Curriculum Book

and

Assessment and Evaluation Scheme

based on

Outcome Based Education (OBE)

and

Choice-Based Credit System (CBCS)

in

Bachelor of Technology in Biotechnology

B. Tech. (Biotechnology)

4 Year Degree Program

Revised as on 01 August 2023
Applicable w.e.f. Academic Session 2023-24

AKS University

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AKS University

Faculty of Life Sciences and Technology

Department of Biotechnology

Curriculum of B.Tech. Biotechnology Program

(Revised as on 2023)

Foreword

I am delighted to see that the Biotechnology Department's redesigned curriculum for the B. Tech. (Biotechnology) Programme smoothly incorporates the newest technological developments while adhering to AICTE criteria. The curriculum has been redesigned with consideration to include the Sustainable Development Goals and NEP-2020 guidelines.

The alignment of course outcomes (COs), Programme Outcomes (POs), and Programme Specific Outcomes (PSOs) has been intricately executed, aligning perfectly with the requisites of NEP-2020 and NAAC standards. I hold the belief that this revised syllabus will significantly enhance the skills and employability of our students.

With immense satisfaction, I hereby present the revised curriculum for the M. Sc. (Biotechnology) program for implementation in the upcoming session.

Er. Anant Soni

Pro Chancellor & Chairman

01 August 2023

AKS University, Satna

From the Desk of the Vice-Chancellor

AKS University is currently undergoing a process to revamp its curriculum into an outcome-based approach, to enhance the teaching and learning process. The foundation of quality of quality education lies in the implementation of a curriculum that aligns with both societal and industrial needs, focusing on relevant outcomes. This entails dedicated and inspired faculty members, as well as impactful industry internships. Hence, it is of utmost importance to begin this endeavour by crafting an outcome-based curriculum in collaboration with academia and industry experts.
This curriculum design should be informed by the latest technological advancements, market demands, the guidelines outlined in the National Education Policy (NEP) of 2020, and sustainable goals.

I'm delighted to learn that the revised curriculum has been meticulously crafted by the Biotechnology Department, in consultation with an array of experts from the Biotechnology industry, research institutes, and academia. This curriculum effectively integrates the principles outlined in the NEP-2020 guidelines, as well as sustainable goals. It also adeptly incorporates the latest advancements in Biotechnology manufacturing technology.

The curriculum tailored for the Indian biotechnology industry prioritizes the production of cost-effective, high-quality microbial products while emphasizing energy optimization. It integrates insights on waste heat recovery systems to minimize power consumption in biotechnological plants, fostering independent thinking among students for potential enhancements. This holistic approach not only equips students with essential knowledge but also nurtures a culture of innovation, preparing them to make meaningful contributions to the industry's advancement.

I am confident that the updated curriculum for B.Tech. Biotechnology will not only enhance students' technical skills but also contribute significantly to their employability. During the process of revising the curriculum, I am pleased to observe that the Biotechnology department has diligently adhered to the guidelines provided by the AICTE. Additionally, they have maintained a total credit requirement of 92 for the B.Tech. Biotechnology program.

It's worth noting that curriculum revision is an ongoing and dynamic process, designed to address the continuous evolution of technological advancements and both local and global concerns. This ensures that the curriculum remains responsive and attuned to the changing landscape of education and industry. AKS University warmly invites input and suggestions from industry expert technocrats and Alumni students to enhance the curriculum and make it more student-centered. Your valuable insights will greatly contribute to shaping an education that best serves the needs and aspirations of our students.

AKS University, Satna — ***Professor B. A. Chopade***
01 August 2023 — *Vice-Chancellor*

Preface

As part of our commitment to ongoing enhancement, the Department of Biotechnology consistently reviews and updates its B.Tech. Biotechnology curriculum every three years. Through this process, we ensure that the curriculum remains aligned with the latest technological advancements, as well as local and global industrial and social demands.

During this procedure, the existing curriculum for the B.Tech. BiotechnologyProgram undergoes evaluation by a panel of technocrats, industry specialists, and academics. Following meticulous scrutiny, the revised curriculum has been formulated and is set to be implemented starting from August 01, 2023. This implementation is contingent upon the endorsement of the curriculum by the University's Board of Studies and Governing Body.

This curriculum closely adheres to the AICTE model syllabus distributed in May 2023. It seamlessly integrates the guidelines set forth by the Ministry of Higher Education, Government of India, through NEP- 2020, as well as the principles of Sustainable Development Goals. To foster the holistic skill development of students, a range of practical activities, including Hands-On Training, Industrial Visits, Project planning and execution, Report Writing, Seminars, and Industrial on-the-job training, have been incorporated. Furthermore, in alignment with AICTE's directives, the total credit allocation for the B.Tech. Biotechnology program is capped at 93 credits.

This curriculum is enriched with course components in alignment with AICTE guidelines, encompassing various disciplines such as Fundamental Science Concepts: 24 credits, Engineering Science: 25 credits, Humanities and Social Sciences: 12 credits, Core Program Courses: 66 credits, Elective Program Courses: 9 credits, Open Electives: 9 credits, Project and Practical Training: 17 credits, Seminars: 3 credits, Indian Knowledge System: 2 credits, Sustainable Development Goals: 2 credits.

To ensure a comprehensive learning experience, detailed evaluation schemes and rubrics have also been meticulously provided.

For each course, a thorough mapping of Course Outcomes, Program Outcomes, and Programme Specific Outcomes has been undertaken. As the course syllabus is meticulously developed, various elements such as session outcomes, laboratory instruction, classroom instruction, self-learning activities, assignments, and mini-projects are meticulously outlined.

We hold the belief that this dynamic curriculum will undoubtedly enhance the independent thinking, skills, and overall employability of the students.

INTRODUCTION

OVERVIEW OF THE DEPARTMENT OF BIOTECHNOLOGY

The Department of Biotechnology is established in 2006 with the objective to provide excellent and sensible teaching with maximum practical and research exposure to create skilled and well-trained bio-technocrats and entrepreneurs as per academia and industry needs in the frontier areas of Microbiology and Biotechnology. We, at the Department of Biotechnology, endorse each student by providing them maximum practical approach to understand their subjects in a better way of global standards and making them technologically advanced and ethically of high quality to serve the society.

VISION

The vision of the department is to dedicate research for Human and Environmental welfare. To become a centre of excellence for biotechnology education, research, training, and entrepreneurship under the direction of good scientific principles, excellent instruction, and an ambition for continuous improvisation.

MISSION

At the Biotechnology Department, our mission is to be at the forefront of biotechnological innovation, research, and education. We are committed to advancing the frontiers of biotechnology through cutting-edge research, interdisciplinary collaboration, and the development of skilled and ethical professionals. Our aim is to address global challenges, improve human well-being, and contribute to sustainable development through the application of biotechnological solutions by following aspects:

M1. To develop a strong Biotechnology program based on quality education, research and training.

M2. To impart quality education to the students and enhance their skills which will make them globally competitive.

M3. To create trained biotechnology professionals who can contribute to the continuous improvement of biotechnological services and products.

M4. To design scientific and/or technical resources as per biotechnology industry demands.

M5. To develop as a benchmark University in emerging technologies.

M6. To provide state-of-the-art teaching learning process and R&D environment.

M7. To harness human capital for sustainable competitive edge and social relevance.

Program Outcomes (POs) as defined by NBA

B. Tech. Biotechnology Graduates will be able to:

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 Educational Objectives (PEOs)

Program Educational Objectives for B. Tech. Program

Students will:

PEO-1: Understand and inculcate the ability to apply, update, extend and to develop deep knowledge through flexible, research-intensive program designed to meet the current demand of academia and industry.

PEO-2: Acknowledge the basic engineering and applied biological mechanisms used in biopharmaceutical industries

PEO-3: Utilize their profession skills with social awareness and responsibility in the industry

PEO-4: Interact with their peers in biotech industry or organizations and society and contribute to the economic growth of the country

PEO-5: Participate in individual and team oriented, open ended activities promoting productive thinking to provide opportunities for students to manage and work on multidisciplinary projects through interaction with their peers in industry.

Program Specific objectives (PSOs)

Program Specific objectives (PSOs) for B.Tech. Biotechnology program

PSO 1: Acquire knowledge in domain of biotechnology enabling their applications in industry and research.

PSO 2: Empower the students to acquire technological knowhow by connecting disciplinary and interdisciplinary aspects of biotechnology.

PSO 3: Recognize the importance of Bioethics, IPR, entrepreneurship, Communication and management skills so as to usher next generation of Indian industrialists.

General Course Structure and Credit Distribution

A. Definition of Credit:

1 Hr. Lecture (L) per week	1 Credit
1 Hr. Tutorial (T) per week	1 Credit
1 Hr. Practical (P) per week	0.5 Credit
2 Hours Practical (P) per week	1 Credit

B. Range of Credits:

As per the AICTE model Curriculum for the UG Degree Course in Biotechnology, the total number of credits proposed for the Four-year B.Tech. (Biotechnology) is kept as 90.

C. Structure of UG Program in Biotechnology:

The structure of the UG program in Biotechnology shall have essentially the following categories of courses with the breakup of credits as given:

S. No.	**Category**	**Breakup of Credits**
2.	Basic Science Courses	20
3.	Engineering Science Courses	26
4.	Program Core Courses (Branch specific)	21
5.	Professional Elective Courses (Branch specific)	6
6.	Open Elective Courses (from Humanities, Technical Emerging or other Subjects)	2
7.	Project work, Seminars and Internships in Industry or elsewhere, or research courses	15
	TOTAL	**92**

D. Course Code and Definition:

Course code	Definitions
L	Lecture
T	Tutorial
P	Practical
C	Credits
HS	Humanities & Social Science Courses
BS	Basic Science Courses
ES	Engineering Science Courses
PC	Program Core Courses
PE	Professional Elective Courses
OE	Open Elective Courses
AU	Audit Courses
EEC	Employment Enhancement Courses (Internship / Seminar) (Project / Summer Training)

- **Course level coding scheme:** Three-digit number (odd numbers are for the odd semester courses and even numbers are for even semester courses) used as a suffix with the Course Code for identifying the level of the course. The digit at hundred's place signifies the year in which the course is offered. e.g. 101, 102 … etc. for the first year. 201, 202 …. etc. for second year. 301, 302 … for third year.

Department of Biotechnology

Scheme and Syllabus

The department provides a four-year **B.Tech. in Biotechnology** using a Choice Based Credit System (CBCS) that consists of four semesters. The regulations for the B.Tech. in Biotechnology provided by AKS University under the Choice Based Credit System (CBCS) are shown here.

Scheme of B. Tech. Biotech 1stSemester

S. No	Subject Code	SUBJECT	Subject AREA	Periods			Credit
				L	T	P	
1	98BT101	Biology For Engineers	**BSC**	**1**	**1**	**-**	**2**
2	98CH102	Engineering Chemistry	**BSC**	**2**	**1**	**-**	**3**
3	98BT103	Cell Biology and Genetics	**BSC**	**3**	**-**	**-**	**3**
4	98ME104	Basic Mechanical Engineering & Manufacturing Process	**ESC**	**2**	**1**	**-**	**3**
5	98CS105	Communication Skill	**HS**	**2**	**-**	**-**	**2**
6	98BT106	Introduction to Biotechnology	**PC**	**3**	**-**	**-**	**3**
7	98SDG108	Sustainable Development Goal	**HS**	**2**	**-**	**-**	**2**
8	98SYN109	Sports & Yoga / NSS / NCC / UCC	**AU**	**-**	**-**	**-**	**-**
9	98ME151	Workshop Practice (lab)	**ESC**	**-**	**-**	**2**	**1**
10	98CH152	Engineering Chemistry (Lab)	**BSC**	**-**	**-**	**2**	**1**
11	98BT153	Cell Biology and Genetics Lab	**BSC**	**-**	**-**	**2**	**1**
12	98ME154	Basic Mechanical Engineering (Lab)	**ECC**	**-**	**-**	**2**	**1**
		Total		**15**	**3**	**8**	**22**

Scheme of B. Tech. Biotech 2nd Semester

S. No	Subject Code	SUBJECT	Subject AREA	Periods			Credit
				L	T	P	
1	98EE201	Basic Electrical & Electronics Engineering	**ESC**	**1**	**1**	**-**	**2**
2	98PH202	Engineering Physics	**ESC**	**2**	**1**	**-**	**3**
3	98BT203	Biochemistry & Metabolism	**BSC**	**2**	**1**	**-**	**3**
4	98CA204	Fundamentals of Computer & Programming	**ESC**	**1**	**1**	**-**	**2**
5	98EV205	Ecology & Environmental Science	**HS**	**2**	**-**	**-**	**2**
6	98ME206	Engineering Drawing	**ESC**	**1**	**1**	**-**	**2**
7	98MS207	Mathematics	**BSC**	**2**	**1**	**-**	**3**
8	98IKS208	Indian Knowledge System	**HS**	**2**	**-**	**-**	**2**
9	98EE251	Basic Electrical and Electronic Engineering (Lab 1)	**ESC**	**-**	**-**	**2**	**1**
10	98PH252	Engineering Physics (Lab 2)	**ESC**	**-**	**-**	**2**	**1**
11	98BT253	Biochemistry & Metabolism (Lab 3)	**BSC**	**-**	**-**	**2**	**1**
		TOTAL		**13**	**6**	**6**	**22**

Scheme of B. Tech. Biotech 3rdSemester

S. No	Subject Code	SUBJECT	Subject AREA	Periods			Credit
				L	**T**	**P**	
1	98BT301	Computational Biology & Bioinformatics	**PC**	**3**	**-**	**-**	**3**
2	98BT302	Principles of Microbiology	**BSC**	**3**	**-**	**-**	**3**
3	98BT303	Biostatistics	**BSC**	**1**	**1**	**-**	**2**
4	98BT304	Biophysical Tools and Techniques	**PC**	**3**	**-**	**-**	**3**
5	98ME305	Fluid Mechanics	**OS**	**2**	**-**	**-**	**2**
6	98EN306	Entrepreneurship Development	**HS**	**2**	**1**	**-**	**3**
7	98UHV307	Universal Human Values	**VAC**	**3**	**1**	**-**	**4**
8	98BT351	Computational Biology & Bioinformatics (Lab 1)	**PC**	**-**	**-**	**2**	**1**
9	98BT352	Principles of Microbiology (Lab 2)	**BSC**	**-**	**-**	**2**	**1**
10	98BT353	Biostatistics (Lab 3)	**PC**	**-**	**-**	**2**	**1**
11	98BT354	Biophysical Tools and Techniques (Lab 4)	**OS**	**-**	**-**	**2**	**1**
12	98ME355	Fluid Mechanics (Lab 5)	**OS**	**-**	**-**	**2**	**1**
		TOTAL		**17**	**3**	**10**	**30**

Scheme of B. Tech. Biotech 4thSemester

S. No	Subject Code	SUBJECT	Subject AREA	Periods			Credit
				L	**T**	**P**	
1	98BT401	Molecular Biology	**PC**	**3**	**-**	**-**	**3**
2	98BT402	Biochemical Engineering	**PC**	**2**	**1**	**-**	**3**
3	98BT403	Genetic Engineering and Molecular Diagnostics	**PC**	**3**	**-**	**-**	**3**
4	98BT404	Immunology & Immuno-Technology	**PC**	**3**	**-**	**-**	**3**
5	98BT405	Biosafety, Bioethics and IPRs	**HS**	**2**	**-**	**-**	**2**
6	98BT406	Industrial Fermentation	**PC**	**1**	**1**	**-**	**2**
7	98BT451	Molecular Biology (Lab)	**PC**	**-**	**-**	**2**	**1**
8	98BT452	Biochemical Engineering (Lab)	**PC**	**-**	**-**	**2**	**1**
9	98BT453	Genetic Engineering and Molecular Diagnostics (Lab)	**PC**	**-**	**-**	**2**	**1**
10	98BT454	Immunology & Immuno-Technology (Lab)	**PC**	**-**	**-**	**2**	**1**
11	98BT455	Biosafety, Bioethics and IPRs (Lab)	**PC**	**-**	**-**	**2**	**1**
12	98BT456	Industrial Fermentation (Lab)	**HU**	**-**	**-**	**2**	**1**
		Total		**14**	**2**	**12**	**22**

Scheme of B. Tech. Biotech 5th Semester

S. No	Subject Code	SUBJECT	Subject AREA	Periods			Credit
				L	T	P	
1	98BT501	Plant Biotechnology	**PC**	**3**	**-**	**-**	**3**
2	98BT502	Enzyme Engineering and Technology	**PC**	**2**	**1**	**-**	**3**
3	98BT503	Animal Biotechnology	**PC**	**3**	**-**	**-**	**3**
4	98BT504	Distillates and Fermentation Technology	**PC**	**3**	**-**	**-**	**3**
5	98BT505	Bioseparations	**PC**	**2**	**1**	**-**	**3**
6	98BT506-A	Nanotechnology and Engineering	**PE**	**3**	**-**	**-**	**3**
7	98BT506-B	Pharmaceutical Biotechnology	**PE**	**3**	**-**	**-**	**3**
8	98BT506-C	Molecular Modeling and Drug Designing	**PE**	**3**	**-**	**-**	**3**
9	98BT551	Plant Biotechnology (Lab 1)	**PC**	**-**	**-**	**2**	**1**
10	98BT552	Enzyme Engineering and Technology (Lab 2)	**PC**	**-**	**-**	**2**	**1**
11	98BT553	Animal Biotechnology (Lab 3)	**PC**	**-**	**-**	**2**	**1**
12	98BT554	Distillates and Fermentation Technology (Lab 4)	**PC**	**-**	**-**	**2**	**1**
13	98BT555	Bioseparations (Lab 5)	**PE**	**-**	**-**	**2**	**1**
14	98BT556-A/B/C	Nanotechnology and Engineering /Pharmaceutical Biotechnology /Molecular Modelling and Drug Designing (Lab 6)	**PE**	**-**	**-**	**2**	**1**
		Total		**16**	**2**	**12**	**24**

Scheme of B. Tech. Biotech 6thSemester

S. No.	Subject Code	SUBJECT	Subject AREA	Periods			Credit
				L	T	P	
1	98BT601	Advanced Bioanalytical Technique	**PC**	**3**	**-**	**-**	**3**
2	98BT602	Metabolic Engineering	**PC**	**2**	**1**	**-**	**3**
3	98BT603	Bioreactor Design	**PC**	**2**	**1**	**-**	**3**
4	98BT604	Waste Treatment	**PC**	**2**	**-**	**-**	**2**
5	98BT605	Genomics & Proteomics	**PE**	**3**	**-**	**-**	**3**
6	98BT606-A	Food Biotechnology	**PE**	**3**	**-**	**-**	**3**
7	98BT606-B	Vaccine Biotechnology	**PE**	**3**	**-**	**-**	**3**
8	98BT606-C	Bioprograming and Soft Computing Techniques	**PE**	**3**	**-**	**-**	**3**
9	98BT651	Advanced Bioanalytical Technique (Lab 1)	**PC**	**-**	**-**	**2**	**1**
10	98BT652	Metabolic Engineering (Lab 2)	**PC**	**-**	**-**	**2**	**1**
11	98BT653	Bioreactor Design (Lab 3)	**PC**	**-**	**-**	**2**	**1**
12	98BT654	Waste Treatment (Lab 4)	**PC**	**-**	**-**	**2**	**1**
13	98BT655	Genomics & Proteomics (Lab 6)	**PE**	**-**	**-**	**2**	**1**
14	98BT656 A/B/C	Food Biotechnology / Vaccine Biotechnology /Bioprogramming and Soft Computing Techniques (Lab 5)	**PE**	**-**	**-**	**2**	**1**
		Total		**15**	**2**	**12**	**23**

Scheme of B. Tech. Biotech 7th Semester

S. No.	Subject Code	SUBJECT	Subject AREA	Periods			Credit
				L	T	P	
1	98BT701	Stem Cell and Tissue Engineering	**PE**	**3**	**-**	**-**	**3**
2	98BT702	Bioprocess Engineering and Unit Operation	**PC**	**2**	**1**	**-**	**3**
3	98BT703	Proteomics & Protein Engineering	**PC**	**2**	**1**	**-**	**3**
4	98BT704 -A	Biofuels and Bioenergy	**PE**	**2**	**-**	**-**	**2**
5	98BT704 -B	Bioremediation	**PE**	**2**	**-**	**-**	**2**
6	98Bt704-C	Metagenomics	**PE**	**2**	**-**	**-**	**2**
7	98BT705	Research Methodology	**PC**	**2**	**-**	**-**	**2**
8	98BT751	Stem Cell and Tissue Engineering (Lab 1)	**PE**	**-**	**-**	**2**	**1**
9	98BT752	Bioprocess Engineering and Unit Operation (Lab 2)	**PC**	**-**	**-**	**2**	**1**
10	98BT753	Proteomics & Protein Engineering (Lab 3)	**PE**	**-**	**-**	**2**	**1**
11	98BT754 A/B/C	Biofuels and Bioenergy /Bioremediation /Metagenomics (Lab 4)	**PE**	**-**	**-**	**2**	**1**
12	98BT755	Industrial Training (Lab 5)	**PS**	**-**	**-**	**10**	**5**
		TOTAL		**09**	**2**	**18**	**20**

Scheme of B. Tech. Biotech 8thSemester

S.No	Subject Code	SUBJECT	Subject AREA	Periods			Credit
				L	T	P	
1	98BT851	Project Work/Dissertation/Biotech industrial or Biotech in House Project or Biopreneurship/ Bio-Startups	**PS**	**-**	**-**	**18**	**9**
		TOTAL		**0**	**0**	**18**	**9**

Program name	**Bachelor of Technology (B.Tech) Biotechnology**	
Semester	I	
Course Code:	**98BT101**	
Course title:	**Biology for engineers**.	Developer: **Mr. PARAS KOSHE**
Pre-requisite:	Student should have basic knowledge about Physiology and biology and various system of our body	
Rationale:	The paper on "Biology" in B.tech. Biotechnology program allow students to know that Biology is related to mankind ever since the origin of man, therefore this branch of science stands first in order of studies as compared to other branches of science. Ever since the origin of life man is eager to know about various phenomenon of life processes such as health and disease, birth, growth and death,	
CourseOutcomes (COs):	**98BT101: 1** The basic idea of cell organization, classification of living organism and nomenclature and biodiversity covered in the unit. **98BT101 2** Explain morphology, anatomy and function of different parts of flowering plants and emphasis on plant physiology, **98BT101. 3** Learn about the human physiology with emphasis on various organ systems of human body. **98BT101. 4** Understand the male and female reproductive system and know about sexually transmitted diseases **98BT101. 5** The student gains an understanding of the fundamentals of immunology and Origin of life and mechanism of evolution.	

Scheme of Studies:

Board ofStudy	Cours eCode	Course Title	Scheme ofstudies (Hours/Week)					Total Credits(C) (L: T: P=3:0:1)
			CI	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
Program Core(PCC)	98BT101	**Biology for engineers**.	3	0	1	1	5	3

*Legends:*CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial(T) and others);

LI: Laboratory Instruction(Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks) — Progressive Assessment (PRA): Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	ClassActivityanyone (CAT)	Class Attendance (AT)	Total Marks (CA+CAT+CT+SA+AT)	End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
PCC	98BT101	**Biology for engineers.**	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Course-Curriculum:

<table>
<tr><td rowspan="3">This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.</td><td colspan="6">ApproximateHours</td></tr>
<tr><td>Item</td><td>Cl</td><td>LI</td><td>SW</td><td>SL</td><td>Total</td></tr>
<tr><td>Approx.Hrs</td><td>09</td><td>00</td><td>01</td><td>04</td><td>14</td></tr>
</table>

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO 1: The basic idea of cell organization, classification of living organism and nomenclature and biodiversity covered in the unit	**SO1.1**: Able to define the Diversity of living organisms		**CI 1.1**: Diversity of living organisms	**SL 1.1**: Study about the basic of Biology
	SO1.2 Describe various criteria of classification of organism.		**CI 1.2:** classification of living organisms	**SL 1.2**: Learn about various scientists who classified organism.
	SO1.3: Understanding Systematic system of nomenclature.		**CI 1.3**: Systematic system of nomenclature	**SL 1.3**: Classify organism on the basis of cellularity.
	SO1.4: Understanding Binomial system of nomenclature		**CI 1.4**: Binomial system of nomenclature	**SL 1.4:** Compare prokaryotic and eukaryotic cells.

	SO1.5: In depth study about the cell and cell theory.		**CI 1.5**: Cell theory	
	SO1.6: Categorizing the components of cell and learn about cell organelles and structure.		**CI 1.6**: Cell organization	
	SO1.7: Basic and advanced understanding of Types of cells		**CI 1.7**: Types of cells	
	SO1.8: Explain basic constituents of living bodies		**CI 1.8**: Basic constituents of living bodies	
	SO1.9: Explain chemical constituents of living bodies		**CI 1.9** chemical constituents of living bodies	

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Describe in detail about the diversity and classification of living organism
	SW1.2 Mini Project	Draw well labelled diagram of Plant cell and animal cell.
	SW1.3 Other Activities (Specify)	Write a note on Red data book and collect information about recently endangered and extinct species,

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	ApproximateHours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	00	01	05	15

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO 2: Explain morphology, anatomy and function of different parts of flowering plants and emphasis on plant physiology	**SO2.1**: Discuss the properties structure and types of animal tissues.		**CI 2.1**: Animals tissues	**SL 2.1**: Fundamental structure of Plant and animal tissue.
	SO2.2: Discuss the properties structure and types of Plant tissues.		**CI 2.2**: plant tissues	**SL 2.2**: Study the mechanism of opening and closing of stomata.
	SO2.3 Explain : morphology, and function of different parts of flowering plants		**CI 2.3**: morphology, and function of different parts of flowering plants	**SL 2.3**: Read in detail about the Ascent of sap.
	SO2.4: Explain anatomy and functions of different parts of flowering plants.		**CI 2.4**: Anatomy and function of different parts of flowering plants	**SL 2.4** Learn about the modification of root and shoots in plants.

