www.youtube.com/watch?v=ToHIfshAt3g							
	https://www.youtube.com/watch?v=f3JTA0YN3Hk							
Reference NPTEL	https://nptel.ac.in/courses/126105015							

	rse Code Course Title FOOD SAFETY, QUALITY AN												L	T	<u> </u>	P	С
10212BT	135	FC	OD		ETY EGU				Y A	.ND	)		3	0		0	3
Course C:	atagory	Prog	ram	Floct	tiva												
	0.	To pi				nuate	e kn	owl	edge	e to	lear	rn fo	od s	afetv	, and	l auc	ilitu
Preamble		audit										5				1	
Prerequis	ite Course	s NIL															
C																	
Course Outcome	$  I   n \cap n$	successful	comp	letio	n of	the c	cour	se, s	stud	ents	s wil	l be	able	e to:			
CO Nos.	•	Course Outcomes											now (Base) loom	d on	revis	ed	
CO1		ite differen ological in								al, c	hem	nical			K2		
CO2	Acquai	int knowle	dge o	n fo	od sa	afety	sur	veil	lanc	e					K2		
CO3		y the quali	•												K3		
CO4	Develo system	p Pre-Req	uisite	pro	gram	n on 1	food	l pla	nt n	nana	agen	nent			K3		
CO5		ite awaren nd the woi		n reg	gulat	ory	and	stat	utor	y b	odie	es in			K3		
<u>Correlatio</u>	on of COs w	vith POs:															
		<b>iiii i 050</b>													Р	rogra	m
CO Nos.	Course O					Prog	ramı	me O	utcol	mes	(POs)	)				rogra pecifi utcom PSOs	ic 1es
CO Nos.	Course O		1	2	3	Prog	ramı 5	me O 6	utco 7	mes (		) 10	11	12		pecifi utcom	ic 1es
CO1 p b iii	Compute di of food physical, ch piological	Dutcomes fferent typ hazards	e s, d e H	2 M	<b>3</b> Н			1	1				11	12		pecifi utcon PSOs	ic ies ()
CO1 P b in s	Compute di of food ohysical, ch oiological ndustry	Dutcomes fferent typ hazards temical an in th and foo owledge o	e s, d e H d					1	7				11	12	8 0 ( 1	pecifi utcon PSOs	ic ies ()
CO1 b in s CO2 A fr	Compute di of food ohysical, ch oiological ndustry ervice Acquaint kn	Dutcomes fferent typ hazards iemical an in th and foo owledge o surveillanc ne qualit	$ \begin{array}{c} e \\ s, \\ e \\ d \\ d \\ \end{array} $		Н			1	7				11	12 M	8 0 ( 1	PSOs	ic ies )
CO1 CO1 CO2 CO3 CO3 CO4 CO4 CO3 CO4 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3 CO3	Compute di of food ohysical, ch oiological ndustry ervice Acquaint kn ood safety s dentify th	outcomes fferent typ hazards iemical an in th and foo owledge o surveillanc ne qualit food re-Requisit food plar	e s, d e d H H e H y H e	М	Н			1	7	8			11		8 0 ( 1	PSOs	ic (1995)

<b>Course Cont</b>	ent:							
UNIT I	FOOD SAFETY AND SECURITY	9 hours						
Introduction	to food safety and security, Factors contributing to physic	ical, chemical and						
biological co	ntamination in food chain, prevention and control of foo	od borne hazards,						
Regulation of	food sanitation, personal hygiene-food handlers, cleaning con	npounds, sanitation						
methods, was	e disposal strategy (solid and liquid waste) and pest control							
UNIT II	FOOD SAFETY SURVEILLANCE	9 hours						
Food Adulter	ation, Food Additives, Food Packaging & labeling. Sanitation	on in warehousing,						
storage, shipp	ing, receiving, containers and packaging materials. Cleaning	g and Disinfection,						
ISO 22000 –	Importance and Implementation. Requirements Specific t	to Food Testing -						
Physical and	Chemical Parameters, Requirements Specific to Food Te	sting – Biological						
Parameters, G	eneral Topics: Related to Food Testing Laboratories.							
UNIT III	FOOD QUALITY SYSTEM	9 hours						
Various Qual	ity attributes of food, Instrumental, chemical and microbia	al Quality control.						
Sensory evalu	ation of food and statistical analysis - Descriptive testing and	Product Matching.						
Water quality	and other utilities. Laboratory Quality Management System	tem:Overview and						
Requirements	of ISO 17025, Food Bioterrorism Acts. Food inspection an	nd Food Law, Risk						
assessment –	microbial risk assessment, dose response and exposure respon	nse modelling, risk						
management,	implementation of food surveillance system to monitor	food safety, risk						
communicatio	n							
UNIT IV	PRE-REQUISITE PROGRAM	9 hours						
Good Manuf	acturing Practices - Personal hygiene - occupational	health and safety						
specification,	Food Plant Sanitation Management - Plant facilities	construction and						
maintenance	- exterior of the building- interior of the building- equ	uipments. Storage,						
transportation	, traceability, recalling procedures, training.							
UNIT V	FOOD SAFETY REGULATIONS	9 hours						
Indian and g	lobal regulations: International Agencies in Food Regula	tion: Food Codex						
Alimentarius:	Codex India - Role of Codex Contact point, National Co	odex contact point						
(NCCP), National Codex Committee of India - ToR, Functions, Shadow Committees etc.								
Various aspects and relation with domestic laws; FAO, WHO, WTO. FAO in India, Technical								
Cooperation p	programmes, Bio-security in Food and Agriculture, World H	ealth Organization						
(WHO), Worl	d Animal Health Organization (OIE), International Plant Pro	tection Convention						
(IPPC).								

LEARNING	RESOURCES
Text Books	<ol> <li>Handbook of food toxicology by S. S. Deshpande, 2002</li> <li>The food safety information handbook by Cynthia A. Robert, 2009</li> <li>Nutritional and safety aspects of food processing by Tannenbaum SR, Marcel Dekker Inc., New York 1979</li> </ol>
Reference Books	1. Microbiological safety of Food by Hobbs BC, 1973
Reference videos	https://www.youtube.com/watch?v=0J2Qv_72Xzo https://www.youtube.com/watch?v=rkuInbWL_pI https://www.youtube.com/watch?v=yxIC-ffnfrY https://www.youtube.com/watch?v=ZvmMMDRQoyw https://www.youtube.com/watch?v=_mcsYYbhEhE
Reference NPTEL	https://nptel.ac.in/courses/126105336

Course Code	•	Course Title	L	Т	Р	С								
10212BT130		PRECISION AGRICULTURAL BIOTECHNOLOGY	3	0	0	3								
<b>Course Categ</b>	ory	Program Elective												
Preamble		Provide an in-depth exploration of the principles, technologies, and applications of precision agriculture.												
Prerequisite (	Courses	NIL												
Course Outcomes	Upon suce	cessful completion of the course, students will	be abl	e to:										
CO Nos.		Course Outcomes	(	Knowledge Leve (Based on revised Bloom's Taxonomy										
CO1		d basic concepts, history and basic practices of agriculture	f	K2										
CO2	Identify th	ne soil and soil interactions for farming		К3										
CO3	Utilize G applicatio	eoinformatics tools for Precision Agricultur	e	К3										
CO4	Develop developm	electronics and imagery tools for agricultura	ıl	К3										
CO5	Model th strategies	e Greenhouse with latest technologies an	d	К3										
			1											

CO Nos.	Course Outcomes	Programme Outcomes (POs)											Program Specific Outcomes (PSOs)			
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	
CO1	Understand basic concepts, history and basic practices of Precision agriculture	Н	Н										Н	Н	L	
CO2	Identify the soil and soil interactions for farming	Η	Н	М	Н	М	L						Н	L	Н	
CO3	Utilize Geoinformatics tools for Precision Agriculture applications	Н	М	L	L	М	М						Н	М	М	
CO4	Develop electronics and imagery tools for agricultural development	Н	М	М	Н	L	L						Н	М	М	
CO5	Model the Greenhouse with latest technologies and strategies	Н	Н	М	М	Н	М						Н	М	L	

Course Con	ntent:	
UNIT I	PRECISION AGRICULTURE	9 hours
Precision ag	riculture: concepts and techniques; their issues and concerns for	Indian agriculture;
Historic Per	spectives of Precision Agriculture. Laser leveling, mechanized	direct seed sowing;
seedling and	d sapling transplanting, mapping of soils and plant attributes,	site specific input
application,	weed management, insect pests and disease management,	Good Agricultural
Practices in	precision farming, yield mapping in horticultural crops. Peat	moss and mixtures,
rock wool a	nd other inert media for soilless culture, nutrient film technique (	NFT)/ hydroponics.
UNIT II	CULTIVATION TECHNIQUES	9 hours
Growing m	edia, soil culture, Selection Criteria for soil media, soil p	basteurization. Soil
Variability a	and Soil Mapping - Factors affecting soil variability, Digital so	il data and sources,
Correlating	soil data to other crop production data. Proximate Sensors: meas	sure soil parameters
- N status a	and soil pH. Crop discrimination and Yield monitoring, soil	mapping; fertilizer
recommend	ation using geospatial technologies	
UNIT III	GEOINFORAMTICS	9 hours
Geoinforma	tics- definition, concepts, tool and techniques; their use in Pre-	ecision Agriculture
Spatial data	and their management in GIS; Geodesy and its basic principles	s; Image processing
and interpre	etation; Global positioning system (GPS), components and its	functions; System
Simulation-	Concepts and principles, Introduction to crop Simulation. S	TCR approach for
precision a	griculture; Agricultural GIS software programs. Mobile	GIS/GPS software
programs. H	Principles and applications of mapping data in precision agri	culture, GIS, GPS
sensors, dro	nes, data acquisition and management. Yield Maps. Applicati	ons of Big Data ir
Precision A	griculture. Variable Rate Technology (VRT) - Grid Sampli	ng, VRT Seeding
Planter Unit	Controllers, Variable Hybrid/Variety Planting, VRT Pesticide	s, Spray Boom and
Nozzle Con	trol, Automatic Boom Leveling.	
UNIT IV	SENSORS	9 hours
Electronic s	systems and Signal processing: Communications data netwo	rk for tractors and
machinery 1	for agriculture applications. Remote sensing basics- Applicat	ions in agriculture
correlating	imagery to other crop production data, Remote sensing data	a sources. Sensors
Sensing Pla	tforms—Satellite, UAV, Aerial, Proximal, The Electromagneti	c Spectrum, Active
vs. Passive	Remote Sensing, Spectral, Spatial, and Temporal Resolution,	Soil Sensors, Crop
Sensors, We	eather Sensors	
UNIT V	GREEN HOUSE TECHNOLOGY	9 hours
Green house	e technology - Introduction, Types of Green Houses; Plant respo	onse to Greenhouse

Green house technology - Introduction, Types of Green Houses; Plant response to Greenhouse environment, planning and design of greenhouses, Design criteria of green house for cooling and heating purposes. Green house equipments, materials of construction for traditional and low-cost greenhouses. Design and construction of green houses., Greenhouse heating – necessity, components, methods, design of heating system. Root media –types – soil and soil less media, composition, estimation, preparation and disinfection, bed preparation. Irrigation requirement, fertilizer management, cultivation, harvesting and post harvest techniques; Typical applications. Problems/constraints of greenhouse cultivation and future strategies.

LEARNING	RESOURCES
Text Books	<ol> <li>Singh Brahma and Balraj Singh. 2014. Advances in protected cultivation, New India Publishing Company.</li> <li>Sharma P. 2007. Precision Farming. Daya Publishing House New Delhi.</li> <li>Ghosh Arupratan, Green house Technology, the future concept of Horticulture, Kalyani Publishers, Ludhiana.</li> </ol>
Reference Books	<b>1.</b> Tiwari G.N., Green house Technology for Controlled Environment, Narosa Pub. House Pvt. Ltd., New Delhi.
Reference videos	https://www.youtube.com/watch?v=WhAfZhFxHTs https://www.youtube.com/watch?v=yEejDAwu4RE https://www.youtube.com/watch?v=6ct7uDKHEj8 https://www.youtube.com/watch?v=Tl1YkbdcEgU https://www.youtube.com/watch?v=8APpeti82hw
Reference NPTEL	https://onlinecourses.nptel.ac.in/noc24_bt30/preview
Reference research/ review articles	<ol> <li>Ahmad, U., &amp; Sharma, L. (2023). A review of best management practices for potato crop using precision agricultural technologies. Smart Agricultural Technology, 100220.</li> <li>Mwangi, R. W., Mustafa, M., Kappel, N., Csambalik, L., &amp; Szabó, A. (2024). Practical applications of spent mushroom compost in cultivation and disease control of selected vegetables species. Journal of Material Cycles and Waste Management, 1-16.</li> <li>Saranya, T., Deisy, C., Sridevi, S., &amp; Anbananthen, K. S. M. (2023). A comparative study of deep learning and Internet of Things for precision agriculture. Engineering Applications of Artificial Intelligence, 122, 106034.</li> <li>El-Hageen, H. M., Alatwi, A. M., &amp; Zaki Rashed, A. N. (2024). High-speed signal processing and wide band optical semiconductor amplifier in the optical communication systems. Journal of Optical Communications, 44(s1), s1277-s1284.</li> <li>Al-Naemi, S., &amp; Al-Otoom, A. (2023). Smart sustainable greenhouses utilizing microcontroller and IOT in the GCC countries; energy requirements &amp; economical analyses study for a concept model in the state of Qatar. Results in Engineering, 17, 100889.</li> </ol>

Course	Code				Сог	irse	Titl	e						L	Т	]	P	С	
10212B	T104		AGRICUL	JTU	RA	L BI	OT	ECI	HN(	DLC	)G?	Y		3	0	(	0	3	
			Γ																
Course	Catego	ory	Program I																
Preamb	le		To compre agricultur			he k	now	ledg	e a	nd d	ippi	lica	tions	of	biote	chno	ology	in i	
Prerequ Courses	isite		NIL																
Cours Outcon		Upon s	successful c	omp	oletio	on oj	f the	сои	rse,	stu	den	ts w	vill b	e abl	'e to:				
CO No	CO Nos. Course Outcomes											(	nowl Basec oom'	l on r	evise	ed			
CO1		Understand the basic concepts of normal and hybrid pl cells development for agricultural applications.									lant			K2					
CO2	,		the various rove the gro									neth	ods			K2			
CO3			plant grov ltural field omass.											К2					
CO4			proper pla ation of ma					ies	cor	iserv	vatio	on	and			K2			
CO5		Make develo	use of ethic pment	cal I	knov	vled	ge o	f G	M f	or a	gric	cult	ural	К3					
Correlat	ion of	COs w	ith POs:																
CO Nos.		Course Ou					Prog	ramı	ne O	utco	mes (	(POs	5)			S Ot	Program Specific Outcomes (PSOs)		
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	conce hybrid develo	pts of 1 d pla opment	the basic normal and ant cells for agri ications.	Н		L	М			L					Н	Н	М		
CO2	impro	ic e and n ve the g	various engineering nethods to growth and f plant.	Н	Н	М	М	М	Н	М	М				Н	Н	М	L	
CO3	Solve prome proble field produ and b	Н		L	М		Н	Н	Н				Н	Н	Н	Н			

			r					r					1		r	
CO4	Apply proper plan for rare species conser- vation and degradation of materials by plants	. н	Н	L	Н		Н	М	Н				Н	Н	М	Н
CO5	Make use of ethical knowledge of GM for agricultural development		М	Н	М		Н	Н	М				Н	Н	М	М
H – Hig	h; M- Medium; L- Low			1	I	1		1					1		1	11
Course Content:																
UNIT I	INTRODUCTIO	DN											ç	) hou	irs	
Basic concepts of Agriculture, Role of Genetic engineering for increasing crop productivity,																
Agricultural Applications of Genetic Engineering, : shoot - tip - cultures, shoot - tip - grafting,																
viricidal compound, Protoplast isolation: culture and fusion, selection of hybrid cells and																
regeneration of hybrid plants, somatic hybridization, Introducing genes into pro-and eukaryotes																
using gene transfer methods, DNA mediated and Agrobacterium mediated transfers,																
microinjection, electroporation, somatic cell hybridization.																
UNIT II     GENETIC ENGINEERING TECHNOLOGIES IN AGRICULTURE     9 hours																
Techniq	ues for the insertion of	gene	s int	o pl	ant c	ells	, Ti	pla	smi	d a	nd v	ector	s, (i)	Tra	nsge	enic
plants (	ii) Gene cloning, Restr	ictio	n Fi	ragn	nent	Len	igth	Po	lym	orp	hisn	ns, T	rans	poso	ns, a	and
Insertion	nal mutagenesis. Molec	ular	Far	ming	g: P	lants	s A	s fa	icto	ries	for	· bio	phar	mace	eutic	als,
Transge	nic value added specia	lty (	crop	s, U	se c	of a	ntis	ense	R	NA	and	ł otł	ner t	echn	olog	ies,
Develop	ing stress tolerant vari	eties	s, va	accir	ne ai	nd a	antil	oody	/ pi	rod	ucing	g pl	ants.	Ter	mina	ator
technolo	bgy, Introduction of male	stei	ility	thro	ough	gen	etic	eng	gine	erir	ig. G	lenet	ic en	gine	ering	g in
	ng nitrogen fixation in pl		•		U	U					C			C		
UNIT I				ΠΟ	PC/	NI	C F	AD	мп					) hou	ire	
	lizer: Mass cultivation o											 alo:				lla
	al products and plant						-				-	-				
	and products and prant							-		-		-				ŕ
C	•		•		U						·		-			
	al herbicides, Organic		-													
	rces, Organic standards Global initiatives and fu					010	rgai	ne p	лос	uce	e anc	ı pro	ducts	5, B10	JIOg	ical
control,									-							
UNIT I	PRESERVATIO	)N												) hou		
Preserve	Preservation of rare plant species germplasm collection and conservation. Soil Reclamation:															

Preservation of rare plant species germplasm collection and conservation, Soil Reclamation: Phytoremediation

World Food Security: Causes of food insecurity, social economic issues, ensuring food security, BIS regulations, GM food, GM Crops – Ethical challenges.