	SO2.5: Build up the concept about the Plant physiology.		**CI 2.5** Plant physiology	**SL 2.5** Study about short day and Long day Plants**.**
	SO2.6: Summarizing the mechanism of movement of water in plant body and various theories related to it.		**CI 2.6**: movement of water	
	SO2.7: Learn how movement of food, nutrients and gases take place in plants.		**CI 2.7**: movement of food, nutrients and gases	
	SO 2.8:Describe the process and types of respiration in plants including various cycles such as glycolysis , Kreb's cycle ETS etc.		**CI 2.8**: Respiration	
	SO 2.9 Focus on the mechanism and steps of photosynthesis (light reaction and dark reaction) photsystem I and photo system II also describe plant growth and development (Phytohormones)		**CI 2.9** Photosynthesis and plant growth and development	

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Explain the process of photosynthesis in detail,
	SW1.2 Mini Project	Draw well labelled diagrams of plant tissues and animal tissues.
	SW1.3 Other Activities (Specify)	Watch animation and learn more about the plant growth and development. Grow a baby plant and watch and observe the growth and development practically and minutely.

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Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	0	01	04	14

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO 3: Learn about the human physiology with emphasis on various organ systems of human body	**SO3.1**: Discuss about the Human physiology.		**CI 3.1**: Human physiology	**SL3.1**: Study about the history of human physiology and its various aspects.
	SO3.2: Linking different fundamental organs related to human digestive system.		**CI3.2**: Digestive system	**SL 3.2**: Learn about the various digestive disorders.
	SO3.3: Able to visualize mechanism and importance of respiratory system.		**CI3.3**: Respiratory system	**SL 3.3** Learn about the various respiratory diseases.
	SO 3.4: : Able to visualize mechanism and importance of circulatory system		**CI 3.4**: circulatory system	**SL 3.4** Study about different types of blood vessels**.**
	SO 3.5: Learn about the different types of body fluids (blood and Lymph).		**CI 3.5**: Body fluids	
	SO 3.6: Learn the structure and function Human brain and its role in Neural control and coordination.		**CI 3.6**: Neural control and coordination,	

	SO 3.7 Explain different parts of Human Brain		**CI 3.7** Parts of Brain	
	SO 3. Describe Chemical coordination and regulation.		**CI 3.8** Chemical coordination and regulation	
	SO 3.9 8 Discuss various types of hormones and their role in Chemical coordination and regulation		**CI 3.9** Hormones	

Suggested Sessional Work (SW): *anyone*	Assignments:	Describe endocrine system and the various types of gland in body.
	Mini Project:	Draw structure of different types of system of human body.(Digestive system respiratory system)
	Other Activities (Specify):	Watch animation on explaining the organ transplantation and try to write article on Red biotechnology.

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Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	0	01	04	14

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO 4: Understand the male and female reproductive system and know about sexually transmitted diseases	**SO4.1**: Discuss about Reproduction system in male		**CI4.1**: Reproduction system in male	**SL4.1**: In our society the women are often blamed for giving birth to daughters. Explain why this is not correct.
	SO 4.2: Describe Parts of male reproductive system		**CI 4.2:** Parts of male reproductive system.	**SL 4.2**: Study about parturition and hormones involved in induction of parturition
	SO4.3: Explain Reproduction system in female.		**CI4.3**: Reproduction system in female,	**SL 4.3**: Learn about the use of contraceptives.
	SO 4.4: Describe the Parts of female reproductive system		**CI 4.4:** Parts of female reproductive system.	**SL 4.**4 Draw a labelled diagram of a section through ovary and a diagram of Graafian follicle**.**
	SO4.5: Explain the mechanism Menstrual cycle in female and its importance in reproduction		**CI4.5**: Menstrual cycle	
	SO4.6: Elaborate the production of Gametes in human.		**CI4.6** production of gametes	

	SO 4.7: Discuss the process of fertilization and embryo development		**CI 4.7**: fertilization, embryo development.	
	SO 4.8: Discuss various types of **:** sexually transmitted diseases.		**CI 4.8:** sexually transmitted diseases,	
	SO 4.9 Explain infertility and its causes.		**CI 4.9** Infertility	

Suggested Sessional Work (SW): *anyone*	Assignments:	Suggest the aspects of reproductive health which need to be given special attention in present scenario.
	Mini Project:	Draw the structure of male and female reproductive system on chart paper.
	Other Activities (Specify):	Write an article on Medical Termination of Pregnancy (MTP).

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	ApproximateHours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	00	01	04	14

Course outcome (COs)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO 5 The student gains an understanding of the fundamentals of immunology and Origin of life and mechanism of evolution	**SO 5.1**: Explain about Origin of life		**CI 5.1**: Origin of life	**SL 5.1:** Study more about the origin and evolution of man.
	SO 5.2: Explain different theories and evidences related to origin of life.		**CI 5.2**: theories and evidences	**SL 5.2**: Learn various techniques of phylogenetic analysis..
	SO5.3: Illustrate the adaptive radiation by giving examples.		**CI 5.3**: adaptive radiation	**SL 5.3** Learn the structure and types of immunoglobulins.
	SO5.4 Explain the mechanism of evolution,		**CI 5.4**: mechanism of evolution	**SL 5.4** Learn more about immune deficiency disorders
	SO5.5 Discuss about the origin and evolution of man		**CI 5.5:** origin and evolution of man	
	SO5.6: Demonstrate about Basic concepts of immunology		**CI 5.6**: Basic concepts of immunology	

	SO5.7: Explain about the vaccines and its types.		**CI 5.7** vaccines	
	SO5.8: Describe the causes precautions and possible treatment for AIDS.		**CI 5.8:** AIDS	
	SO5.9 Describe the causes precautions and possible treatment for Cancer.		**CI 5.9:** cancer.	

Suggested Sessional Work (SW): Anyone	Assignments:	Detail explanation of principle of vaccine and its production
	Mini Project:	Collect some old photographs showing of early man and make poster showing evolution of man with many evidences.
	Other Activities (Specify):	Write an article on modern vaccine (Recombinant DNA vaccine and sub unit vaccine)

Course duration (in hours) to attain Course Outcomes:

Course Title: Biology for engineers. **Course Code: 98BT101**

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
98BT101: 1 The basic idea of cell organization, classification of living organism and nomenclature and biodiversity covered in the unit.	9	0	4	1	14
98BT101 2 Explain morphology, anatomy and function of different parts of flowering plants and emphasis on plant physiology,	9	0	5	1	15
98BT101. 3 Learn about the human physiology with emphasis on various organ systems of human	9	0	4	1	14

body.					
98BT101. 4 Understand the male and female reproductive system and know about sexually transmitted diseases	9	0	4	1	14
98BT101. 5 The student gains an understanding of the fundamentals of immunology and Origin of life and mechanism of evolution.	9	0	4	1	14
Total Hours	45	00	21	05	71

End-semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Biology for engineers. **Course Code:52BT201**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
98BT101: 1 The basic idea of cell organization, classification of living organism and nomenclature and biodiversity covered in the unit.	2	1	1	1	5
98BT101 2 Explain morphology, anatomy and function of different parts of flowering plants and emphasis on plant physiology,	2	4	2	2	10
98BT101. 3 Learn about the human physiology with emphasis on various organ systems of human body.	3	5	5	2	15
98BT101. 4 Understand the male and female reproductive system and know about sexually transmitted diseases	2	3	3	2	10
98BT101. 5 The student gains an understanding of the fundamentals of immunology and Origin of life and mechanism of evolution.	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

***Legend*:A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Roitt I.M, Brostoff, J., Male D.K., Immunology (Illustrated Publisher, Mosby).
2	T. J. Kindt, R.A. G. B. A. Osborne, J. Kuby. Immunology (W.H. Freeman and Company, New York).

3	Biology by Peter H Raven, George B Johnson, Kenneth A. Mason, Jonathan Losos, Susan Singer (Macgraw Hill)
4	Campbell, N.A. and Reece, J.B. (2008) Biology 8th edition, Pearson Benjamin Cummings, San Francisco.

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B.Tech. Biotechnology
Semester: I Semester
Course Title: **Biology for engineers**.
Course Code: 98BT101

CO/PO/PSO Mapping		
Course Outcome (Cos)	**Program Outcomes (POs)**	**Program Specific Outcomes (PSOs)**

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3
98BT101: **1** The basic idea of cell organization, classification of living organism and nomenclature and biodiversity covered in the unit.	1	2	2	3	1	2	2	1
98BT101 **2** Explain morphology, anatomy and function of different parts of flowering plants and emphasis on plant physiology,	1	2	3	2	1	1	1	2
98BT101. **3** Learn about the human physiology with emphasis on various organ systems of human body.	1	2	3	2	1	1	1	1
98BT101. **4** Understand the male and female reproductive system and know about sexually transmitted diseases	-	1	1	-	2	1	1	3
98BT101. **5** The student gains an understanding of the fundamentals of immunology and Origin of life and mechanism of evolution.	1	1	1	-	-	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	**COs**	**SOs No.**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
PO 1,2,3,4,5	**98BT101:** **1** The basic idea of cell organization, classification of living organism and nomenclature	SO1.1, SO1.2 SO1.3, SO1.4SO1.5, SO1.6, SO1.7, SO1.8, SO1.9		1.1,1.2,1.3,1.4, 1.5,1.6,1.7,1.8,1.9	**1SL-1,2,3,4,5**

PSO 1,2,3	and biodiversity covered in the unit.				
PO 1,2,3,4,5 PSO 1,2,3	**98BT101 2** Explain morphology, anatomy and function of different parts of flowering plants and emphasis on plant physiology,	SO2.1 SO2.2 SO2.3 SO2.4, SO2.5 SO2.6, SO2.7, SO2.8, SO2.9		2.1, 2.2, 2.3, 2.4,2.5, 2.6,2.7,2.8,2.9	**2SL-1,2,3,4**
PO 1,2,3,4,5 PSO 1,2,3	**98BT101. 3** Learn about the human physiology with emphasis on various organ systems of human body.	SO3.1 SO3.2 SO3.3 SO3.4, SO3.5, SO3.6, SO3.7, SO3.8, SO3.9		3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9	**3SL-1,2,3,4**
PO 1,2,3,4,5 PSO 1,2,3	**98BT101. 4** Understand the male and female reproductive system and know about sexually transmitted diseases	SO4.1 SO4.2 SO4.3 SO4.4, SO4.5, SO4.6, SO4.7 SO4.8, SO4.9		4.1,4.2,4.3,4.4,4.5,4.5,4.6,4.7,4.8,4.9	**4SL-1,2,3,4**
PO 1,2,3,4,5 PSO 1,2,3	**98BT101. 5** The student gains an understanding of the fundamentals of immunology and Origin of life and mechanism of evolution.	SO5.1 SO5.2 SO5.3, SO5.4, SO5.5, SO5.6, SO5.7, SO5.8, SO5.9		5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9	**5SL-1,2**

Curriculum development team:
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Course Code:	98CH102
Course Title:	Engineering Chemistry
Pre- requisite:	Students must have fundamental knowledge of mathematics, nature of molecule, valence shell electron pair repulsion theory, and different concentration terms to understand the concept of engineering chemistry.
Rationale:	The students studying engineering chemistry should possess foundational understanding about basic mathematics, different concentration terms and valence shell electron pair repulsion theory to understand the basic principle of chromatography and spectroscopic analysis.

Course Outcomes (COs)
98CH102.1: Apply VSEPR theory to predict the three-dimensional shapes of molecules.
98CH102.2: Describe the concept of symmetry, chirality, and optical activity, and synthesize chiral drug molecules.
98CH102.3: Explain and apply the concept of intermolecular forces, hydrogen bonds, and transition metal complexes.
98CH102.4: Predict the concept of thermodynamics, free energy, and entropy, and apply Nernst equation, water chemistry, as well as explain concepts of acid-base, metallurgy, EMF cell, and corrosion.

Scheme of Studies:

Board of Study	**Course Code**	**Course Title**	**Scheme of studies(Hours/Week)**					**Total Credits (C)**
			Cl	**LI**	**SW**	**SL**	**Total Study Hours (CI+LI+SW+SL)**	
Program Core (PCC)	98CH102	Engineering Chemistry	3	2	2	1	8	4

Legend: **CI:** Classroom Instruction (Includes different instructional strategies i.e., Lecture(L) and Tutorial (T)and others),

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)

SW: Sessional Work (includes assignment, seminar, mini projected.),

SL: Self-Learning,

C: Credits.

Scheme of Assessment:

Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA +
			Class/ Home Assign ment 5 number	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar	Class Activity	Class Attenda	Total Marks (CA+CT+		
BS	98CH102	Engineering Chemistry	15	20	5	5	5	50	50	100

Practical

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA +
			Class/ Home Assign ment 5 number	Class Test 2 (2 best out of 3) 10 marks each (CT)	Semina r	Class Activity	Class Attenda	Total Marks (CA+CT+		
B S	98CH152	Engineering Chemistry	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

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Approximate Hours

Item	App X Hrs.
Cl	9
LI	6
SW	2
SL	1
Total	18

Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
SO1.1: Describe the classification of different types of orbit and orbitals.	LI1.1: Determination of specific density of a given liquid.	CI1.1: Describe the classification of different types of orbit and orbitals.	
SO1.2. Introduction of orbit, orbitals, and electronic configuration.		CI1.2. Introduction of orbit, orbitals, and electronic configuration.	
SO1.3: Discuss the fundamental concept of the wave function and probability distribution curve.	LI1.2: Determination of viscosity of a given liquid.	CI1.3: Discuss the fundamental concept of the wave function and probability distribution curve.	LI1.1: Atomic Spectroscopy: Energies of atomic orbitals.
SO1.4: Explain and apply atomic spectroscopy: energies of atomic orbitals.		CI1.4: Explain and apply atomic spectroscopy: energies of atomic orbitals.	
SO1.5: Apply the concept of VSEPR in the determination of geometry of various molecules.	LI1.3: Paper chromatography and thin-layer chromatography.	CI1.5: Apply the concept of VSEPR in the determination of geometry of various molecules.	

Category	Details
Assignments	Applications of molecular orbital theory for the determination of bond order and magnetic behavior.
Mini Project	Hybridization and its application.
Other Activities	Write an essay on different types of chemical bonds.

Item	App X Hrs.
Cl	8
LI	6
SW	2
SL	1
Total	18

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
SO2.1: Understand the concept of representations of 3-dimensional structures.	LI.2.1: To synthesize drug molecules and determine their percentage yield.	Unit 2: CI2.1 Stereochemistry, Organic Reactions, and Synthesis of a Drug Molecule	
SO2.2: Representations of 3-dimensional structures.		CI2.2: Representations of 3-dimensional structures	
SO2.3: Explain structural isomers and stereoisomers.	LI.2.2: To determine the acid value or saponification value of oil/fat.	CI2.3 Structural isomers and stereoisomers.	2. Types of symmetry.
SO2.4: Describe symmetry, chirality, and optical activity.	LI.2.3: To determine the partition coefficient of an organic substance between two immiscible liquids.	CI2.4 Symmetry, chirality, optical activity, and absolute configurations.	
SO2.5: Enantiomers and diastereomers.		CI2.5 Enantiomers and diastereomers.	

Category	**Details**
Assignments	Conformational isomerism and conformational analysis.

Item	Approximate Hours (App X Hrs.)
Classroom Instruction (CI)	8
Laboratory Instruction (LI)	6
Sessional Work (SW)	2
Self-Learning (SL)	1
Total	17

Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
SO3.1: Describe ionic, dipolar, London dispersion forces, and van der Waals interactions.	LI3.1: Synthesize an inorganic metal complex.	CI3.1: Describe ionic, dipolar, London dispersion forces, and van der Waals interactions.	
SO3.2 Ionic, dipolar, and London dispersion forces.		CI3.2 Ionic, dipolar, and London dispersion forces.	
SO3.3 van der Waals interactions.	LI3.2 Coordination compounds: IUPAC naming and Werner theory.	CI3.3 van der Waals interactions.	
SO3.4: Explain hydrogen bonds and types of hydrogen bonds.		CI3.4: Explain hydrogen bonds and types of hydrogen bonds.	
SO3.5: Describe coordination compounds.	LI3.3: Determine two acidic and two basic radicals.	CI3.5: Describe coordination compounds.	
SO3.6: Describe metal-ligand bonding using Valence Bond Theory (VBT).		CI3.6: Describe metal-ligand bonding using Valence Bond Theory (VBT).	SL3.1 The energy level diagrams for transition metal ions and their magnetic properties.
SO3.7: Explain metal-ligand bonding using Crystal Field	LI3.4: Determine chloride content of water.	CI3.7: Explain metal-ligand bonding using Crystal Field	

Theory (CFT).		Theory (CFT).	
SO3.8: Magnetic properties of transition metal ions.		CI3.8: Magnetic properties of transition metal ions.	

Category	Details
Assignments	VBT theory, CFT theory, The energy level diagrams for transition metal ions and their magnetic properties.
Mini Project	Applications of transition metal complexes.
Other Activities	BSC-103.4: Predict the concept of thermodynamics, free energy & entropy, and apply the Nernst equation, water chemistry, as well as explain the concepts of acid-base, metallurgy, EMF cell, and corrosion.

Activity	Approximate Hours (Appx. Hrs.)
Classroom Instruction (Cl)	9
Laboratory Instruction (LI)	6
Suggested Sessional Work (SW)	2
Self-Learning (SL)	1

Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
SO4.1: Restate the concept of free energy, enthalpy, entropy, and types of different thermodynamic systems.	LI4.1: Determination of hardness of water.	CI4.1: Use of free energy in chemical equilibrium	SL4.1: Restate the concept of free energy, enthalpy, entropy, and types of different thermodynamic systems.
SO4.2: Discuss the fundamental concept of water chemistry.	LI4.2: Determination of alkalinity.	CI4.3 Water chemistry: Hardness of water, temporary and permanent hardness.	
SO4.3: Explain and apply different concepts used in	LI4.3: Chemical analysis of a salt.	CI4.3 Water softening methods.	

softening of water and purification of water.			
SO4.4: Explain and apply different concepts used in softening of water and purification of water.	LI4.4: Chemical analysis of a salt.	CI4.4 Introduction to corrosion: Mechanism of corrosion.	
SO4.5: Understand and apply the concept of corrosion for the development of green corrosion inhibitors.		CI4.5 Factors affecting the rate of corrosion.	
SO4.6 Various acid-base concepts: Arrhenius concept, Lewis acid-base concept, Bronsted-Lowry concept.		CI4.6 Various acid-base concepts: Arrhenius concept, Lewis acid-base concept, Bronsted-Lowry concept.	
SO4.7 Brief idea about ionic and solubility equilibria.		CI4.7 Brief idea about ionic and solubility equilibria.	
SO4.8: Understand different acid-base concepts, ionic, and solubility product of salts.		CI4.8: Understand different acid-base concepts, ionic, and solubility product of salts.	

Category	**Details**
Assignments	VBT theory, CFT theory, The energy level diagrams for transition metal ions and their magnetic properties.
Mini Project	Applications of transition metal complexes.
Other Activities	Specify any additional activities here.

Approximate Hours

Item	**Appx. Hrs.**
Cl	Cl 9
LI	LI 6
SW	SW 2
SL	SL 1
Total	Total 18

Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
SO5.1: Understand identification and classification of different types of EMR and vibrational modes in molecules.	LI5.1: Verification of Beer-Lambert law.	CI5.1: Spectroscopic techniques and applications	
SO5.2: Introduction to spectroscopy, discovery, properties, and types of electromagnetic radiation.	LI5.2: Applications of Nuclear Magnetic Resonance (NMR) and magnetic resonance imaging.	CI5.2 Classification of different types of vibrational modes in molecules (stretching, bending, torsional, etc.). IR activity.	
SO5.3: Explain and apply Atomic Spectroscopy: Energies of atomic orbitals.	LI5.3: Determination of cell constant and conductance of solutions.	CI5.3 Energies of atomic orbitals and electronic transitions, Frank-Condon principle.	
SO5.4: Understand and apply the concept of NMR, nuclear spin, and nuclear resonance.		CI5.4 Introduction to NMR.	
SO5.5 Nuclear spin, nuclear resonance.		CI5.5 Nuclear spin, nuclear resonance.	
SO5.6 Principle and instrumentation of NMR.		CI5.6 Principle and instrumentation of NMR.	

SO5.5: Understand the introduction of X-ray diffraction for the determination of crystallographic structures.		CI5.5: Understand the introduction of X-ray diffraction for the determination of crystallographic structures.	
SO5.6: Shielding and deshielding of magnetic nuclei.		CI5.6: Shielding and deshielding of magnetic nuclei.	
SO5.7: Surface characterization techniques		CI5.7: Surface characterization techniques	
SO5.8: Diffraction and scattering.		CI5.8: Diffraction and scattering.	

Category	Details
Assignments	Applications of Nuclear Magnetic Resonance (NMR) and Magnetic Resonance Imaging (MRI).
Mini Project	Fluorescence and its applications in medicine.
Other Activities	Write an essay on surface characterization techniques, diffraction, and scattering.

Brief of Hours suggested for the Course Outcome

Course Outcomes	**Class Lecture (Cl)**	**Lab Instruction (LI)**	**Sessional Work (SW)**	**Self-Learning (SL)**	**Total hour (Cl+Li+SW+Sl)**
98CH102.1: Apply VSEPR theory to predict the three-dimensional shapes of molecules.	09	04	02	01	16
98CH102.2: Describe the concept of symmetry, chirality and optical activity and synthesize chiral drug molecule	09	06	02	01	18

98CH102.3: Explain and apply the concept of Intermolecular forces, Hydrogen bond, and transition metal complexes	09	04	02	01	16
98CH102.4: Predict the concept of thermodynamics, free energy & entropy and apply Nernst equation, water chemistry as well as explain concept of acid-base, metallurgy, Emf cell and corrosion.	09	04	02	01	16
98CH102.5: Collectively aim to equip students with a comprehensive understanding of the theoretical principles, practical methodologies, and diverse applications of various spectroscopic techniques.	09	04	02	01	14
Total Hours	45	22	10	05	80

Suggestion for End Semester Assessment

Suggested Specification Table (For ESA)

CO	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
98CH102CO-1	Atomic and Molecular Structure & Periodic properties	03	01	01	05
98CH102CO-2	Stereochemistry, Organic reactions and synthesis of a drug molecule	02	06	02	10
98CH102CO-3	Intermolecular forces and Transition metal complexes	03	07	05	15
98CH102CO-4	Use of free energy in chemical equilibrium	-	10	05	15
98CH102CO-5	Spectroscopic techniques and applications	03	02	-	05
	Total	11	26	13	50

Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Case Method
4. Group Discussion
5. Role Play
6. Visit to NCL, CSIR laboratories
7. Demonstration
8. ICT Based Teaching Learning (Video Demonstration/Tutorials CBT,Blog, Facebook, Twitter, WhatsApp, Mobile, Online sources)
9. Brainstorming

Suggested Learning Resources:

(a) Books:

S. No.	Title	Author	Publisher	Edition & Year
1	A textbook of engineering chemistry	Shyamala Sundara	S. Chand	Edition 2008
2	A Textbook of Engineering Chemistry	Shashi Chawla |	Dhanpat Rai Prakashan	Edition 2020
3	A Textbook of Engineering Chemistry	PC Jain and Monika Jain	Dhanpat Rai Prakashan	Edition2018

Program: B.Tech. BioTech. Ist

Course Title: Engineering Chemistry Course

Code: 98CH102

Course Outcomes	Program Outcomes												Program Specific Outcome				
	PO 1	PO 2	PO3	PO 1	PO 2	PO6	PO 1	PO 2	PO9	PO 1	PO 2	PO12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
	Engineering knowledge	Problem analysis	Design/development of solutions	Conduct studies of difficult problems	Utilization of modern tools	Engineers and society	Environment and sustainability	Ethics	Individual and team work	Communication	Project management and finance	Life-longlearning	Use fundamental knowledge of math, science, and engineering to comprehend, evaluate, and create computer Programmes in the fields of algorithms, multimedia, big data analytics, machine learning, artificial intelligence, and networking for the effective design of computer-based systems of various complexity	Utilize relevant methods and cutting- edge hardware and software engineering tools to develop and integrate computer systems and related technologies. This PSO2 also encourages lifelong learning for the advancement of technology and its use in multidisciplinary settings	Applying professional engineering solutions for societal improvement while taking into account the environmental context, being conscious of professional ethics, and being able to effectively communicate.	Learn and use the most recent Artificial Intelligence and Data Science technologies in the fields of engineering and computer science	Recognize and examine issues in real life, then offer creative software solutions with the help of AI and Data Science Technologies.
CO1: Apply VSEPR theory to predict the three-dimensional shapes of molecules.	3	1	2	2	3	2	3	2	2	1	3	2	2	3	1	2	-
CO 2 Describe the concept of symmetry, chirality and optical activity and synthesize chiral drug molecule.	2	1	2	2	1	2	3	2	1	1	2	2	2	3	1	2	-
CO3 Explain and apply the concept of Intermolecular forces, Hydrogen bond, and transition metal complexes.	2	2	1	1	1	2	2	2	1	2	1	2	1	3	1	2	-
CO4: Predict the concept of thermodynamics, free energy & entropy and apply	2	2	2	2	3	2	3	2	2	1	2	3	3	3	2	2	-

Nernst equation, water chemistry as well as explain concept of acid-base, metallurgy, Emf cell and corrosion.																	
CO5 Collectively aim to equip students with a comprehensive understanding of the theoretical principles, practical methodologies, and diverse applications of various spectroscopic techniques	**2**	**-**	**-**	**1**	**1**	**3**	**3**	**3**	**1**	**1**	**2**	**2**	**3**	**3**	**2**	**2**	**-**

Legend:1–Low,2–Medium, 3–High

Course Curriculum Map:

POs &PSOs No.	**Cos. No. &Titles**	**SOs No.**	**Laboratory instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning(SL)**
PO1,2,3,4,5, 6, 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO1:** Apply VSEPR theory to predict the three-dimensional shapes of molecules.	SO1.1 SO1.2 SO1.3, SO1.4 SO1.5	LI.1.1, LI.1.2, LI.1.3	**Unit-1.0 Atomic and Molecular Structure & Periodic properties** 1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9	History of development of periodic table 2-Elecronegativity and its application
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO2:** Describe the concept of symmetry, chirality and optical activity and synthesize	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5	LI.2.1, LI.2.2, LI.2.3	Unit-2 **Stereochemistry, Organic reactions and synthesis of a drug molecule** 2.1,2.2,2.3,2.4,2.5,2.6, 2.7, 2.8,2.9	Resonance Raman Spectroscopy, coherent anti- stokes Raman Spectroscopy

	chiral drug molecule.				(CARS).
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO3** Explain and apply the concept of Intermolecular forces, Hydrogen bond, and transition metal complexes.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5	LI.3.1, LI.3.2 LI.3.3	Unit-3 **Intermolecular forces and Transition metal complexes** 3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9	Nature of M-L bond, coordination number, structure and detection of oxidation state.
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO 4** Predict the concept of thermodynamics, free energy & entropy and apply Nernst equation, water chemistry as well as explain concept of acid-base, metallurgy, Emf cell and corrosion	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5	LI.4.1, LI.4.2, LI.4.3	Unit-4: **Use of free energy in** chemical **equilibrium** 4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8,4.9	Quadrupole nuclei, quadrupole moments, electric field gradient, coupling constant splitting. Applications
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO 5** Collectively aim to equip students with a comprehensive understanding of the theoretical principles, practical methodologies, and diverse applications of various spectroscopic techniques.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5	LI.1.1, LI.1.2, LI.1.3	**Unit 5: Spectroscopic** techniques **and applications** 5.1,5.2,5.3,5.4,5.5,5.6,5.7	Low energy electron diffraction and structure of surfaces.

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	II	
Course Code:	98BT103	
Course title:	Cell Biology and Genetics	**Curriculum Developer**: Dr. Ashwini A. Waoo, Professor
Pre-requisite:	Student should have basic knowledge of cell structure and organelles	
Rationale:	The B.Tech first-semester course in cell biology and genetics serves as a crucial introduction to the fundamental building blocks of life—cells and genetic mechanisms. By delving into cellular structures, processes, and genetic principles, students establish a foundational understanding of life at the molecular level. This course paves the way for comprehending intricate biological phenomena, ranging from cellular functions to inheritance patterns, and sets the stage for future explorations in biotechnology, genetics, and related fields.	
Course Outcomes (COs):	**CO1-98BT103.1**: Students will demonstrate a thorough understanding of cell, cell theory, cell types and pre cellular evolution. **CO2-98BT103.2**: Students will exhibit proficiency in drawing and explaining ultrastructure of cell membrane and cell organelles. **CO3-98BT103.3**: Evaluate the roles cell division, cell cycle and cell signaling. **CO4-98BT103.4**: Students will exhibit mastery of Genetic Principles and Mendel's laws of inheritance. **CO5-98BT103.5**: Illustrate molecular organization of chromosome and its alterations.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=3:0:0)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Core (PC)	98BT103 98BT155	Cell biology and genetics Cell Biology and Genetics lab	3	2	1	5	9	3:2

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		

PE	98BT103	Cell Biology and Genetics	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
PE	98BT153	Cell Biology and Genetics	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	04	01	05	18

Course outcome (CO)	**Session Outcomes**	**Laboratory Instruction**	**Class room**	**Self-Learning (SL)**

	(SOs)	(LI) 98BT155	Instruction (CI)	
CO1-98BT103.1: Students will demonstrate a thorough understanding of cell, cell theory, cell types and pre cellular evolution.	**SO1.1** Understand Cell as basic unit of living System	LI1Study and observation of Prokaryotic cell and eukaryotic under microscope	**Unit-1** **CI1.1** Cell as basic unit of living System	**SL1.1** Study of prokaryotic and eukaryotic cell
	SO1.2 Understand pre cellular evolution		**CI1.2** pre-cellular evolution	**SL1.2** What do you mean by pre cellular
	SO1.3 Illustration of cell theory		**CI1.3** cell theory	**SL1.3** Write postulates of cell theory
	SO1.4 Learn and draw PPLO cell		**CI1.4** ultra structure of cell types PPLOs,	
	SO1.5 Learn and draw Bacterial cell		**CI1.5** Bacteria	**SL1.4** Draw and label ultrastructure of bacteria
	SO1.6 Learn and draw Plant cell		**CI1.6** Plant Cell	
	SO1.7 Learn and draw animal cell		**CI1.7** Animal Cell	
	SO1.8 Illustrate tools and techniques of cell	LI 2 Demonstration of all equipment used in cell	**CI1.8** tools and techniques of	**SL1.5** List out adaptations for

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Differentiate between prokaryotic and eukaryotic cell
	SW1.2 Mini Project	Prepare list of microorganisms of prokaryotic and eukaryotic type
	SW1.3 Other Activities (Specify)	Prepare chart on tools and techniques of cell biology

		biology	biology and genetics lab	cell biology	bioremediation

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-98BT103.2: Students will exhibit proficiency in drawing and explaining ultrastructure of cell membrane and cell organelles.	**SO2.1** Explore fluid mosaic model		**Unit-II** **CI2.1** Ultrastructure of cell membrane	**SL2.1** Learn structure and function of membrane
	SO2.2 Describe the Golgi complex		**CI2.2** structure and function of cell organelles, Golgi bodies,	**SL2.2** Write a note on Golgi complex
	SO2.3 Study endoplasmic reticulum		**CI2.3** cytosol, endoplasmic reticulum	**SL2.3** Learn about contents of cytosol
	SO2.4		**CI2.4** ribosome	**SL2.3**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	00	01	05	14

	Explain structure and function of Mitochondria		mitochondria	Discuss **r**ole of ribosome in protein synthesis
	SO2.5 Assessing the need of peroxisome in cell		**CI2.5** peroxisomes	
	SO2.6 Explaining the structure of nucleus		**CI2.6** Nucleus	**SL2.5** Prepare diagram of nucleus and nuclear pore
	SO2.7 Explaining cytoskeleton elements and types		**CI2.7** cytoskeleton structure intermediate filament, microtubules, actin filament,	
	SO2.8 Understand the cilia and flagella		**CI2.8** cilia and centrioles.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Draw a well labelled diagram of fluid mosaic model and describe it.
	SW2.2 Mini Project	Prepare chart on cell organelles.
	SW2.3 Other Activities (Specify)	Prepare collection of photos from internet of different cellular organisations and electron micrograph of cell organelles

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	0 4	01	05	18

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-98BT103.3:	**SO3.1** Illustrate Cell	Li 1 Study of mitosis with	**Unit-III**	**SL3.1** Read about cell division

Evaluate the roles cell division, cell cycle and cell signaling.	cycle and all stages	onion root tip	**CI3.1** Cell division and cycle: Mitosis	
	SO3.2 Assessing stages of meiosis	LI 2 Study of meiosis with onion bud	**CI3.2** meiosis	**SL3.2** Draw a diagram of Meiosis
	SO3.3 Understand regulation of cell cycle		**CI3.3** Cell cycle regulation.	**SL3.3** Illustration about different stages of cell cycle and checkpoints
	SO3.4 Study cell junctions and types		**CI3.4** cell junctions, cell adhesion and extracellular matrix	
	SO3.5 Describe PCD		**CI3.5** programmed cell death,	
	SO3.6 Illustrate the mechanism of cell signaling		**CI3.6** cell signaling,	**SL3.4** Write a note on cell signalling
	SO3.7 Describe various signaling molecules		**CI3.7** signaling molecules and their receptor.	**SL3.5** Diagrammatically explain structure of cell surface receptor
	SO3.8 Study Intracellular signal transduction pathway,		**CI3.8** Intracellular signal transduction pathway	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe cell division and cell cycle
	SW3.2 Mini Project	Prepare complete draft on cell signalling and its types
	SW3.3 Other Activities (Specify)	Collect links of videos based on cell division process and explain them in front of class

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO4-98BT103.4: Students will exhibit mastery of Genetic Principles and Mendel's laws of inheritance.	**SO4.1** Understand principles of Mendelian genetics	LI 1 Demonstration of law of segregation	**Unit-IV** **CI4.1** Mendelian Genetics: Mendel and his experiment	**SL4.1** Learn about terms used in genetics
	SO4.2 Assessing the interaction of multiple alleles		**CI4.2** Multiple alleles, Chromosomal Theory of Inheritance,	**SL4.2** Discuss multiple alleles and examples
	SO4.3 Illustration of incomplete dominance		**CI4.3** Interaction of genes- Intragenic and Intergenic Interaction, Incomplete dominance	**SL4.3** Learn about examples of incomplete dominance
	SO4.4 Illustrate mechanism complementary genes with example	LI 2 Demonstration of complementary genes	**CI4.4** lethal genes, Complementary genes	**SL4.4** Studies related to lethal genes and their effects
	SO4.5 Understand supplementary and inhibitory gene action		**CI4.5** Supplementary genes, inhibitory genes	
	SO4.6 Learn duplicate genes		**CI4.6** duplicate genes,	**SL4.5** Evaluate the

Item	Cl	LI	SW	SL	Total
Approx. Hrs	07	04	01	05	17

	and epistasis		epistatic genes	phenomenon of epistasis
	SO4.7 Evaluate the need of population genetics		**CI4.7** population genetics.	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	06	01	05	20

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe laws of inheritance given by Mendel
	SW4.2 Mini Project	Describe the examples of Intergenic interactions
	SW4.3 Other Activities (Specify)	Prepare list of assumption of Hardy-Winberg Law /equilibrium and give its derivation

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO5-98BT103.5: Illustrate molecular organization of	**SO5.1** Illustrate molecular organization of prokaryotic	LI 1 Study karyotyping	**Unit-V** **CI5.1** Molecular	**SL5.1** learn about molecular organization of

chromosome and its alterations.	chromosome.		organization of chromosome: Chromosome structure and organization in prokaryotes	genome
	SO5.2 Illustrate molecular organization of eukaryotic chromosome.	LI 2 Identify Barr Body in female buccal epithelium	**CI5.2** eukaryotes	**SL5.2** learn about molecular organization of eukaryotic genome
	SO5.3 Understand extranuclear genome and its importance	LI 3 Study pedigree analysis	**CI5.3** extranuclear genome,	**SL5.3** Give role of extra nuclear genome
	SO5.4 Understand abnormal chromosomes and diseases		**CI5.4** abnormal chromosomes,	**SL5.4** Learn about diseases caused by abnormal chromosomes
	SO5.5 Understand the process of chromosomal mutation		**CI5.5** chromosomal mutation, deletion duplication, Inversion, translocation,	Give diagrammatic representation of types of chromosomal mutation
	SO5.6 Describe aneuploidy and polyploidy,		**CI5.6** aneuploidy and polyploidy,	
	SO5.7 Describe process of crossing over		**CI5.7** Crossing over	
	SO5.8 Elaborate the sex determination		**CI5.8** sex determination.	**SL5.5** Learn sex determination and its types

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Describe molecular organization of eukaryotic chromosome.
	SW5.2 Mini Project	Describe the chromosomal mutations in detail
	SW5.3 Other Activities (Specify)	Prepare a detail draft on sex determination and its examples

Course duration (in hours) to attain Course Outcomes:
Course Title: Cell Biology and Genetics

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-98BT103.1: Students will demonstrate a thorough understanding of cell, cell theory, cell types and pre cellular evolution.	8	4	5	1	18
CO2-98BT103.2: Students will exhibit proficiency in drawing and explaining ultrastructure of cell membrane and cell organelles.	8	0	5	1	14
CO3-98BT103.3: Evaluate the roles cell division, cell cycle and cell signaling.	8	4	5	1	18
CO4-98BT103.4: Students will exhibit mastery of Genetic Principles and Mendel's laws of inheritance.	7	4	5	1	17
CO5-98BT103.5: Illustrate molecular organization of chromosome and its alterations.	8	6	5	1	20
Total Hours	39	18	25	05	87

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Cell Biology and Genetics **Course Code: 98BT103**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate;

Course Outcomes	**A**	**An**	**E**	**Total Marks**
CO1-98BT103.1: Students will demonstrate a thorough understanding of cell, cell theory, cell types and pre cellular evolution.	02	02	01	05
CO2-98BT103.2: Students will exhibit proficiency in drawing and explaining ultrastructure of cell membrane and cell organelles.	03	05	02	10
CO3-98BT103.3: Evaluate the roles cell division, cell cycle and cell signaling.	05	05	05	15
CO4-98BT103.4: Students will exhibit mastery of Genetic Principles and Mendel's laws of inheritance.	04	03	03	10
CO5-98BT103.5: Illustrate molecular organization of chromosome and its alterations.	05	04	01	10
Total Marks	19	19	12	50

Suggested learning Resources:

(a) Books:

(b)

S.No.	**Title/Author/Publisher details**
1	Cell & molecular biology- De Robertis B.J. publications Pvt.Ltd.
2	Cell & molecular biology - Gerald karp john wills & essential cell biology Balberts D. Bray
3	Developmental biology- SF Gilbert senior associates.
4	Molecular Biology of Cell- Alberts, B et al.
5	Genetics- Strickberger, 2 nd
6	Microbial Genetics – D. Frifielder.

(c) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology
Semester: I
Course Title: Cell Biology and Genetics
Course Code: 98BT103

CO/PO Mapping		
Course Outcome	**Program Outcomes (POs)**	**Program Specific Outcomes (PSOs)**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-98BT103.1: Students will demonstrate a thorough understanding of cell, cell theory, cell types and pre cellular evolution.	-	-	1	2	2	2	2	-	1	2	2	3	3	-	-
CO2-98BT103.2: Students will exhibit proficiency in drawing and explaining ultrastructure of cell membrane and cell organelles.	-	-	-	-	-	-	-	-	2	2	3	3	2	-	1
CO3-98BT103.3: Evaluate the roles cell division, cell cycle and cell signaling.	-	1	1	1	-	2	2	-	3	3	3	2	2	2	1
CO4-98BT103.4: Students will exhibit mastery of Genetic Principles and Mendel's laws of inheritance.	-	1	1	2	2	2	2	3	-	1	2	2	2	2	2
CO5-	1	1	1	-	-	3	3	3	1	2	3	2	2	2	1

98BT103.5: Illustrate molecular organization of chromosome and its alterations.															

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)

PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2,3	**CO1-98BT103.1:** Identify the different types of bioremediation techniques, mechanism and microbes for bioremediation	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8	LI1, LI2	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8	1SL-1,2,3,4,5
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2,3	**CO2-98BT103.2:** Differentiate criteria of types of bioremediations and its detail process.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8		2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8	2SL-1,2,3,4,5
PO 1,2,3,4,5,6,7,8,9,10,11,12	**CO3-98BT103.3:** Evaluate the roles Bio sorption & Bioleaching	SO3.1 SO3.2	LI1, LI2	3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8	3SL-1,2,3,4,5

PSO 1,2,3	and phytoremediation.	SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8			
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2,3	**CO4-98BT103.4:** Use of Bioremediation of phenols, cyanides, dyes, understand biodegradation through pathway engineering.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7	LI1, LI2	4.1,4.2,4.3,4.4, 4.5, 4.6, 4.7,	4SL-1,2,3,4,5
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2,3	**CO5-98BT103.5:** Case study and demonstration of bioremediation plan for industrial waste.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8	LI1, LI2, LI3	5.1,5.2,5.3,5.4,5.5, 5.6, 5.7, 5.8	5SL-1,2,3,4,5

Curriculum Development Team

Prof. Kamlesh Choure
Prof Ashwini A. Waoo
Prof. Deepak Mishra

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	I	
CourseCode:	98ME104	
Coursetitle:	Basic Mechanical Engineering and Manufacturing Process	**Curriculum Developer**: Er. Ketan Agrawal, Assistant Professor
Pre-requisite:	Students should have basic knowledge of physics.	
Rationale:	The curriculum for basic mechanical engineering and manufacturing processes provides students with foundational knowledge in mechanics, thermodynamics, and materials science, alongside practical skills in manufacturing techniques. It emphasizes industry relevance, problem-solving abilities, interdisciplinary understanding, and professional development to prepare students for successful careers in engineering..	

CourseOutcomes (COs):	**CO1-98ME104.1.** Acquiring knowledge of materials and their properties for engineering applications **CO2-98ME104.2.** Understand casting and forming principles, ability to select processes, analyze defects, and optimize production for efficient manufacturing. **CO3-98ME104.3.** Acquiring knowledge of working of lathe machine and drilling machine and welding process **CO4-98ME104.4.** Enhancement of fundamental knowledge of Thermodynamics. Demonstrate various types of boilers and their relative merits and demerits. Define the fundamental of IC engine . **CO5-98ME104.5.** Explain stress, strain and their relationship with different material .

Scheme of Studies:

Board ofStudy	**CourseCode**	**CourseTitle**	**Scheme ofstudies (Hours/Week)**					**Total Credits(C) (L:T:P=3:1:1)**
			Cl	LI	SW	SL	**Total Study Hours(CI+LI+SW+SL)**	
ProgramCommon(PC)	98ME104	Basic Mechanical Engineering and Manufacturing Process	4	2	1	2	9	3+1+1=5

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		
PC	98ME104	Basic Mechanical Engineering and Manufacturing Process	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

				Scheme of Assessment (Marks)

Board of Study	Couse Code	Course Title	Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		
ECC	98ME154	Basic Mechanical Engineering and Manufacturing Process	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

ApproximateHours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	02	21

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-98ME104.1. Acquiring knowledge of materials and their properties for engineering applications	**SO1.1** Knowledge of mechanical, thermal, electrical, and chemical properties of materials.	**LI1.1** Introduction of basic mechanical engineering lab.	**Unit-1** **CI1.1** Classification of engineering material	**SL1.1** Compare ferrous and non-ferrous materials.

	SO1.2 Ability to select materials suitable for specific engineering applications.	**LI1.2** To demonstrate the working of 2-stroke petrol engine.	**CI1.2** Properties of Materials: Strength, elasticity, stiffness, malleability, ductility, brittleness	**SL1.2** Classify different type of steel used in engineering purpose.
	SO1.3 Understanding material behavior under various types of stress, including tensile, compressive, shear, and torsional.	**LI1.3** To demonstrate the working of 4-stroke petrol engine.	**CI1.3** toughness and hardness. Elementary ideas of fracture, fatigue & creep.	
	SO1.4 Ferrous Materials: Carbon steels, its classification based on % carbon as low, mild, medium & high carbon steel, its properties & applications		**CI1.4** Ferrous Materials: Carbon steels, its classification based on % carbon as low, mild, medium & high carbon steel, its properties & applications	
	SO1.5 Wrought iron. Cast iron		**CI1.5** Wrought iron. Cast iron	
	SO1.6 Alloy steels: stainless steel, tool steel		**CI1.6** Alloy steels: stainless steel, tool steel	
	SO1.7 Elementary introduction to Heat-treatment of carbon steels: annealing, normalizing		**CI1.7** Elementary introduction to Heat-treatment of carbon steels: annealing, normalizing	
	SO1.8		**CI1.8**	

	quenching & tempering and case-hardening.		quenching & tempering and case-hardening.	
	SO1.9 Common uses of various non-ferrous metals & alloys		**CI1.9** Common uses of various non-ferrous metals & alloys	
	SO1.10 its composition such as Cu-alloys: Brass, Bronze		**CI1.10** its composition such as Cu-alloys: Brass, Bronze	
	SO1.11 Al-alloys such as Duralumin		**CI1.11** Al-alloys such as Duralumin	
	SO1.12 Advantages and disadvantages of non-ferrous metals		**CI1.12** Advantages and disadvantages of non-ferrous metals	

Suggested Sessional Work (SW):	**SW1.1** Assignments	Compare wrought iron, cast iron and steel in terms of their mechanical properties and application.

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ApproximateHours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	02	21

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**

CO2-98ME104.2. Understand casting and forming principles, ability to select processes, analyze defects, and optimize production for efficient manufacturing.	**SO2.1** Understanding the principles of molten metal flow, solidification, and mold design	**LI2.1** To demonstrate the working of 4-stroke diesel engine.	**Unit-2** **CI2.1** Basic metal forming operations & uses of such as : Forging , Rolling	**SL2.1** Explain different defects generated during casting process
	SO2.2 Knowledge of forming processes including forging, rolling, extrusion, and sheet metal forming	**LI2.2** To demonstrate the working of 2-stroke petrol engine.	**CI2.2** Wire & Tube-drawing/making and Extrusion	**SL2.2** Compare hot and cold rolling process.
	SO2.3 Skills to identify and analyze defects in cast and formed parts such as porosity, shrinkage, and surface irregularities.	**LI2.3** Comparison of 2-stroke and 4-stroke engines.	**CI2.3** Applications of metal forming operations	
	SO2.4 Press-work, & die & punch assembly		**CI2.4** Press-work, & die & punch assembly	
	SO2.5 cutting and forming, its applications. Hot-working versus cold-working		**CI2.5** cutting and forming, its applications. Hot-working versus cold-working	
	SO2.6 Pattern & allowances		**CI2.6** Pattern & allowances	
	SO2.7 Molding sands and its desirable properties		**CI2.7** Molding sands and its desirable properties	

	SO2.8 Mould making with the use of a core		**CI2.8** Mould making with the use of a core	
	SO2.9 Gating system		**CI2.9** Gating system	
	SO2.10 Casting defects & remedies		**CI2.10** Casting defects & remedies	
	SO2.11 Cupola Furnace		**CI2.11** Cupola Furnace	
	SO2.12 Die-casting and its uses		**CI2.12** Die-casting and its uses	

Suggested Sessional Work (SW):	**SW2.1** Assignments	Explain different type of patterns used in casting process.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**ApproximateHours**

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	02	21

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO3-98ME104.3. Acquiring knowledge of working of lathe machine and drilling machine and welding process	**SO3.1** Understand lathe machine principles and perform basic lathe operations.	**LI3.1** To demonstrate the working of lathe machine.	**Unit-3** **CI3.1** Basic principles of Lathe-machine	**SL3.1** Classify oxy-acetylene gas flames used in gas welding and their application.
	SO3.2	**LI3.2**	**CI3.2**	**SL3.2**

	Describe the machines and operations of shaper, planer, drilling, milling, and grinding.Apply knowledge of machining processes to practical applications.	To demonstrate the working of drilling machine.	operations performed on lathe machine	Explain lathe accessories and lathe attachments.
	SO3.3 Explain the importance and fundamental concepts of welding.	**LI3.3** To demonstrate the working of milling machine.	**CI3.3** Basic description and operations of Shaper machine	
	SO3.4 Identify types of flames in gas welding and demonstrate their appropriate uses.		**CI3.4** Basic description and operations of Drilling machine	
	SO3.5 Basic description and operations of Milling machine		**CI3.5** Basic description and operations of Milling machine	
	SO3.6 Basic description and operations of Grinding machine		**CI3.6** Basic description and operations of Grinding machine	
	SO3.7 Importance &basic concepts of welding		**CI3.7** Importance &basic concepts of welding	
	SO3.8 classification of welding processes		**CI3.8** classification of welding processes	
	SO3.9 Gas welding, types of		**CI3.9** Gas welding, types of	

	flames		flames	
	SO3.10 Electric-Arc welding		**CI3.10** Electric-Arc welding	
	SO3.11 Resistance welding		**CI3.11** Resistance welding	
	SO3.12 Soldering & Brazing and its uses		**CI3.12** Soldering & Brazing and its uses	

Suggested Sessional Work (SW):	**SW3.1** Assignments	Classify welding processes, including gas welding, electric arc welding, resistance welding, soldering, and brazing.

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ApproximateHours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	16	06	01	03	26

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-98ME104.4. **Enhancement of fundamental knowledge of Thermodynamics. Demonstrate various types of**	**SO4.1** Analyze steam properties, processes, boiler classification,	**LI4.1** To demonstrate the working of Cochran Boiler.	**Unit-4** **CI4.1** First and second law of thermodynamics	**SL4.1** List down the different types of mountings used in

boilers and their relative merits and demerits.Define the fundamental of IC engine .	efficiency, and performance			the boiler.
	SO4.2 Describe refrigeration cycles, COP, and refrigerant properties, including eco-friendly options.	**LI4.2** To demonstrate the working of Babcock and Wilcox Boiler.	**CI4.2** steam properties	**SL4.2** Define thermodynamics and classify thermodynamic system.
	SO4.3 Understand the operation of two-stroke and four-stroke petrol/diesel engines.	**LI4.3** To demonstrate the working of Bension Boiler.	**CI4.3** steam processes at constant pressure	**SL4.3** Explain terminology of I.C. Engine.
	SO4.4 Evaluate the efficiency and performance of internal combustion engines.		**CI4.4** volume, enthalpy & entropy	
	SO4.5 classification and working of boilers		**CI4.5** classification and working of boilers	
	SO4.6 efficiency & performance analysis		**CI4.6** efficiency & performance analysis	
	SO4.7 natural and induced draught		**CI4.7** natural and induced draught	
	SO4.8 calculation of chimney height		**CI4.8** calculation of chimney height	
	SO4.9		**CI4.9**	

	Refrigeration, vapor absorption & compression cycles		Refrigeration, vapor absorption & compression cycles	
	SO4.10 coefficient of perform (COP), refrigerant properties & eco friendly refrigerants		**CI4.10** coefficient of perform (COP), refrigerant properties & eco friendly refrigerants	
	SO4.11 Steam engines, hypothetical and actual indicator diagram		**CI4.11** Steam engines, hypothetical and actual indicator diagram	
	SO4.12 Carnot cycle and ideal efficiency		**CI4.12** Carnot cycle and ideal efficiency	
	SO4.13 Otto and diesel cycles		**CI4.13** Otto and diesel cycles	
	SO4.14 working of two stroke & four stroke petrol engine		**CI4.14** working of two stroke & four stroke petrol engine	
	SO4.15 working of two stroke & four stroke diesel engine		**CI4.15** working of two stroke & four stroke diesel engine	
	SO4.16 Numerical on I C Engine		**CI4.16** Numerical on I C Engine	

Suggested Sessional Work (SW):	**SW4.1** Assignments	Explain steam engines, indicator diagrams, Carnot, Otto, and diesel cycles.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**ApproximateHours**

Item	Cl	LI	SW	SL	Total
Approx.Hrs	08	06	01	02	17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-98ME104.5 Explain stress, strain and their relationship with different material .	**SO5.1** Understand basics of stress, strain, and stress-strain diagrams.	**LI5.1** To demonstrate the working of Double Acting Steam Engine.	**Unit-5** **CI5.1** Introduction, normal and shear stresses	**SL5.1** Define poisons ratio.
	SO5.2 Apply knowledge of elastic constants and strain energy concepts.	**LI5.2** To demonstrate the working different boiler mountings.	**CI5.2** stress-strain diagrams for ductile materials	**SL5.2** Solve the numerical problems associated bending stresses in beam.
	SO5.3 Analyze pure bending of beams and torsion in	**LI5.3** To demonstrate the working of different	**CI5.3** stress-strain diagrams for brittle materials	

	shafts effectively.	boiler accessories.		
	SO5.4 elastic constants, strain energy.		**CI5.4** elastic constants, strain energy.	
	SO5.5 Introduction, simple bending theory		**CI5.5** Introduction, simple bending theory	
	SO5.6 stress in beams of different cross sections and bending moment		**CI5.6** stress in beams of different cross sections and bending moment	
	SO5.7 torsion of shafts of circular section		**CI5.7** torsion of shafts of circular section	
	SO5.8 torque and twist and shear stress due to torque		**CI5.8** torque and twist and shear stress due to torque	

Suggested Sessional Work (SW):	**SW5.1** Assignments	Draw and explain stress –strain diagram for mild steel.