# LEARNING RESOURCES

Text Books	
Reference Books	<ol> <li>Arie Altman, "Agricultural Biotechnology', Marcel Dekker, Inc., 2001.</li> <li>Henry R.J., "Practical applications of Plant Molecular Biology", Chapman &amp; Hall London, UK,1997.</li> <li>Chrispeels M.J. and Sadava D.E., "Plants, Genes and Crop Biotechnology", 2nd Edition, American Society of Plant Biologists, Jones and Bartlett Publishers, USA, 2003.</li> <li>Lindsey K, Jones M.G.K., "Plant biotechnology In Agriculture", Prentice hall, 1990.</li> <li>Bhojwani S.S. and Razdan M.K., "Plant Tissue culture Theory and Practice", Elsevier Science, Netherlands, 2004.</li> </ol>
Reference videos	https://www.youtube.com/watch?v=ICv9o3dexrc https://www.youtube.com/watch?v=Un_LA9s9y-E https://www.youtube.com/watch?v=2wStx02R_qg https://www.youtube.com/watch?v=dtKThKBq454 https://www.youtube.com/watch?v=tLMW96vkduI https://www.youtube.com/watch?v=iyT0wTEPOO8
Reference NPTEL	https://onlinecourses.nptel.ac.in/noc24_ag08/preview
Reference research/ review articles	<ol> <li>Ahmad, U., &amp; Sharma, L. (2023). A review of best management practices for potato crop using precision agricultural technologies. Smart Agricultural Technology, 100220.</li> <li>Mwangi, R. W., Mustafa, M., Kappel, N., Csambalik, L., &amp; Szabó, A. (2024). Practical applications of spent mushroom compost in cultivation and disease control of selected vegetables species. Journal of Material Cycles and Waste Management, 1-16.</li> <li>Saranya, T., Deisy, C., Sridevi, S., &amp; Anbananthen, K. S. M. (2023). A comparative study of deep learning and Internet of Things for precision agriculture. Engineering Applications of Artificial Intelligence, 122, 106034.</li> <li>El-Hageen, H. M., Alatwi, A. M., &amp; Zaki Rashed, A. N. (2024). High-speed signal processing and wide band optical semiconductor amplifier in the optical communication systems. Journal of Optical Communications, 44(s1), s1277-s1284.</li> <li>Al-Naemi, S., &amp; Al-Otoom, A. (2023). Smart sustainable greenhouses utilizing microcontroller and IOT in the GCC countries; energy requirements &amp; economical analyses study for a concept model in the state of Qatar. Results in Engineering, 17, 100889.</li> </ol>

Specialization Regenerative Medicine, Health Diagnosis and Disease Control

Course	Code				Co	ours	e Tit	tle						L	Т	]	P	С	
10212B	T117		Bl	-		RM/ CHN	-	-	-	L				3	0	(	)	3	
~	~																		
Course	Categoi	·у	Program El			,					0					6	7.		
Preamb	le		To understa as per norm		lrug	deve	elopi	nen	t pro	oces	s fo	r th	e pr	epar	ation	of n	iedic	cine	
Prerequ Courses			NIL																
	Course Outcomes     Upon successful completion of the course, students v											will	be a	ble t	<i>o:</i>				
CO N	los.	C	ours	e Oi	utco	mes						(1	nowl Based oom's	l on r	evise	d			
СО	1	Understand the various types of therapeutic agents used in pharmaceutical industry, their use and regulatory aspects.												K2					
СО	2		ucidate the dr emical proper	0					•			•		K2					
CO	3		monstrate the volved in bulk						rea	ctio	n p	oroc	ess	K2					
CO	4		ply the analy cking techniq			thod	s in	drug	g ma	nuf	actu	ire a	and			K3			
CO	5	me	•	thei			naceutical products, current ications in therapeutic and												
Correlat	ion of (	106	with POs:																
CO Nos.			Outcomes				Prog	ramı	me O	utco	mes	(POs	5)			Pi S Ou (	c ies		
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	types agents ceutica	of use 1 in and	l the various therapeutic d in pharma dustry, their regulatory	М		М									М	Н	М		
CO2	Elucidate the drug metabolism involving					Н	Н	Н							Н	Н	н		

CO3	differ reaction involv	21	Н	Н	Н	Н	Н							Н	Н	Н	Н
CO4	metho	7 the analytical ods in drug facture and ng techniques.	н	Н	Н	Н	Н							Н	Н	Н	Н
CO5	pharm produ medic applic therap	fy the various naceutical cts, current cines and their cations in peutic and ostic fields.	Н	Н	Н	Н	Η		М	Н				Н	Н	Η	Н
H – Hig	h; M- I	Medium; L- Low															
Course	Conte	nt·															
UNIT I	Conte	INTRODUCTIO	ON											9	) hou	irs	
Develop	ment o	of Drug and Pharm		utica	l Inc	lustr	y, ty	/pes	of	her	ape	utic	agen	its an	d the	eir us	ses;
economi	ics and	regulatory aspects	5.														
UNIT II	[	DRUG METAB PHARMACOK				D								9	) hou	irs	
Drug me	etaboli	sm – physico che	mica	al pı	rincij	ples,	rad	lioad	ctivi	ty -	- p]	harm	nacoł	cineti	ics-ao	ction	of
drugs on	huma	n bodies.															
UNIT II	I	MANUFACTU APPLICATION		OF	D	RUC	GS,	PF	ROC	ES	S	AN	D	9	) hou	irs	
Bulk dru	ıg man	ufacturers, Type o	of re	eactio	ons i	n bu	ılk c	lrug	ma	nuf	actu	ire a	nd p	roces	sses.	Spee	cial
requirem	nent for	r bulk drug manufa	actu	re.													
UNIT I	V	MANUFACTU	RIN	GP	RIN	CIP	LES	S						9	) hou	rs	
Compres	ssed ta	table, wet granulation-dry granulation or slugging-direct compression-tablet															
presses,	coatin	coating of tablets, capsules, sustained action dosage forms-parental solution-oral															
liquids-i	njectio	ns-ointment-topic:	al ap	pplic	ation	ns,Pı	esei	rvat	ion,	ana	alyt	ical	metł	nods	and	test	for
various o	drug ar	nd pharmaceuticals	s, pa	ckin	g-pa	ckin	g te	chni	ique	s, q	ual	ity N	lana	geme	ent,G	MP.	
UNIT V	r	PHARMACEU	ГІС	AL	PRC	DU	CTS	S						9	) hou	Irs	
		tegories such as v blogical, Hormone		nins	, lax	ativo	es, a	anal	gesi	cs,	nor	i-ste	roida	ıl coı	ntrac	eptiv	ves,

LEARNING RE	SOURCES
	1. Finkel Richard, <i>et al.</i> , "Lippincott's Illustrated Reviews: Pharmacology", 4 th Edition, Wolters Kluwer / Lippincott Williams & Wilkins, 2009.
Text Books	<ol> <li>Shayne Cox Gad, "Pharmaceutical Manufacturing Handbook", John Wiley &amp; Sons, Inc., 2008.</li> <li>Description of the state of the st</li></ol>
	3. Bernd Meibohm, "Pharmacokinetics and Pharmacodynamics of biotech drugs", Wiley-VCH, 2006.
Reference	1. Leon Lachman, "Theory and Practice of Industrial Pharmacy", 3 rd Edition, Lea and Febiger, 1986.
Books	<ol> <li>Remington, "Pharmaceutical Sciences", 17thEdition, Mark Publishing &amp; co, 1985.</li> </ol>
	https://www.youtube.com/watch?v=FPLzzuwZyMo https://www.youtube.com/watch?v=qvucMHUVZA4
Reference	https://www.youtube.com/watch?v=u0ulEC-shAI
videos	https://www.youtube.com/watch?v=bGwR_7BqXfA
	https://www.youtube.com/watch?v=ElTMeiMgsG8
Reference NPTEL	https://archive.nptel.ac.in/courses/102/107/102107028/
	1. Sharma, D., Patel, P., & Shah, M. (2023). A comprehensive study on Industry 4.0 in the pharmaceutical industry for sustainable development. Environmental Science and Pollution Research, 30(39), 90088-90098.
	2. Yadav, U., & Bhatted, S. K. (2023). A comparative analysis of Vamana and Shamana Chikitsa in prediabetes management: A randomized clinical trial. Journal of Ayurveda and Integrative Medicine, 14(5), 100764.
Reference research/ review articles	3. Panchal, K., Katke, S., Dash, S. K., Gaur, A., Shinde, A., Saha, N., & Chaurasiya, A. (2023). An expanding horizon of complex injectable products: Development and regulatory considerations. Drug Delivery and Translational Research, 13(2), 433-472.
	4. Gozdzialski, L., Wallace, B., & Hore, D. (2023). Point-of-care community drug checking technologies: an insider look at the scientific principles and practical considerations. Harm Reduction Journal, 20(1), 39.
	5. Kiruba, J., Justin Thenmozhi, A., Jayalakshmi, M., & Arockia Jeya Yasmi Prabha, E. (2023). Role of Vitamins in Alzheimer's Disease. In Nutraceuticals for Alzheimer's Disease: A Promising Therapeutic Approach (pp. 27-42). Singapore: Springer Nature Singapore.

Course	Code				0	Cour	se T	itle						L	T		P	С	
10212B	ST125		HERE	BAL		D P GIN				2MI	CA	L		3	0		0	3	
Course	Catego	ory	Progra	m E	Elect	ive													
Preamb	le	-	To stu metabo charac	lite	s f	rom	th	e	plar								cona sola		
Prerequ	isite C	ourse	es NIL																
Cour Outco		Upor	n successful	сот	plet	ion q	of the	e coi	urse	, stu	ıder	nts v	vill b	e ab	le to	:			
CO N	05.			С	ours	se O	utco	mes	5					Knowledge Leve (Based on revised Bloom's Taxonomy					
CO	1		marize the tion methods		ferer	nt ty			K2										
CO	2		ze and categ ructural and			ased													
CO	3		ze and categ ructural and					ased	К3										
CO4	4		elop the dru ne and plant			ising	, me			K3									
CO	5		ke use of chromatography techniques and analytical culations to for phytocompound estimations.													K3			
Correlat	ion of	COs v	with POs:																
CO Nos.	0	course (	Dutcomes				Prog	ramı	ne O	utcol	mes	(POs	s)			Pi S Ou (	ic 1es		
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	Sumn differ alkalo isolati	ent oids	the types of and its ethods	Η	Н	Н	L				L	М			М	Н	Н	H	
CO2	Utiliz the alkalo struct functi	diffen oids ural		L	М					L				М	Н	Н	Н		
CO3	the Steroi struct	diffei ds ural	l categorize rent types based its and properties	Н	Н	Н		М			М			М	М	Н	L	L	

CO4 usin	velop the drugs by ng medicinal npounds of marine I plant sources M L H L M M M M M									L				М	М	М	
CO5 tecl ana to	ke use omatography miques lytical calcu for phytocom mations.	and 1ations	М		Н		Н		М		L		М			М	М
H – High; M	- Medium; L	- Low															
Course Con	tont.																
UNIT I	INTRODU	CTION	T	) PH	IYT	<b>OC</b>	HEN	MIS	TR	Y				9	) hou	irs	
Introduction				_							gen	eral	meth				tion
of alkaloids -					•												
UNIT II	SYNTHES CONSTIT			RBA	L- I	PHY	то							9	) hou	irs	
Alkaloids: E				chy	nine	, Pij	peri	ne,	Ber	ber	ine,	Тах	xol,	Vinc	a all	kolo	ids,
Glycosides:	Digitoxin, Gl	ycyrrhiz	in,	Senr	nosic	les, l	Baco	osid	es, (	Que	rcit	in.					
UNIT III	SYNTHES CONSTIT				L- I	PHY	то							9	) hou	irs	
Steroids: H	ecogenin, g	uggulos	terc	one	and	W	itha	noli	des-	0	Cou	mari	n: U	Jmbo	ellife	rone	; -
Terpenoids:	Cucurbitacing	s.															
UNIT IV	NATURAI	PROD	UC	CTS	AS I	MEI	DIC	INF	2					9	) hou	irs	
Marine Drug	gs, cardiovas	cular, cy	/tot	oxic	or a	antic	anc	er, a	antir	nic	rob	ials,	anti-	infla	mma	atory	<i>k</i>
marine toxin	s;Antibiotics,	definiti	on,	class	sifica	ation	ı, na	tura	l soi	urce	es a	nd th	erap	eutic	indi	catio	ons.
UNIT V	ANALYTI	CAL M	ЕТ	HO	DS I	N P	HΥ	го	СНІ	EM	IST	RY		9	) hou	irs	
Chromatogra	phy techniqu	ies- Pape	er-T	hin i	Laye	er- G	iC- (	GCN	MS-	UV	-IR	-HPI	LC-H	IPTL	.C –	NM	R.
LEARNING	RESOURC	CES															
Text Books	<ol> <li>Harbong plant an</li> <li>Trease a</li> <li>Dewick Wiley &amp;</li> </ol>	alysis", and Evar	Thi 1s, ' Mee	rd eo Phai dicin	ditio rmac	n ,C cogn	hapı osy'	man ',16'	anc th Ec	l Ha litic	all,∶ on, l	2005 Elsev	vier, 1	New	Yorl	k, 20	09.
Reference Books	Interceptt Ltd., New York.																
		3. Jarald E.E. and Jarald S.E., "Textbook of Pharmacognosy and Phytochemistry", CBS Publishers & Distributors, New Delhi, 2009.															

	4. Jean Bruneton, "Pharmacognosy, Phytochemistry, Medicinal plants", English edition,Levoisier Publishing, Paris, 1995.
Reference videos	https://www.youtube.com/watch?v=aLfabuFo7qo https://www.youtube.com/watch?v=6ZCnbCrYlJo https://www.youtube.com/watch?v=nVEopYV7dK4 https://www.youtube.com/watch?v=3wvwtv4sAPA https://www.youtube.com/watch?v=ByJ6lzD2Vbg
Reference NPTEL	https://nptel.ac.in/courses/102105342
Reference research/ review articles	<ol> <li>Faisal, S., Badshah, S. L., Kubra, B., Emwas, A. H., &amp; Jaremko, M. (2023). Alkaloids as potential antivirals. A comprehensive review. Natural Products and Bioprospecting, 13(1), 4.</li> <li>Liu, W., Tang, X., Fan, C., He, G., Wang, X., Liang, X., &amp; Bao, X. (2023). Chemical constituents, pharmacological action, antitumor application, and toxicity of strychnine semen from Strychnons pierriana AW Hill.: a review. Journal of Ethnopharmacology, 116748.</li> <li>Bai, B., Liu, C., Zhang, C., He, X., Wang, H., Peng, W., &amp; Zheng, C. (2023). Trichoderma species from plant and soil: An excellent resource for biosynthesis of terpenoids with versatile bioactivities. Journal of advanced research, 49, 81-102.</li> <li>Hu, D., Jin, Y., Hou, X., Zhu, Y., Chen, D., Tai, J., &amp; Lu, Y. (2023). Application of marine natural products against Alzheimer's disease: past, present and future. Marine Drugs, 21(1), 43.</li> <li>Demyanovich, R. J. (2024). High energy dissipation rates from the impingement of free paper-thin sheets of liquids: Determination of the volume of the energy dissipation zone. Chemical Engineering Science, 294, 120128.</li> </ol>

Course	Code				(	Cour	se T	itle						L	Т		P	С
10212B	T115			С	AN	CER	BIC	)L(	)GY	l				3	0		0	3
Course	Catego	ory	Progra	m E	Elect	ive												
Preamb	le		To crea from th detection	ie fi	unda	men	tal p	orinc	ciple	es to								
Prerequ	isite (	Course	s 102111 102111							ogy:	Со	nce	pts a	nd T	Techn	ique	s	
Cour: Outcor		Upon	successful c	com	pleti	on o	f the	сои	irse,	stu	den	ts v	vill b	e ab	le to:			
CO N	08.			Course Outcomes												ledg d on 1 's Tax	revis	ed
COI			rate and dia to the second second second second second second second second second second second second second s	-			reg	ulati	ions	of	ce	11 0	cycle			K2		
CO2	2		prehend the size regulatory					Caro	cino	gen	ic n	nate	erials			K2		
CO3	3		understandir		es o	f car	cers	bas	K.3									
CO4	ł		ify the caus and its regu						K3									
COS	5			ne proper therapy for different types of cancer to their markers and proteins														
Correlat	ion of		vith POs:															
CO Nos.			Outcomes				Prog	ramı	ne O	utcol	mes	(POs	\$)			Pı S Ou (	c ies	
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	the recycle	egulati	d diagnosis ons of cell kpoints in	Н	М										Н	Н	М	
CO2	vario Carci and		types of c materials regulatory	Н		М	М	L						Н	Н	Н	Н	
CO3	of car moleo	ncers t	erent stages based on its level ng		М	Н	L							Н	М	Н	Н	

H L								
5								
anism								
signal								
g and								
5								
mical								
fects,								
cation								
5								
stasis;								
vation								
d to								
5								
static								
e, Proteinases and tumor cell invasion, Introduction to oncogenes and oncoproteins,								
or suppression genes - p53 genes, activation, evasion of apoptosis, DNA repair defects and								
<b>C</b> 1								
rofile								
rofile								
Š								

LEARNING	RESOURCES
Text Books	
Reference Books	<ol> <li>Weinberg R.A., "The Biology of Cancer", Garland Science, 2007.</li> <li>Ian F.Tannock, Richard P. Hill, Robert G. Bristow and Lea Harrington, "The Basic Sciences of Oncology, 4thEdition, McGraw-Hill, 2005.</li> <li>PelengarisS. and Khan M., "The Molecular Biology of Cancer", Wiley Blackwell Publishing, USA, 2006.</li> <li>Margaret A. Knowles and Peter T. Selvo, "An introduction to cellular and molecular biology of cancer", Oxford Medical publication, 1991.</li> </ol>
Reference videos	https://www.youtube.com/watch?v=46Xh7OFkkCE https://www.youtube.com/watch?v=NO0eKiIUcBg https://www.youtube.com/watch?v=8fwmSnkdY8Q https://www.youtube.com/watch?v=bdWRZd19swg https://www.youtube.com/watch?v=-6j0e_1ZC6o
Reference NPTEL	https://nptel.ac.in/courses/102106025
Reference research/ review articles	<ol> <li>Huang, Z., Xie, N., Illes, P., Di Virgilio, F., Ulrich, H., Semyanov, A., &amp; Tang, Y. (2021). From purines to purinergic signalling: molecular functions and human diseases. Signal transduction and targeted therapy, 6(1), 162.</li> <li>Stading, R., Gastelum, G., Chu, C., Jiang, W., &amp; Moorthy, B. (2021, November). Molecular mechanisms of pulmonary carcinogenesis by polycyclic aromatic hydrocarbons (PAHs): Implications for human lung cancer. In Seminars in cancer biology (Vol. 76, pp. 3-16). Academic Press.</li> <li>Schulz, W. A. (2023). Molecular biology of human cancers. Springer Nature Switzerland AG.</li> <li>Schiller, J. T., &amp; Lowy, D. R. (2021). An introduction to virus infections and human cancer. Viruses and human cancer: from basic science to clinical prevention, 1-11.</li> <li>Gavas, S., Quazi, S., &amp; Karpiński, T. M. (2021). Nanoparticles for cancer therapy: current progress and challenges. Nanoscale research letters, 16(1), 173.</li> </ol>

Course CodeCourse TitleLTP									
10212BT11	8		STEM CELL TECHNOLOGY		3	0	0	3	
	ł					1			
Course Cate	gory		Program Elective						
Preamble			To study the unique properties of stem cell to understand its application in the treatm				cation	and	
Prerequisite	Cours	ses	10211BT`116- Immunology						
Course Outcomes	Upon	succe	essful completion of the course, students wi	ll be a	ble t	<i>o</i> :			
CO Nos.			<b>Course Outcomes</b>		(B	ased o	dge L on revi Faxono	sed	
CO1	Outlin stem o		properties, classification and preservation	on of		ŀ	ζ2		
CO2			d the source and characterization of huster cell.	ıman		ŀ	ζ2		
CO3		entify and study about the properties of different types of K2							
CO4			of the hematopoietic stem cells for bone rengineering tools	epair		ŀ	ζ3		
CO5	Identi techne	•	solution for various diseases by using stem	n cell		ŀ	ζ3		

### **Correlation of COs with POs:**

CO Nos.	CO Nos. Course Outcomes				Pr S Ou (1	c ies										
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Outline the properties, classification and preservation of stem cell	Н		Н									M	Н	М	
CO2	Comprehend the source and characterization of human embryonic stem cell.	н											Н	Н	М	
CO3	Identify and study about the properties of different types of adult stem cell.	ц											Н	Н	М	
CO4	Make use of the hematopoietic stem cells for bone repair with tissue engineering tools	Н	М	Н	Н	Н	М		Н				Н	Н	Н	М

	ntify the solution for														
usi usi	ious diseases by ng stem cell hnology.	Н Н	Н	Н	Н	М	Η	Η				Η	Н	Н	L
L	- Medium; L- Low					I									1
Course Cor	tent:														
UNIT I	INTRODUCTION	N TO S	TEN	I CE	CLL	S							9 ho	urs	
Scope of S	tem Cells -Unique	e prop	erties	of	f ste	em	cell	s –	di	ffere	entiat	ion,	mat	urati	ion,
proliferation	, pluripotency, self –	mainte	enance	e and	l sel	f – 1	rene	wal	-c	lassi	ficati	ion-	prob	olem	s in
measuring s	em cells – preservati	on prot	ocols	•											
UNIT II	HUMAN EMBRY												9 ho		
Stem cells	and their developme	ental p	otenti	ial. 1	ln v	itro	fer	tiliz	zatio	on-ci	ılturi	ing o	of er	nbry	'OS-
blastocyst-ir	ner cell mass-isola	ation a	and g	grow	ving	ES	s c	ells	in	lał	o Id	entif	icati	on	and
characteriza	tion of human ES cell	s-Clon	ing a	nd co	ontro	ollec	l dif	fere	entia	ation	ofh	uma	n em	bryc	onic
stem cells. A	pplications of Embry	vonic st	tem c	ells.	Ethi	cal	issu	es a	ind	regu	latio	ns.			
UNIT III	HUMAN ADULT	STEM	1 CE	LL									9 ho	urs	
Somatic ster	n cells-test for identif	ication	ofad	ult st	tem	cells	s- ac	lult	ster	n cel	ll dif	feren	tiatio	on-tr	ans
differentiation	on-plasticity-different	types	ofadu	ılt ste	em c	ells	-live	er st	em	cells	-ske	letal	mus	cle st	tem
cells-bone n	arrow derived stem c	ells.													
UNIT IV	STEM CELLS IN	TISS	UE E	NGI	NE	ERI	NG	r					9 ho	urs	
Haematopoi	etic Stem Cells-Grov	vth fac	tors a	and t	he r	egu	latio	on c	of h	aema	atopo	oietic	e stei	n ce	ells-
clinical app	ications of haematop	oietic	stem	cells	s. M	eser	nchy	/ma	l st	em c	cells	and	their	· role	e in
bone tissue	engineering-bone repa	air. Ste	m cel	l bas	ed g	gene	the	rap	y an	id be	nefit	s to	huma	an.	
UNIT V	APPLICATIONS	OF ST	ГЕМ	CEI	$\mathbf{L}$								9 ho	urs	
Therapeutic	applications-Parkins	ons dis	ease,	Can	cer	sten	n ce	- 11 -	Ne	eural	sten	n cel	l for	cen	tral
nervous syst	em repair – Spinal co	ord inju	ry – ı	ise o	fES	SC to	o tre	at h	lear	t dise	ease	– Bu	irns a	and s	kin
ulcers – Ort	hopaedic application	s of ste	em ce	- 11	Insu	lin-j	proc	luci	ng	Cells	s De	rivec	l fro	m S	tem
Cells: A Potential Treatment for Diabetes.															
LEARNIN	G RESOURCES														
Text Books	<ol> <li>Potten C.S., "S</li> <li>Robert Lanza, "</li> </ol>							1റെ	v."	Acad	lemi	e Pre	ess 2	009	
	1. AriffBongso, E	EngHin													
Reference	Scientific, 2011 2. Daniel R. Mar		Stem	cel	l bio	olog	у,"	Col	ld S	prin	g Ha	arboi	: Lał	oorat	ory
Books	Press, 2001. 3. Peter Quesenb	erry, "	Stem	cell	l bio	olog	y a:	nd	Ger	ne T	heraj	ру,"	Wil	ey-L	iss,
	1998.														

Reference videos	https://www.youtube.com/watch?v=evH0I7Coc54 https://www.youtube.com/watch?v=gxAVnoarveE https://www.youtube.com/watch?v=fp5H3SslskQ https://www.youtube.com/watch?v=ca3H2vemYXo
Reference NPTEL	https://www.youtube.com/watch?v=o7dDKMOMYWk https://nptel.ac.in/courses/102106036
Reference research/ review articles	<ol> <li>Das, M., &amp; Sloan, A. J. (2023). Stem cell sources from human biological waste material: a role for the umbilical cord and dental pulp stem cells for regenerative medicine. Human Cell, 36(4), 1312-1325.</li> <li>Abel, A., &amp; Sozen, B. (2023). Shifting early embryology paradigms: Applications of stem cell-based embryo models in bioengineering. Current Opinion in Genetics &amp; Development, 81, 102069.</li> <li>Tkemaladze, J. (2023). Reduction, proliferation, and differentiation defects of stem cells over time: a consequence of selective accumulation of old centrioles in the stem cells?. Molecular Biology Reports, 50(3), 2751-2761.</li> <li>Plakhova, N., Panagopoulos, V., Vandyke, K., Zannettino, A. C., &amp; Mrozik, K. M. (2023). Mesenchymal stromal cell senescence in haematological malignancies. Cancer and Metastasis Reviews, 42(1), 277-296.</li> <li>Wu, B., Shi, X., Jiang, M., &amp; Liu, H. (2023). Cross-talk between cancer stem cells and immune cells: potential therapeutic targets in the tumor immune microenvironment. Molecular Cancer, 22(1), 38.</li> </ol>

Course	Code				Co	urse	Tit	le						L	Т	]	P	С	
10212B	ST126		MEI	MEDICAL GENOMICS AND PROTEOMICS										3	0	(	0	3	
Course	Cotogor		Program		actin	0													
		y	-	Program Elective To know more about the techniques involved in the genomics and															
Preamb	le		proteomics for medical applications.																
Prerequ	isite Co	urses		10211BT108 - Molecular Biology: Concepts and Techniques 10211BT112 – Genetic Engineering															
Cou Outco		Upon	successful	l coi	mple	etion	of th	he co	ours	e, si	tude	ents	will	be a	ble t	<i>o</i> :			
CO N	los.			C	ours	se O	utco	mes	•					(	Based	edge I on r s Tax	evise	d	
CO	1		narize the nes of prol							-	izat	tion	of			K2			
CO	2		ate the phy				-		-							K2			
CO	03	Devel genon	op the k nics.	now	ledg	ge o	on v	ario	us	tech	niq	ues	in	К3					
СО	4	Construct the importance of techniques involved in proteomic analysis.								l in	К3								
CO	95	Apply profili		knowledge of proteomics for protein K3															
Camalat	·	0	h DO																
Correlat	ion of C	Us wit	h POs:													Pı	rogra	m	
CO Nos.	Сог	irse Out	comes	Programme Outcomes (POs)								5)	Specific Outcomes (PSOs)						
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	Summa structur organizz genome and euk	e ation s of pr	and of okaryotes	L											Н	L	L		
CO2	Illustrate the		physical	L											Н	L		М	
CO3	on vari	elop the knowledge various techniques enomics.			L	L	L								М	М			
CO4	Constru importa techniqu proteon	nce ies inv	М	L	L	L								Н	М				

CO5 prote profi		Н	М								
H – High; M- Medium; L- Low											
Course Conte	nt:										
UNIT I	OVEDVIEW OF CENOMES OF BACTEDIA										
Genome organization of prokaryotes and eukaryotes, Gene structure of Bacteria, Archaea and											
Eukaryotes, Human genome project, Introduction to functional and comparative genomics.											
UNIT II	PHYSICAL MAPPING TECHNIQUES	9	) hou	irs							
Cytogenetic n	apping, Radiation hybrid mapping, Fish-STS mapping, SNI	P mapp	ing,	Opti	ical						
mapping. Top	down and bottom up approach, Linking and jumping of cl	ones, (	Gap	closi	ıre,						
Pooling strate	gies, Automation in Genome sequencing-Next Generation Sec	quencir	ıg.								
UNIT III	FUNCTIONAL GENOMICS	9	) hou	irs							
Gene finding,	Annotation of genome - experimental and computational a	pproac	h. O	RF a	and						
functional pr	ediction, Subtractive DNA library screening, Differen	ntial c	lispla	ıy a	and						
representation	al difference analysis, SAGE.										
UNIT IV	PROTEOMICS TECHNIQUES	9	) hou	irs							
Protein level	estimation-Edman protein microsequencing, Protein of	cleavag	e, 2	2D	gel						
electrophoresi	s, metabolic labelling. Detection of proteins on SDS gels.	Mass s	pect	rome	etry						
principles of 1	MALDITOF, Fourier Transform Ion Cyclotron Resonance M	Mass S	pectr	ome	ter,						
Orbitrap Mass	Analyzer, Tandem MS, Peptide mass fingerprinting.										
UNIT V	PROTEIN PROFILING	9	) hou	irs							
Post translat	ional modification, Protein-protein interactions, Glyco	oprotei	n a	naly	sis,						
Phosphoprote	n analysis.										
LEARNING	RESOURCES										
<ul> <li>Text Books</li> <li>1. Twyman R.M. and PrimroseS.B., "Principle of Genome Analysis and Genomics", Wiley Blackwell Publications, 2007.</li> <li>2. Brown T.A., "Introduction to Genetic: A molecular Approach", Garland Science, Taylor and Francis, 2012.</li> </ul>											
Reference Books	Reference 1. Liebler, "Introduction to Proteomics", Humana Press, 2002 2. Veenstra, T.W. and Tates, III. Ir. "Proteomics for Biological Discovery"										
Reference       https://www.youtube.com/watch?v=mg6tXQaiBaI         https://www.youtube.com/watch?v=KXn533DTrsM         https://www.youtube.com/watch?v=D-Ljd5Uex0s         https://www.youtube.com/watch?v=k2ie0sWZKkc											

	https://www.youtube.com/watch?v=5h3JGVlwR_8
Reference NPTEL	https://nptel.ac.in/courses/102101072
Reference research/ review articles	<ol> <li>Shine, M., Gordon, J., Schärfen, L., Zigackova, D., Herzel, L., &amp; Neugebauer, K. M. (2024). Co-transcriptional gene regulation in eukaryotes and prokaryotes. Nature Reviews Molecular Cell Biology, 1-21.</li> <li>Puebla-Aparicio, M., Ascencio-Elizondo, C., Vieira, M., Amorim, M. C. P., Duarte, R., &amp; Fonseca, P. J. (2024). Characterization of the fish acoustic communities in a Mozambican tropical coral reef. Marine Ecology Progress Series, 727, 143-158.</li> <li>Lang, B. F., Beck, N., Prince, S., Sarrasin, M., Rioux, P., &amp; Burger, G. (2023). Mitochondrial genome annotation with MFannot: a critical analysis of gene identification and gene model prediction. Frontiers in Plant Science, 14, 1222186.</li> <li>Gosset-Erard, C., Aubriet, F., Leize-Wagner, E., François, Y. N., &amp; Chaimbault, P. (2023). Hyphenation of Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS) with separation methods: The art of compromises and the possible-A review. Talanta, 257, 124324.</li> <li>Lee, J. M., Hammarén, H. M., Savitski, M. M., &amp; Baek, S. H. (2023). Control of protein stability by post-translational modifications. Nature Communications, 14(1), 201.</li> </ol>

Course Code	Course Title	Р	С									
10212BT116	MOLECULAR PATHOGENESIS	3	0	0	3							
Course Category	Program Elective											
Preamble	To introduce the molecular basis and factor and the various strategies designed to stup pathogenesis.											
Prerequisite Courses	v											

Course Outcomes	able to:									
CO Nos.	CO Nos. Course Outcomes									
CO1	Explain the historical background of molecular pathogenesis and basic mechanisms.	K2								
CO2	Comprehend the interactions mechanism of pathogens toward host organism and resistance development.	K2								
CO3	Identify the molecular mechanisms of various Enteric pathogens for disease causing in human.	K3								
CO4	К3									
CO5	Develop the diagnosis and prevention tools for various pathogenic infections.	К3								

# **Correlation of COs with POs:**

CO Nos. Course Outcomes		Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Explain the historical background of molecular pathogenesis and basic mechanisms.		М										Н	Н	М	
CO2	Comprehend the interactions mechanism of pathogens toward host organism and resistance development.	н	Н										Н	Н	Н	
CO3	Identify the molecular mechanisms of various Enteric pathogens for disease causing in human.		М		L								Н	Н	Н	

CO4	Make use of moleculat level experiments to understand hos pathogen interactions	ь	Н	М	Н	Н							Н	Н	Н	M
CO5	Develop the diagnosis and prevention tools for various pathogenic infections.	r _H	Н	М	Н	L	Н						Н	Н	Н	L
H – Higl	H – High; M- Medium; L- Low															
~	~															
Course					FOI	TTA	D									
UNIT I	INTRODUCTIO PATHOGENES		UN	UL	ECU	LA	ĸ						ç	) hou	ırs	
Historica	l background, Introd	lucti	on	to	infec	ctiou	IS	dise	ease	s,	Cor	cept	s of	vi	rulei	nce,
pathoger	icity, commensalism,	syn	nbios	sis,	oppo	ortur	nism	1, p	oara	siti	sm;	Sig	nifica	nce	of	the
discover	y of Microscope in path	noge	nesis	s, Si	gnifi	can	t co	ntri	buti	ons	of	Loui	s Pas	teur,	Ro	bert
Koch po	stulates, Microbial tox	ins -	dise	cove	ry, a	issa	ys,	und	erly	ing	me	chan	isms	of b	oacte	erial
coloniza	ion and infection.				•				Ţ	-						
UNIT II	HOST DEFENSI STRATEGIES	E A(	GAI	NST	PA	ГНO	DGI	ENS	5,				Ģ	) hou	urs	
Basic co	nponents and nature of	path	ogen	esis,	Hos	st de	fens	se m	nech	ani	sms	- Sk	in, M	ucos	a, C	ilia,
Secretion	s, Physical movements	, lim	itatio	on of	free	e iro	n, a	ntin	nicr	obi	al co	mpc	ounds,	mee	chan	ism
of killing	by humoral and cellul	ar de	efens	e me	echa	nism	ıs, r	esis	tano	ce c	leve	lopn	nent in	ı pat	hog	ens,
Pathogen	ic adaptations.															
UNIT II	I MECHANISM I	N M	OLI	ECU	LAI	R PA	ATH	100	GEI	NE:	SIS		9	) hou	irs	
Underlyi	ng mechanisms of Mo	lecu	lar p	oathc	gen	esis,	Ro	ole	of l	Mo	ecul	ar g	eneti	es ar	nd g	ene
regulatio	n in virulence of pathog	ens, İ	Influ	ence	ofli	ifest	yle	fact	ors	on	virul	ence	e, Clin	ical	featı	ıres
and mol	ecular mechanism of p	oatho	ogen	esis:	Ent	eric	pat	thog	gens	- E	Inter	opat	hogen	nic (	EPE	EC),
Enteroin	vasive (EIEC), Enteroag	gres	sive	E.co	oli (E	EAE	C),S	Shig	ella	, Sa	ılmo	nella	a, Der	mate	ophy	rtes,
Candidiasis, Plasmodium - Life cycle, Malaria, different stages of Influenza virus.																
UNIT IV	INIT IV EXPERIMENTAL STUDIES ON HOST PATHOGEN 9 hours															
Assays	for Virulence, Princip	les	of A	Adhe	renc	e, l	[nva	sior	ı, (	Cyte	opat	hic	effect	s; T	ests	in
identifyi	ng virulence factors, a	tten	latec	l mi	ıtant	s, N	Aole	ecul	ar	cha	racte	eriza	tion o	of v	irule	ence
factors, Signal transduction and host responses.																
	INIT VPATHOGEN DIAGNOSIS AND CONTROL METHODS9 hours						NT	RO	L				ç	) hou	ırs	
UNII V	Classical methods- Serotyping, Diagnosis using Virulence factors, Immuno, DNA based techniques, Precipitation, Agglutination, ELISA, RIA, PCR, Blotting techniques - Southern and															

Western blotting, Bioinformatics/whole genome analysis for pathogen diagnosis, Vaccines -Types, applications, advantages and disadvantages, Cocktail vaccines, New therapeutic strategies based on recent findings on molecular pathogenesis of pathogens.