Course duration (in hours)to attain Course Outcomes:

Course Title: Basic Mechanical Engineering and Manufacturing Process **Course Code:**98ME104

Course Outcomes(COs)	**Class lecture (CI)**	**Laboratory Instruction(LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-98ME104.1. Acquiring knowledge of	12	6	2	1	21

materials and their properties for engineering applications					
CO2-98ME104.2. Understand casting and forming principles, ability to select processes, analyze defects, and optimize production for efficient manufacturing.	12	6	2	1	21
CO3-98ME104.3. Acquiring knowledge of working of lathe machine and drilling machine and welding process	12	6	2	1	21
CO4-98ME104.4. Enhancement of fundamental knowledge of Thermodynamics. Demonstrate various types of boilers and their relative merits and demerits.Define the fundamental of IC engine .	16	6	3	1	26
CO5-98ME104.5. Explain stress, strain and their relationship with different material .	08	6	2	1	17
Total Hours	60	30	11	05	106

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Basic Mechanical Engineering and Manufacturing Process **Course Code:**98ME104

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-98ME104.1. Acquiring knowledge of materials and their properties for engineering applications	2	1	1	1	5
CO2-98ME104.2. Understand casting and forming principles, ability to select processes, analyze defects, and optimize production for efficient manufacturing.	2	4	5	1	12
CO3-98ME104.3. Acquiring knowledge of working of lathe machine and drilling machine and welding process	3	5	5	1	14
CO4-98ME104.4. Enhancement of fundamental knowledge of Thermodynamics. Demonstrate various types of boilers and their relative merits and demerits.Define the fundamental of IC engine .	2	3	5	1	11
CO5-98ME104.5. Explain stress, strain and their relationship with different	2	4	1	1	08

material .					
Total Marks	**11**	**17**	**17**	**05**	**50**

***Legend*:A,** Apply;**An,** Analyze;**E,** Evaluate;**C,** Create

Suggested learning Resources:

(a) Books:

(b)

S.No.	Title/Author/Publisher details
1	Sawhney GS; Fundamentals of Mechanical Engg; PHI.
2	Agrawal B & CM; Basic Mechanical Engg. Wiley India.
3	Nag PK, Tripathi et al; Basic Mechanical Engg; TMH.
4	Mubeen, A., Mechanics of solids , Pearson Education Asia.
5	Irving H. Shames, Engineering Mechanics, Prentice Hall
6	Nakra and Chaudhary; Instrumentation & measurement; TMH.
7	Nag PK; Engineering Thermodynamics; TMH.

(c) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Beverage producing plants & Distillery/Fermenter units
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology
Semester:I Semester
Course Title: Basic Mechanical Engineering and Manufacturing Process
Course Code: 98ME104

CO/PO/PSO Mapping									
Course Outcome (Cos)	**Program Outcomes (POs)**						**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1-98ME104.1. Acquiring knowledge of materials and their properties for engineering applications	2	-	-	1	2	1	2	2	1
CO2-98ME104.2. Understand casting and forming principles, ability to select processes, analyze defects, and optimize production for efficient manufacturing.	1	-	1	1	-	1	1	1	2
CO3-98ME104.3. Acquiring knowledge of working of lathe machine and drilling machine and welding process	1	1	1	1	-	1	1	1	1
CO4-98ME104.4. Enhancement of fundamental knowledge of Thermodynamics. Demonstrate various types of boilers and their relative merits and demerits.Define the fundamental of IC engine .	1	-	1	-	2	1	1	1	3
CO5-98ME104.5. Explain stress, strain and their relationship with different material .	1	1	1	-	1	1	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO1-98ME104.1.** Acquiring knowledge of materials and their properties for engineering applications	SO1.1 SO1.2 SO1.3	**LI 1,LI 2,LI 3**	1.1,1.2,1.3,1.4,1.5,1.6 1.7,1.8,1.9,1.10,1.11,1.12	**1SL-1,2**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO2-98ME104.2.** Understand casting and forming principles, ability to select processes, analyze defects, and optimize production for efficient manufacturing.	SO2.1 SO2.2 SO2.3	**LI 1,LI 2,LI 3**	2.1, 2.2, 2.3, 2.4,2.5,2.6 2.7,2.8,2.9,2.10,2.11,2.12	**2SL-1,2**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO3-98ME104.3.** Acquiring knowledge of working of lathe machine and drilling machine and welding process	SO3.1 SO3.2 SO3.3 SO3.4	**LI 1,LI 2,LI 3**	3.1,3.2,3.3,3.4,3.5,3.6 3.7,3.8,3.9,3.10,3.11,3.12	**3SL-1,2**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO4-98ME104.4.** Enhancement of fundamental knowledge of Thermodynamics. Demonstrate various types of boilers and their relative merits and demerits.Define the fundamental of IC engine .	SO4.1 SO4.2 SO4.3 SO4.4	**LI 1,LI 2,LI 3**	4.1,4.2,4.3,4.4, 4.5,4.6 4.7,4.8,4.9,4.10,4.11,4.12 4.13,4.14,4.15,4.16	**4SL-1,2**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO5-98ME104.5.** Explain stress, strain and their relationship with different material .	SO5.1 SO5.2 SO5.3	**LI 1,LI 2,LI 3**	5.1,5.2,5.3,5.4,5.5, 5.6 5.7,5.8	**5SL-1,2**

Program Name	**BTech Biotechnology**	
Semester	1	
Course Code:	98CS105	
Course title:	Communication Skills	**Curriculum Developer**:
Pre-requisite:	Students should have basic knowledge of English Language	
Rationale:	In order to compete in this fast growing world, LSWR skills of the students should be well developed and enhanced. Besides, they must have effective communication skills as it plays a vital role in shaping individual's personality and career. It also boosts the confidence and prepares them to face the audience fearlessly	
Course Outcomes (COs):	**CO1- 98CS105.1 Students will learn confident speaking skills** **CO2 - 98CS105.2 Students learn leadership skill and team spirit.** **CO3- 98CS105.3 Students will be able to communicate effectively in Hindi and English languages without hindrances.** **CO4- 98CS105.4 Students learn basis grammar skills** **CO5- 98CS105.5 The study of Dramas and Poems written by Indian Writers.**	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Common (PC)	98CS105	Communication Skills	3	0	1	1	5	3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/ Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Classroom Activity (CA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		

HS	**98CS105**	**Communication Skills**	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Course-Curriculum:

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Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	0	01	01	12

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO1: Students will learn confident speaking skills	SO1.1: Students will be able to introduce themselves.		CI1.1: Self-introduction.	SL1.1: Prepare a presentation on the given topics.
	SO1.2: Understand the concept of oral presentation.	CI1.2: Oral Presentation on topics: The importance of education, The importance of English in today's world, Necessity of uniforms in a college.		
	SO1.3: Students will be able to dress and present effectively.	CI1.3: Professional dressing and grooming etiquettes.	SL1.2: Prepare a play on the given topics.	

	SO1.4: Understand the importance of body language.	CI1.4: Body language tips and techniques.		
	SO1.5: Students will be able to influence mass through skits and dramas.	CI1.5: Role play conducted on following topics: Classroom interaction, Hospital scene, and Scene at railway station.		

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	0 0	01	01	12

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
SO2.1: Students learn leadership skills and team spirit	SO2.1: Understand the techniques of Group Discussion.	CI2.1: Students learn leadership skills and team spirit	CI2.1: Group discussion on topics: Impact of COVID-19 on mental health, Impact of social media on lives, Pros and cons of technology.	SL2.1: Prepare a debate on the given topics.
	SO2.2: Understand the concept of Debate.	CI2.2: Students will be able to present debates effectively on topics: Should the use of plastic be banned? Should parents decide which career their children will	SL2.2: Prepare a resume.	

		pursue? Is Artificial Intelligence useful or dangerous?		
	SO2.3: Students will be able to design a professional resume and crack interviews.	CI2.3: Interviews and their kinds (Mock Interview Session) and resume writing.		
	SO2.4: Explain the concept of how to ace in an interview.	CI2.4: Explain the concept of how to ace in an interview.		
	SO2.5: Revision	CI2.5: Revision		

Item	Cl	LI	SW	SL	Total
Approx. Hrs	8	0	0	02	10

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO3 - 98CS105.3: Students will be able to communicate effectively in Hindi and English languages without hindrances	SO3.1: Students will be able to organize and prepare speeches.		3.1: Speech/Anchoring on topics like National Science Day, Valedictory Speech, Patriotic Speech.	SL3.1: Prepare a speech on the given topics.
	SO3.2: Students will be able to think and speak instantaneously.	LI 3.2: Extempore speeches on topics such as Pros and Cons of Online Teaching, Environment Conservation, and	SL3.2: Prepare for conversational topics.	

		Education of a Girl Child.		
	SO3.3: Students will be able to understand the different types of speeches.	LI3.3: Conversational topics: Inquiry at the bank, Airport, Station, and Hospitals.		
	SO3.4: To make them understand the inquiry procedure at public places.	LI3.4: Telephonic conversation, e.g., Describing Your College Day to Parents from Hostel, Talking with Customer Care Executive of an E-Commerce company.		

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	02	01	03	16

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO4 - 98CS105.4: Students learn basic grammar skills	SO4.1: Understanding about the use of Prepositions.		CI4.1: Prepositions (Place, Time, and Direction).	SL4.1: Prepare the structure of Tenses and Active Passive.
	SO4.2: Students will be able to understand the usage of Tenses.		CI4.2: Tenses (Present, Past, and Future).	
	SO4.3: Understand the concept of Active and		CI4.3: Voice (Active and Passive).	

	Passive Voice.			
	SO4.4: To understand the usage of Modals.		CI4.4: Modals.	
	SO4.5: Students will be able to interchange tenses and voices.		CI4.5: Students will be able to interchange tenses and voices.	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	0	01	01	12

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO5 - 98CS105.5: The study of Dramas and Poems written by Indian Writers	SO5.1: Students will be able to understand the value of Indian Literature (R.K. Narayan)		CI5.1: The Axe - R.K. Narayan	SL5.1: Prepare the summary of all the topics (The Axe, The Night of the Scorpion, The Portrait of a Lady, The Lost Child, The Shroud).
	SO5.2: Students will be able to understand the value of Indian Literature (Nissim Ezekiel)		CI5.2: The Night of the Scorpion - Nissim Ezekiel	
	SO5.3: Students will be able to understand the		CI5.3: The Portrait of a Lady - Khushwant	

	value of Indian Literature (Khushwant Singh)		Singh	
	SO5.4: Students will be able to understand the value of Indian Literature (Mulk Raj Anand)		CI5.4: The Lost Child - Mulk Raj Anand	
	SO5.5: Students will be able to understand the value of Indian Literature (Premchand)		CI5.5: The Shroud - Premchand	

Course duration (in hours) to attain Course Outcomes:

Course Title: Recent Trends in Virology and Mycology **Course Code:** 56MB205

Course Outcomes (COs)	Class lecture (Cl)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+Cl+SL+SW)
CO1- 98CS105 Students will learn confident speaking skills	10	0	1	1	12
CO2- 98CS105 Students learn leadership skill and team spirit	10	0	1	1	12
CO3- 98CS105.3 Students will be able to communicate effectively in Hindi and English languages without hindrances	8	0	2	0	10
CO4- 98CS105.4 Students learn basis grammar skills	10	2	1	3	16
CO5-- 98CS105.5 The study of Dramas and Poems written by Indian Writers	10	0	1	1	12
Total Hours	48	2	06	06	62

Course Title: Communication Skills **Course Code: 98CS105**

Course Outcomes	**Marks Distribution**	**Total Marks**			
	A	**An**	**E**	**C**	
CO1- 98CS105.1 Students will learn confident speaking skills					
CO2- 98CS105.2 Students learn leadership skill and team spirit					
CO3- 98CS105.3 Students will be able to communicate effectively in Hindi and English languages without hindrances					
CO4-- 98CS105.4 Students learn basis grammar skills					
CO5- 98CS105.5 The study of Dramas and Poems written by Indian Writers					
Total Marks					

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

(b)

S.No.	**Title/Author/Publisher details**
1	Communication Skills by Dr. Meenu Pandey Nirali Praksahan

2	A Practical Guide to English Grammar by K.P. Thakur
3	English Conversation Practise by Grant Taylor Tata McGraw Hill Education Private Limited.
4	Advanced Language Practice by Michael Vince Macmillan Education, Oxford 2003
5	Six Weeks to Words of Power by Wilfred Funk W.R. Goyal Publishers and Distributors

(c) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: BTech Biotechnology
Semester: I Semester
Course Title: Communication Skills
Course Code: 98CS105

CO/PO/PSO Mapping		
Course Outcome (Cos)	**Program Outcomes (POs)**	

	PO1	PO2	PO3	PO4	PO5	PO6	PO8	PO9	P10	PO11	PO12
CO1- 98CS105.1 Students will learn confident speaking skills	1	1	2	1	2	3	3	3	3	3	3
CO2- 98CS105.2 Students learn leadership skill and team spirit	1	2	2	2	2	2	3	2	3	1	3
CO3- 98CS105.3 Students will be able to communicate effectively in Hindi and English languages without hindrances	1	1	2	2	3	2	3	2	3	2	3
CO4-- 98CS105.4 Students learn basis grammar skills	-	1	1	1	2	2	1	2	3	2	3
CO5- 98CS105.5 The study of Dramas and Poems written by Indian Writers	-	1	1	1	-	-	3	2	3	3	3

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	**COs**	**SOs No.**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
PO 1,2,3,4,5 PSO 1,2,3	**CO1-- 98CS105.1 Students will learn confident speaking skills**	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		1.1,1.2,1.3,1.4,1.5	**1SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO2- 98CS105.2 Students learn leadership skill and team spirit**	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5		2.1, 2.2, 2.3	**2SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO3- 98CS105.3 Students will be able to communicate effectively in Hindi and English languages without hindrances**	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5		3.1,3.2,3.3,3.4	**3SL-1,2**
PO	**CO4--- 98CS105.4 Students learn basis**	SO4.1 SO4.2		4.1,4.2,4.3,4.4	**SL4-1,2**

1,2,3,4,5 PSO 1,2,3	**grammar skills**	SO4.3 SO4.4 SO4.5			
PO 1,2,3,4,5 PSO 1,2,3	**CO5- 98CS105.5 The study of Dramas and Poems written by Indian Writers**	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5		5.1,5.2,5.3,5.4,5.5	**5SL-1**

Program Name	**Bachelor of Technology- Biotechnology**	
Semester	I	
Course Code:	98BT106	
Course title:	Introduction To Biotechnology	**Curriculum Developer**: Dr. Deepak Mishra, Professor
Pre-requisite:	Student should have basic knowledge of Botany, Zoology and other related fields of life sciences.	
Rationale:	The paper on Introduction To Biotechnology in a B.Tech. Biotechnology program explores the concept and techniques used for improvement development and growth of plant tissues in laboratorial conditions. It delves into the use of precise instruments and techniques for micro propagation of plants. The second part of this course will provide precise knowledge of genetic engineering tools for improvement in plant varieties and stable genetic transformation. This study enables students to understand how recombinant DNA technology helps us for development of new plant varieties. It also explore the knowledge of biotechnology for generation of novel characteristics in plants.	
Course Outcomes (COs):	**CO1-98BT106.1:** Familiarization with the basic concepts, ideas and scope of Biotechnology. **CO2-98BT106.2:** Understand concepts of cell structure, Biomolecules and microbial culture techniques. **CO3-98BT106.3:** Acquired Skills of the various methods and processes used to create recombinant DNA molecules and its application. **CO4-98BT106.4:** Recognize various methods related to tissue culture for improvement in plants and animals. **CO5-98BT106.5:** Explore application of Biotechnology for improvement and development of novel characters in living organisms.	

Scheme of Studies:

<table>
<tr><th rowspan="2">Board of Study</th><th rowspan="2">Course Code</th><th rowspan="2">Course Title</th><th colspan="5">Scheme ofstudies (Hours/Week)</th><th rowspan="2">Total Credits(C)
(L:T:P=3:0:1)</th></tr>
<tr><th>Cl</th><th>LI</th><th>SW</th><th>SL</th><th>Total Study Hours(CI+LI+SW+SL)</th></tr>
<tr><td>Program Common (PC)</td><td>98BT106</td><td>Introduction To Biotechnology</td><td>4</td><td></td><td>1</td><td>5</td><td>10</td><td>4+0</td></tr>
</table>

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

<table>
<tr><th rowspan="3">Board of Study</th><th rowspan="3">Couse Code</th><th rowspan="3">Course Title</th><th colspan="7">Scheme of Assessment (Marks)</th></tr>
<tr><th colspan="5">Progressive Assessment (PRA)</th><th rowspan="2">End Semester Assessment (ESA)</th><th rowspan="2">Total Marks
(PRA+ ESA)</th></tr>
<tr><th>Class/Home Assignment 5 number 3 marks each (CA)</th><th>Class Test 2 (2 best out of 3) 10 marks each (CT)</th><th>Seminar one
(SA)</th><th>Class Attendance
(AT)</th><th>Total Marks
(CA+CT+SA+AT)</th></tr>
<tr><td>PC</td><td>98BT106</td><td>Introduction To Biotechnology</td><td>15</td><td>20</td><td>10</td><td>5</td><td>50</td><td>50</td><td>100</td></tr>
</table>

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	07	00	01	05	13

Course outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Class room Instruction(CI)**	**Self-Learning(SL)**
CO1-98BT106.1: Familiarization with the basic concepts, ideas and scope of Biotechnology.	**SO1.1** Define and Describe concept of biotechnology		**Unit-1** **CI1.1 Introduction to Biotechnology:** Definition	**SL1.1** Search various reference books and study material to start the learning of biotechnology
	SO1.2 Describe about historical development		**CI1.2** Historical perspectives	**SL1.2** Study the mythological evidences of biotechnology
	SO1.3 Explain about scope and importance		**CI1.3** Scope and importance	**SL1.3** To search scope of biotechnology in various fields
	SO1.4 Describe commercial potential of biotech		**CI1.4** Commercial potential	
	SO1.5 Discuss concept of interdisciplinary challenge.		**CI1.5** An interdisciplinary challenge	**SL1.4** To analyze impact of biotech research in different disciplines
	SO1.6 Study of concept and principle of GLP.		**CI1.6** Good laboratory practices	**SL1.5** To optimize protocols for maintaining GLP
	SO1.7 Describe status of biotechnology		**CI1.7** Biotechnology in India and Global trends	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Describe in detail about scope and importance of biotechnology.
	SW1.2 Mini Project	Standardize the protocols for implantation of GLP principles in biotechnological research.

	SW1.3 Other Activities (Specify)	Collection of different evidences of existence of biotechnology in ancient era.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08		01	05	14

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-98BT106.2: Understand concepts of cell structure, Biomolecules and microbial culture techniques.	**SO2.1** Explore the concept of cell and biomolecules.		**Unit-II** **CI2.1** Cell and biomolecules	**SL2.1** Search various contents for studying cell, biomolecules and microbial culture
	SO2.2 Describe structure and function of cell		**CI2.2** Ultra structure and function of cell	**SL2.2** design the protocol for fermentation
	SO2.3 Reflecting about cell types		**CI2.3** prokaryotic and eukaryotic cell	
	SO2.4 Explain concept and types of biomolecules.		**CI2.4** introduction to biomolecules	**SL2.3** to learn about different categories of biomolecules
	SO2.5 Assessing the concept of microbial culture		**CI2.5** Microbial culture and Application: Introduction	**SL2.4** standardize the protocol for microbial culture
	SO2.6 Explaining the steps of microbial culture.		**CI2.6** microbial culture techniques	**SL2.5** to learn the methods of microbes isolation and characterization
	SO2.7 Explaining the concept of fermentation		**CI2.7** fermentation	
	SO2.8 Assessing the role of microbial culture		**CI2.8** application of microbial culture technology	

Suggested Sessional Work (SW):*anyone*	**SW2.1** Assignments	Describe in detail about different types of cell and classify organism on the basis of cells

	SW2.2 Mini Project	Designing of a fermentation model.
	SW2.3 Other Activities (Specify)	Collection, isolation and characterization of microbes from different sources.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10		01	05	16

Course Outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Class room Instruction (CI)**	**Self-Learning(SL)**
98BT106.3: Acquired Skills of the various methods and processes used to create recombinant plants.	**SO3.1** Explain the concept of recombinant DNA technology		**Unit-III** **CI3.1 Recombinant DNA Technology:** Introduction	**SL3.1** Read about various types of vectors used for cloning
	SO3.2 Assessing the tools of rDNA technology		**CI3.2** Tools of rDNA Technology	**SL3.2** Study the structure and function of Plasmid
	SO3.3 Explaining concept of DNA library		**CI3.3** DNA Library	**SL3.3** Illustration about mechanism of DNA transfer.
	SO3.4 Assessing the role of trasformation		**CI3.4** Introduction of Recombinant DNA into host cells	
	SO3.5 Describe about recombinant screening		**CI3.5** Identification of Recombinants	**SL3.4** Study of different categories of PCR
	SO3.6 Assessing the role of the PCR		**CI3.6** Polymerase Chain Reaction (PCR)	**SL3.5** Study the application of recombinant DNA technology
	SO3.7 Describe about hybridization techniques		**CI3.7** Hybridization Techniques	

	SO3.8 Describe about concept of DNA sequencing		**CI3.8** DNA Sequencing	
	SO3.9 Describe about concept of bioinformatics		**CI3.9** Introduction to bioinformatics	
	SO3.10 Describe about genome sequencing		**CI3.10** Genome Sequencing Projects	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail cloning vector and mechanism of DNA transfer.
	SW3.2 Mini Project	Describe the role of different vectors in genetic transformation.
	SW3.3 Other Activities (Specify)	Prepare a list of application of genetic engineering.