LEARNING RE	SOURCES
Text Books	
Reference Books	<ol> <li>Iglewski B.H. and Clark V.L., "Molecular basis of Bacterial Pathogenesis", Academic Press, 1990.</li> <li>Eduardo A. Groisman, "Principles of Bacterial Pathogenesis", Academic Press, 2001.</li> <li>Peter Williams, Julian Ketley and George Salmond, "Methods in Microbiology: Bacterial Pathogenesis", Academic Press, 1998.</li> <li>Brenda B. Wilson, Abigail A. Salyers, Dixie D. Witt and Malcolm E. Winkler, "Bacterial Pathogenesis", 3rdEdition, ASM press, 2011.</li> </ol>
Reference videos	https://www.youtube.com/watch?v=_2vTa4P6Tbg https://www.youtube.com/watch?v=X6wrFMvK804 https://www.youtube.com/watch?v=oaqwrJ-SZGE https://www.youtube.com/watch?v=XvIY0zvKbm4 https://www.youtube.com/watch?v=SwNXNFBIGKc
Reference NPTEL	https://nptel.ac.in/courses/102106025
Reference research/ review articles	<ol> <li>Milgroom, M. G. (2023). The Germ Theory Paradigm. In Biology of Infectious Disease: From Molecules to Ecosystems (pp. 9-22). Cham: Springer International Publishing.</li> <li>Iannacone, M., &amp; Guidotti, L. G. (2022). Immunobiology and pathogenesis of hepatitis B virus infection. Nature Reviews Immunology, 22(1), 19-32.</li> <li>Alfinete, N. W., Bolukaoto, J. Y., Heine, L., Potgieter, N., &amp; Barnard, T. G. (2022). Virulence and phylogenetic analysis of enteric pathogenic Escherichia coli isolated from children with diarrhoea in South Africa. International Journal of Infectious Diseases, 114, 226-232.</li> <li>Ahmadi, M., Ranjbar, R., Behzadi, P., &amp; Mohammadian, T. (2022). Virulence factors, antibiotic resistance patterns, and molecular types of clinical isolates of Klebsiella Pneumoniae. Expert Review of Anti- infective Therapy, 20(3), 463-472.</li> <li>Sanya, D. R. A., Onésime, D., Vizzarro, G., &amp; Jacquier, N. (2023). Recent advances in therapeutic targets identification and development of treatment strategies towards Pseudomonas aeruginosa infections. BMC microbiology, 23(1), 86.</li> </ol>

Minors In Bioprocess Control and Devices

Course Cod	e	Course Title	L	Т	Р	С								
10213BT107	1	BIOPROCESS CONTROL COMPONENTS	3	0	0	3								
Course Categ	gory	Open Elective												
Preamble		The courses introduces various process variables and control measures in bioprocess												
Prerequisite	Courses	NIL												
Course Outcomes	Upon suce	ccessful completion of the course, students will be able to:												
CO Nos.		Course Outcomes	(	Knowledge Leve (Based on revised Bloom's Taxonomy										
CO1	Understar Bioreacto	nd Process variables and their application i rs	n	К2										
CO2		d Different online and offline analysis s and electrical components	,	]	K2									
CO3		etween different processes and strategies of ion process control	f	K2										
CO4	Understar	d the variables of incubation control		]	K2									
CO5		principles of digital process control and use c s in bioprocess control.	of K3											

### **Correlation of COs with POs:**

CO Nos.	Course Outcomes Programme Outcomes (POs) Sp Out Out (P								Program Specific Outcomes (PSOs)							
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand Process variables and their application in Bioreactors	L	L	М									Н	Н		
CO2	Understand Different online and offline analysis, biosensors and electrical components	н	М			Н	Н						Н	L	М	
CO3	Relate between different processes and strategies of fermentation process control	Н	М	L	L	М	М	L					Н	М	Н	
CO4	Understand the variables of incubation control		L	L	L	М	L						Н	М	Н	

Methods of on-line and off-line biomass estimation. Flow injection analysis for measurement of substrates, products, and other metabolites-Data analysis-state and parameter estimation techniques for biochemical processes-biosensors in bioprocess monitoring, biosensors based on thermal effects, optical effects, potentiometric biosensors, amperometric biosensors, enzyme electrodes, transducers, electrochemical probes.UNIT IIIFERMENTATION CONTROL SYSTEMS9 hoursControl of fermentation; requirement of control, nature of control, control loop strategy, typical fermentation sensors, control action, types of control, feedback and feed forward control loop, different types of controllers,P,PI,PD and PID.9 hoursUNIT IVFERMENTATION PARAMETERS9 hoursController characteristics and tuning, ultimate gain method, cascade control system- fermentation control, advanced incubation control-fermentation profile-other advanced fermentation control.9 hoursUNIT VDIGITAL PROCESS CONTROL AND ANN9 hoursFundamentals of digital process control; Use of computer in control and optimization of microbiological processes. Artificial neural networking and use in prediction of bioprocess and	CO5 digitand	ly the principles of tal process control use of computers in process control. M L H H H M	Н М
UNIT IMEASUREMENTS IN BIOCHEMICAL PROCESS9 hoursBiochemical process variables and their measurements; Control principles and their applicationin bioreactors; Theory of electrode processes and their applications; Measurement and controlof pH, temperature, dissolved oxygen, aeration and agitation, redox potential, foam. Online dataanalysis for measurement of important physico-chemical and biochemical parameters.UNIT IIBIOSENSORS9 hoursMethods of on-line and off-line biomass estimation. Flow injection analysis for measurementof substrates, products, and other metabolites-Data analysis-state and parameter estimationtechniques for biochemical processes-biosensors in bioprocess monitoring, biosensors based onthermal effects, optical effects, potentiometric biosensors, amperometric biosensors, enzymeelectrodes, transducers, electrochemical probes.9 hoursUNIT IIIFERMENTATION CONTROL SYSTEMS9 hoursControl of fermentation; requirement of control, nature of control, control loop strategy, typicalfermentation sensors, control action, types of control, feedback and feed forward control loop,different types of controllers,P,PI,PD and PID.UNIT IVFERMENTATION PARAMETERS9 hoursController characteristics and tuning, ultimate gain method, cascade control system-fermentation profile-otheradvanced ferruentation control.unity, advanced incubation control-ferrmentation profile-otheradvanced ferruentation control.UNIT VDIGITAL PROCESS CONTROL AND ANN9 hoursFundamentals of digital process control; Use of computer in control and optimization ofmicrobiological processes andferuncitation of <th>H – High; M</th> <th>Medium; L- Low</th> <th>· · · · ·</th>	H – High; M	Medium; L- Low	· · · · ·
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UNIT IVFERMENTATION PARAMETERS9 hoursController characteristics and tuning, ultimate gain method, cascade control system- fermentation control system objectives-fermenter control specification, control of incubation, specification for incubation control, advanced incubation control-fermentation profile-other advanced fermentation control.9 hoursUNIT VDIGITAL PROCESS CONTROL AND ANN9 hoursFundamentals of digital process control; Use of computer in control and optimization of microbiological processes. Artificial neural networking and use in prediction of bioprocess and			
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fermentation control system objectives-fermenter control specification, control of incubation, specification for incubation control, advanced incubation control-fermentation profile-other advanced fermentation control.         UNIT V       DIGITAL PROCESS CONTROL AND ANN       9 hours         Fundamentals of digital process control; Use of computer in control and optimization of microbiological processes. Artificial neural networking and use in prediction of bioprocess and	Control of fer fermentation	mentation; requirement of control, nature of control, control lo sensors, control action, types of control, feedback and feed for	oop strategy, typical
specification for incubation control, advanced incubation control-fermentation profile-other advanced fermentation control.         UNIT V       DIGITAL PROCESS CONTROL AND ANN       9 hours         Fundamentals of digital process control; Use of computer in control and optimization of microbiological processes. Artificial neural networking and use in prediction of bioprocess and	Control of fer fermentation	mentation; requirement of control, nature of control, control lo sensors, control action, types of control, feedback and feed for s of controllers,P,PI,PD and PID.	oop strategy, typical rward control loop,
advanced fermentation control.         UNIT V       DIGITAL PROCESS CONTROL AND ANN       9 hours         Fundamentals       of digital process control; Use of computer in control and optimization of microbiological processes. Artificial neural networking and use in prediction of bioprocess and	Control of fer fermentation different type UNIT IV	mentation; requirement of control, nature of control, control lo sensors, control action, types of control, feedback and feed for s of controllers,P,PI,PD and PID. FERMENTATION PARAMETERS	oop strategy, typical rward control loop, 9 hours
UNIT VDIGITAL PROCESS CONTROL AND ANN9 hoursFundamentalsof digital process control; Use of computer in control and optimization of microbiological processes. Artificial neural networking and use in prediction of bioprocess and	Control of fer fermentation different type UNIT IV Controller cl	mentation; requirement of control, nature of control, control lo sensors, control action, types of control, feedback and feed for s of controllers,P,PI,PD and PID. FERMENTATION PARAMETERS haracteristics and tuning, ultimate gain method, cascade	oop strategy, typical rward control loop, 9 hours e control system-
Fundamentals of digital process control; Use of computer in control and optimization of microbiological processes. Artificial neural networking and use in prediction of bioprocess and	Control of fer fermentation different type <b>UNIT IV</b> Controller cl fermentation	mentation; requirement of control, nature of control, control lo sensors, control action, types of control, feedback and feed for s of controllers,P,PI,PD and PID. FERMENTATION PARAMETERS haracteristics and tuning, ultimate gain method, cascade control system objectives-fermenter control specification, cor	oop strategy, typical rward control loop, <b>9 hours</b> e control system- ntrol of incubation,
microbiological processes. Artificial neural networking and use in prediction of bioprocess and	Control of fer fermentation different type UNIT IV Controller cl fermentation specification	mentation; requirement of control, nature of control, control lo sensors, control action, types of control, feedback and feed for s of controllers,P,PI,PD and PID. FERMENTATION PARAMETERS haracteristics and tuning, ultimate gain method, cascade control system objectives-fermenter control specification, cor for incubation control, advanced incubation control-ferment	oop strategy, typical rward control loop, <b>9 hours</b> e control system- ntrol of incubation,
	Control of fer fermentation different type UNIT IV Controller cl fermentation specification	mentation; requirement of control, nature of control, control lo sensors, control action, types of control, feedback and feed for s of controllers,P,PI,PD and PID. FERMENTATION PARAMETERS haracteristics and tuning, ultimate gain method, cascade control system objectives-fermenter control specification, cor for incubation control, advanced incubation control-ferment nentation control.	op strategy, typical rward control loop, <b>9 hours</b> e control system- ntrol of incubation, tation profile-other
control.	Control of fer fermentation different type UNIT IV Controller cl fermentation specification advanced ferr UNIT V	<ul> <li>mentation; requirement of control, nature of control, control lo sensors, control action, types of control, feedback and feed for s of controllers, P, PI, PD and PID.</li> <li>FERMENTATION PARAMETERS         <ul> <li>haracteristics and tuning, ultimate gain method, cascade control system objectives-fermenter control specification, cor for incubation control, advanced incubation control-ferment nentation control.</li> </ul> </li> <li>DIGITAL PROCESS CONTROL AND ANN</li> </ul>	oop strategy, typical rward control loop, 9 hours e control system- ntrol of incubation, tation profile-other 9 hours
	Control of fer fermentation different type UNIT IV Controller cl fermentation specification advanced ferr UNIT V Fundamentals	mentation; requirement of control, nature of control, control lo sensors, control action, types of control, feedback and feed for s of controllers, P, PI, PD and PID.          FERMENTATION PARAMETERS         haracteristics and tuning, ultimate gain method, cascade control system objectives-fermenter control specification, cor for incubation control, advanced incubation control-ferment nentation control.         DIGITAL PROCESS CONTROL AND ANN         s of digital process control; Use of computer in control ar	op strategy, typical rward control loop, <b>9 hours</b> e control system- ntrol of incubation, tation profile-other <b>9 hours</b> nd optimization of
	Control of fer fermentation different type UNIT IV Controller cl fermentation specification advanced ferr UNIT V Fundamentals	mentation; requirement of control, nature of control, control lo sensors, control action, types of control, feedback and feed for s of controllers, P, PI, PD and PID.          FERMENTATION PARAMETERS         haracteristics and tuning, ultimate gain method, cascade control system objectives-fermenter control specification, cor for incubation control, advanced incubation control-ferment nentation control.         DIGITAL PROCESS CONTROL AND ANN         s of digital process control; Use of computer in control ar	op strategy, typical rward control loop, <b>9 hours</b> e control system- ntrol of incubation, tation profile-other <b>9 hours</b> nd optimization of

LEARNING RE	SOURCES
Text Books	
Reference Books	<ol> <li>Shuler M. L. and Kargi F, Bio-process Engineering, 2nd Edition, Prentice Hall of India, New Delhi, 2002.</li> <li>Bailey J.E and Ollis D.F, Biochemical Engineering Fundamentals, 2nd Ed., McGraw-Hill Publishing Co.</li> <li>Yang, V.C and Ngo T.T, Biosensors and Their Applications, Kluwer Academic/Plenum Publishers, 2000.</li> <li>Stephanopoulose G. Chemical Process Control, An introduction to theory and practice, Prentice Hall of India, New Delhi, 1993.</li> <li>Seborg E and Edgar J.F and Mellichamp, Process Dynamics and Control, John Wiley.</li> </ol>
Reference videos	https://www.youtube.com/watch?v=7uIIq_Ofzgw https://www.youtube.com/watch?v=hdaVgptDQA https://www.youtube.com/watch?v=ndoXG0NfiYc https://www.youtube.com/watch?v=yjAdp2aO7XM https://www.youtube.com/watch?v=uBY9YTYd5SU
Reference NPTEL	https://nptel.ac.in/courses/102106053
Reference research/ review articles	<ol> <li>Jerkiewicz, G. (2020). Standard and reversible hydrogen electrodes: Theory, design, operation, and applications. ACS Catalysis, 10(15), 8409-8417.</li> <li>Ding, J., &amp; Qin, W. (2020). Recent advances in potentiometric biosensors. TrAC Trends in Analytical Chemistry, 124, 115803.</li> <li>Schachinger, F., Chang, H., Scheiblbrandner, S., &amp; Ludwig, R. (2021). Amperometric biosensors based on direct electron transfer enzymes. Molecules, 26(15), 4525.</li> <li>Krieger-Weber, S., Heras, J. M., &amp; Suarez, C. (2020). Lactobacillus plantarum, a new biological tool to control malolactic fermentation: A review and an outlook. Beverages, 6(2), 23.</li> <li>Sklar, B. (2021). Digital communications: fundamentals and applications. Pearson.</li> </ol>

Course Code	<b>Course Title</b>	L	Т	Р	С
10213BT108	ADVANCED ANALYTICAL AND INSTRUMENTATION BIOPROCESS APPLICATIONS	3	0	0	3
<b>Course Category</b>	Open Elective				
Preamble	The course introduces the learner to bas involved for analytical and instrumentation applications.				
Prerequisite Courses	NIL				

Course Outcomes	Upon successful completion of the course, students will	be able to:
CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Differentiate the variables and basic criteria for design of bioreactor	K2
CO2	Understand different modes of Bioreactor operation	K2
CO3	Solve Oxygen transfer in bioreactors in relation to transfer coefficients	К3
CO4	Analyze Oxygen transfer in bioreactors in relation to power requirements	K4
CO5	Examine scale up and scale down criteria in fermenter	K4

Correlation	of COs	with POs:
Correlation	01 0 0 5	, ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,

CO Nos.	Course Outcomes				Prog	ramı	ne O	utcoi	nes	(POs	5)			S] Ou	ograi pecifi itcom PSOs)	c es
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Differentiate the variables and basic criteria for design of bioreactor	T.											Н	L		
CO2	Understand different modes of Bioreactor operation		L	М	L		Н						Н	М	L	
CO3	Solve Oxygen transfer in bioreactors in relation to transfer coefficients		М	L	L								L	М		
CO4	Analyze Oxygen transfer in bioreactors in relation to power requirements	м	Н	Н	М								L	Н		

CO5		e scale up and own criteria in er		Н	Н	Н	Н	Н						М	Н	М	
H – Hig	h; M- Me	edium; L- Low															
Course	Content:																
UNIT I		BIOPROCES	SS II	NST	RUN	MEN	ITA	TIC	)N					9	hou	Irs	
Bioproc	ess Instru	mentation: Tem	pera	ature	, pH	, Lev	vel, I	Flov	v, P	ress	ure	, DO	sens	sors.	Resp	oonse	eof
First ord	ler systen	ns: Transfer Fur	nctic	n, T	ransi	ient	Resp	pons	se, F	Forc	ing	Fun	ctior	ns an	d Re	spon	ses
Basic cr	iteria for	design of biorea	ictor	ſ													
UNIT I	[	BIOREACTO	ORS												9 ho	urs	
		ion of bioreacto			h op	berat	ion	(enz	zym	atic	an	d m	icrot				ous
		ne analysis of p			•				•								
UNIT I	II	OXYGEN TH	RAN	SFE	R II	N BI	OR	EA	СТ	OR-	I				9 ho	urs	
Oxygen	transfer i	n bioreactors-I:	Oxy	gen	tran	sfer	to c	ells	– tra	ansf	fer r	esist	tance	es – r	nass	trans	sfer
coefficie	ents – det	ermination of or	xyge	en tra	nsfe	er co	effic	eient	ts								
UNIT I	V	OXYGEN TH	RAN	SFE	R II	N BI	OR	EA	СТ	OR-	II				9 ho	urs	
Oxygen	transfer i	in bioreactors –	II: ]	Powe	er re	quire	eme	nt fo	or m	ixir	ng i	n ae	rated	and	non	-aera	ted
tanks, ag	gitated an	d non-agitated	tank	s foi	Ne	wton	ian	and	nor	1-No	ewt	onia	n liq	uid.	Mixi	ng ti	me
in agitat	ed reactor	r															
UNIT V	7	SCALE -UP	PRO	OCE	SS										9 ho	urs	
Scale –	Up: Reac	tor scale up – Se	cale	up c	riter	ia –	Scal	e do	own								
	-	-		-													
IFADN	INC PF	SOURCES															
Text Bo																	
Referen Books		<ol> <li>Michael L Engineerir</li> <li>Pauline M Academic</li> </ol>	ıg, 3 Dor	rd E an (2	ditio	n, P	renti	ice I	Hall	Inte	erna	ation	al Se	eries.		•	
Referen videos	ce	https://www.y https://www.y https://www.y https://www.y https://www.y	outu outu outu	ıbe.c ıbe.c ıbe.c	om/v om/v om/v	watc watc watc	h?v= h?v= h?v=	=ml =SU =vsr	JDX Vei wzr	Kupi qR( 2Za	n2E QYI 10Y	)hk Bg					
Referen NPTEL		https://archiv	e.np	otel.	ac.in	/cou	rses	s/10	2/1(	07/1	021	070	28/				
Referen researcl review a	h/	1. Pásztory, conductivi Engineerir	ty	of t	ouild	ing											

2.	Battiston, F., Amico, E., Barrat, A., Bianconi, G., Ferraz de Arruda, G., Franceschiello, B., & Petri, G. (2021). The physics of higher-order interactions in complex systems. Nature Physics, 17(10), 1093-1098.
3.	Boughton, C. K., & Hovorka, R. (2021). New closed-loop insulin systems. Diabetologia, 64, 1007-1015.
4.	Shen, Y., Borowski, J. E., Hardy, M. A., Sarpong, R., Doyle, A. G., & Cernak, T. (2021). Automation and computer-assisted planning for chemical synthesis. Nature Reviews Methods Primers, 1(1), 1-23.
5.	Farhan Hashosh, A., & Basirzadeh, H. (2024). Routh stability criterion and Lyapunov-Routh method in control theory. International Journal of Nonlinear Analysis and Applications, 15(5), 111-120.

Course Code		Course Title	L	Т	Р	С							
10213BT109		BIOSENSORS	3	0	0	3							
	· · ·												
<b>Course Categ</b>	ory	Open Elective											
Preamble		This course helps to understand the use of biomolecues as recognition elements for detection of a particular analyte and the use of biological elements such as proteins in place of silicon chips.											
Prerequisite (	Courses	NIL											
Course Outcomes	Upon su	accessful completion of the course, students will be able to:											
CO Nos.		Course Outcomes	(I	Knowledge Leve (Based on revised Bloom's Taxonomy									
CO1	Explain applicat	the application of biomolecules in sensing ions.	5	ł	ζ2								
CO2		and principle behind the functions of the immune ors and immobilized enzymes.	;	K2									
CO3		he biochemical and electrochemical mechanism lop biosensors and oligonucleotide sensitive	K2										

electrodes.

CO4

CO	CO5Analyze the metals and minerals by using biosensors.												K4				
Correlat	Correlation of COs with POs:																
CO Nos.	Cours	se Outcomes	Programme Outcomes (POs)									Program Specific Outcomes (PSOs)					
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	of bior	he application nolecules in pplications.	Η	Η	Н	Н								Н	Н	М	L
CO2	behind th	nd principle le functions of er biosensors.		Η	Н	Н		М	М					Н	Н	Н	L
CO3	and el mechanis	e biochemical lectrochemical m to detect the in biosensors.	Η	Η	Н	Н	Η	Н	М					М	М	М	Н
CO4		e of biosensors ous medicinal ons.		Η	М	Н		Η						Н	Н	Н	

Make use of chromophores and fluorophore to construct

enzyme based fiberoptic biosensors.

K3

									1	1				r		1	1	
CO5	mine Nanc	-	ls and using based	Μ	Н	Н	Н	Н	Н	Н	L				М	Н	Н	L
H – High	h; M-	Medium; L-	Low					-										
Course (	Conte	ent:																
UNIT I		INTRODUC	TION	T	) BI	[OS]	ENS	OR	S							9 ho	urs	
Definitio	ons, b	iological ins	piratio	on,	type	s of	ser	isor	s, ta	arge	t a	naly	vtes,	vari	ous	reco	gniti	on,
Recognit	tion ev	vent: Catalyti	c, Sing	le a	nd n	nulti	ple e	nzy	me,	Bio	Af	finit	y: La	abele	ed an	d Lal	bel f	ree,
-		sing – bacte	-			-	-	•					•					
		n Techniques	•	,					,						,			
UNIT II	[	BASIC DES	SIGN A	NI	) TF	RAN	SDI	JCE	R							9 ho	urs	
UNIT IIBASIC DESIGN AND TRANSDUCER9 hoursConsiderations calibration, dynamic Range, signal to noise, sensitivity, selectivity, Interference													nce					
			•		-		-						•		•			
Recognition/Transduction membrane protein sensors: ion channels, Types of Transducer, Ontical: Fiber Ontic FET Impedance Piezoelectric: Cantilever													,					
Optical; Fiber Optic, FET, Impedance, Piezoelectric; Cantilever																		
UNIT II								1	<b>F</b>			0	<u> </u>			9 ho		
		Spectroscopy				-		and	Em	18810	on,	Sur	face	Plas	smon	Res	onar	ice,
Magnetic	c labe	ling, Electroo	chemic	al I	Detec	ction	•											
UNIT IV	V	APPLICAT	IONS	OF	BIC	DSE	NSC	DRS								9 ho	urs	
Biosenso	ors and	d diabetes ma	nagem	ent	, Mie	crofa	bric	ated	bio	sens	sors	and	l poi	nt-of	f-care	e diag	gnos	tics
systems,	Non	invasive bio	osensoi	s i	n c	linic	al a	inaly	ysis;	Sı	urfa	ice	plas	mon	res	onan	ce	and
evanesce	ent wa	ve biosensor	s, Bios	ens	or in	ı can	cer a	and	HIV	ear	ly d	liag	nosi	s.				
UNIT V		APPLICAT BIOSENSO		OF	NA	NO	MA	FER	RIAI	LS I	IN					9 ho	urs	
Nano Ma	ateria	ls in biosens	ors; Ca	arbo	on ba	ased	Nar	no N	/late	rial	, M	etal	oxi	de a	nd na	ano j	parti	cle,
Quantum	n dots	, Role of na	ano ma	ater	ial i	n Si	gnal	An	nplit	ficat	tion	s, I	Detec	ction	and	Tra	nsdu	lcer
Fabricati							-		•									
IFADN		DEGOUDOI	20															
		RESOURCE	79															
Text Boo		1 Jaama V	ol V-	07	<b>"Т</b>	tro 1-	lot:-	n +-	<u>. п</u> .	0000	nca	<b>n</b> a •	Gran	, E1-	noteri -	Cir	an:+-	. <b>t</b> c
		1. Jeong-Ye Immunos													curic	UI	cuits	10
Referen	ce	2. Mohamm													ors",	1 st	Edit	ion,
Books		Springer-	-	-						-		_	•		-			
		3. ZviLiron,' Edition, S		-	-			Bios	enso	ors a	and	Raj	pid E	Diagr	nostic	c Ass	ays'	',1 st
Reference videos	ce	Edition, Springer US, 2001.         https://www.youtube.com/watch?v=9SF_8LP2xKM																

	https://www.youtube.com/watch?v=4PvOLVzHV3g&list=PLkqcnysg6e- tdd24uyfDKlaC0vyFbkNdF https://www.youtube.com/watch?v=ER6YIeYjluY&list=PLkqcnysg6e- tdd24uyfDKlaC0vyFbkNdF&index=3 https://www.youtube.com/watch?v=IY0PswHQS9k https://www.youtube.com/watch?v=0-PvA1Sl4WE
Reference NPTEL	https://nptel.ac.in/courses/115107122
Reference research/ review articles	<ol> <li>Barhoum, A., Altintas, Z., Devi, K. S., &amp; Forster, R. J. (2023). Electrochemiluminescence biosensors for detection of cancer biomarkers in biofluids: Principles, opportunities, and challenges. Nano Today, 50, 101874.</li> <li>Lu, J., Zhuang, X., Wei, H., Liu, R., Ji, W., Yu, P., &amp; Mao, L. (2024). Enzymatic Galvanic Redox Potentiometry for In Vivo Biosensing. Analytical Chemistry.</li> <li>Singh, A. K., Mittal, S., Das, M., Saharia, A., &amp; Tiwari, M. (2023). Optical biosensors: A decade in review. Alexandria Engineering Journal, 67, 673- 691.</li> <li>Selvolini, G., &amp; Marrazza, G. (2023). Sensor principles and basic designs. In Fundamentals of Sensor Technology (pp. 17-43). Woodhead Publishing.</li> <li>Rubino, A., &amp; Queirós, R. (2023). Electrochemical determination of heavy metal ions applying screen-printed electrodes based sensors. A review on water and environmental samples analysis. Talanta Open, 100203.</li> </ol>

Course	Cod	e			(	Cour	se T	itle						L	T		P	С	
10213B	ST110	)			]	BIO	CHI	PS						3	0		0	3	
Carrier	Catao		Orner	Ela	4:											·			
Course	Categ	gory	Open To k			05501	tial	cor	icon	ts c	f h	incl	inc	and	mici	oar		with	
Preamb	le		то к. тајо									iocr	ups	ana	micr	ourr	ay	viin	
Prerequ	isite	Course	s NIL					_	_	_	_								
~																			
Cours Outcon		Upon s	successful	comp	letio	on of	the o	cour	se, s	stua	lent.	s wi	ll be	able	e to:				
CO No	os.			ours	e Ou	tcor	nes							now (Base) loom	d on	revis	ed		
CO1			stand the on mechar		king	, pr	incip	oles	of	bi	ochi	ips	and			K2			
CO2			op Acquisi or various				ysis	tecł	nniq	ues	wit	h n	nicro			K2			
CO3			e different j cal frame v	-				-	-	_					К3				
CO4			se the D cular devi							omj	puti	ng	and		K4				
CO5			ne the bioc ics, drug d	-					-		-			K4					
														-					
Correlat	tion of	f COs w	vith POs:	I												1			
CO Nos.		Course O	Outcomes				Prog	ram	me O	utco	mes	(POs	s)			rogram Specific utcomes (PSOs)			
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	work		inciples o			Н	Η								Н	Н	M		
	mecł	nanism	d detectio																
CO2	with	analysis micro	Acquisitio technique array fo ications.	s	H	M	М		M						H	Н	Н		
CO3	gene statis for	ze ictive regul stical f gene analysi:	d k	Н	М	L	L	Н						М	М	М			

CO4 M an	nalyse the athematical models id Modeling in DNA icroarray		Н	М	Н	Н	Н	Н					Н	Н	Н								
fo dia CO5 ge dia ep	kamine the biochips r molecular agnostics, pharmacc enomics, drug scovery and bidemiology pplications.	g M	Н	М	М	М	L	L	L				М	Н	Η	L							
H – High; M	M- Medium; L- Low																						
Course Contonts																							
Course Content:																							
UNIT IINTRODUCTION9 hoursBasics of Biochips: Types of Biochips - DNA MicroarraysProtein Microarrays																							
Basics of Biochips; Types of Biochips - DNA Microarrays, Protein Microarrays,																							
Oligonucleotide, cDNA and genomic microarrays, Integrated biochip system; microarray																							
scanners./headers, microarray robotics; microfluidics systems, chips and mass spectrometry.																							
UNIT IICONSTRUCTION OF BIOCHIPS9 hours																							
UNIT II         CONSTRUCTION OF BIOCHIPS         9 hours           Biochips assays, combination of microarray and biosensor technology, biochip versus gel-based         9 hours																							
Biochips as	says, combination of	nicr	oarra	iy an	d bio	osen	lsor	tech	nol	ogy	, bio	methods, process flow for production and analysis of a chip, standardization of microarray											
-	-			•								-		-									
methods, pr	rocess flow for prod	uctio	on ar	nd ar	nalys	sis c	of a	chij	p, s	tan	dard	izatio	on of	f mic	eroar	ray							
methods, pr analysis, bi	rocess flow for prod oinformatics and mid	uctio croar	on ar rays	nd ar , eva	nalys aluat	sis c ion	of a of c	chij conv	p, s vent	tan ion	dard al m	izatio	on of array	f mic tech	roar nolo	ray gy.							
methods, pr analysis, bi	rocess flow for prod oinformatics and mid etection methods for	uctio croar	on ar rays	nd ar , eva	nalys aluat	sis c ion	of a of c	chij conv	p, s vent	tan ion	dard al m	izatio	on of array	f mic tech	roar nolo	ray gy.							
methods, pr analysis, bi Electrical d	rocess flow for prod oinformatics and mid etection methods for parrays.	uctio croar	on ar rays oarra	nd an , eva	nalys iluat SER	sis c ion .S (S	of a of c Surfa	chij conv ace-	p, s vent	tan iona	dard al m	izatio icroa Rama	on of urray an spo	f mic tech	eroar nolo scop	ray gy.							
methods, pr analysis, bi Electrical d based micro UNIT III	rocess flow for prod oinformatics and mic etection methods for parrays. GENOME SIC	uctio croar micr	on ar rays oarra	nd an , eva ays, f	nalys aluat SER	sis c ion .S (S SSI	of a of c Surfa NG	chij conv ace-	p, s vent Enh	tand iona nand	dard: al m ced F <b>DN</b>	izatio icroa Rama	on of urray un spo g	f mic tech ectro <b>) hou</b>	roar nolo scop	ray gy. y)-							
methods, pr analysis, bi Electrical d based micro UNIT III Genome sig	rocess flow for prod oinformatics and mid etection methods for parrays. GENOME SIC COMPUTING	uctic croar micr ENA	on ar rays oarra L	nd an , eva ays, <b>PRC</b> //ath	nalys iluat SER DCE ema	sis c ion .S (S SSI tical	of a of c Surfa NG	chij conv ace- A dels	p, s vent Enh	tandiona nanc	dard al m ced F DN	izatio icroa Rama A ing I	on of urray an spo g ONA	f mic tech ectro <b>) hou</b> Mic	roar nolo scop Irs	ray gy. y)-							
methods, pr analysis, bi Electrical d based micro <b>UNIT III</b> Genome sig DNA Comp	rocess flow for prod oinformatics and mid etection methods for parrays. GENOME SIC COMPUTING gnal processing: Introd	uctic croar micr MA luctif Junc	on ar rays oarra L on, N	nd an , eva ays, <b>PRC</b> //ath	nalys iluat SER DCE ema	sis c ion .S (S SSI tical	of a of c Surfa NG	chij conv ace- A dels	p, s vent Enh	tandiona nanc	dard al m ced F DN	izatio icroa Rama A ing I	on of urray an spo g ONA	f mic tech ectro <b>) hou</b> Mic	roar nolo scop <b>irs</b> roarr	ray gy. y)-							
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LEARNING	RESOURCES
Text Books	
Reference Books	<ol> <li>Isaac S. Kohane, Alvin Kho, Atul J. Butte., "Microarrays for an Integrative Genomics (Computational Molecular Biology)", 1st edition, MIT Press, 2002.</li> <li>Helen C. Causton, John Quackenbush, Alvis Brazma., "Microarray Gene Expression Data Analysis: A Beginner's Guide", 1st edition, Wiley- Blackwell, 2003.</li> <li>Sorin Draghici, "Data Analysis Tools for DNA Microarrays", Har/Cdr Re edition, Chapman &amp; Hall/CRC, 2003.</li> <li>DNA Computing: 15th International Meeting on DNA Computing, DNA 15, Fayetteville, AR, USA, June 8-11, 2009, Springer, 2009.</li> <li>Grigorenko E., "DNA Arrays: Technology and Experimental Strategies", Vth Edition, CRC Press, 2002.</li> <li>Wan-Li Xing and Jing Cheng., "Biochips: Technology and Applications", Springer, 2003.</li> </ol>
Reference videos	https://www.youtube.com/watch?v=208pMhKoQeo https://www.youtube.com/watch?v=g8Qav3vIv9s https://www.youtube.com/watch?v=vefBhhjodpE https://www.youtube.com/watch?v=-EO5fmz0tts https://www.youtube.com/watch?v=HZ8f0F2RMuo
Reference NPTEL	https://nptel.ac.in/courses/112104029
Reference research/ review articles	<ol> <li>Gmuender, H. (2024). Perspectives and challenges for DNA microarrays in drug discovery and development. Biotechniques, 32(1).</li> <li>Zhang, D., Pu, H., Huang, L., &amp; Sun, D. W. (2021). Advances in flexible surface-enhanced Raman scattering (SERS) substrates for nondestructive food detection: Fundamentals and recent applications. Trends in Food Science &amp; Technology, 109, 690-701.</li> <li>Fruncillo, S., Su, X., Liu, H., &amp; Wong, L. S. (2021). Lithographic processes for the scalable fabrication of micro-and nanostructures for biochips and biosensors. ACS sensors, 6(6), 2002-2024.</li> <li>Azizipour, N., Avazpour, R., Rosenzweig, D. H., Sawan, M., &amp; Ajji, A. (2020). Evolution of biochip technology: A review from lab-on-a-chip to organ-on-a-chip. Micromachines, 11(6), 599.</li> <li>Azizipour, N., Avazpour, R., Rosenzweig, D. H., Sawan, M., &amp; Ajji, A. (2020). Evolution of biochip technology: A review from lab-on-a-chip to organ-on-a-chip. Micromachines, 11(6), 599.</li> </ol>