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO4-98BT106.4: Recognize various methods related to tissue culture for improvement in plants and animals.	**SO4.1** Exploring the concept of plant cell culture		**Unit-IV** **CI4.1** Plant Cell Culture and Application: Introduction	**SL4.1** Learn about different categories of tissue culture
	SO4.2 Assessing role of cell and tissue culture techniques		**CI4.1** Cell and Tissue Culture Techniques	**SL4.2** Standardize the Protocol of cell culture
	SO4.3 Explaining the applications of tissue culture		**CI4.2** Applications of Cell and Tissue Culture	**SL4.3** Learn about various examples of tissue culture

	SO4.4 Explaining the role of transgenic plants		**CI4.3** Transgenic Plants with Beneficial Traits.	**SL4.4** Case studies related to success of transgenics
	SO4.5 Evaluate impact of animal cell culture		**CI4.4** Animal Cell Culture and Applications: Introduction	**SL4.5** Case studies related to animal cell culture
	SO4.6 Describe the impact of animal cell culture techniques		**CI4.5** Animal Cell Culture Techniques	
	SO4.7 Explaining primary culture and cell lines		**CI4.6** Primary culture and cell lines	
	SO4.8 Describe applications of cell lines		**CI4.7** Applications of Animal Cell Culture,	
	SO4.9 Explaining stem cell technology		**CI4.8** Stem Cell Technology	

Item	Cl	LI	SW	SL	Total
Approx.Hrs	08	00	01	05	14

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain about different types of tissue culture techniques.
	SW4.2 Mini Project	Describe the various techniques used in development of transgenic plants.
	SW4.3 Other Activities (Specify)	Prepare one article on stem cell technology

Item	Cl	LI	SW	SL	Total
Approx.Hrs	05	00	01	05	11

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO5-98BT106.5: Explore application of Biotechnology for improvement and development of novel characters in living organisms.	**SO5.1** Define the role of biotechnology in society		**Unit-V** **CI5.1** Biotechnology and Society	**SL5.1** learn about basic concept & requirement of chloroplast genome
	SO5.2 Able to execute role of biotechnology for health care		**CI5.2** Biotechnology and medicines	**SL5.2**Review concept of chloroplast transformation
	SO5.3 Apply the role of biotechnology in agriculture		**CI5.3** Biotechnology in agriculture	**SL5.3**learn how to apply transgenic technology in plants
	SO5.4 Apply the biotechnology for food industry		**CI5.4** food, and beverages technology	
	SO5.5 Apply the role of biosafety and bioethics		**CI5.5** biosafety and bioethics in biotechnology	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain applications of biotechnology
	SW5.2 Mini Project	Describe the role of biotechnology in various sectors
	SW5.3 Other Activities (Specify)	Prepare a detail document on biosafety in labs

Course duration (in hours) to attain Course Outcomes:

Course Title: Introduction To Biotechnology **Course Code:**98BT106

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)

CO1-98BT106.1: Familiarization with the basic concepts, ideas and scope of Biotechnology.	7	0	5	1	13
CO2-98BT106.2: Understand concepts of cell structure, Biomolecules and microbial culture techniques.	8	0	5	1	14
CO3-98BT106.3: Acquired Skills of the various methods and processes used to create recombinant DNA molecules and its application.	10	0	5	1	16
CO4-98BT106.4: Recognize various methods related to tissue culture for improvement in plants and animals.	8	0	5	1	14
CO5-98BT106.5: Explore application of Biotechnology for improvement and development of novel characters in living organisms.	5	0	5	1	11
Total Hours	38	00	25	05	68

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Introduction To Biotechnology **Course Code:** 98BT106

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-98BT106.1: Familiarization with the basic concepts, ideas and scope of Biotechnology.	2	1	1	1	5
CO2-98BT106.2: Understand concepts of cell structure, Biomolecules and microbial culture techniques.	2	4	2	2	10
CO3-98BT106.3: Acquired Skills of the various methods and processes used to create recombinant DNA molecules and its application.	2	3	3	2	10
CO4-98BT106.4: Recognize various methods related to tissue culture for	3	5	5	2	15

improvement in plants and animals.					
CO5-98BT106.5: Explore application of Biotechnology for improvement and development of novel characters in living organisms.	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1 **1.**	Introduction to Biotechnology by P. K Gupta, Rastogi Publications
2	Biotechnology by Smith, Cambridge Press
3	Textbook of Biotechnology By R C Dubey
4	Biotechnology Expending Horizons By B D Singh

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology
Semester:I Semester
Course Title: Introduction To Biotechnology
Course Code: 98BT106

CO/PO/PSO Mapping															
Course Outcome (Cos)	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-98BT106.1: Familiarization with the basic concepts, ideas and scope of Biotechnology.	-	1	-	1	2	2	3	-	2	1	2	3	2	2	3
CO2-98BT106.2: Understand concepts of cell structure, Biomolecules and microbial culture techniques.	-	1	-	-	-	-	3	-	2	2	2	3	1	3	3
CO3-98BT106.3: Acquired Skills of the various methods and processes used to create recombinant DNA molecules and its application.	-	1	1	1	-	-	3	-	2	1	2	3	1	2	2
CO4-98BT106.4: Recognize various methods related to tissue culture for improvement in plants and animals.	-	-	1	-	2	2	3	3	1	1	3	3	1	3	3
CO5-98BT106.5: Explore application of Biotechnology for improvement and development of novel characters in living organisms.	-	-	1	-	-	2	3	3	1	2	3	3	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-98BT106.1:** Familiarization with the basic concepts, ideas and scope of Biotechnology.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7		1.1,1.2,1.3,1.4,1.5, 1.6, 1.7	1SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO2-98BT106.2:** Understand concepts of cell structure, Biomolecules and microbial culture techniques.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8		2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8	2SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO3-98BT106.3:** Acquired Skills of the various methods and processes used to create recombinant DNA molecules and its application.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9 SO3.10		3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8, 3.9, 3.10	3SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO4-98BT106.4:** Recognize various methods related to tissue culture for improvement in plants and animals.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8		4.1,4.2,4.3,4.4, 4.5, 4.6, 4.7, 4.8	4SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO5-98BT106.5:** Explore application of Biotechnology for improvement and development of novel characters in living organisms.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5		5.1,5.2,5.3,5.4,5.5	5SL-1,2,3,4,5

Course Code:	98SDG108
Course Title :	**Sustainable Development Goals (SDGs)**
Pre-requisite:	Student should have basic knowledge of Environment, Natural resources, Climate change and sustainability.
Rationale:	To inculcate the knowledge base on sustainable development with a view to balance our economic, environmental and social needs, allowing prosperity for now and future generations. To train students to undertake major initiatives in the efficient management of natural resources and the prevention of environmental pollution with focus on Sustainable Development. To use environmental management tools that help to improve the quality of environment, to assess local vulnerabilities with respect to climate, natural disasters and to achieve sustainable developmental needs.

Course Outcomes:

98SDG108.1: Examine critically the 17 newly minted UN Sustainable Development Goals and understand the historical evolution, key theories, and concepts of sustainable development.

98SDG108.2: Identify and apply methods for assessing the achievement of sustainable development and discover the science, technology, economics, and politics underlying the concepts of sustainability.

98SDG108.3: Understand the implications of overuse of resources, population growth and economic growth and sustainability and explore the challenges the society faces in making transition to renewable resource use.

98SDG108.4: Develop skills to understand attitudes on individuals, society and their role regarding causes and solutions in the field of sustainable development and apply critical thinking skills to evaluate the quality, credibility and limitations of an argument for solution.

98SDG108.5: Describe the steps of the design thinking methodology and how design thinking can accelerate effective SDG implementation. Deepen knowledge and pedagogical tools to incorporate values-based education for sustainable development in educational programmes and processes.

Scheme of Studies:

Board of Study	CourseCode	Course Title		Scheme of studies(Hours/Week)				Total Credits (C)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Core VAC	98SDG108	Sustainable Development Goal	2	0	1	1	4	2

Legend: **CI:** Class room Instruction (Includes different instructional strategies i.e.Lecture (L) and Tutorial (T) and others),
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini projectetc.),
SL: Self Learning,
C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure out come of Learning.

Scheme of Assessment:

Theory

Board of Study	Couse Code	Course Title	**Scheme of Assessment (Marks)**							
			Progressive Assessment (PRA)						**End Semester Assessment**	**Total Marks**
			Class/ Home Assignment 5 number	Class Test 2 (2 best	Seminar one	Class Activity any one	Class Attendance	Total Marks (CA+CT+SA+CAT+AT)		

			3 marks each (CA)	out of 3) 10 marks each (CT)	(SA)	(CAT)	(AT)		**(ESA)**	(PRA + ESA)
VAC	98SDG108	Sustainable Development Goal	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	AppX Hrs
Cl	06
LI	0
SW	1
SL	1
Total	**8**

Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)

SO1.1 Understand about Sustainable Development **SO1.2** Understand the Need and Importance of SDGs **SO1.3** Understand the historical evolution of SDGs **SO1.4** Gain knowledge of SDGs Different goals and their importance **SO1.5** Explain the Challenges & strategies of attaining SDGs in countries..		**Unit-1.0 Introduction to Sustainable Development** 1.1 Need and Importance of Sustainable Development 1.2 Historical & Policy perspectives of Sustainable Development 1.3 Sustainable Development: World and India Perspective 1.4 Introduction to 17 SDGs 1.5 Specific learning objectives for different SDGs 1.6 Challenges & strategies of attaining SDGs in developed and developing nations	Different SDG goals details and its importance

SW-1 Suggested Sessional Work (SW):

a. Assignments:

Overview of SDGs, Sustainable Consumption and Production, Details of 17 SDGs

b. Other Activities (Specify):

Note down the different challenges in our state and district to achieve SDG

Approximate Hours

Item	AppX Hrs
Cl	06
LI	0
SW	1
SL	1
Total	8

Session Outcomes (SOs)	Laboratory Instruction	Classroom Instruction (CI)	Self Learning (SL)

	(LI)		
SO2.1 Explain Sustainable Development **SO2.2** Understand the NEP-2020 and SDG **SO2.3** Discuss higher Education role to achieve SDGs **SO2.4** Explain how education for Sustainable Development **SO2.**5 Explain the measuring techniques for Sustainability .		**Unit-2.0** Special focus on SDG 4-Quality Education and Lifelong Learning: 2.1 Focus of NEP-2020 on SDG 2.2 Education for Sustainable Development (ESD): 2.3 Berlin Declaration 2021 on ESD 2.4 Integration of ESD in curriculum and textbooks 2.5 Tools, Systems, and Innovation for Sustainability 2.6 Measuring Sustainability: How do we measure sustainability	1 NEP2020 objectives and concept for SDGs 2. Concept ,Tools and techniques for measuring sustainability

SW-1 Suggested Sessional Work (SW):

c. **Assignments:**
Education role to achieve SDGs, The role of education in Sustainable Development , Measuring techniques of sustainability, Sustainability Indicators

d. **Other Activities (Specify):** Seminar and group discussion on ESD and measuring sustainability

Millennium Development Goals (MDGs)

Approximate Hours

Item	AppX Hrs
Cl	06
LI	0
SW	1
SL	1
Total	8

Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
SO3.1 Understand current economic issues in the context of the global sustainable development debate. **SO3.2** Outline of health, hygiene and water sanitation issues. **SO3.3** Discuss the renewable energy resources and its importance in present scenario **SO3.4** Explain the importance of sustainable production and consumption **SO3.**5 Explain the problems and solution in rural and urban areas.		**Unit-3.0 Understanding the SDGs** 3.1 Circular economy (basic model of reuse, recycle, and reduce) 3.2 Rural & urban Problems & Challenges 3.3 Sustainable production and consumption 3.4 Renewable energy 3.5 Health & Hygiene, water , sanitation & water management 3.6 Waste Management	1. Water treatment and management practices. 2. Non renewable energy resources.

SW-1 Suggested Sessional Work (SW):
Smart cities
e. Assignments:

Ecofriendly energy resources importance, types of waste and its management, Urban Problems & Challenges

Other Activities (Specify):

Visit of waste water treatment plant, Visit of water treatment process.

Approximate Hours

Item	AppX Hrs
Cl	06
LI	0
SW	1
SL	1
Total	8

Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
SO4.1 Understand environmental sustainability is crucial in reducing the impacts of climate change **SO4.2** Discuss causes of emission of GHGs and its consequences **SO4.3** Explain how climate change and sustainable development both play a role in shaping the human and environmental factors of the world. **SO4.4** Explain the importance of sustainable production and consumption **SO4.5** Climate change is disrupting national economies and affecting lives and livelihoods, especially for the most vulnerable and its mitigation.		**Unit-4.0 Climate Change, Energy and Sustainable Development** 4.1 The greenhouse effect: Causes and Consequences 4.2 Climate Change: A Threat to Sustainable Development 4.3 Adaptation to Current and Future Climate Regimes 4.4 The consequences: crop failure 4.5 Solutions technology and	1 Agreement on Climate Change, Trade, and Sustainability Carbon Credit, carbon trading Kyoto Protocol

		lifestyle changes 4.6 Mitigating Climate Change	

SW-1 Suggested Sessional Work (SW):

f. **Assignments:**

Urban Sustainability and Climate Change, Sustainable Development Policies, Agreement on Climate Change, Trade and Sustainability, Resilient cities – What makes a city sustainable, green, and resilient

Other Activities (Specify):

Approximate Hours

Item	AppX Hrs
Cl	06
LI	0
SW	1
SL	1
Total	8

Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
SO4.1 Understand the relevance and the concept of sustainability and the global initiatives in this direction **SO4.2** Understand role of Corporations and Ecological Sustainability**.** **SO4.3** Explain role of CSR in Sustainability. **SO4.4** Understand the SD challenge for companies, their responsibility and their potentials for action		**Unit-5.0 Sustainable Business Practices:** 5.1 Corporate Social Responsibility 5.2 Sustainable products and services	Local to the Global: Can Sustainable Development Work

SO4.5 Discuss the role of world government for world justice and peace		5.3 Business and Environment 5.4 Corporations and Ecological Sustainability 5.5 Life Cycle Assessment: • LCA Overview and Application 5.6 World peace and justice: • United nations goals for peace and justice • World Government for peace	

SW-1 Suggested Sessional Work (SW):

g. **Assignments:**
Consumption Patterns and Lifestyles, Company Perspectives for Environmental Sustainability, An Introduction to Economic Growth

Other Activities (Specify):

.

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
98SDG108.1: Examine critically the 17 newly minted UN Sustainable Development Goals and understand the historical evolution, key theories, and concepts of sustainable development.	6	1	1	8

98SDG108.2: Identify and apply methods for assessing the achievement of sustainable development and discover the science, technology, economics, and politics underlying the concepts of sustainability.	6	1	1	8
98SDG108.3: Understand the implications of overuse of resources, population growth and economic growth and sustainability and explore the challenges the society faces in making transition to renewable resource use.	6	1	1	8
98SDG108.4: Develop skills to understand attitudes on individuals, society and their role regarding causes and solutions in the field of sustainable development and apply critical thinking skills to evaluate the quality, credibility and limitations of an argument for solution.	6	1	1	8
98SDG108.5: Describe the steps of the design thinking methodology and how design thinking can accelerate effective SDG implementation. Deepen knowledge and pedagogical tools to incorporate values-based education for sustainable development in educational programmes and processes.	6	1	1	8
Total Hours	30	5	5	40

Suggestion for End Semester Assessment

Suggested Specification Table(For ESA)

CO	**Unit Titles**	**Marks Distribution**			**Total Marks**
		R	**U**	**A**	
CO-1	Need and Importance of Sustainable Development	03	01	01	05
CO-2	Education for Sustainable Development (ESD): Tools, Systems, and Innovation for Sustainability	02	06	02	10
CO-3	Discuss the sustainable production and consumption	03	07	05	15
CO-4	How Climate Change may be Threat to Sustainable Development	-	10	05	15
CO-5	Role of Corporations and Ecological Sustainability	03	02	-	05
Total		11	26	13	50

Legend: R: Remember, U: Understand, A: Apply A: Analyse E:Evaluate C:Create

The end of semester assessment for Sustainable Development Goals will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Case Method
4. Group Discussion
5. Role Play
6. Visit to industry, water treatment plant
7. Demonstration
8. ICTBasedTeachingLearning(VideoDemonstration/ TutorialsCBT,Blog,Facebook,Twitter,Whatsapp,Mobile,Onlinesources)
9. Brainstorming

Suggested Learning Resources:

(a) Books:

S. No.	Title	Author	Publisher	Edition & Year
1	The Economics of Sustainable Development: The Case of India (Natural Resource Management and Policy)"	Surender Kumar and Shunsuke Managi	Springer Switzerland	2009

2	Corporate Social Responsibility in Developing and Emerging Markets	Onyeka Osuji	Cambridge	New Edition June 2022
3	Smart Cities for Sustainable Development	Ram Kumar Mishra, Ch Lakshmi Kumari, Sandeep Chachra, P.S. Janaki Krishna	Springer Switzerland	March 2022
4	Sustainable Development: Linking Economy, Society, Environment	Tracey Strange and Anne Bayley		
5	Management Of Resources For Sustainable Devpt	Sushma Goyal	The Orient Blackswan	2016
6	Energy, Environment and Sustainable Development: Issues and Policies	S. Ramaswamy Sathis G. Kumar	Regal Publications	2009
7	The New Map: Energy, Climate, and the Clash of Nations	Daniel Yergin	Penguin Press	September 2015
8	Contributions of Education for Sustainable Development (ESD) to Quality Education:	Laurie, R., Nonoyama-Tarumi, Y., Mckeown, R., & Hopkins, C.	A Synthesis of Research. Journal of Education for Sustainable Development, 10(2), 226–242.	2016
9	Sustainable Results in Development: Using the SDGs for Shared Results and Impact	OECD	OECD Publishing, Paris	2019
10	Development Discourse and Global History from colonialism to the sustainable development goals	Ziai, Aram	Routledge, London & New York	2016
11	Sustainable Development Goals An Indian Perspective,	Hazra, Somnath., Bhukta, Anindya	Springer Switzerland	2020

12	Environmental Ecology, Biodiversity and Climate Change	HM Saxena	Rawat Publication	January 2021
13	https://www.un.org/sustainabledevelopment/			
14	https://www.aiu.ac.in/documents/AIU_Publications/UN-SDG goals			
15	https://www.unesco.org/en/education-sustainable-development			
16	https://onlinecourses.nptel.ac.in/noc23_hs57/preview			
17	ttps://www.iau-hesd.net/news/5180-berlin-declaration-education-sustainable development-adopted-unesco-esd-conference-17-19			

Curriculum Development Team

Professor G C Mishra, Director Cement Technology, AKS University
Professor Kamlesh Choure, Head Dept of Biotechnology AKS University

COs, POs and PSOs Mapping

Course Code : 98SDG108
Course Title: Sustainable Development Goals (SDGs)

Course Outcomes (COs)	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1: Examine critically the 17 newly minted UN Sustainable Development Goals and understand the historical evolution, key theories, and concepts of sustainable development.	1	1	1	2	3	2	3	2	2	1	3	2	2	3	3	1
CO2: Identify and apply methods for assessing the achievement of sustainable development and discover the science, technology, economics, and politics	1	1	2	2	1	2	3	2	1	1	2	2	2	2	2	1

underlying the concepts of sustainability.																
CO3: Understand the implications of overuse of resources, population growth and economic growth and sustainability and explore the challenges society faces in making the transition to renewable resource use.	2	2	1	1	1	2	2	2	1	2	1	2	1	1	2	2
CO4: Develop skills to understand attitudes on individuals, society and their role regarding causes and solutions in the field of sustainable development	3	2	2	2	3	2	3	2	2	1	2	3	3	3	3	2

and apply critical thinking skills to evaluate the quality, credibility and limitations of an argument for solution.																
CO5: Describe the steps of the design thinking methodology and how design thinking can accelerate effective SDG implementation. Deepen knowledge and pedagogical tools to incorporate values-based education for sustainable development in educational programmes and processes.	-	-	-	1	1	3	3	3	1	1	2	2	3	3	1	3

Legend:1–Low,2–Medium, 3–High

Course Curriculum Map:

POs &PSOsNo.	Cos No. & Titles	SOs No.	Laboratory Instruction (LI)	Classroom Instruction(CI)	Self Learning (SL)
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4, 5	**CO1:** Examine critically the 17 newly minted UN Sustainable Development Goals and understand the historical evolution, key theories, and concepts of sustainable development.	SO1.1SO1.2SO1.3SO1.4 SO1.5		Unit-1.0 Introduction to Sustainable Development: 1.1,1.2,1.3,1.4,1.5,1.6,1.7,	As mentioned in page number 17to 25
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4, 5	**CO2:** Identify and apply methods for assessing the achievement of sustainable development and discover the science, technology, economics, and politics underlying the concepts of sustainability.	SO2.1SO2.2SO2.3 SO2.4 SO2.5		Unit-2 Special focus on SDG 4-Quality Education and Lifelong Learning: 2.1,2.2,2.3,2.4,2.5,2.6, 2.7, 2.8,2.9	
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4, 5	**CO3:** Understand the implications of overuse of resources, population growth and economic growth and sustainability and explore the challenges the society faces in making transition to renewable resource use.	SO3.1SO3.2 SO3.3 SO3.4 SO3.5		Unit-3 : Understanding the SDGs: 3.1, 3.2,3.3,3.4,3.5,3.6,3.7,3.8	
PO1,2,3,4,5,6	**CO4:** Develop skills to	SO4.1SO4.2SO4.3SO4.4		Unit-4 : Climate Change,	

7,8,9,10,11,12 PSO 1,2, 3, 4, 5	understand attitudes on individuals, society and their role regarding causes and solutions in the field of sustainable development and apply critical thinking skills to evaluate the quality, credibility and limitations of an argument for solution.	SO4.5		Energy and Sustainable Development 4.1, 4.2,4.3,4.4,4.5,4.6,4.7	
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4, 5	**CO5:** Describe the steps of the design thinking methodology and how design thinking can accelerate effective SDG implementation. Deepen knowledge and pedagogical tools to incorporate values-based education for sustainable development in educational programmes and processes	SO5.1SO5.2SO5.3SO5.4 SO5.5		Unit 5: Sustainable Business Practices, LCA and World peace and justice 5.1,5.2,5.3,5.4,5.5,5.6	

Yoga and Meditation

Course Code:	98SYN109
Course Title :	Yoga and Meditation
Pre-requisite:	Student should have basic knowledge of Applications of Yoga and Meditation and its concepts
Rationale:	Students of Yoga should have a legal understanding of Yoga and its original text Yoga. At the same time, they should also have adequate knowledge of Yoga and Meditation in which they should have knowledge of its basic principles and elements.

Course Outcomes:

98SYN109.1: A students shall be able to describe the Brief Introduction of yoga and its practices

98SYN109.2: A students shall be able to describe the pranayama with the practice of bandh ,mudra .

98SYN109.3: A students shall be able to describe the mediation .

Scheme of Studies:

Board of Study	**Course Code**	**Course Title**	**Scheme of studies(Hours/Week)**					**Total Credits (C)**
			Cl	**LI**	**SW**	**SL**	**Total Study Hours (CI+LI+SW+SL)**	

AU	70 YS303	Swami Vivekananda's Four Yoga Streams	2	0	1	1	4	2

Legend: **CI:** Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini project etc.),
SL: Self Learning,
C:Credits.

Theory

Board of Study	Couse Code	Course Title	**Scheme of Assessment (Marks)**							
			Progressive Assessment (PRA)						**End Semester Assessment**	**Total Marks**
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA+CAT+AT)	**(ESA)**	(PRA+ ESA)
AU	70 YS303	Yoga and Meditation	05	05	0	0	0	05	40	50

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	AppX Hrs
Cl	05
LI	05
SW	1
SL	1
Total	12

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO1.1 Student will able to Understand the Introduction to Yoga and Yogic Practices **SO1.2**Student will able to Understand the Shatkarma: SO1.3 Student will able to Describe	.	**Unit-1.0** Introduction to Yoga and Yogic Practices . 1.1Yoga: Etymology, definitions, aim, objectives and misconceptions 1.2. Yoga: Its Origin, history and development 1.3. Rules and regulations to be followed by Yoga ractitioners 1.4. Introduction to Yoga practices	1. Introduction to Yoga 2. Shatkarma

Item	AppX Hrs
Cl	05
LI	05
SW	1
SL	1
Total	12

		1.5. Shatkarma: meaning, purpose and their significance in Yoga Sadhana 1.6. Introduction to Yogic Loosening practices and Surya Namaskar Key Words: History and Development of Yoga, Shatkarma, Common	

Approximate Hours

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO2.1 Student will able to Understand the Breathing Practices and Pranayama **SO2.2**Student will able to Understand the Concept of Puraka, Rechaka and Kumbhaka SO2.3 Student will able to Describe Concept of Bandha and Mudra	.	**Unit-1.0** Yogic Practices. Breathing Practices and Pranayama 2.1. Sectional Breathing (Abdominal, Thoracic and Clavicular) 2.2.Yogic Deep Breathing 2.3.Concept of Puraka, Rechaka and Kumbhaka 2.4. Concept of Bandha and Mudra 2.5.AnulmoaViloma/NadiShodhana 2.6. Shitali7. Bhramari Key Words: Sectional breathing, Deep breathing, Bandha & Mudra, Shitali, Bhramari	1. Breathing Practices 2. Concept of Bandha and Mudra

Approximate Hours

Item	AppX Hrs

Cl	05
LI	05
SW	1
SL	1
Total	12

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO3.1 Student will able to Understand the Practices leading to Meditation **SO3.2**Student will able to Understand the Recitation of Pranava Mantra SO3.3 Student will able to Describe Breath Meditation	.	**Unit-1.0** **Practices leading to Meditation** **3.1.Recitation of Pranava Mantra** **3.2. Recitation of Hymns, in vocations and prayers** **3.3. Anter Maun** **3.4, Breath Meditation** **3.5.0m Dhyana** **Key Words: Pranav Mantra, Antermaun, Breath Meditation, Om Dhyan.**	1. Practices leading to Meditation 2. Anter Maun

Text-

1- Singh S.P. & yogi Mukesh ,Foundation of yoga , standard publication , new Delhi ,2010
2- Swami dherendra brhamchari , yogasana vigyaan , dherendra yoga prakshan , new Delhi 1966
3- Sarswati , swami satyananda , asan pranayama mudra bandha ,yog prakshan trust munger ,2013
4- H.R. nagendra , asan pranayama mudra bandha,swami Vivekananda yog prakshan ,banglore 2002
5- Ishwer Bhardwaj , saral yogashan , satyam publication house , new Delhi 2018

6- Shri ram chauhaan , mudra rahasya , bhartiye yog sansthan , new delhi 2014
7- Dr Vishwanath Prasad sangha , dhyan yog , bhartiye yog sansthan , new delhi 1987
8- Shri Deshraj ,Dhyan sadhna , bhartiye yog sansthan , new delhi 2015
9- bhartiye yog sansthan , new delhi 2014

<table>
<tr><td>Program Name</td><td colspan="2">Bachelor of Technology (B.Tech.)- Biotechnology</td></tr>
<tr><td>Semester</td><td colspan="2">I</td></tr>
<tr><td>CourseCode:</td><td colspan="2">98ME151</td></tr>
<tr><td>Coursetitle:</td><td>Workshop Practice Lab</td><td>Curriculum Developer: Er. Ketan Agrawal, Assistant Professor</td></tr>
<tr><td>Pre-requisite:</td><td colspan="2">Basic knowledge of mathematical skill with some scientific temperament.</td></tr>
<tr><td>Rationale:</td><td colspan="2">It is a place of work for preparing variety of jobs/products by using different kinds of Instruments, hand tools and Machines. In order to prepare the products in workshop, the workshop is divided into many branches according to nature of work. Ex: 1.Fitting shop 2. Welding shop 3. Sheet metal shop 4. M/c Shop 5. Foundry & Forging shop etc.</td></tr>
<tr><td>CourseOutcomes (COs):</td><td colspan="2">CO1-98ME151.1. Understand various production processes, selecting appropriate methods for different material, optimizing manufacturing efficiency and ensuring product quality.
CO2-98ME151.2. Acquired proficiency in using hand tools , understanding different types of fits and tolerances, interpreting engineering drawing and precision measurement techniques.
CO3-98ME151.3. Develop fundamental skills such as measuring , cutting and joining wood. Gain expertise in handling various carpentry tools and machinery.
CO4-98ME151.4. Appreciate and access the use of casting processes in manufacturing and understand the working of various casting processes.
CO5-98ME151.5. Analyze and access the importance of welding processes in manufacturing and apply knowledge to select appropriate welding process based on the type of industrial application.</td></tr>
</table>

Scheme of Studies:

Board ofStudy	Cours eCode	CourseTitle	Scheme ofstudies (Hours/Week)					Total Credits(C) (L:T:P=0:0:1)
			CI	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
Program Common(PC)	98ME151	Workshop Practice Lab		2	1	1	4	0+0+1=1

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment:Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each	Class Test 2 (2 best out of 3)	Seminar one (SA)	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		

			(CA)	10 marks each (CT)						
PC	98ME151	Workshop Practice Lab	**35**	**-**	**5**	**5**	**5**	**50**	**50**	**100**

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<td>ApproximateHours
<table>
<tr><td>Item</td><td>Cl</td><td>LI</td><td>SW</td><td>SL</td><td>Total</td></tr>
<tr><td>Approx.Hrs</td><td>0</td><td>03</td><td>01</td><td>01</td><td>05</td></tr>
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Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-98ME151.1. Understand various production processes, selecting appropriate methods for different material, optimizing manufacturing efficiency	**SO1.1** Understand various manufacturing processes, materials and technologies.	**LI1.1** Safety aspects pertaining to common manufacturing practices.		**SL1.1** Introduction to additive manufacturing .

and ensuring product quality.				
	SO1.2 Acquire knowledge in cost estimation resource management and sustainable manufacturing practices.	**LI1.2** Introduction of tools and machines used in each processes.		
		LI1.3 Basic instructions and procedures for using lathe and drilling machine.		