Course Code	e	Course Title	L	Т	Р	С							
10213BT120	)	BIOMATERIALS	3	0	0	3							
Course Categ	gory	Open Elective											
Preamble		0	This Course will give a broad view towards various types of biomaterials, its properties, manufacturing methods and its applications.										
Prerequisite	Courses	NIL											
		•											
Course Outcomes	I non successful completion of the course students will be able to												
CO Nos.Course OutcomesKnowledgeColoredCourse Outcomes(Based on the sector)													

CO Nos.	Course Outcomes	(Based on revised Bloom's Taxonomy)
CO1	Understand the physiochemical properties of Biomaterials	K2
CO2	Apply the Metallic and Ceramic biomaterials for various medical applications	К3
CO3	Make use of biopolymers for various industrial applications.	К3
CO4	Select the biomaterials according to the mechanisms and regularities of friction and wear.	К3
CO5	Develop and identify the degradation and Corrosion characteristics of biomaterials	К3
	•	

CO Nos.	Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand the physio chemical properties of Biomaterials			М									Н	Н	М	
CO2	Apply the Metallic and Ceramic biomaterials for various medical applications		М	М									Н	Н	Н	
CO3	Make use of biopolymers for various industrial applications.		М	М									Н	Н	Н	L
CO4	Select the biomaterials according to the mechanisms and regularities of friction and wear.	Н	Н	Н	М								Н	Н	М	L

CO5 Corro chara	lop and identify degradation and osion H H H M H cteristics of aterials	H H M L											
H – High; M-	Medium; L- Low												
Course Conte	nt:												
UNIT I	BIOMATERIALS	9 hours											
Introduction t	Biomaterials, Physical and Chemical properties, perform	mance, response to											
implants, blood compatibility, Nanoscale phenomena.													
UNIT II	METALLIC AND CERAMIC BIOMATERIALS	9 hours											
Different impl	plants - Stainless steels, cobalt-based alloys, Titanium-based alloys, shape memor												
alloy, ceramic implant, nanostructured metallic implants, biodegradable or bioresorbable													
bioactive ceramics, nanostructured bio ceramics.													
UNIT III	POLYMERIC BIOMATERIALS 9 hou												
Polymer as b	omaterials, Polymerization, properties of polymers, biode	gradable polymers,											
Introduction b	io polymers: Collagen, Elastin and chitin, Medical Textiles.												
UNIT IV	FAILURE AND TRIBOLOGY OF BIOMATERIALS	9 hours											
Failure and	Tribology of Biomaterials: Deformation Mechanics, Fi	racture Mechanics,											
Classification	of Fracture, Brittle to Ductile Transition of Biomaterials, 7	Foughness Analysis											
of Biomaterial	S.												
UNIT V	DEGRADATION AND CORROSION OF BIOMATERIALS	9 hours											
Degradation a	nd Corrosion of Biomaterials: Surface Properties, Degradati	on of Biomaterials,											
Corrosion of E	Biomaterials, Methods of Corrosion Testing, Biocompatibility	y of Implants.											
LEARNING	RESOURCES												
Text Books													
Reference Books	<ol> <li>Sujata V. Bhatt, "Biomaterials", Second Edition, Naros 2005.</li> <li>Sreeram Ramakrishna, Murugan Ramalingam, Sampa Winston O. Soboyejo, "Biomaterials: A Nano Appr 2010</li> </ol>	th Kumar T.S., and											
	2010.												
	https://www.youtube.com/watch?v=XqFSlG6WKO0 https://www.youtube.com/watch?v=k ftHmWEHm8												
Reference	https://www.youtube.com/watch?v=QBDsAR2Dw6g												
videos	https://www.youtube.com/watch?v=og4BLTXJv-o												
	https://www.youtube.com/watch?v=wxaPXGcC-SU												
Reference NPTEL	https://nptel.ac.in/courses/113104009												

	1. Marin, E., Boschetto, F., & Pezzotti, G. (2020). Biomaterials and biocompatibility: An historical overview. Journal of Biomedical Materials Research Part A, 108(8), 1617-1633.
Reference research/ review articles	<ol> <li>Gritsch, L., Perrin, E., Chenal, J. M., Fredholm, Y., Maçon, A. L., Chevalier, J., &amp; Boccaccini, A. R. (2021). Combining bioresorbable polyesters and bioactive glasses: Orthopedic applications of composite implants and bone tissue engineering scaffolds. Applied Materials Today, 22, 100923.</li> <li>Samir, A., Ashour, F. H., Hakim, A. A., &amp; Bassyouni, M. (2022). Recent advances in biodegradable polymers for sustainable applications. Npj Materials Degradation, 6(1), 68.</li> </ol>
	<ol> <li>Monn, M. A., Vijaykumar, K., Kochiyama, S., &amp; Kesari, H. (2020). Lamellar architectures in stiff biomaterials may not always be templates for enhancing toughness in composites. Nature Communications, 11(1), 373.</li> <li>Kumar, A., &amp; Pandey, P. M. (2020). Development of Mg based biomaterial with improved mechanical and degradation properties using powder metallurgy. Journal of Magnesium and Alloys, 8(3), 883-898.</li> </ol>

**Honors in Bioengineering** 

Course	Code				С	ours	e Ti	tle						L	Л	Г	P	С	
10212B	ST137		INSTRU	MF		ATI ON			D P	RO	CE	SS		3	0	)	0	3	
Course	Catego	rv	Open E	Elect	tive														
Preamb		- 5	The c	our	se							to	) le	arn	abo	out	var	ious	
			Instrun	ient	atio	n an	d Pr	oces	s co	ontro	ol								
Prerequ	isite Co	ourses	NIL																
Cours Outcon		Upon suc	ccessful c	omp	oletic	on of	^c the	сои	rse,	stu	dent	ts w	ill be	e abl	e to:				
CO No	DS.	Course Outcomes									(	lnow (Base loom	d on	revis	ed				
CO1		Understand the principles and classification of bioprocess variables									5		K2						
CO2		Apply La calculation	aplace tr	ansf	orm	atio	n to	sol	ve v	ario	ous	pro	ocess			K3			
CO3			e of close or fermen		-		ther	con	npor	nent	s in	pro	ocess		К3				
CO4		Build to application	different ons	typ	es o	f co	ntrol	l sys	stem	is fo	or in	ndu	strial		К3				
CO5		•	sh differ of reactor				d cr	iteri	a f	or (	cont	trol	and		K4				
<u>a</u>		~~																	
Correlat	tion of <b>(</b>	COs with	POs:													Р	rogra	m	
CO Nos.	Co	ourse Outco	omes				Prog	ramı	me O	utco	mes	(POs	5)				Program Specific Outcomes (PSOs)		
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	ciples	stand tl and class process v	ification	L			Н	Н							Н	L	Н		
CO2	Apply transfc variou calcula	ormation s	М	Н	М	Н		Н						Н	М	L			
CO3	and o in pro	ther con	osed loop nponents ntrol for gn	М	М	Н	М		М						L	М		L	
CO4	of con		ent types tems for cations	Μ	Н	Н	М	Н							L	Н		Н	

CO5	stand contr		different iteria for stability of ns	н	Н	Н	Н	Н							М	Н	М	М
H – Hig	h; M-	Medium	ı; L- Low		I		I	1	I							1	1	1
Course		1																
UNIT I			DDUCTIO													9 ho		
1			ements an															
tempera	ture,	pressure	, fluid flo	w,	liqu	uid y	weig	ht	and	we	eigh	t f	low	rate	, vis	scosi	ty,	pН,
concent	ration,	, electrica	al and therr	nal	cond	lucti	vity,	hur	nidi	ty o	f ga	ises	•					
UNIT I	I	MATH SYSTI	IEMATIC EMS	AL	MO	DE	LIN	G A	ND	CO	NT	RC	DL			9 ho	urs	
Laplace	transf	formation	n, applicatio	on to	o sol	ve C	DEs	s. Op	ben-	loop	o sy	ster	ns, f	irst c	order	syste	ems	and
their tra	nsient	response	e for standa	ard i	inpu	t fun	ction	ns, f	irst	orde	er sy	yste	ems i	n sei	ries,	linea	rizat	ion
and its a	applica	ation in p	process con	trol	, sec	ond	orde	r sy	sten	ns a	nd t	hei	r dyr	nami	cs; tr	ansp	orta	tion
lag.																		
UNIT I	II	CLOS	ED-LOOP	CC	)NT	ROI	LSY	ST	EM	S						9 ho	urs	
Closed l	oopco		stems, deve								r fee	ed-ł	back	cont	rol sy	ysten	ns se	rvo
and regu	ulatory	y problen	ns, transfer	fun	octio	n foi	con	trol	lers	and	fin	al c	ontr	ol el	emer	ıt, pr	incip	oles
of pneur	matic	and elect	tronic contr	olle	ers, t	rans	ient	resp	ons	e of	clo	sed	-looj	p coi	ntrol	syste	ems	and
their sta	bility							-					-	-		-		
UNIT I	V	ADVA	NCED CC	DNT	RO	L SY	<b>ST</b>	EM	S							9 ho	urs	
Introduc	ction 1	to advar	nced contro	ol s	yste	ms,	case	cade	co	ntro	l, f	eed	for	ware	d con	ntrol	, Sn	nith
predicto	or cont	roller, co	ntrol of dis	tilla	tion	tow	ers a	nd h	eat	excl	nang	gers	, int	rodu	ction	to co	omp	uter
control	of che	mical pro	ocesses															
UNIT V	7	ADVA ANAL	NCED PR YSIS	<b>O</b> C	ESS	S CO	NT]	ROI	[ A]	ND	ST	AB	ILIT	Υ		9 ho	urs	
Stability	v criter	ria- Rout	h's stability	/ cri	teria	1 - R	oot l	ocu	s dia	igra	m -	Fre	eque	ncy	respo	nse	anal	ysis
- Gain r	nargin	1 - Phase	margin an	d ci	ross	over	free	quen	icy -	- Bo	de	plo	t - P	olar	plot	and	Nyq	uist
plot. Pro	ocess	reaction	curve - Co	oher	n-Co	on n	neth	od -	IM	C ti	unir	ng -	Zie	gler	Nich	ols	meth	od
Introduc	ction to	o multiv	ariable con	trol	- C	omp	uter	app	lica	tion	s in	ı pr	oces	s co	ntrol	- A	dvan	ced
control s	strateg	gies - Cas	scade contr	ol -	Rati	o co	ntro	l - F	eed-	For	war	d c	ontro	ol - I	nfere	ntial	con	trol
- Adapti	ive cor	ntrol - Co	ontrol of Re	eact	or -	Disti	llati	on t	owe	rs -	Hea	at E	xcha	angei	S			
LEARN	NING	RESOU	RCES															
Text Bo	ooks	-	ghanowr C. , McGraw l		-	•				ess S	Syst	em	Ana	lysis	and	Con	trol,	3rd

DC	1. Seborg D. E., Edgar, T. F., Mellichamp D. A., Process Dynamics and
Reference	Control, 3 rd ed., Wiley India, New Delhi, 2013.
Books	2. Stephanopoulos G., Chemical Process Control, 1 st ed., Pearson Education
	India, New Delhi, 2015.
	https://www.youtube.com/watch?v=azdVSr7DBlg
Deference	https://www.youtube.com/watch?v=mUDXupn2Dhk
Reference videos	https://www.youtube.com/watch?v=SUVeiqRQYBg
viucos	https://www.youtube.com/watch?v=vsrwzr2ZaoY
	https://www.youtube.com/watch?v=h4z979NFmWA
Reference	https://nptel.ac.in/courses/103103037
NPTEL	
Reference research/ review articles	<ol> <li>Pásztory, Z. (2021). An overview of factors influencing thermal conductivity of building insulation materials. Journal of Building Engineering, 44, 102604.</li> <li>Battiston, F., Amico, E., Barrat, A., Bianconi, G., Ferraz de Arruda, G., Franceschiello, B., &amp; Petri, G. (2021). The physics of higher-order interactions in complex systems. Nature Physics, 17(10), 1093-1098.</li> <li>Boughton, C. K., &amp; Hovorka, R. (2021). New closed-loop insulin systems. Diabetologia, 64, 1007-1015.</li> <li>Shen, Y., Borowski, J. E., Hardy, M. A., Sarpong, R., Doyle, A. G., &amp; Cernak, T. (2021). Automation and computer-assisted planning for chemical synthesis. Nature Reviews Methods Primers, 1(1), 1-23.</li> <li>Farhan Hashosh, A., &amp; Basirzadeh, H. (2024). Routh stability criterion and Lyapunov-Routh method in control theory. International Journal of Nonlinear Analysis and Applications, 15(5), 111-120.</li> </ol>

<b>Course Co</b>	de	Course Title	L	Τ	Р	С									
10212BT13	38	BIOMOLECULAR MODELLING	3	0	0	3									
	<u>.</u>														
Course Cat	egory	Open Elective													
Preamble															
Prerequisite	e Courses	NIL	NIL												
Course Outcomes	Upon suc	cessful completion of the course, students will b	be able to	<i>):</i>											
CO Nos.		<b>Course Outcomes</b>	(Ba	wled sed on m's Ta	revise	ed									
CO1		nd basic applications of molecular modelling and energy concepts.	;,	К2											
CO2	Outline tequations	he computational mechanics, Hartree Foch	x	K2											
CO3	Understar mechanic	d fundamental principles governing molecula s	r	К2											
CO4	Relate mo to process	lecular simulation dynamics and its application control	К2												
CO5	Apply Cl design	eminformatics and learn structure-based drug	g	K.	3										

Correlation	of	COs	with	POs:
Contenation	•••	$\mathbf{v}\mathbf{v}\mathbf{s}$	** ****	1 0 0 •

Correlat	ion of COs with POs:															
CO Nos.	Course Outcomes				Prog	ramı	ne O	utcoi	nes (	(POs	5)			S] Ou	ograi pecifi itcom PSOs	c es
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Understand basic applications of molecular modelling, graphics and energy concepts.				М	L	М						Н	L		
CO2	Outline the computational mechanics, Hartree Fock equations	Μ	L	М	L								Н	М	L	L
CO3	Understand fundamental principles governing molecular mechanics		М	L	L		Н						Н	М		
CO4	Relate molecular simulation dynamics and its applications to process control	м	Н	Н	М	Н	Н						Н	Н		

CO5 CO5 Apply Chemi learn drug d	informatics and structure-based H H H H H H H H															
H – High; M- M	ledium; L- Low															
Course Conten			TO			am			00	<b>FI</b>			0			
UNIT I	INTRODUCTI								-				_	hou		
	concept of mole				-											
••	nolecular graphic	s, co	ora	nate	sysi	lems	s, po	lent	.181	ene	rgy s	uria	ces, c	iiscu	SSIO	101
local and global	energy minima.															
UNIT II	INTRODUCTI QUANTUM M					OM	PU	ГАТ	ГΙΟ	NA	L		9	hou	rs	
Introduction to t	the computational	qua	ntur	n me	echa	nics	; on	e ele	ectr	on a	atom	, ply	elec	troni	c ato	oms
and molecules,	Hartree Fock equ	iatio	ons;	calc	ulati	ng 1	nole	ecul	ar p	orop	oertie	s us	ing a	ıb in	itio	and
semi empirical r	nethods.															
UNIT III	MOLECULAR	M	ECH	IAN	ICS									9 ho	urs	
Molecular Mech	nanics – Introduct	ion,	The	Mo	rse P	oter	ntial	, Th	e H	arn	nonic	: Osc	cillat	or M	odel	for
Molecules, Con	nparison of Morse	e an	d Ha	armo	onic	Pote	entia	al, T	wo	ato	oms (	conn	ected	l by	a bo	nd,
Poly atomic Mo	olecules, Energy d	lue t	to S	tretc	h, B	end,	, Str	etch	n-Be	end	, Tor	sion	al sti	ain,	van	der
Waals and Dipo	le-Diploe interact	ions	. Ty	pes o	of Pc	otent	ials	: Le	nna	rd-J	Jones	s, Tri	incat	ted L	enna	rd-
jones, Exponent	ial-6, Ionic and P	olar	pot	entia	ls. T	уре	s of	Foi	ce	Fiel	ds: /	AME	BER,	CHA	ARM	IM,
Merck Molecula	ar Force Field, Co	nsis	tent	Fore	ce Fi	eld,	MN	<i>A</i> 2,	MN	13 a	und N	/M4	forc	e fie	lds.	
UNIT IV	MOLECULAR	DY	'NA	MIC	CS S	IM	ULA	TI	ON					9 ho	urs	
Molecular Dyna	mics Simulation	– Int	trod	uctic	on, R	adia	ıl di	strił	outi	on f	funct	ions	, Pair	Cor	relat	ion
function, Newto	nian dynamics, In	tegr	ator	s-Le	eapfi	oga	and '	Verl	let a	lgo	rithn	n, Po	tenti	al tru	incat	ion
and shifted-for	ce potentials, In	nplic	it a	ind	expl	icit	Sol	lvati	ion	mo	odels	, Pe	riodi	ic bo	ound	ary
conditions, Tem	perature and pres	sure	con	trol	in m	olec	cula	r dy	nan	nics	sim	ulati	ons			
UNIT V	INTRODUCTI MOLECULAR					INF	OR	MA	TI	CS	ANI	)		9 ho	urs	
Introduction to	cheminformatics	, M	acro	mol	ecul	ar n	node	eling	g, ċ	lesi	gn o	f lig	ands	for	kno	wn
macro molecula	r target sites, Drug	g- re	cept	or in	itera	ctio	n, cl	assi	cal	SA	R/Q	SAR	stuc	lies a	nd th	neir
implications to t	he 3 D modeler, 2	-D a	ind 3	8-D 0	latal	oase	sea	rchi	ng,	pha	rma	coph	ore i	denti	ficat	ion
and novel drug d	lesign, molecular	docł	cing	, Stri	uctu	re-ba	ased	l dru	ıg d	esig	gn fo	r all (	class	es of	targ	ets.
LEARNING R	ESOURCES															
Text Books																

	1. Seborg D. E., Edgar, T. F., Mellichamp D. A., Process Dynamics and Control, 3 rd ed., Wiley India, New Delhi, 2013.
Reference Books	<ol> <li>Stephanopoulos G., Chemical Process Control, 1 st ed., Pearson Education India, New Delhi, 2015.</li> </ol>
	3. Coughanowr C. R., Koppel L. M., Process System Analysis and Control, 3rd ed., McGraw Hill, New Delhi, 2013.
	https://www.youtube.com/watch?v=dJg6Wc-4Ri0
Reference	https://www.youtube.com/watch?v=U3PFAoeT4eI
videos	https://www.youtube.com/watch?v=I57cyNqMYqc
	https://www.youtube.com/watch?v=g55QvpAev0I
	https://www.youtube.com/watch?v=XYkDL8Dl-2Q
Reference NPTEL	https://nptel.ac.in/courses/103103036
	1. Manzhos, S., & Carrington Jr, T. (2020). Neural network potential energy surfaces for small molecules and reactions. Chemical Reviews, 121(16), 10187-10217.
	2. Lafleche, L., & Saffirio, C. (2023). Strong semiclassical limits from Hartree and Hartree–Fock to Vlasov–Poisson equations. Analysis & PDE, 16(4), 891-926.
Reference research/ review articles	<ol> <li>Qin, M., Zeng, Z., Wu, Q., Yan, H., Liu, M., Wu, Y., &amp; Xie, J. (2023). Dipole-dipole interactions for inhibiting solvent co-intercalation into a graphite anode to extend the horizon of electrolyte design. Energy &amp; environmental science, 16(2), 546-556.</li> </ol>
	4. Carle, C., Hochbruck, M., & Sturm, A. (2020). On leapfrog-Chebyshev schemes. SIAM Journal on Numerical Analysis, 58(4), 2404-2433.
	<ol> <li>Francoeur, P. G., Masuda, T., Sunseri, J., Jia, A., Iovanisci, R. B., Snyder, I., &amp; Koes, D. R. (2020). Three-dimensional convolutional neural networks and a cross-docked data set for structure-based drug design. Journal of chemical information and modeling, 60(9), 4200-4215.</li> </ol>

Course	Code				Co	urse	Tit	le						L	, r	Г	P	С	
10212E	BT139			BI	OM	EC	HAN	NIC	S					3	(	)	0	3	
Course	0		Ope Prov com	vide	an	in-d									tical appl			ons, of	
			bion	-					~,			P						-5	
Prerequ	isite C	ourses	NIL																
Cour Outco		Upon succes.	sful o	com	plet	ion c	of the	e co:	urse	, stı	ıdei	nts -	will	be al	ole to	:			
CO N	<b>0S</b> .			C	our	se O	utco	ome	5						Knov (Base Bloom	ed on	revis	sed	
CO	1	Describe bas human physi			cepts	s of	Kir	nema	atics	s in	re	latio	on te	o		K2			
CO	2	physiologica	-	ces	ses a	ind r	nove	emer	nts		in		iriou			K2			
CO	3	Relate human														K2	,		
CO4	4	Develop mod and basic law							s of	flui	d m	ech	anic	s	K2				
CO	5	Select and stu	udy 1	the l	oody	/ flui	ds a	nd c	once	epts	of	viso	cosit	y		K3			
		<u></u>																	
Correlat	tion of	COs with PO	s:													р	rogra		
CO Nos.	C	ourse Outcomes					Prog	ram	me O	utco	mes	(PO	s)			0 0	ini ic nes s)		
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1			epts in man	L			М	L	М						Н	L			
CO2		nics involvec s physiolog ses								Н	М	L	Н						
CO3	Relate mover with la			М	М	L	L		Н						н	М			
CO4	differe fluid	ent concepts mechanics laws govern	model with concepts of nechanics and M H H M H H ws governing							Н	Н		Н						

CO5 body concep	and study the fluids and ts of viscosity	нн	Н	Н	Н	Н					М	Н	М	Н
H – High; M- N	ledium; L- Low													
~ ~ ~														
Course Conten														
UNIT I	INTRODUCTIO											9 ho		<u> </u>
	Basic Concepts: I					-								
to Forces – I	ntroduction to S	tatics	and	Dyı	nam	ics	- I	3io-	fluid	mech	anics	: V	iscos	sity,
classification of	fluids, blood rheo	ology, f	funda	men	tal r	neth	nod f	for 1	neast	iring v	iscos	ity, r	heol	ogy
of blood in micr	ovessels, mechanic	cal mo	del of	fcaro	liov	ascı	lar	syst	em, r	elation	ship	amoi	ng bl	ood
velocity, blood	pressure and blood	l vesse	l diai	nete	r in	the	vasc	ula	r tree.					
UNIT II	CONNECTIVE	TISS	UE N	ЛЕС	НА	NIC	CS					9 ho	urs	
Mechanics of b	reathing, physical	aspec	ts of	alve	oli,	diff	usio	n, a	irway	/ resist	ance	. Co	nnec	tive
tissue mechani	es: structure and	biome	chani	cal	prop	oerti	es c	of c	ollage	en, ter	idon,	liga	men	t &
cartilage; comp	osition, structure	and b	oiome	char	nical	pro	oper	ties	of b	one, t	one	fract	ure	and
	cs, skeletal muscle					_	-							
	sture; Effects of ag											-,		
			•						i posi	urc.				
UNIT III	HUMAN MOV											9 ho		
	ent mechanics: lin						-							-
of gait, projecti	e motion, linear ki	inemat	ics of	fwal	king	g & 1	runr	ing	, angı	ılar kiı	nema	tics-	type	s of
angles, lower ex	tremity joint angl	es, ang	gular	moti	ion 1	relat	tions	hip	s, rela	ationsh	ip be	twee	en lir	near
and angular mo	tion, angle-angle d	liagran	ns, lir	near	kine	tics	- lav	vs o	f mot	tion				
UNIT IV	INTRODUCTI	ON TO	) FL	UID	MF	ECH	IAN	ICS	5			9 ho	urs	
Introduction to	fluid mechanics: N	Newton	n and	non	-Ne	wto	n flu	ids	Lam	inar a	nd tu	rbule	ent fl	ow,
Viscosity, elasti	city, viscoelasticit	y; Bas	ic lav	vs go	over	ning	g rhe	olo	gy					
UNIT V	BODY FLUIDS										(	) ho	urs	
	ood, plasma, CSF		plasi	n, ly	mp	h, s	ynov	vial	fluid	, swea				ous
	fluids, cystic fluid		•		•								•	
· ·	uence of varied vi	ĺ.	2							U		<u> </u>		
			,		-60	- 5 ^{al}		5.01			,11			
	FCOUDCES													
LEARNING R		king	"Ini-	t C	truc	ture	0.4	4 5	un at	on A	Ca	mm	ahon	ivo
Text Books	1. Cynthia Nor Analysis", 2019,											mpre	enen	sive
	1. Susan J Hall							-			9, M	c Gr	aw I	Hill,
Reference	USA	<b>.</b> .				1		P				т.		<b>a</b> 1
Books	2. Y C Fung, "E Edition, 1993								•	es of L	iving	T _{1SS}	sue"	2nd
	20101011, 1992	-, - <b>ce</b> pi		4		, ~P	35	,	- ~1 1					

Reference videos	https://www.youtube.com/watch?v=LnM74brIZPE https://www.youtube.com/watch?v=cMrUhjrV9ks https://www.youtube.com/watch?v=YFf41uGO1wU https://www.youtube.com/watch?v=IJM4GuUd3Hk https://www.youtube.com/watch?v=9NYs3Y-IjGw
Reference NPTEL	https://archive.nptel.ac.in/courses/102/106/102106098/
Reference research/ review articles	<ol> <li>Liu, R., Qian, D., Chen, Y., Zou, J., Zheng, S., Bai, B., &amp; Chen, Y. (2024). Investigation of normal knees kinematics in walking and running at different speeds using a portable motion analysis system. Sports Biomechanics, 23(4), 417-430.</li> <li>Sorushanova, A., Skoufos, I., Tzora, A., Mullen, A. M., &amp; Zeugolis, D. I. (2021). The influence of animal species, gender and tissue on the structural, biophysical, biochemical and biological properties of collagen sponges. Journal of Materials Science: Materials in Medicine, 32, 1-12.</li> <li>Green, W. H. (2020). Moving from postdictive to predictive kinetics in reaction engineering.</li> <li>Alharbi, K. A. M., Ullah, A., Fatima, N., Khan, R., Sohail, M., Khan, S., &amp; Ali, F. (2022). Impact of viscous dissipation and coriolis effects in heat and mass transfer analysis of the 3D non-Newtonian fluid flow. Case Studies in Thermal Engineering, 37, 102289.</li> <li>Rus, G., Faris, I. H., Torres, J., Callejas, A., &amp; Melchor, J. (2020). Why are viscosity and nonlinearity bound to make an impact in clinical elastographic diagnosis. Sensors, 20(8), 2379.</li> </ol>

Course	Code	Code Course Title												L	T		P	С				
10212B	ST140		BI	ON	AN	ОТЕ	СН	NO	LO	GY				3	0	)	0	3				
Course	Catego	ry	Open E	Elec	tive																	
Preamb	le		This co and bi sustain	iolo	gica																	
Prerequ	isite C	ourses	NIL																			
Cours	e .	- <b>T</b>					,															
Outcon		pon suc	cessful co	mp	letio	n of	the c	cour	se, s	stud	ents	s wi	ll be	able	e to:							
CO No	os.			Co	ourse	e Ou	tcon	nes						(	now Base loom	d on	revis	ed				
CO1		llustrate process.	the basic	S O	f na	note	chno	olog	y ar	nd it	ts s	yntl	nesis			K2						
CO2	Ι	Demonstr	ate the te	chn	ique	s use	ed in	nar	ote	chno	olog	gy.				K2						
CO3			e importa								•					K2						
CO4			e applica												K2							
CO5			strong k elp of na			-	bout	dru	ıg d	eliv	ery	pro	cess		К3							
Correlat	ion of (	C <b>O</b> s with	n POs:													1						
CO Nos.	С	ourse Outc	omes				Prog	ram	me O	utco	mes	(POs	\$)			S Ou	rogra pecifi itcom PSOs	ic ies				
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3				
CO1	nanote		pasics of y and its ess.	Н	L	М	М								Н	Н	Н					
CO2	techni	nstrate ques u chnolog		Н	М	Н	н								Н	Н	Н					
CO3	of	d the im nano hnology.										Н	Н	Н	L							
CO4	of na		olications vices in		Н	М			Н	L					М	М	Н	L				
CO5	delive	ry proce help o	strong out drug ess with f nano		Н	М	М			L					Н	Н	Н					
H – Higł	n; M- N	ledium;	L- Low																			

<b>Course Cont</b>		I
UNIT I	BASICS OF NANOTECHNOLOGY	9 hours
A Brief His	story and development of Nanotechnology, Definition of	nanotechnology,
Nanobiotechr	nology v/s Bionanotechnology, Bottom-Up versus Top-De	own approaches;
Methods of s	ynthesis of nanoparticles or fabrication, Surface property relation	onship.
UNIT II	METHODS IN NANOTECHNOLOGY	9 hours
Types of Nan	omaterials, Characterization techniques by SEM, TEM, Atomic	force microscopy,
Dynamic ligh	tt scattering (DLS), XRD. Surface Plasmon resonance (SPR), R	aman shift, FTIR.
UNIT III	STRUCTURAL AND FUNCTIONAL ASPECTS OF NANOTECHNOLOGY	9 hours
Lipid Bilayer	s, liposomes, Neosomes, Polysacharides, Peptides, Nucleic acid	ls, DNA scaffolds,
Enzymes, Bio	omolecular motors: linear, rotary mortors, Immunotoxins, Mem	brane transporters
and pumps; S	-layer proteins: structure, chemistry and assembly; engineered 1	Nanopores.
UNIT IV	CLINICAL APPLICATIONS OF NANODEVICES	9 hours
Artificial neu	rons. Real-time nanosensors- Synthetic retinyl chips based on ba	acteriorhodopsins.
High through	put DNA sequencing with nanocarbon tubules, Nanoparticles	for Bioanalytical
Applications;	Applications in cancer biology.	
UNIT V	NANOPARTICLES IN DRUG DELIVERY	9 hours
Delivery of N	Ianoparticles: Brain Delivery, Ocular Drug Delivery, Gene Deli	
Carriers in C	ancer Therapy; Natural polymers in tissue engineering applica	tions, Degradable
polymers for	tissue engineering, Controlled release strategies in tissue	engineering and
Nanotoxicolo	ogy.	
LEARNING	RESOURCES	
Text Books	<ol> <li>David S Goodsell, "Bionanotechnology", John Wiley &amp; Se</li> <li>Christof M. Niemeyer, Chad A. Mirkin, "Nanobiotechr Applications and Perspectives", 1stEdition, Wiley-VCH, 2</li> <li>Charles P. Poole Jr. and Frank J. Owens, "Introduction to E A Wiley-Interscience publication, India, 2003.</li> </ol>	nology: Concepts, 2006.
Reference Books	<ol> <li>Bernd Rehm, "Microbial bionanotechnology: Biologics Systems and Biopolymer-Based Nanostructures", Taylor a</li> <li>SalataO.V., "Applications of nanoparticles in biology &amp; n of nanobiotechnology, 2004.</li> <li>Vladimir P Torchilin, "Nanoparticulates Drug Carriers", Press, 2006.</li> <li>https://youtu.be/DAOFpgocfrg</li> </ol>	and Francis, 2006. nedicine", Journal
Reference videos	https://youtu.be/a0G7iyz4McM https://youtu.be/J5pWH1r3pgU	

	https://youtu.be/psJ5J0daSsk
	https://youtu.be/wYnCYq93c9s
Reference NPTEL	https://archive.nptel.ac.in/courses/118/107/118107015/
Reference research/ review articles	<ol> <li>Harish, V., Ansari, M. M., Tewari, D., Gaur, M., Yadav, A. B., García-Betancourt, M. L., &amp; Barhoum, A. (2022). Nanoparticle and nanostructure synthesis and controlled growth methods. Nanomaterials, 12(18), 3226.</li> <li>Patil, R. M., Deshpande, P. P., Aalhate, M., Gananadhamu, S., &amp; Singh, P. K. (2022). An Update on Sophisticated and Advanced Analytical Tools for Surface Characterization of Nanoparticles. Surfaces and Interfaces, 33, 102165. https://doi.org/10.1016/j.surfin.2022.102165.</li> <li>Lu, D., Wu, P., Yang, W., Wang, Y., Yang, J., Zhang, G., Wang, C., Yang, L., Zhu, L., &amp; Sun, Z. (2023). Recent advances in lipid nanovesicles for targeted treatment of spinal cord injury. Frontiers in Bioengineering and Biotechnology, 11. https://doi.org/10.3389/fbioe.2023.1261288</li> <li>Ohshiro, T. (2021). Nanodevices for Biological and Medical Applications: Development of Single-Molecule Electrical Measurement Method. Applied Sciences, 12(3), 1539. https://doi.org/10.3390/app12031539</li> <li>Mundekkad, D., &amp; Cho, W. C. (2022). Nanoparticles in Clinical Translation for Cancer Therapy. International Journal of Molecular Sciences, 23(3). https://doi.org/10.3390/ijms23031685</li> </ol>