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<tr><td>Approx.Hrs</td><td>0</td><td>03</td><td>01</td><td>01</td><td>05</td></tr>
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Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-98ME151.2. Acquired proficiency in using hand tools , understanding different types	**SO2.1** Understand	**LI2.1** Instructions for using proper fitting tools in the correct way.		**SL2.1** Types of drilling tools

of fits and tolerances, interpreting engineering drawing and precision measurement techniques.	different cutting tools like hacksaw, chisels etc.			and threading tools.
	SO2.2 Acquire knowledge of various fitting and assembly techniques.	**LI2.2** Drawing of a simple workpiece for carrying out different fitting operations.		
		LI2.3 Demonstration of different inspection , checking and measuring methods used for proper fitting work.		

Suggested Sessional Work (SW):	**SW2.1** Assignments	Classification and uses of different fitting hand tools.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

ApproximateHours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	0	03	01	01	05

Course outcome (CO)	**Session Outcomes**	**Laboratory Instruction**	**Class room**	**Self-Learning (SL)**

	(SOs)	(LI)	Instruction (CI)	
CO3-98ME151.3. Develop fundamental skills such as measuring , cutting and joining wood. Gain expertise in handling various carpentry tools and machinery.	**SO3.1** Proficiency in measuring cutting and assembling wood.	**LI3.1** Carpentry tools introduction.		**SL3.1** Explain defects in timber and conversion of wood.
		LI3.2 Drawing of a simple workpiece for preparation of common carpentry joinery work.		
		LI3.3 Demonstration of different inspection , checking and measuring methods used for proper carpentry work.		

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Explain the different types of wood working machines used in modern wood work.
	SW3.2 Mini Project	Production of any one type of joints listed below- Dovetail Joint/Corner Joint/Mortise and Tenon Joint etc.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall	**ApproximateHours**

achievement of Course Outcomes (COs) upon the course's conclusion.	

Item	Cl	LI	SW	SL	Total
Approx.Hrs	08	04	01	04	17

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO4-98ME151.4. Appreciate and access the use of casting processes in manufacturing and understand the working of various casting processes.	**SO4.1** The production of cast metal component, quality control measures and adherence to manufacturing standards.	**LI4.1** Safety instructions for foundry shop, pattern making , mould preparation.		**SL4.1** Explain types of moulding sand.
		LI4.2 Drawing of a simple work piece for preparation of a pattern.		
		LI4.3 Instructions for sand preparation, mould preparation, melting and casting properly in the safe manner.		

Suggested Sessional Work (SW):	**SW4.1** Assignments	Explain various defects generated during casting process.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes	**ApproximateHours**

<table>
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<td>of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.</td>
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<tr><td>Item</td><td>Cl</td><td>LI</td><td>SW</td><td>SL</td><td>Total</td></tr>
<tr><td>Approx.Hrs</td><td>0</td><td>03</td><td>01</td><td>01</td><td>05</td></tr>
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Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-98ME151.5 Analyze and access the importance of welding processes in manufacturing and apply knowledge to select appropriate welding process based on the type of industrial application.	**SO5.1** Peforming set up, adjustment of flame and gas pressure, and shutdown procedure for oxyacetylene welding and cutting equipment.	**LI5.1** Welding tools introduction for Electric Arc Welding process.		**SL5.1** Study of TIG and MIG welding process.
	SO5.2 Aquire knowledge about setting up and shutting down SMAW equipment.	**LI5.2** Drawing of a simple welded joint viz. Square butt joint, T joint , Lap joint etc.		

		LI5.3 Actual production of a welded joint as described above.		

Suggested Sessional Work (SW):	**SW5.1** Mini Project	Preparing lap joint using arc welding process.

Course duration (in hours)to attain Course Outcomes:

Course Title: Workshop Practice Lab **Course Code:**98ME151

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98ME151.1. Understand various production processes, selecting appropriate methods for different material, optimizing manufacturing efficiency and ensuring product quality.	-	3	1	1	5
CO2-98ME151.2. Acquired proficiency in using hand tools , understanding different types of fits and tolerances, interpreting engineering drawing and precision measurement techniques.	-	3	1	1	5
CO3-98ME151.3. Develop fundamental skills such as measuring , cutting and joining wood. Gain expertise in handling various carpentry tools and machinery.	-	3	1	1	5
CO4-98ME151.4. Appreciate and access the use of casting processes in manufacturing and understand the working of various casting processes .	-	3	1	1	5

CO5-98ME151.5. Analyze and access the importance of welding processes in manufacturing and apply knowledge to select appropriate welding process based on the type of industrial application.	-	3	1	1	5
Total Hours		15	05	05	25

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Workshop Practice Lab **Course Code:**98ME151

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-98ME151.1. Understand various production processes, selecting appropriate methods for different material, optimizing manufacturing efficiency and ensuring product quality.	2	1	1	1	5
CO2-98ME151.2. Acquired proficiency in using hand tools , understanding different types of fits and tolerances, interpreting engineering drawing and precision measurement techniques.	2	4	4	2	12
CO3-98ME151.3. Develop fundamental skills such as measuring , cutting and joining wood. Gain expertise in handling various carpentry tools and machinery.	3	5	3	3	14
CO4-98ME151.4. Appreciate and access the use of casting processes in manufacturing and understand the working of various casting processes .	2	3	4	2	11
CO5-98ME151.5. Analyze and access the importance of welding processes in manufacturing and apply knowledge to select appropriate welding process based on the type of industrial application.	2	3	1	2	8
Total Marks	**11**	**16**	**13**	**10**	**50**

***Legend*:A,** Apply;**An,** Analyze;**E,** Evaluate;**C,** Create

Suggested learning Resources:

(a) Books:

(b)

S.No.	Title/Author/Publisher details
1	Elements of Workshop Technology, Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., Media promoters and publishers private limited, Mumbai , Vol. I 2008 and Vol. II 2010.
2	Manufacturing Engineering and Technology, Kalpakjian S. And Steven S. Schmid , Pearson Education India, Edition, 2002
3	Manufacturing Technology, Rao P.N , Tata McGraw Hill House , Vol. I and Vol. II 2007
4	Processes and Materials of Manufacture, Roy A. Lindberg, Prentice Hall India,4th edition, 1998

(c) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Beverage producing plants & Distillery/Fermenter units
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology
Semester:I Semester
Course Title: Workshop Practice Lab
Course Code: 98ME151

CO/PO/PSO Mapping			
Course Outcome (Cos)	**Program Outcomes (POs)**		**Program Specific Outcomes (PSOs)**

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1-98ME151.1. Understand various production processes, selecting appropriate methods for different material, optimizing manufacturing efficiency and ensuring product quality.	2	-	-	1	2	1	2	2	1
CO2-98ME151.2. Acquired proficiency in using hand tools , understanding different types of fits and tolerances, interpreting engineering drawing and precision measurement techniques.	1	-	1	1	-	1	1	1	2
CO3-98ME151.3. Develop fundamental skills such as measuring , cutting and joining wood. Gain expertise in handling various carpentry tools and machinery.	1	1	1	1	-	1	1	1	1
CO4-98ME151.4. Appreciate and access the use of casting processes in manufacturing and understand the working of various casting processes .	1	-	1	-	2	1	1	1	3
CO5-98ME151.5. Analyze and access the importance of welding processes in manufacturing and apply knowledge to select appropriate welding process based on the type of industrial application.	1	1	1	-	1	1	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO1-98ME151.1.** Understand various production processes, selecting appropriate methods for different material, optimizing manufacturing efficiency and ensuring product quality.	SO1.1 SO1.2	**LI 1** **LI 2** **LI 3**		**1SL-1**
PO 1,2,3,4,5,6	**CO2-98ME151.2.** Acquired proficiency in using hand tools , understanding different types of fits and	SO2.1 SO2.2	**LI 1** **LI 2**		**2SL-1**

PSO 1,2, 3	tolerances, interpreting engineering drawing and precision measurement techniques.		**LI 3**		
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO3-98ME151.3.** Develop fundamental skills such as measuring , cutting and joining wood. Gain expertise in handling various carpentry tools and machinery.	SO3.1	**LI 1** **LI 2** **LI 3**		**3SL-1**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO4-98ME151.4.** Appreciate and access the use of casting processes in manufacturing and understand the working of various casting processes .	SO4.1	**LI 1** **LI 2** **LI 3**		**4SL-1**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO5-98ME151.5.** Analyze and access the importance of welding processes in manufacturing and apply knowledge to select appropriate welding process based on the type of industrial application.	SO5.1 SO5.2	**LI 1** **LI 2** **LI 3**		**5SL-1**

Program Name	**BTech Biotechnology**	
Semester	II	
Course Code:	**98EE201**	
Course title:	Basic Electrical & Electronics Engineering	**Curriculum Developer**: Er. K K Tripathi, Assistant Professor
Pre-requisite:	Students should have basic knowledge of electrical and electronics circuits.	
Rationale:	A process of introducing formal knowledge of basic electrical elements and AC, DC, and magnetic circuit in electrical and electronic devices along with necessary knowledge about single-phase Transformer.	
Course Outcomes (COs):	**CO1-98EE201.1.** Recall the concepts of voltage, current, power and energy for different circuit elements. Apply the Kirchhoff laws to identify the node voltages and branch currents, apply different network theorems in the complex networks. **CO2-98EE201.2.** Understand the concept of single phase and poly phase AC circuits and construct the phasor diagrams. **CO3-98EE201.3.** Understand the basic operating principle, types, efficiency of Transformers. **CO4-98EE201.4.** Design and analyze the different types of digital circuits. **CO5-98EE201.5.** Understand and analyze the various types of semiconductor devices.	

Scheme of Studies: Theory

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L: T:P=2:1:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
ESC	98EE201	Basic Electrical & Electronics Engineering	3	2	1	1	7	3+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Studies: Practical

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L: T:P=2:1:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
ESC	98EE251	Basic Electrical & Electronics Engineering	3	2	1	1	7	3+1=4

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		
ESC	98EE201	Basic Electrical & Electronics Engineering	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	03	1	02	15

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO1-98EE201.1. Recall the concepts of voltage, current, power and	SO1.1: Understand the importance of electrical engineering in daily life.	LI1.1: Explore real-world applications of electrical engineering.	CI1.1: Lecture on the significance of electrical engineering in various	SL1.1: Research and write a report on the impact of electrical

energy for different circuit elements. Apply the Kirchhoff laws to identify the node voltages and branch currents, apply different network theorems in the complex networks.			industries.	engineering in modern society.
	SO1.2: Identify different electrical elements and their classifications.		CI1.2: Discuss various electrical elements and their classifications.	
	SO1.3: Understand the basic concepts of electrical networks.		CI1.3: Lecture on the fundamentals of electrical network theory.	
	SO1.4: Differentiate between active and passive elements in a circuit.	LI1.2: Identify active and passive elements in sample circuits.	CI1.4: Discuss the characteristics of active and passive circuit elements.	
	SO1.5: Understand voltage and current sources.		CI1.5: Lecture on voltage and current sources, including dependent and independent sources.	
	SO1.6: Perform source conversion in electrical circuits.		CI1.6: Demonstrate source conversion techniques with examples.	
	SO1.7: Analyze DC circuits using the mesh method.	LI1.3: Practice DC circuit analysis using the mesh method.	CI1.7: Lecture on the mesh analysis method for DC circuits.	
	SO1.8: Analyze DC circuits using the nodal		CI1.8: Demonstrate the nodal analysis method	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	7	02	1	02	12

	method.		with practical examples.	
	SO1.9: Apply Thevenin's and superposition theorems to solve circuits.		CI1.9: Lecture on Thevenin's and superposition theorems with problem-solving sessions.	SL1.2: Develop a presentation on the application of Thevenin's theorem in circuit design.

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Numerical Problems on mesh and nodal analysis.
	SW1.2 Assignments	Derive different network theorems
	SW1.3 Other Activities (Specify)	Make a power point presentation on "Importance of electrical engineering in day-to-day life"

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO2-98EE201.2. Understand the concept of single phase and poly phase AC circuits and construct the phasor diagrams.	SO2.1: Understand the basics of 1-phase AC circuits under sinusoidal steady state.	LI2.1: Measure voltage and current in 1-phase AC circuits.	CI2.1: Lecture on 1-phase AC circuits and sinusoidal steady state.	SL2.1: Research and write a report on the applications of 1-phase AC circuits.
	SO2.2: Differentiate between active, reactive, and apparent power.		CI2.2: Discuss the concepts of active, reactive, and apparent power.	
	SO2.3: Explain the physical meaning of reactive power.		CI2.3: Lecture on the physical interpretation and significance of reactive power.	

	SO2.4: Calculate power factor and its importance in AC circuits.		CI2.4: Demonstrate power factor calculation with examples.	
	SO2.5: Analyze 3-phase balanced supply systems.	LI2.2: Experiment with 3-phase balanced supply and measure power.	CI2.5: Lecture on 3-phase balanced supply systems and their analysis.	
	SO2.6: Understand 3-phase unbalanced supply systems and their challenges.		CI2.6: Discuss the differences and challenges of unbalanced 3-phase systems.	

98EE201.4. Design and analyse the different types of digital circuits.	Understand number systems used in digital electronics.	Experiment on converting between decimal, binary, octal, and hexadecimal.	on the various number systems and their uses.	Research the history and development of digital number systems.
	SO4.2: Learn about complements, operations, and conversions in number systems.		CI4.2: Discuss the concepts of complements and number operations.	
	SO4.3: Understand floating point and signed numbers in digital electronics.		CI4.3: Lecture on floating point representation and signed numbers.	
	SO4.4: Explore Demorgan's theorem and basic logic gates.		CI4.4: Lecture on Demorgan's theorem and its applications.	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	04	01	02	17

Item	Cl	LI	SW	SL	Total
Approx . Hrs	11	03	01	03	18

	SO4.5: Understand the function and representation of logic gates.	LI4.2: Implement basic logic gates using digital electronics kits.	CI4.5: Discuss the AND, OR, NOT, NOR, NAND, EX-NOR EX-OR gates.	

	SO4.6: Learn to create and interpret truth tables for logic gates.		CI4.6: Lecture on constructing truth tables for different logic gates.	
	SO4.7: Design and analyze half and full adder circuits.	LI4.3: Construct half and full adder circuits and test their functionality.	CI4.7: Lecture on the design and operation of adder circuits.	SL4.2: Research applications of adders in digital systems.
	SO4.8: Understand the operation of R-S and J-K flip flops.		CI4.8: Discuss the principles of R-S and J-K flip flops.	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	9	03	1	2	15

	SO4.9: Learn about proportional, integral, and derivative controls.	LI4.4: Implement a PID control system and analyze its response.	CI4.9: Lecture on PID control and its application in process control.	
	SO4.10: Explore computer interfacing and applications in fermentation processes.		CI4.10: Discuss computer interfacing techniques in fermentation processes.	SL4.3: Develop a project proposal for using computer interfacing in a bioreactor.

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Implement logic circuit for full adder.
	SW4.2 Mini Project	Implement logic circuit for SR flip flop.
	SW4.3 Mini Project	Perform various arithmetic operation on various types of number system.

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO5-98EE201.5 Understand and analyse the various types of semiconductor devices.	SO5.1: Understand the different types of passive components: resistors, inductors, and capacitors.	LI5.1: Experiment on measuring and identifying resistors, inductors, and capacitors.	CI5.1: Lecture on the properties and types of resistors, inductors, and capacitors.	SL5.1: Research and present a report on applications of passive components in electronic circuits.
	SO5.2: Learn the basics of semiconductors and their importance in		CI5.2: Lecture on the fundamentals of semiconductors.	

	electronics.			
	SO5.3: Explore the V-I characteristics of diodes.		CI5.3: Lecture and demonstration on the V-I characteristics of diodes.	
	SO5.4: Understand the structure and working of bipolar junction transistors (BJT).	LI5.2: Experiment on the V-I characteristics of BJTs.	CI5.4: Discuss the working principle and applications of BJTs.	SL5.2: Study and write about the historical development of BJTs and their impact on technology.
	SO5.5: Learn about CC (common collector), CB (common base), and CE (common emitter) transistor configurations.		CI5.5: Lecture on the different transistor configurations.	
	SO5.6: Understand the different modes of operation of BJTs.		CI5.6: Discuss the active, cutoff, and saturation modes of BJTs.	
	SO5.7: Explore the concept of DC biasing in BJTs.		CI5.7: Lecture on DC biasing techniques for BJTs.	SL5.3: Create a simulation of a transistor amplifier circuit and analyze its performance.
	SO5.8: Apply knowledge of BJTs in practical circuits.		CI5.8: Discuss practical applications of BJTs in electronic circuits.	

Suggested Sessional Work (SW):	**SW5.1** Assignments	Describe how transistor works as an amplifier.
	SW5.2 Assignments	How will you compare different configuration of transistor.
	SW5.3 Assignments	Find the current gain in various configuration of transistor.

Course duration (in hours) to attain Course Outcomes:

Course Title: Basic Electrical & Electronics Engineering **Course Code:** 98EE201

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (LI+CI+SL+SW)**
CO1-98EE201.1. Recall the concepts of voltage, current, power and energy for different circuit elements. Apply the Kirchhoff laws to identify the node voltages and branch currents, apply different network theorems in the complex networks.	9	3	2	1	15
CO2-98EE201.2. Understand the concept of single phase and poly phase AC circuits and construct the phasor diagrams.	11	3	3	1	18
CO3-98EE201.3. Understand the basic operating principle, types, efficiency of Transformers.	7	2	2	1	12
CO4-98EE201.4. Design and analyse the different types of digital circuits.	10	4	2	1	17
CO5-98EE201.5. Understand and analyse the various types of semiconductor devices.	9	3	2	1	15
Total Hours	46	15	11	5	72

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Bioreactor Engineering **Course Code:** 55MBT102

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-98EE201.1. Recall the concepts of voltage, current, power and energy for different circuit elements. Apply the Kirchhoff laws to identify the node voltages and branch currents, apply different network theorems in the complex networks.	2	1	1	1	5
CO2-98EE201.2. Understand the concept of single phase and poly phase AC circuits and construct the phasor diagrams.	2	4	5	1	12
CO3-98EE201.3. Understand the basic operating principle, types, efficiency of Transformers.	3	5	5	1	14
CO4-98EE201.4. Design and analyse the different types of digital circuits.	2	3	5	1	11
CO5-98EE201.5. Understand and analyse the various types of semiconductor devices.	2	4	1	1	10
Total Marks	**11**	**17**	**17**	**05**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

1. Integrated Electronics by Millman and Halkias, McGraw Hill
2. Electronics Devices and Circuits by R. Boylested and L. Nashelsky, Prentice Hall India
3. Digital Logic and Computer Design by M. M. Mano, Pearson Education India
4. Theory and Problems of Basic Electrical Engineering by D.P. Kothari and I. J. Nagrath, Prentice Hall India Learning Private Limited
5. Basic Electrical Engineering by D. C. Kulshreshtha, McGraw Hill
6. Fundamentals of Electrical Engineering by Ashfaq Hussain, Dhanpat Rai and Co

(b) Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Beverage producing plants & Distillery/Fermenter units
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology **Semester:** II Semester
Course Title: Basic Electrical and Electronic Engineering **Course Code:** 98EE201

Course Outcome (Cos)	**Program Outcomes (POs)**												Program Specific Outcomes (PSOs)		
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-98EE201.1. Recall the concepts of voltage, current, power and energy for different circuit elements. Apply the Kirchhoff laws to identify the node voltages and branch currents, apply different network theorems in the complex networks.	3	3	2	2	2	1	1	1	2	2	2	2	3	2	2
CO2-98EE201.2. Understand the concept of single phase and poly phase AC circuits and construct the phasor diagrams.	3	2	2	2	2	1	1	1	2	2	2	2	3	3	2
CO3-98EE201.3. Understand the basic operating principle, types, efficiency of Transformers.	3	2	2	2	2	1	1	1	2	2	2	2	3	3	2
CO4-98EE201.4. Design and analyse the different types of digital circuits.	3	3	3	2	3	1	1	1	2	3	2	2	3	3	3
CO5-98EE201.5. Understand and analyse the various types of semiconductor devices.	3	2	2	2	2	1	1	1	2	2	2	2	3	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2, 3	**CO1-98EE201.1.** Recall the concepts of voltage, current, power and energy for different circuit elements. Apply the Kirchhoff laws to identify the node voltages and branch currents, apply different network theorems in the complex networks.	SO1.1 SO1.2 SO1.3 SO1.4	**LI 1** **LI 2** **LI 3** **LI 4**	1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8, 1.9,1.10,1.11,1.12,1.13,1.14	**1SL-1**
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2, 3	**CO2-98EE201.2.** Understand the concept of single phase and poly phase AC circuits and construct the phasor diagrams.	SO2.1 SO2.2 SO2.3	**LI 1**	2.1, 2.2,2.3,2.4,2.5,2.6,2.7, 2.8,2.9,2.10,2.11,2.12,2.13	**2SL-1,2,3**
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2, 3	**CO3-98EE201.3.** Understand the basic operating principle, types, efficiency of Transformers.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5	**LI 1** **LI 2** **LI 3**	3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8	**3SL-1**
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2, 3	**CO4-98EE201.4.** Design and analyse the different types of digital circuits.	SO4.1 SO4.2 SO4.3 SO4.4	**LI 1**	4.1,4.2,4.3,4.4, 4.5 4.6,4.7,4.8,4.9,4.10	**4SL-1,2**
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2, 3	**CO5-98EE201.5.** Understand and analyse the various types of semiconductor devices.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5	**LI 1** **LI 2** **LI 3** **LI 4**	5.1,5.2,5.3,5.4,5.5, 5.6 5.7,5.8,5.9,5.10	**5SL-1**

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	II	
Course Code:	98PH202	
Course title:	Engineering Physics	**Curriculum Developer**: Dr. O.P. Tripathi, and Mr. Saket Kumar
Pre-requisite:	Students should be familiar with the fundamentals of Wave Mechanics laser & fiber optics, Quantum Mechanics, Solid State Physics & Superconductivity, and Nano Technology.	
Rationale:	Students should study fundamentals of Wave Mechanics, Laser & Fiber Optics, Quantum Mechanics, Solid State Physics & Superconductivity, and Nano Technology to understand their impact on modern technology and scientific advancement. These fields are essential in optics, acoustics, quantum mechanics, telecommunications, medical imaging, and more. Mastering these disciplines equips students to contribute to cutting-edge research and innovation.	
Course Outcomes (COs):	**CO1-98PH202.1:** Through this chapter students are brought to learn about historical development of optics, atomic physics and biomechanics to the modern concepts. **CO2-98PH202.2:** Explain the concept of coherence and its importance in laser operation and optical fiber communication. **CO3-98PH202.3:** Quantum mechanics math covers operators, eigenvalues, eigenvectors, phase, group velocities, uncertainty principle, Debroglie's matter waves, Schrodinger's wave equation, wave function interpretation, eigenvalues, and Compton's effect. **CO4-98PH202.4:** Evaluate current research topics and advancements in solid-state physics and superconductivity, including high-temperature superconductors, topological superconductors, and quantum computing applications. **CO5-98PH202.5:** Investigate the applications of nanotechnology in various fields, including electronics, nanorobotics, quantum computing, space energy, DNA manipulation, biomedical engineering, polymers, textiles, and nano composites.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L+T+P)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
ESC	98PH202	Engineering Physics	3	2	1	2	8	4

Legend:

CI: Classroom Instruction (Includes different instructional strategies i.e., Lecture (L) and Tutorial (T) and others),
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini project etc.),
SL: Self Learning,
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment: Theory

Scheme of Assessment (Marks)											
Board of Study	Course Code	Course Title	Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA+CAT+AT)		
ESC	98PH202	Engineering Physics	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

This course syllabus outlines the expected learning outcomes that students should achieve through different modes of instruction, such as classroom instruction (CI), laboratory instruction (LI), sessional work (SW), and self-learning (SL), at both the course and session levels. Students should demonstrate their mastery of Session Outcomes (SOs) as the course proceeds, which will lead to their overall attainment of Course Outcomes (COs) at the end of the course.