Course	Code				С	ours	e Ti	tle						L	ſ		P	С		
10212B	T141		BIOC	CHE	MI	CAL	EN	GIN	NEE	RI	NG			3	0	)	0	3		
Course	Category	7	Open E	Eleci	tive															
Preamb	le		princip	les,	in	ıclud	ling	bi	iore	acto	r	de	sign,	chemical engineering enzyme kinetics, cessing.						
Prerequ	isite Cou	e Courses 10211BT106-Chemical Reaction Engineering																		
Course OutcomesUpon successful completion of the course, students will be able to:																				
CO No:	s. Course Outcomes										now (Base loom ⁹	d on i	revis	ed						
CO1			ferent ty heir grov		of	mi	croo	rgar	nism	IS 8	nd	fa	ctors			K2				
CO2			out Enzyr ial applic			ics i	n rel	atio	n to	imn	nob	iliz	ation			K2				
CO3		Classify between kinetics in different types of fermenter design											К2							
CO4		Identify different methodologies of fermenter operating conditions									,		K3							
CO5			oduct re analysis					vnsti	ean	n pr	oce	sse	s for		K3					
Correlat	ion of C(	Ds with	POs:																	
CO Nos.	Cou	rse Outco	omes				Prog	ramı	ne O	utcoi	nes	(POs	5)			Program Specific Outcomes (PSOs)				
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3		
CO1	Relate d microor factors growth	ganisms	s and	L		Н	Н								Н	Н	М			
CO2	kinetics immobil	tline about Enzyme etics in relation to mobilization and ustrial applications				М	L	Н	L						Н	М	L	Н		
CO3		etics in different es of fermenter ign			Н	L	L	М	L						Н	М	Н			
CO4	Identify methodo fermente conditio	tify different nodologies of nenter operating			Н	Н	М	Н	L						L	Н	L	Н		

for d	•	Н	Н	Н		L						М	Н	М	Н
H – High; M-	Medium; L- Low		1	l				LI					I		1
Course Content:															
UNIT I	INTRODUCTION	TOI	BIO	SCII	ENC	CE							9 ho	urs	
Introduction to Bioscience: Types of Microorganisms: Structure and function of microbial cells.															
Fundamentals of microbial growth, batch and continuous culture. Isolation and purification of															
Enzymes from	cells. Cell Growth M	easu	reme	nt											
UNIT II	ENZYME KINET	CS											9 ho	urs	
Enzyme kinet	cs: Simple enzyme k	netic	s, Er	nzym	ne re	acto	or w	rith	sim	ple	kinet	tics.	Inhit	oition	n of
enzyme reacti	ons. Other influences	on er	nzym	e ac	tivit	y. Iı	nme	obil	izat	ion	of er	nzym	es. E	Effec	t of
mass transfer	nass transfer in immobilised enzyme particle systems. Industrial applications of enzymes.														
UNIT III	CELL KINETICS	CELL KINETICS AND FERMENTER DESIGN 9 hours													
Cell kinetics a	nd fermenter design:	Grow	th cy	cle	for ł	oatc	h cu	ltiv	atio	on, S	tirre	d-tan	k fer	men	ter,
Multiple fermenters connected in series. Cell recycling. Structured Model.															
UNIT IV OPERATION AND CONTROL OF BIOREACTORS 9 hours															
Stoichiometry	of microbial growth	and	proc	luct	forr	nati	on,	Me	diu	m fo	ormu	latio	n, oj	perat	ing
conditions of	suspended and immob	oilize	d cel	ls in	bio	reac	tors	-Ba	tch	, fed	bate	ch; o	perat	ion	and
control of bior	eactors.														
UNIT V	DESIGN AND AN	ALY:	SIS	OF I	BIO	RE	AC	ΓOI	RS				9 ho	urs	
Product reco	very: Filtration, sed	imen	tatio	n, c	entr	ifug	atic	on,	cel	l di	srup	tion,	ext	tracti	ion,
crystallization	, drying, Design and a	nalys	is of	bio	react	tors.									
LEARNING	RESOURCES														
	1. Biochemical eng	ineer	ing f	unda	amer	ntals	s bv	J.E.	Bai	ileva	and I	D.F.0	Ollis.	2nd	ed.
	1986, McGraw I	Hill.	C				2			•					
Text Books	2. Bioprocess Engi		ng by	y Mi	chae	el L.	Shı	ıler	anc	l Fik	retK	argi,	2nd	editi	ion,
<ul><li>Pearson education.</li><li>3. Biochemical engineering by James M.Lee – Prentice-Hall-1992.</li></ul>															
	1. Trevan, Boffey,													/IcG1	raw
Reference	Hill Publishing (	20., N	lew I	Delh	i, 19	87.					<b>.</b>				
Books	Pauline M. Dora						1			<b>-</b>	1 1			D 1.	I
	2. Biochemical En 1997	ginee	rıng,	H.\	w. E	3lan	ch a	and	D.9	s. c	Iark,	Ma	rcel	Dek	ker,
Reference	https://www.youtube	e.com	n/wat	ch?v	v=9J	W6	3U2	2mz	qo						
videos	https://www.youtube								•						

	https://www.youtube.com/watch?v=8AhDxAQaDOA https://www.youtube.com/watch?v=mUDXupn2Dhk&t=2s https://www.youtube.com/watch?v=VKpthcW11lU
Reference NPTEL	https://archive.nptel.ac.in/courses/103/105/103105054/
Reference research/ review articles	<ol> <li>Corrêa, P. S., Morais Júnior, W. G., Martins, A. A., Caetano, N. S., &amp; Mata, T. M. (2020). Microalgae biomolecules: Extraction, separation and purification methods. Processes, 9(1), 10.</li> <li>Ashkan, Z., Hemmati, R., Homaei, A., Dinari, A., Jamlidoost, M., &amp; Tashakor, A. (2021). Immobilization of enzymes on nanoinorganic support materials: An update. International Journal of Biological Macromolecules, 168, 708-721.</li> <li>Malairuang, K., Krajang, M., Sukna, J., Rattanapradit, K., &amp; Chamsart, S. (2020).</li> <li>High cell density cultivation of Saccharomyces cerevisiae with intensive multiple sequential batches together with a novel technique of fed-batch at cell level (FBC). Processes, 8(10), 1321.</li> <li>Cui, Y., Zhang, Y., Duan, C., Wang, X., Zhang, X., Ju, W., &amp; Fang, L. (2020). Ecoenzymatic stoichiometry reveals microbial phosphorus limitation decreases the nitrogen cycling potential of soils in semi-arid agricultural ecosystems. Soil and Tillage Research, 197, 104463.</li> <li>Meldrum, F. C., &amp; O'Shaughnessy, C. (2020). Crystallization in confinement. Advanced Materials, 32(31), 2001068.</li> </ol>

Course	Code					С	our	se Ti	itle						L	T		P	С
10212B	<b>ST142</b>			0	MI	CS [	ГЕС	HN	OL	DGI	ES				3	0		0	3
Course	Catego	ory		Open	Ele	ctive	2												
Preamb	Preamble techn					Students will gain a deep understanding of the experimental techniques, data analysis methods, and biological insights derived from these powerful tools.													
Prerequ	Prerequisite Courses       10211BT105-Genetic Engineering         10211BT104-Molecular Biology: Concepts							pts a	nd T	<i>echn</i>	ique.	<u>s</u>							
	Course         Upon successful completion of the course, students will									vill b	e ab	le to:							
CO N	05.				Со	ours	e Ou	itcoi	nes						(	now Base loom'	d on r	evise	ed
COI	1	Und	erstand	Geno	mic	s an	d Co	ncep	ots o	f Ge	ene	libr	arie	s			K2		
CO2	2		nonstrat ications			ledg naly		n ′	Trar	nscri	ipto	mic	s	and			K2		
CO3	3	Utilize the Proteomics and protein-protein interaction knowledge									tion			K3					
CO4	1	Make use of knowledge in Metabolomics and lipidomics									nics			K3					
COS	5		ly the a ifferent							dat	a m	ana	gen	nent			K3		
Correlat	tion of	COs	with PC	Ds:															
CO Nos.	0	Course	Outcome	s				Prog	ramı	ne O	utco	mes	(POs	5)	Progra Specifi Outcom (PSOs				c ies
					1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	1	Conce	d Geno epts of		L		М		Н							Н	L		
CO2	Demo know Trans applic analys	ledge cripto catior	in and data	L	L	М		Н							Н	L	Н	Н	
CO3	Utiliz and intera	pr		L	М		Н							Н	М				
CO4	Make know Metal lipido	ledge oolon	nics	L	L	М	М	Н							М	М	Н	Н	

CO5 differe	the applications MICS and data gement in ent fields of hnology	L	L	М	М	Н							Н	М	Н	Н
<u> </u>	Aedium; L- Low												I		I	1 1
Course Conten	nt:															
UNIT I	INTRODUCTI	ON	то	GEI	NON	Æ S	STF	RUC	CTU	RF	2		ļ	) hou	irs	
Genomics: Intro	oduction to Genon	ne S	truc	ture;	Ger	nom	e se	quer	ncin	g -	Who	ole g	enon	ne an	d No	GS;
Genome mapping; Overview of methodologies for detecting genetic variations: SNVs, small																
insertions and	deletions (indels)	, cc	ру	num	ber	vari	ants	s (C	NV	s)	or r	earra	inger	nents	s; G	ene
Library construct	ction strategies															
UNIT II     TRANSCRIPTOMICS     9 hours																
Transcriptomics	s: RNA sequenci	ng	& a	naly	sis	of t	rans	scrip	oton	nic	data	ı, Re	efere	nce	genc	me
sequence; Con	cepts and princi	ples	s of	ge	ne a	anno	otati	on;	Ge	ene	exp	oress	ion	profi	ling	&
sequence; Concepts and principles of gene annotation; Gene expression profiling & quantification; Differential expression analysis; Introduction to Statistical transcriptomic data									lata							
analysis.	_			-										_		
UNIT III	PROTEOMICS	1												) hou	ire	
	ass spectrometry –		izati	ion r	neth	ods	(M/	ALE	DI. e	elec	trost	orav)				ers.
	intact protein a										-	• ·			•	
	quantitative & Di	•		•			Ū									•
	ata & Protein-prot			-			,								•	/
UNIT IV	METABOLOM		5										ļ	) hou	irs	
Metabolomics:	Metabolomics-an	ov	ervi	ew,	Ana	lytic	cal t	tech	niqu	ıes	for	met	abolo	mics	s; M	[ass
spectrometry in	n metabolomics.	Гarg	geted	l Vs	Un	targe	eted	me	etab	oloi	mics	; M	etabo	lic p	oathv	vay
analysis; Metal	bolomics data an	alys	sis –	- ca	se s	tudi	es;	Intr	odu	ctic	on t	o lip	oidon	nics	and	its
workflow.																
UNIT V OMICS AND BIG DATA MANAGEMENT 9 hou								irs								
OMICS and Big Data management: Data acquisition, cleaning, distribution, and best practices								ces;								
Visualization and design principles of big data; Biological databases for big data management;																
Computational techniques in data integration; Omics projects worldwide; Application of Omics																
in different field	ds of biotechnolog	y.														
LEARNING R	RESOURCES															
Text Books	1. Principles of and Twyman				-								-			

	2. Introduction to Proteomics – Tools for the new biology (1st Ed.) by Liebler, D.C., Humana Press Inc., New Jersey, USA. 2002
Reference Books	<ol> <li>Barh D, Azevedo V, Omics Technologies and Bio-engineering: Towards Improving Quality of Life, Academic Press</li> <li>Pevsner J, Bioinformatics and Functional Genomics, Wiley- Blackwell,ISBN: 978-81-265-3834-8</li> <li>Primrose, S.B. and Twyman. "Principles of Genome Analysis and Genomics". 7th Edition,Blakwell Publishing, 2006</li> </ol>
Reference videos	https://www.youtube.com/watch?v=2JUu1WqidC4 https://www.youtube.com/watch?v=uIl0i7HWZdQ https://www.youtube.com/watch?v=vnW9kH0agcE https://www.youtube.com/watch?v=0cuTCimrSoM https://www.youtube.com/watch?v=bAyrObI7TYE
Reference NPTEL	https://nptel.ac.in/courses/102101072
Reference research/ review articles	<ol> <li>Naseri, G., &amp; Koffas, M. A. (2020). Application of combinatorial optimization strategies in synthetic biology. Nature communications, 11(1), 2446.</li> <li>Moses, L., &amp; Pachter, L. (2022). Museum of spatial transcriptomics. Nature methods, 19(5), 534-546.</li> <li>Morato, N. M., &amp; Cooks, R. G. (2023). Desorption electrospray ionization mass spectrometry: 20 years. Accounts of chemical research, 56(18), 2526-2536.</li> <li>Perez De Souza, L., Alseekh, S., Brotman, Y., &amp; Fernie, A. R. (2020). Network-based strategies in metabolomics data analysis and interpretation: from molecular networking to biological interpretation. Expert Review of Proteomics, 17(4), 243-255.</li> <li>Koppad, S., Gkoutos, G. V., &amp; Acharjee, A. (2021). Cloud computing enabled big multi-omics data analytics. Bioinformatics and biology insights, 15, 11779322211035921.</li> </ol>

COURSE CODE	<b>Community Service Project</b>	L	Т	Р	С
10214BT501		0	0	4	2

### **Course Category: Independent Learning**

#### 1. Preamble

This course imparts the knowledge to familiarize with scientific literature, to assimilate, synthesize and integrate information for solving the problem in a group.

### 2. Prerequisite

Program Core and Electives

#### 3. Links to other courses: Minor Project I-10214BT601

#### 4. Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Identify a problem in real life through proper survey	К3
CO2	Select the project methodology to solve those problems	K5
CO3	Solve the problem and interpret the results as a Team	K6

## 5. Correlation of COs with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	<b>PO7</b>	<b>PO8</b>	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	L	Н	L	Н	L	Н	Н	L	Н	Н	L	L	Η	Н	Η
CO2	М	Н	Н	Н	Н	М	М	М	Н	L	М	L	Н	Н	Н
CO3	Н	Н	Н	Н	М	М	L	М	Н	L	Η	М	Н	Н	Н

H-High; M-Medium; L-Low

## 6. Course Description

Students should conduct literature survey/visit industry/analyze current trends and identify the problem for Project and finalize in consultation with Guide. Students should use multiple literatures and understand the problem. The community service project may address societal problems/issues related to the Programme.

COURSE CODE	MINOR PROJECT I	L	Т	Р	С
10214BT601		0	0	4	2

#### **Course Category: Independent Learning**

# 1. Preamble

This course imparts the knowledge to familiarize with scientific literature, to assimilate, synthesize and integrate information for solving the problem in a group.

### 2. Prerequisite

Program Core and Electives

# 3. Links to other courses:

Minor Project II-10214BT602

### 4. Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Select the problem statement through literature survey / field work	K3
CO2	Analyze and problem solving methodology and remunerate social, ethical, economic and business aspects	K4
CO3	Select the process/ protocol/ tools to fine the solution to solve the problems	К5
CO4	Perform an experiment as a team/individual and discuss the results	K6
CO5	Practice engineering report preparation and life long learning	K6

## 5. Correlation of COs with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Н	Н	L	Н	L	M	-	-	Н	L	-	-	H	L	-
CO2	Н	Н	Н	М	М	M	L	Н	Н	-	М	M	H	-	M
CO3	М	М	Н	L	Н	М	L	М	Н	-	Н	Н	M	M	L
CO4	М	М	М	Н	Н	М	L	Н	М	Н	М	Н	M	Н	Н
CO5	М	L	L	L	М	М	L	М	Н	Н	Н	Н	М	М	-

H- High; M-Medium; L-Low

## 6. *Course Description*

Students should conduct literature survey/visit industry/analyze current trends and identify the problem for Project and finalize in consultation with Guide. Students should use multiple literatures and understand the problem. The minor project may address societal problems/issues related to the Programme.

COURSE CODE	MINOR PROJECT II	L	Т	Р	С
10214BT602		0	0	4	2

## **Course Category: Independent Learning**

# 1. Preamble

This course imparts the knowledge to familiarize with scientific literature, to assimilate, synthesize and integrate information for solving the problem in a group.

## 2. Prerequisite

Program Core and Electives

## 3. Links to other courses:

Major Project - 10214BT701

## 4. Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Select the problem statement through literature survey / field work	K3
CO2	Analyze and problem solving methodology and remunerate social, ethical, economic and business aspects	K4
CO3	Select the process/ protocol/ tools to fine the solution to solve the problems	K5
CO4	Perform an experiment as a team/ individual and discuss the results	K6
CO5	Practice engineering report preparation and life long learning	K6

#### 5. *Correlation of COs with Programme Outcomes*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Н	Н	L	Н	L	М	-	-	Н	L	-	-	Н	L	-
CO2	Н	Н	Н	М	М	М	L	Н	Н	-	М	M	Н	-	M
CO3	М	М	Н	L	Н	М	L	М	Н	-	Н	Н	M	M	L
CO4	M	M	М	Н	Н	М	L	Н	М	Н	M	Н	M	Н	Н
CO5	М	L	L	L	М	М	L	М	Н	Н	Н	Н	М	М	-

## H- High; M-Medium; L-Low

## 6. *Course Description*

Students should conduct literature survey/visit industry/analyze current trends and identify the problem for Project and finalize in consultation with Guide. Students should use multiple literatures and understand the problem. The minor project may address societal problems/issues related to the Programme.

COURSE CODE	MAJOR PROJECT	L	Т	Р	С
10214BT701		0	0	18	9

## Course outcomes and K levels for the self-learning course - Major Project:

Course Category: Independent Learning

### 1. Preamble

This course imparts the knowledge to implement the principles of engineering learnt by them in practical applications with innovative ideas and thus enable them to have a practical exposure.

- 2. *Prerequisite* Program Core and Electives
- 3. Links to other courses:

Nil

# 4. Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Identify problem through literature survey / field work	К3
CO2	Select the problem solving methodology based on practical aspects	K5
CO3	Plan the sequence of experiments and equipment require for analysis	K6
CO4	Perform experiment as per the scientific ethics and discuss the results	K6
CO5	Prepare project report and practice lifelong learning from the major findings	K6

### 5. Correlation of COs with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	Н	Н	L	Н	L	М	-	-	Н	L	-	-	Н	L	-
CO2	Н	Н	Н	М	М	М	L	Н	Н	-	М	М	Н	-	М
CO3	М	М	Н	L	Н	М	L	М	Н	-	Н	Н	М	М	L
CO4	М	М	М	Н	Н	М	L	Н	М	Н	М	Н	М	Н	Н
CO5	М	L	L	L	М	М	L	М	Н	Η	Н	Н	М	М	-

## H-High; M-Medium; L-Low

#### 6. Course Description

Students should conduct literature survey/visit industry/analyze current trends and identify the problem for Project and finalize in consultation with Guide. Students should use multiple literatures and understand the problem. Students should attempt solution to the problem by experimental/simulation methods. The solution to be validated with proper justification and report to be compiled in standard format.