Item	CI	LI	SW	SL	Total
Approx Hrs	12	04	01	02	19

Course Outcome (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
98PH202.1: Through this chapter students are brought to learn about historical development of optics, atomic physics and biomechanics to the modern concepts.	SO 1.1: Understanding interference, coherent sources, and the principle of superposition for various applications in physics, optics, acoustics, and engineering.	LI 1.1: Demonstration of coherent sources and superposition principles.	CI 1.1: Explanation of interference, coherent sources, and principle of superposition.	SL 1.1: Study historical experiments on interference and superposition principles.
	SO 1.2: Design and analyze interference-based devices, such as interferometers, for precision measurements.	LI 1.2: Demonstration of different types of interference.	CI 1.2: Discussion on types of interference and their practical applications.	SL 1.2: Research practical applications of interference in various fields.
	SO 1.3: Experimental explanation about interference from parallel thin films.		CI 1.3: Study the effects of parallel thin films on interference patterns.	
	SO 1.4: Experimental explanation about wedge-shaped films.		CI 1.4: Explanation of interference in wedge-shaped films and related phenomena.	
	SO 1.5: Experimental explanation about Newton's rings and Michelson's Interferometer, and their applications.		CI 1.5: Detailed study of Newton's rings and Michelson's Interferometer.	
	SO 1.6: Introduce Fresnel diffraction, diffraction at a straight edge, and diffraction at double and		CI 1.6: Explanation of Fresnel diffraction and its mathematical	

	n-slits.		formulations.	
	SO 1.7: Explain the dispersive and resolving power of diffraction gratings and prisms.		CI 1.7: Study the principles behind diffraction gratings and resolving power calculations.	
	SO 1.8: Explain the production of plane-polarized light by different methods.		CI 1.8: Explanation of polarization and polarizing materials.	
	SO 1.9: Discuss Brewster's law, Malus's law, and double refraction.		CI 1.9: Detailed explanation of Brewster's and Malus's laws and their applications.	
	SO 1.10: Explain double refraction using Nicol prism.		CI 1.10: Discuss the phenomenon of double refraction and the use of Nicol prisms.	
	SO 1.11: Explain quarter and half-wave plates.		CI 1.11: Explanation of phase retardation using quarter and half-wave plates.	
	SO 1.12: Explain the components and function of a polarimeter.		CI 1.12: Explanation of polarimeter components and calibration procedures.	

SW-1 Suggested Sessional Work (SW)	**SW-1 Suggested Sessional Work (SW):** **A. Assignments:** **1.** Explain the phenomenon of wave reflection and calculate the reflection coefficient for a given interface. **2.** Wave Equation Problems: a. Derive the wave equation for a traveling wave on a string under tension. b. Solve the wave equation to find the general solution for a harmonic wave propagating in one dimension. c. Investigate the behavior of standing waves on a vibrating string and determine the node and antinode positions.

	d. Analyze the properties of electromagnetic waves and relate them to Maxwell's equations.
	Mini Project: Develop computational models to study wave interference, diffraction, and scattering effects in complex geometries and materials.
	Other Activities (Specific): **BS-101.2:** Explain the concept of coherence and its importance in laser operation and optical fiber communication.

Item	CI	LI	SW	SL	Total
Approx Hrs	09	04	01	01	16

Course Outcome (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
98PH202.2: Explain the concept of coherence and its importance in laser operation and optical fiber communication.	SO 2.1: Understand LASER principles, including absorption, stimulated and spontaneous emission, coherence, pumping, and population inversion.	LI 2.1: Conduct hands-on experiments to demonstrate LASER principles, such as: LASER beam propagation and divergence	CI 2.1: Define LASER (Light Amplification by Stimulated Emission of Radiation) and its basic principles.	SL 2.1: Emphasize the importance of proper training, handling, and maintenance of LASER systems.
	SO 2.2: Discuss the coherence, directionality, and monochromaticity of laser light.		CI 2.2: Explanation of coherence, directionality, and monochromaticity of laser light.	
	SO 2.3: Provide a mathematical explanation of Einstein's coefficients.		CI 2.3: Discussion on the significance of Einstein's coefficients in LASER operations.	
	SO 2.4: Explain the principle		CI 2.4: Detailed study of	

	and working of He-Ne and Ruby lasers with energy level diagrams.		the working principles of He-Ne and Ruby lasers.	
	SO 2.5: Provide a fundamental overview of optical fibers and their types.		CI 2.5: Explanation of different types of optical fibers and their applications.	
	SO 2.6: Explain the principle of total internal reflection (TIR) and its significance in optical fiber transmission.	LI 2.2: Engage students in activities such as measuring numerical aperture, analyzing dispersion characteristics, and testing fiber coupling techniques to reinforce theoretical concepts and practical skills.	CI 2.6: Explanation of TIR and its role in optical fibers.	
	SO 2.7: Explain the role of each component in transmitting, receiving, and processing optical signals.		CI 2.7: Discussion on optical communication system components and their functions.	
	SO 2.8: Explore practical applications of optical communication, including telecommunications and data networking.		CI 2.8: Discussion on emerging applications in fiber-optic sensing, biomedical imaging, and quantum communication.	
	SO2.9: Apply differentiation techniques to solve real-world problems.		CI2.9: Discussion on the applications of differentiation in various fields.	

SW-2 Suggested Sessional Work (SW)	**SW2.1 Assignments:** • Determine the equation of motion for system

	• What would be the steady state of solution. **SW2.2 Other Activities (Specific):**

Item	CI	LI	SW	SL	Total
Approx Hrs	10	04	01	02	19

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instructions (LIs)	Classroom Instruction (CIs)	Self-Learning (SL)
CO3-98PH202.3: Quantum mechanics math covers operators, eigenvalues, eigenvectors, phase, group velocities, uncertainty principle, Debroglie's matter waves, Schrodinger's wave equation, wave function interpretation, eigenvalues, and Compton's effect.	SO 3.1: Explain the difference between phase velocity and group velocity.	LI 3.1: Conduct experiments to measure phase and group velocities using wave packets.	CI 3.1: Explain the relationship between phase velocity and group velocity.	
	SO 3.2: Explain the uncertainty principle with elementary proof and applications.	LI 3.2: Provide opportunities for students to practice calculating uncertainty relations and interpreting their physical meaning in different scenarios.	CI 3.2: Discussion on the commutator relationship and its implications for position and momentum uncertainties.	SL 3.1: Research historical experiments demonstrating the uncertainty principle.
	SO 3.3: Present de Broglie's concept of matter waves.		CI 3.3: Explain de Broglie's equation: $\lambda = h / p$, where h is Planck's constant.	SL 3.2: Explore applications of matter waves in modern physics.
	SO 3.4: Explain Schrödinger's wave equation		CI 3.4: Explain the significance of the time-	

	(time-dependent and time-independent).		independent Schrödinger equation: $\hat{H}\Psi = E\Psi$.	
	SO 3.5: Discuss the interpretation of wave functions and the matching of impedances.		CI 3.5: Classroom discussion on the interpretation of wave functions in quantum mechanics.	
	SO 3.6: Present the mathematical definition of eigenvalues and eigenfunctions.		CI 3.6: Explain the role of eigenvalues and eigenfunctions in linear transformations and operators.	
	SO 3.7: Derive the Compton shift formula using relativistic energy and momentum conservation principles.		CI 3.7: Discuss the implications of the Compton effect in quantum mechanics and particle physics.	
	SO 3.8: Discuss the concept of quantum tunneling and its applications.		CI 3.8: Explain quantum tunneling, its principles, and its significance in quantum mechanics.	
	SO 3.9: Explain the concept of wave-particle duality.		CI 3.9: Discuss the historical context and significance of wave-particle duality in quantum mechanics.	
	SO3.10 Assessment and revision		CI 3.10: Assessment and revision	

SW-3 Suggested Sessional Work (SW) *(anyone)*	**SW 3.1: Assignments** In the double-hole experiment using white light, consider two points on the projection screen, one corresponding to a path difference of 5000 Å (point A), and the other corresponding to a path difference of 40,000 Å (point B). Find all the wavelengths (in the visible region) which correspond to constructive and destructive interference at point A and B. **SW3.2 Mini Project:** Discuss how Compton scattering is used in Compton cameras for gamma-ray imaging, electron microscopy, and spectroscopy techniques. **SW3.3 A. Other Activities:** Discuss limitations of the classical Compton shift formula and extensions to the theory, such as the Klein-Nishina formula for higher-energy photons and relativistic corrections.

Item	CI	LI	SW	SL	Total
Approx Hrs	08	04	01	04	13

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LIs)	Classroom Instruction (CIs)	Self-Learning (SLs)
98PH202.4: Evaluate current research topics and advancements in solid-state physics and superconductivity, including high-temperature superconductors, topological superconductors, and quantum computing applications.	SO 4.1: Define energy bands as ranges of allowed energy levels for electrons in solids.	LI 4.1: Conduct interactive demonstrations to illustrate energy bands using models or simulations.	CI 4.1: Explain the formation of energy bands in solids due to the periodic arrangement of atoms.	SL 4.1: Research historical developments in solid-state physics and energy band theory.
	SO 4.2: Introduce the concept of classification of matter based on properties.	LI 4.2: Conduct activities categorizing various materials based on their properties.	CI 4.2: Discuss the importance of classifying matter in physics and materials science.	SL 4.2: Explore different classifications of matter and their significance.
	SO 4.3: Explain the concept of the band gap in semiconductors.		CI 4.3: Discuss the role of band gaps in determining the electrical properties of semiconductors.	
	SO 4.4: Introduce PN junction diodes and Zener diodes, including their I-V characteristics.		CI 4.4: Explain how Zener diodes operate in the breakdown region and illustrate the I-V characteristics of PN junction diodes.	
	SO 4.5: Define a tunnel diode and its characteristics.		CI 4.5: Explain the concept of negative differential resistance (NDR) in tunnel diodes.	
	SO 4.6: Introduce the Hall effect and its		CI 4.6: Explain the Hall coefficient and its	

	applications.		significance in understanding the Hall effect.	
	SO 4.7: Explain the distinctions between Type-I and Type-II superconductors.		CI 4.7: Discuss the characteristics of superconductors and the Meissner effect.	
	SO 4.8: Discuss practical applications of superconductivity.		CI 4.8: Explain various applications of superconductors in technology and medicine.	

SW- 4 Suggested Sessional Work (SW) *(anyone)*	**SW 4.1 Assignments** • Explore the applications of P-N junction diodes in electronic circuits, including rectification, signal detection, and voltage regulation. • Provide examples of practical applications of the Hall effect in devices such as Hall sensors, magnetic field sensors, and magnetic flux measurement systems. Discuss the advantages and limitations of using the Hall effect for these purposes **SW4.2 Mini Project** **SW4.3 Other Activities** • Engage students in circuit analysis exercises involving PN junction diodes and Zener diodes, challenging them to design and analyze simple diode circuits. • Conduct hands-on experiments to demonstrate the Hall effect using a Hall probe and magnetic field source, allowing students to observe the generation of Hall voltage in real-time.

Item	CI	LI	SW	SL	Total
Approx Hrs	9	4	01	4	18

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-learning**
98PH202.5: Investigate the applications of nanotechnology in various fields, including electronics, nanorobotics, quantum computing, space energy, DNA manipulation, biomedical engineering, polymers, textiles, and nano composites.	SO 5.1: Understand the concept of nanotechnology and its significance in various fields.	LI 5.1: Conduct experiments to demonstrate nanoscale properties using nanomaterials.	CI 5.1: Explain the fundamentals of nanotechnology, including concepts of quantum dots, quantum wires, and quantum wells.	SL 5.1: Research the historical development of nanotechnology and its implications in various fields.
	SO 5.2: Discuss the unique properties of materials at the nanoscale compared to bulk materials.	LI 5.2: Perform comparative analysis of the properties of bulk and nanoscale materials.	CI 5.2: Discuss how size and structure affect the properties of materials at the nanoscale.	SL 5.2: Explore literature on the unique behaviors of nanoscale materials.
	SO 5.3: Describe different types of nanomaterials, including nanoparticles, nanowires, nanotubes, and nanocomposites.		CI 5.3: Explain the differences between various nanomaterials and their specific properties and applications.	SL 5.3: Investigate the applications of different types of nanomaterials in industry.
	SO 5.4: Explore techniques used for the preparation of nanomaterials and nanofibers.		CI 5.4: Discuss various methods for synthesizing nanomaterials and their importance in nanotechnology.	SL 5.4: Research advancements in preparation techniques for nanomaterials.
	SO 5.5: Explain characterization techniques for nanomaterials using XRD and SEM.		CI 5.5: Discuss the principles and applications of XRD and SEM in analyzing nanomaterials.	
	SO 5.6: Discuss potential applications of nanotechnology in		CI 5.6: Explain the impact of nanotechnology on fields like drug delivery	

	medicine and electronics.		and DNA sequencing.	
	SO 5.7: Explore the role of nanotechnology in environmental remediation.		CI 5.7: Discuss case studies on the use of nanotechnology for water purification and air filtration.	
	SO 5.8: Investigate the future trends in nanotechnology and its implications for society.		CI 5.8: Discuss ethical considerations and societal impacts of nanotechnology advancements.	

SW- 5 Suggested Sessional Work (SW) (anyone)	**SW 5.1 Assignments:** • Discuss the different types of nanomaterials, including nanoparticles, carbon nanotubes, nano clays, nano mud, and nano fibers. Explain their structures, properties, and potential applications. • Explain how nanomaterials can be characterized using techniques such as X-ray diffraction (XRD) and scanning electron microscopy (SEM). Discuss the principles behind these characterization methods and their applications in nanoscience. **SW5.2 Mini Project** **SW5.3 Other Activities**

Brief of Hours Suggested for the Course Outcome

Course Outcomes	Class Lecture (CI)	Laboratory Instructions (LI)	Sessional Work (SW)	Self Learning (SL)	Total hour (CI+LI+SW+SL)
98PH202.1: Through this chapter students are brought to learn about historical development of optics, atomic physics and biomechanics to the modern concepts.	12	4	01	02	19
98PH202.2: Explain the concept of coherence and its importance in laser operation and optical fiber communication.	9	04	01	01	15
98PH202.3: Evaluate current research topics and advancements in solid-state physics and superconductivity, including high-temperature superconductors, topological superconductors, and quantum computing applications.	10	04	01	02	19
98PH202.4: Evaluate current research topics and advancements in solid-state physics and superconductivity, including high-temperature superconductors, topological superconductors, and quantum computing applications.	08	04	01	4	13
98PH202.5: Investigate the applications of nanotechnology in various fields, including electronics, nanorobotics, quantum computing, space energy, DNA manipulation, biomedical engineering, polymers, textiles, and nano composites.	9	4	01	4	18
Total Hours	**48**	**20**	**05**	**13**	**84**

Suggestion for End Semester Assessment

Unit	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
Unit-1	Wave Mechanics	03	01	01	05
Unit-2	Laser & Fiber Optics	02	06	02	10
Unit-3	Quantum Mechanics	03	07	05	15
Unit-4	Solid State Physics & Superconductivity	-	10	05	15
Unit-5	Nano Technology	03	02	-	05
Total		11	26	13	50

Legend: **R: Remember,** **U: Understand,** **A: Apply**

The end of semester assessment for Introduction to Portland cement will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

CO-PO-PSO Mapping

Course Outcome (Cos)	Programme Outcome (PO)												Programme Specific Outcome (PSO)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
98PH202.1: Through this chapter students are brought to learn about historical development of optics, atomic physics and biomechanics to the modern concepts.	3	3	1	2	1	1	1	1	1	1	3	2	2	1	3
98PH202.2: Explain the concept of coherence and its importance in laser operation and optical fiber communication.	3	3	3	3	2	1	3	2	2	3	2	1	2	3	2
98PH202.3: Evaluate current research topics and advancements in solid-state physics and superconductivity, including high-temperature superconductors, topological superconductors, and quantum computing applications.	3	3	3	3	2	1	2	1	1	2	1	2	3	2	3
98PH202.4: Evaluate current research topics and advancements in solid-state physics and superconductivity,	3	3	2	3	3	3	2	2	2	3	2	3	2	3	2

including high-temperature superconductors, topological superconductors, and quantum computing applications.															
98PH202.5: Investigate the applications of nanotechnology in various fields, including electronics, nanorobotics, quantum computing, space energy, DNA manipulation, biomedical engineering, polymers, textiles, and nano composites.	3	3	2	3	3	2	1	3	2	3	2	2	2	3	3

Legend: *1 – Low, 2 – Medium, 3 – High*

Course Curriculum Map

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2, 3	**98PH202.1:** Through this chapter students are brought to learn about historical development of optics, atomic physics and biomechanics to the modern concepts.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5, SO1.6, SO1.7, SO1.8, SO1.9 SO 1.10 SO1.11 SO1.12	**1LI-1,2**	CI1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9,1.10,1.11,1.12	**1SL-1,2**
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2, 3	**98PH202.2:** Explain the concept of coherence and its importance in laser operation and optical fiber communication.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5, SO2.6, SO2.7, SO2.8, SO2.9	**1LI-1,2**	CI1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9	**2SL-1**
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2, 3	**98PH202.3:** Evaluate current research topics and advancements in solid-state physics and superconductivity, including high-	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5, SO3.6,	**1LI-1,2**	CI1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9,1.10	**3SL-1,2**

	temperature superconductors, topological superconductors, and quantum computing applications.	SO3.7, SO3.8, SO3.9 SO3.10			
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2, 3	**98PH202.4:** Evaluate current research topics and advancements in solid-state physics and superconductivity, including high-temperature superconductors, topological superconductors, and quantum computing applications.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5, SO4.6, SO4.7, SO4.8	**1LI-1,2**	CI1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8	**4SL-1,2**
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2, 3	**98PH202.5:** Investigate the applications of nanotechnology in various fields, including electronics, nanorobotics, quantum computing, space energy, DNA manipulation, biomedical engineering, polymers, textiles, and nano composites.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5, SO5.6, SO5.7, SO5.8, SO5.9	**1LI-1,2**	CI1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.	**5SL-1,2,3,4**

Suggested Learning Resources:

(a) Books:

1. Engineering Physics by A.B. Bhattacharya, Khanna Publishing House, Revised edition 21, 2020
2. Physics for Engineers by N.K. Verma, Prentice Hall India, 2017
3. Physics of Vibrations and Waves by H.J. Pain, National Council for Cement and Building Materials, 5th Edition, Wiley, 2006
4. Optics by Ajoy Ghatak, McGraw Hill Education India, 2017
5. Department Provided Lab Manual
6. Engineering Physics Lab Manual

(b) Online Resources:

1. MIT OpenCourseWare (OCW): Free courses in Physics, including Engineering Physics. MIT OCW Physics
2. Coursera: Courses from various universities on topics relevant to Engineering Physics. Coursera Physics Courses
3. edX: Courses from institutions like Harvard and MIT on advanced physics topics. edX Physics Courses
4. YouTube Channels: MinutePhysics: Short videos on various physics topics. MinutePhysics YouTube Channel, Veritasium: Explores complex physics concepts. Veritasium YouTube Channel, MIT OpenCourseWare: Full lectures and courses. MIT OCW YouTube Channel
5. HyperPhysics: Exploration environment for physics concepts. HyperPhysics
6. The Feynman Lectures on Physics: Classic physics textbook series available for free online. The Feynman Lectures on Physics
7. OpenStax: Free textbooks, including College Physics. OpenStax College Physics
8. arXiv: Repository of electronic preprints approved for publication. arXiv Physics
9. Google Scholar: Web search engine indexing scholarly literature. Google Scholar
10. PhET Interactive Simulations: Free interactive math and science simulations. PhET Simulations

11. Physlets: Interactive physics animations and simulations. Physlets

(c) Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Beverage producing plants & Distillery/Fermenter units
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	II	
Course Code:	98BT203	
Course title:	Biochemistry and Metabolism	**Curriculum Developer**: Chahana Desai, Teaching Associate
Pre-requisite:	Students should have basic cellular and molecular knowledge of biomolecules,	
Rationale:	Biochemistry combines biology and chemistry to study living matter. It powers scientific and medical discovery in fields such as pharmaceuticals, forensics and nutrition and Metabolism consists of a series of reactions that occur within cells of living organisms to sustain life. The process of metabolism involves many interconnected cellular pathways to ultimately provide cells with the energy required to carry out their function.	
Course Outcomes (COs):	**CO1-98BT203.1.** Summarize concepts of cell biology. **CO2-98BT203.2.** Explain the structure and function of biological molecules **CO3-98BT203.3.** Analyze enzyme kinetic data and regulation of enzyme activity. **CO4-98BT203.4.** Identify the key molecules involved in regulation of metabolic pathways and disorders **CO5-98BT203.5.** Understand the basic mechanisms of metabolic pathways **CO6-98BT203.6.** Evaluate total generation and consumption of ATP in each metabolic pathway	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L: T:P=2:1:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
BSC	98BT203	Biochemistry and metabolism	3	2	1	2	3+2+2+2=8	2+1+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL must be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		
BSC	98BT203	Biochemistry and metabolism	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		
BSC	98BT253	Biochemistry and metabolism	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	02	14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1-98BT203.1 Summarize concepts of cell biology.	SO1.1 Explain concept of Biochemistry	LI1.1 Basic instruments used in biochemical processes	CI1.1 Definition, scope, and importance of biochemistry	SL1.1 Find out some scope of biochemistry
	SO1.2 Define Basic terminology related to biochemistry	LI1.2Demonstrate the working of pH meter	CI1.2 Hydrogen bonding and structure of water molecule	SL1.2 Draw and elaborate structure of water molecule
	SO1.3 Elaborate the various types of bond formation		CI1.3 Chemical foundation of biology: pH, buffer	SL1.3 Write down different types of bonds with required diagrams
	SO1.4 Define the mechanism of pH and buffers		CI1.4 Weak bonds and covalent bonds	
	SO1.5 Explain the concept of and types of biomolecules		CI1.5 Structure, properties, and function of carbohydrate	
	SO1.6 Relate the concept of how biomolecules are involved in various processes		CI1.6 Classification of carbohydrate	

	SO1.7 Outline differences between various biomolecules		CI1.7 Biological role of peptidoglycan	
	SO, 1.8 Define the mechanism of biological separations		CI 1.8 Lipids: classification, structure, and function	
	SO, 1.9 Explain the role of peptidoglycan		CI1.9 Structure and function of fatty acid	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail about the scope and importance of biochemistry.
	SW1.2 Mini Project	Draw a diagram of pH meter and its mechanism.
	SW1.3 Other Activities (Specify)	Draw a structure of water molecule and its properties.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	0 4	01	03	17

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO2-98BT203.2. Explain the structure and function of biological molecules	SO2.1 Explain concept of and types of biomolecules	LI2.1 Perform Benedict's test for reducing sugars	CI2.1 Structure, properties, and function of carbohydrate	SL2.1 Structures of various biomolecules
	SO2.2 Relate the concept of how biomolecules are involved in various processes	LI2.2 Perform Iodine test for starch	CI2.2 Classification of carbohydrate	SL2.2 Different types of bonds present in each biomolecule
	SO2.3 Outline differences between various biomolecules	LI2.3 Perform Biuret test	CI2.3 Biological role of peptidoglycan	SL2.3 Write down a few points on the importance of biomolecules

		for protein		
	SO2.4 Define the mechanism of biological separations	LI2.4 Perform Emulsion test for lipids	CI2.4 Lipids: classification, structure, and function	
	SO2.5 Explain the role of peptidoglycan		CI2.5 Structure and function of fatty acid	
	SO2.6 Compare and contrast the structure of nucleic acids		CI2.6 Protein classification, primary, secondary, tertiary, and quaternary structure	
	SO2.7 Discuss the role of enzymes in biological processes		CI2.7 Enzyme kinetics and regulation	
	SO2.8 Illustrate the metabolic pathways of carbohydrates		CI2.8 Glycolysis and Krebs cycle	
	SO2.9 Analyze the impact of mutations on protein function		CI2.9 Genetic mutations and protein synthesis	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe types and importance of biomolecules.
	SW2.2 Mini Project	Make a flow chart on types of biomolecules with examples.
	SW2.3 Other Activities (Specify)	Make Power point presentation on how biomolecules are generated?

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO3-98BT203.3 Analyse enzyme kinetic data and regulation of enzyme activity.	SO3.1 Elucidate the characteristics and nomenclature parameters of the enzymes	LI3.1 Perform the Centrifugation process as Unit Operation	CI3.1 Introduction, characteristics, and nomenclature of enzymes	SL3.1 Find out the examples of different groups of enzymes according to their classification
	SO3.2 Classify the different types of enzymes according to various criteria		CI3.2 Classification of enzymes	SL3.2 What are vitamins and how are they important to our body?
	SO3.3 Elaborate on the importance, types, and		CI3.3 Application of enzymes	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	03	01	02	15

	classification of vitamins with their respective functions			
	SO 3.4 Explain the role of plant and animal hormones		CI3.4 Vitamins: Introduction, classification, and function	
	SO 3.5 Discuss micro and macronutrients		CI3.5 Micro and macronutrients	
	SO 3.6 Introduce the importance of plant and animal hormones		CI3.6 Introduction and importance of plant and animal hormones	
	SO 3.7 Explain the concept of enzymes	LI3.2 Basic instruments used in biochemical processes	CI 3.7 Definition, scope, and importance of biochemistry	
	SO 3.8 Define Basic terminology related to enzyme kinetics	LI3.3 Demonstrate the working of pH meter	CI 3.8 Hydrogen bonding and structure of water molecule	
	SO 3.9Elaborate the various types of bond formation		CI 3.9 Chemical foundation of biology: pH, buffer	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	03	15

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Classification of vitamins and its sources. Differentiate between fat soluble and water-soluble vitamins.
	SW3.2 Mini Project	Differentiate between micronutrient and macronutrients
	SW3.3 Other Activities (Specify)	Prepare one Power point presentation on Mechanism of action of enzymes.

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO4-98BT203.4 Identify the key molecules involved in regulation of metabolic pathways and disorders. Evaluate total generation and consumption of ATP in each metabolic pathway	SO4.1: Understand the role and characteristics of enzymes.	LI4.1: Perform enzyme assays to determine activity and specificity.	CI4.1: Lecture on the biochemical properties and functions of enzymes.	SL4.1: Research and prepare a report on the latest advancements in enzyme technology.
	SO4.2: Classify enzymes based on their types of reactions.	LI4.2: Analyze vitamin content in food samples using spectrophotometry.	CI4.2: Discuss case studies on industrial applications of enzymes.	SL4.2: Create a chart that categorizes vitamins based on solubility and their functions.
	SO4.3: Explain the application of enzymes in various industries.		CI4.3: Group activities to classify and name different enzymes.	SL4.3: Develop a presentation on the role of different hormones in plant and animal growth.
	SO4.4: Describe the importance of vitamins and their functions.		CI4.4: Presentation on the health benefits and sources of vitamins.	
	SO4.5: Differentiate between water-soluble and fat-soluble vitamins.		CI4.5: Interactive session on the role of macronutrients in the diet.	

	SO4.6: Identify the role of macronutrients in human health.		CI4.6: Explain the differences between micro and macronutrients.	
	SO4.7: Understand the significance of micronutrients and their sources.		CI4.7: Debate on the importance of plant hormones in agriculture.	
	SO4.8: Explain the role of plant hormones in growth and development.		CI4.8: Analyse the physiological effects of animal hormones through examples.	
	SO4.9: Discuss the importance of animal hormones in regulating bodily functions.		CI4.9: Quizzes on the classification and function of vitamins and nutrients.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Detailed description about pentose phosphate pathway
	SW4.2 Mini Project	Draw a flow chart of glycolysis and TCA cycle
	SW4.3 Other Activities (Specify)	Find out some videos about how lipid metabolism takes place.

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO5-98BT203.5 Metabolism- Basic concept, anabolism and catabolism, carbohydrate metabolism, glycolysis, gluconeogenesis, TCA, pentose phosphate pathway and its significance. Lipid metabolism- β-oxidation and ω-oxidation, biosynthesis of fatty	SO5.1: Understand the basic concepts of metabolism.	LI5.1: Perform experiments to measure the rate of glycolysis in yeast cells.	CI5.1: Lecture on the fundamental principles of metabolism.	SL5.1: Research and prepare a report on the significance of the TCA cycle.
	SO5.2: Differentiate between anabolism and catabolism.	LI5.2: Analyze the levels of key intermediates in the TCA cycle.	CI5.2: Discussion on anabolic and catabolic pathways.	SL5.2: Create a flowchart of the glycolysis pathway.
	SO5.3: Explain the steps and significance of glycolysis.		CI5.3: Group activity to map out the glycolysis pathway.	SL5.3: Develop a presentation on the pentose phosphate pathway and its significance.
	SO5.4: Describe gluconeogenesis and its importance.		CI5.4: Presentation on the key enzymes involved in gluconeogenesi	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	03	15

			s.	
	SO5.5: Understand the TCA cycle and its role in metabolism.		CI5.5: Lecture on the TCA cycle and its integration with other pathways.	
	SO5.6: Explain the pentose phosphate pathway.		CI5.6: Interactive session on the significance of the pentose phosphate pathway.	
	SO5.7: Describe β-oxidation and ω-oxidation of fatty acids.		CI5.7: Discussion on the steps involved in β-oxidation and ω-oxidation.	
	SO5.8: Understand the biosynthesis of fatty acids.		CI5.8: Lecture on the biosynthesis of fatty acids and its regulation.	
	SO5.9: Explain the regulation of carbohydrate and lipid metabolism.		CI5.9: Quizzes on carbohydrate and lipid metabolism pathways.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general mechanism of urea cycle
	SW5.2 Mini Project	Describe the biosynthesis of purine and pyrimidine nucleotides and various reactions of amino acids.
	SW5.3 Other Activities (Specify)	Prepare power point presentation of urea cycle.

Course Duration (in hours) to Attain Course Outcomes

Course Title: Biochemistry and metabolism **Course Code:** 98BT203

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-98BT203.1. Summarize concepts of cell biology	9	2	2	1	14
CO2-98BT203.2. Explain the structure and function of biological molecules	9	4	3	1	17
CO3-98BT203.3. Analyse enzyme kinetic data and regulation of enzyme activity	9	3	2	1	15
CO4-98BT203.4. Identify the key molecules involved in regulation of metabolic pathways and disorders. Evaluate total generation and consumption of ATP in each metabolic pathway	9	2	3	1	15
CO5-98BT203.5. Understand the basic mechanisms of metabolic pathways	9	2	3	1	15
Total Hours	45	13	13	05	76

End semester Assessment Scheme for Setting up Question Paper and Assessment to Evaluate the Course Outcome

Course Title: Biochemistry and metabolism **Course Code:** 98BT203

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-98BT203.1. Summarize concepts of cell biology	2	1	1	1	5
CO2-98BT203.2. Explain the structure and function of biological molecules.	2	4	4	1	11
CO3-98BT203.3. Analyze enzyme kinetic data and regulation of enzyme activity.	3	5	4	1	13
CO4-98BT203.4. Identify the key molecules involved in regulation of metabolic pathways and disorders. Evaluate total generation and consumption of ATP in each metabolic pathway.	2	3	5	1	11
CO5-98BT203.5. Understand the basic mechanisms of metabolic pathways.	5	4	1	0	10
Total Marks	**14**	**17**	**15**	**04**	**50**

Legend: **A,** apply; **An,** analyze; **E,** evaluate; **C,** create

Suggested Learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Outlines of Biochemistry: Conn & Stump
2	Principles of Biochemistry: Voet & Voet
3	Principles of Biochemistry: Jeffory Zubey
4	Clinical Biochemistry: D.C Deb.
5	Biochemistry: Stryer
6	Lehninger's Principles of Biochemistry: Nelson & Cox

(b) Online Resources:

1	https://ocw.mit.edu/courses/7-05-general-biochemistry-spring-2020/
2	https://www.nobelprize.org/prizes/lists/all-nobel-prizes-in-chemistry/
3	Biochemical Principles of Energy Metabolism | Coursera

(c) Suggested instructions/Implementation Strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Demonstration
7. ICT Based teaching Learning

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology **Semester:** II Semester

Course Title: Biochemistry and metabolism **Course Code:** 98BT203

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
COs	PO1	PO2	PO3	PO 4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-98BT203.1. Summarize concepts of cell biology	-	1	-	1	2	2	3	-	2	2	3	3	1	2	1
CO2-98BT203.2. Explain the structure and function of biological molecules	-	1	-	-	-	-	3	-	2	2	3	3	3	-	2
CO3-98BT203.3. Analyse enzyme kinetic data and regulation of enzyme activity	-	1	1	1	-	-	3	-	2	2	3	3	1	2	-
CO4-98BT203.4. Identify the key molecules involved in regulation of metabolic pathways and disorders.	-	-	1	-	2	2	3	3	2	2	3	3	2	1	3
CO5-98BT203.5. Understand the basic mechanisms of metabolic pathways	-	-	1	-	-	2	3	3	2	2	3	3	1	1	2
CO6-98BT203.6. Evaluate total generation and consumption of ATP in each metabolic pathway	-	-	1	1	2	2	3	3	2	2	3	3	2	1	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,4,5,6 7,9,10,11,12 PSO 1,2, 3	**CO1-98BT203.1.** Summarize concepts of cell biology	SO1.1 SO1.2 SO1.3 SO1.4	LI 1 LI 2	1.1,1.2,1.3,1.4	1SL-1,2,3
PO 1,2,7,8,9,10,11,12 PSO 1, 3	**CO2-98BT203.2.** Explain the structure and function of biological molecules	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5	LI 1 LI 2 LI 3 LI 4	2.1, 2.2, 2.3, 2.4, 2.5,2.6	2SL-1,2,3
PO 1,2,3,4,5,6 7,9,10,11,12 PSO 1,2	**CO3-98BT203.3.** Analyse enzyme kinetic data and regulation of enzyme activity	SO3.1 SO3.2 SO3.3 SO3.4	LI 1	3.1,3.2,3.3,3.4,3.5, 3.6	3SL-1,2
PO 1,2,3,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-98BT203.4.** Identify the key molecules involved in regulation of metabolic pathways and disorders. Evaluate total generation and consumption of ATP in each metabolic pathway	SO4.1 SO4.2 SO4.3 SO4.4	LI 1	4.1,4.2,4.3,4.4,4.5, 4.6,4.7	4SL-1,2,3
PO 1,2,3,6 7,8,9,10,11,12 PSO 1,2, 3	**CO5-98BT203.5.** Understand the basic mechanisms of metabolic pathways	SO5.1 SO5.2 SO5.3	LI 1	5.1,5.2,5.3,5.4,5.5,	5SL-1,2

Program Name	Bachelor of Technology (B.Tech.)- Biotechnology	
Semester	II	
Course Code:	98EV205	
Course title:	**Ecology & Environmental Studies**	**Curriculum Developer**: Ms. Suman Patel
Pre-requisite:	The student must have a knowledge about the environmental components, pollution, biodiversity, and ecosystem at senior secondary, **Class** 12th level.	
Rationale:	Ecology and environmental science integrate concepts from various disciplines, including biology, chemistry, physics, geography, sociology, and economics. This interdisciplinary approach encourages students to think critically, make connections between different fields of study, and apply their knowledge to real-world problems. It also prepares them for careers in fields such as environmental management, conservation biology, renewable energy, and sustainability.	
Course Outcomes (COs):	**CO1-98EV205.1:** Learn about environment and Natural resources. **CO2-98EV205.2:** Students will learn about natural resources, their importance and environmental impacts of human activities on natural resource. **CO3-98EV205.3:** Gain knowledge about ecosystems & the conservation of biodiversity and its importance. **CO4-98EV205.4:** Aware students about problems of environmental pollution, its impact on human and ecosystem and control measures. **CO5-98EV205.5:** Apply the knowledge to resolve various social & environmental issues.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L: T:P=2:0:0)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
HS	98EV205	Ecology & Environmental Studies	2	0	1	2	5	2

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL must be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
HS	98EV205	Ecology & Environmental Studies	15	20	10	5	50	50	100

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	0	01	02	09

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
98EV205.1: Learn about environment and Natural	SO1.1: Define the scope and importance of natural resources.	LI1.1: Conduct an experiment to	CI1.1: Lecture on the definition and importance	SL1.1: Research and write a report on the need for public awareness regarding natural

resources.		assess the impact of deforestation on soil quality.	of natural resources.	resource conservation.
	SO1.2: Understand the need for public awareness about environmental issues.		CI1.2: Discuss the need for public awareness and its impact on resource conservation.	SL1.2: Develop a presentation on sustainable practices for conserving water resources.
	SO1.3: Identify problems associated with the over-exploitation of forest resources.		CI1.3: Case study analysis on deforestation and its effects.	
	SO1.4: Explain the issues related to water resources, including over-utilization, floods, and droughts.		CI1.4: Group discussion on the benefits and problems of dams.	
	SO1.5: Describe the challenges of land resource management, including land degradation, soil erosion, and desertification.		CI1.5: Lecture on land degradation, soil erosion, and desertification.	
	SO1.6: Discuss the conflicts over water resources and the role of dams in water management.		CI1.6: Interactive session on conflicts over water resources.	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	0	01	02	09

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments: Describe in detail components of environment. **SW1.2**Mini Project **SW1.3** Other Activities (Specify)

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
98EV205.2: Students will learn about natural resource, its importance and environmental impacts of human activities on natural resource.	SO2.1: Understand world food problems and their causes.		CI2.1: Lecture on the global food crisis and contributing factors.	SL2.1: Research and write a report on the effects of modern agriculture on food security.
	SO2.2: Discuss the effects of modern agriculture practices.		CI2.2: Group discussion on sustainable agricultural practices.	SL2.2: Develop a presentation on the benefits and challenges of alternate energy sources.
	SO2.3: Explain the problems associated with fertilizer and pesticide use.		CI2.3: Case study analysis on the environmental impact of fertilizers and pesticides.	
	SO2.4: Identify the uses and environmental effects of extracting and using mineral resources.		CI2.4: Lecture on the exploitation of mineral resources and its environmental consequences.	
	SO2.5: Describe the growing energy needs and the role of		CI2.5: Discussion on the comparison between	

	renewable and non-renewable energy sources.		renewable and non-renewable energy sources.	
	SO2.6: Explain the role of individuals in conserving natural resources and promoting equitable use for sustainable lifestyles.		CI2.6: Interactive session on the role of individuals in resource conservation.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments: Discuss the roll of an individual in conservation of natural resources. **SW2.2** Mini Project **SW2.3** Other Activities (Specify)

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	0	01	03	10

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
98EV205.3: Gain knowledge about ecosystem and the conservation of biodiversity and its importance.	SO3.1: Understand the concept of an ecosystem and its components.		CI3.1: Lecture on the structure and function of ecosystems.	SL3.1: Research and prepare a report on the value of biodiversity at global and local levels.
	SO3.2: Describe the structure and function of different ecosystems.		CI3.2: Discussion on energy flow and ecological succession in ecosystems.	SL3.2: Create a presentation on the types and characteristics of terrestrial and aquatic ecosystems.
	SO3.3: Explain energy flow and ecological succession in ecosystems.		CI3.3: Case study analysis of food chains, food webs, and ecological pyramids.	SL3.3: Write an essay on the threats to biodiversity and conservation strategies.
	SO3.4: Identify food chains, food webs, and ecological pyramids.		CI3.4: Lecture on food chains, food webs, and ecological pyramids.	
	SO3.5: Understand the diversity of ecosystems and their classification.		CI3.5: Presentation on the biogeographical classification of India.	
	SO3.6: Discuss the threats to biodiversity and conservation strategies.		CI3.6: Interactive session on endangered and endemic species of India.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments: Describe the structure of pond ecosystem. **SW2.2** Mini Project **SW2.3** Other Activities (Specify)

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
98EV205.4: Aware students about problems of environmental pollution, its impact on human and ecosystem and control measures.	SO4.1: Define various types of pollution and their causes.		CI4.1: Lecture on the definition, causes, and effects of air and water pollution.	SL4.1: Research and write a report on the effects of noise and thermal pollution.
	SO4.2: Explain the effects and control measures of air and water pollution.		CI4.2: Discussion on control measures for air and water pollution.	SL4.2: Develop a presentation on solid waste management strategies.
	SO4.3: Describe the causes and effects of soil, marine, and noise pollution.		CI4.3: Case study analysis on soil and marine pollution.	SL4.3: Write an essay on the role of individuals in preventing pollution.
	SO4.4: Discuss control measures for soil, marine, and noise pollution.		CI4.4: Lecture on control measures for noise and marine pollution.	
	SO4.5: Understand the role of solid waste management in urban and industrial contexts.		CI4.5: Group discussion on urban and industrial waste management practices.	
	SO4.6: Review disaster management strategies for floods, earthquakes, cyclones, and landslides.		CI4.6: Interactive session on disaster management and case studies.	

Item	Cl	LI	SW	SL	Total
Approx.Hrs	06	0	01	02	9

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments: Discuss the effects of air pollution on plants, humans, animals and environment **SW4.2** Mini Project **SW4.3** Other Activities (Specify)

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	0	01	02	09

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
98EV205.5: Apply the knowledge to resolve various social & environmental issues.	SO5.1: Understand the principles of sustainable development.		CI5.1: Lecture on the concept and principles of sustainable development.	SL5.1: Research and write a report on urban problems related to energy and water conservation.
	SO5.2: Explain water conservation methods including rainwater harvesting and watershed management.		CI5.2: Discussion on rainwater harvesting and watershed management techniques.	SL5.2: Develop a presentation on the resettlement and rehabilitation of people and its associated problems.
	SO5.3: Discuss environmental ethics and possible solutions.		CI5.3: Interactive session on environmental ethics and possible solutions.	SL5.3: Write an essay on the impact of climate change and global warming.
	SO5.4: Describe the impacts of climate change, global warming, and acid rain.		CI5.4: Lecture on climate change, global warming, acid rain, and ozone layer depletion.	
	SO5.5: Identify the causes and effects of ozone layer depletion and nuclear accidents.		CI5.5: Case study analysis on nuclear accidents and their environmental impact.	
	SO5.6: Understand environmental legislation and the importance of public awareness.		CI5.6: Discussion on environmental legislation and public awareness strategies.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments: Explain rainwater harvesting system. **SW5.2** Mini Project **SW5.3** Other Activities (Specify)

Course Duration (in Hours) to Attain Course Outcomes

Course Title: Ecology & Environmental Studies **Course Code:**98EV205

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-98EV205.1: Learn about environment and Natural resources	6	0	2	1	9
CO2-98EV205.2: Students will learn about natural resource, its importance and environmental impacts of human activities on natural resource	6	0	2	1	9
CO3-98EV205.3: Gain knowledge about ecosystem & the conservation of biodiversity and its importance	6	0	3	1	10
CO4-98EV205.4: Aware students about problems of environmental pollution, its impact on human and ecosystem and control measures	6	0	2	1	9
CO5-98EV205.5: Apply the knowledge to resolve various social & environmental issues	6	0	2	1	9
Total Hours	30	0	11	05	46

End Semester Assessment Scheme for Setting Up Question Paper and Assessment to Evaluate the Course Outcome

Course Title: Ecology & Environmental Studies **Course Code:** 98EV205

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-98EV205.1: Learn about environment and Natural resources.	2	1	1	1	5
CO2-98EV205.2: Students will learn about natural resources, its importance and environmental impacts of human activities on natural resource.	2	4	2	2	10
CO3-98EV205.3: Gain knowledge about ecosystem & the conservation of biodiversity and its importance.	2	3	3	2	10
CO4-98EV205.4: Aware students about problems of environmental pollution, its impact on human and ecosystem and control measures.	3	5	5	2	15
CO5-98EV205.5: Apply the knowledge to resolve various social & environmental issues.	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

***Legend**: A: apply; An: analyze, E: evaluate, C: create*

Suggested learning Resources:

(a) Books:

S. No.	Title/Author/Publisher details
1	A textbook of Environmental Studies, Erach Bharucha, UGC Publication Delhi
2	A textbook of Environmental science: Purohit Shami & Agrawal, Agrobios Student edition Jaipur
3	A textbook of Environmental Studies: Kaushi & Kaushik New age International Publication
4	Paryavaran Addhyan: MP Hindi Granth Academy

(b) Online Resources:

1. Khan Academy – Ecology: Khan Academy Ecology Course
2. National Geographic – Environment: National Geographic Environment
3. Coursera - Ecology and Environmental Science Courses: Coursera Ecology Courses

(c) Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B.Tech. Biotechnology **Semester:** II Semester

Course Title: Ecology & Environmental Studies **Course Code:** 98EV205

Course Outcomes (COs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-98EV205.1: Learn about environment and Natural resources.	3	3	2	2	1	1	2	1	2	1	1	1	3	2	2
CO2-98EV205.2: Students will learn about natural resource, its importance and environmental impacts of human activities on natural resource.	3	3	2	3	2	2	3	2	2	1	2	1	3	2	3
CO3-98EV205.3: Gain knowledge about ecosystem & the conservation of biodiversity and its importance.	3	3	2	3	2	2	3	2	2	1	2	1	3	3	3
CO4-98EV205.4: Aware students about problems of environmental pollution, its impact on human and ecosystem and control measures.	3	3	3	3	3	3	3	3	2	2	3	2	3	3	3
CO5-98EV205.5: Apply the knowledge to resolve various social & environmental issues.	3	3	3	3	3	3	3	3	2	3	3	2	3	3	3

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-98EV205.1:** Learn about environment and Natural resources.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8, 1.9	1SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO2-98EV205.2:** Students will learn about natural resource, its importance and environmental impacts of human activities on natural resource.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5		2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7,	2SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO3-98EV205.3:** Gain knowledge about ecosystem & the conservation of biodiversity and its importance.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5		3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8	3SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO4-98EV205.4:** Aware students about problems of environmental pollution, its impact on human and ecosystem and control measures.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5		4.1,4.2,4.3,4.4, 4.5, 4.6, 4.7, 4.8, 4.9	4SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO5-98EV205.5:** Apply the knowledge to resolve various social & environmental issues.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8		5.1,5.2,5.3,5.4,5.5, 5.6, 5.7, 5.8	5SL-1,2,3,4,5

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	II	
Course Code:	98ME206	
Course title:	Engineering Drawing	**Curriculum Developer**: Er. Alok Ranjan Tiwari
Pre-requisite:	Student should have basic knowledge of Geometry, Geometrical Shapes, basic knowledge of Computer, Mouse and keyboard use, navigating menus and dialogs, managing files and directories, etc.	
Rationale:	The students studying Graphics are essential in mechanical engineering, allowing engineers to visualize and communicate complex ideas clearly and concisely. Using graphics, engineers can create detailed plans for construction projects, analyses structural components, and convey design concepts to clients and stakeholders.	
Course Outcomes (COs):	**CO1-98ME206.1.** Get introduced with Engineering Graphics and visual aspects of design. **CO2-98ME206.2.** Know and use common drafting tools with the knowledge of drafting standards. **CO3-98ME206.3.** Apply computer aided drafting techniques to represent line, surface or solid models in different Engineering viewpoints. **CO4-98ME206.4.** Produce part models; carry out assembly operation and show working procedure of a designed project work using animation. **CO5-98ME206.5.** To make the student understand the viewing perception of a solid object in Isometric and perspective Projection, Design modulation and simulation by Auto CAD	

Scheme of Studies:

Board of Study	CourseCode	CourseTitle	Scheme ofstudies (Hours/Week)					Total Credits(C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
ESC	98ME206	Engineering Drawing	2	0	1	1	4	1+1=2

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others).
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies).
SW: Sessional Work (includes assignment, seminar, mini project etc.).
SL: Self Learning.
C: Credits.
Note: SW & SL must be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	**Scheme of Assessment (Marks)**							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		
ESC	98ME206	Engineering Drawing	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hrs

Item	Cl	LI	SW	SL	Total
Approx.Hrs	6	0	01	02	09

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**

CO1-98ME206.1. Get introduced with Engineering Graphics and visual aspects of design.	SO1.1: Understand the concept and applications of representative factor scales.		CI1.1: Lecture on the representative factor and its applications in scales.	SL1.1: Research and prepare a report on the different types of scales used in engineering drawing.
	SO1.2: Learn the construction techniques of plain scales.		CI1.2: Demonstrate the construction of plain scales.	SL1.2: Develop a presentation on the importance and applications of plain scales.
	SO1.3: Understand diagonal scales and their usage.		CI1.3: Discuss the construction and use of diagonal scales.	
	SO1.4: Learn to construct scales of chords.		CI1.4: Lecture on the construction and use of scales of chords.	
	SO1.5: Understand the construction of ellipse, parabola, and hyperbola by different methods.		CI1.5: Discuss different methods for constructing ellipse, parabola, and hyperbola.	
	SO1.6: Learn to draw normal and tangent lines to conic sections.		CI1.6: Lecture on constructing normal and tangent lines to ellipse, parabola, and hyperbola.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Ellipes by concentric circle method, Cycloid, Involutes of Circle
	SW1.2 Mini Project	Model of Hexagon, Pentagon, Square

Item	Cl	LI	SW	SL	Total
Approx.Hrs	6	0	01	02	09

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO2-98ME206.2. Know and use common drafting tools with the knowledge of drafting standards.	SO2.1: Understand the different types of projection.		CI2.1: Lecture on the types of projection and their applications.	SL2.1: Research and write a report on the historical development of projection techniques.
	SO2.2: Learn the principles of orthographic projection.		CI2.2: Demonstrate the process of creating orthographic projections.	SL2.2: Develop a presentation comparing first and third angle projection methods.
	SO2.3: Differentiate between first and third angle projection.		CI2.3: Discussion on the differences between first and third angle projections.	
	SO2.4: Understand the projection of points and lines.		CI2.4: Lecture on projecting points and lines in different planes.	
	SO2.5: Learn to project a line inclined to one plane.		CI2.5: Demonstrate the projection of lines inclined to one plane.	
	SO2.6: Understand the projection of a line inclined to both planes.		CI2.6: Interactive session on projecting lines inclined to both planes.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Draw Projection of point & Projection of Straight Line
	SW2.2 Mini Project	Make a project on different first & Third angle projection

Item	Cl	LI	SW	SL	Total
Approx. Hrs	0 6	00	01	02	09

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO3-98ME206.3. Apply computer aided drafting techniques to represent line, surface or solid models in different engineering viewpoints.	SO3.1: Understand the projection of planes such as circles and polygons in different positions.	-	CI3.1: Lecture on the principles of projecting planes in different positions.	SL3.1: Research and create a report on the applications of plane projections in engineering.
	SO3.2: Learn to project polyhedrons like prisms in different positions.	-	CI3.2: Demonstrate the projection techniques for prisms.	SL3.2: Develop a presentation on the significance of prism projections in technical drawing.
	SO3.3: Understand the projection of pyramids in various orientations.	-	CI3.3: Discussion on the methods for projecting pyramids.	
	SO3.4: Learn the projection techniques for solids of revolution such as cylinders.	-	CI3.4: Lecture on projecting cylinders in different positions.	
	SO3.5: Understand the projection of cones in various orientations.	-	CI3.5: Demonstrate the projection methods for cones.	
	SO3.6: Apply knowledge of projecting different solids in practical scenarios.	-	CI3.6: Interactive session on the applications of projections of solids in engineering and design.	

Suggested	**SW3.1** Assignments	Draw three problems of projection of plane

Item	Cl	LI	SW	SL	Total
Approx. Hrs	0 6	00	01	02	09

Sessional Work (SW): *anyone*	**SW3.2** Mini Project	Make models of plane and solid by thermocol

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO4-98ME206.4. Produce part models; carry out assembly operation and show working procedure of a designed project work using animation.	SO4.1: Understand the sectioning of right solids by normal planes.		CI4.1: Lecture on the principles of sectioning right solids with normal planes.	SL4.1: Research and write a report on the applications of solid sectioning in engineering.
	SO4.2: Learn to section right solids using inclined planes.		CI4.2: Demonstrate sectioning techniques for right solids with inclined planes.	SL4.2: Develop a presentation on the importance of inclined plane sectioning in design.
	SO4.3: Understand the intersection of cylinders.		CI4.3: Discussion on the methods for determining the intersection of cylinders.	
	SO4.4: Learn the development of surfaces using the parallel line method.		CI4.4: Lecture on the parallel line method for surface development of right solids.	
	SO4.5: Understand the radial line method for surface development.		CI4.5: Demonstrate the radial line method for developing surfaces of right solids.	
	SO4.6: Apply knowledge of sectioning and surface development in practical scenarios.		CI4.6: Interactive session on the applications of sectioning and surface development in engineering and design.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Develop prism and cylinder
	SW4.2 Mini Project	Develop pyramid and Cone

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	00	01	02	09

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO5-98ME206.5 To make the student understand the viewing perception of a solid object in Isometric and perspective Projection, Design modulation and simulation by Auto CAD	SO5.1: Understand the concept of isometric scale and isometric axes.		CI5.1: Lecture on isometric scale, axes, and their applications.	SL5.1: Research and write a report on the historical development and applications of isometric projections.
	SO5.2: Learn to create isometric projections from orthographic drawings.		CI5.2: Demonstrate the process of converting orthographic drawings to isometric projections.	SL5.2: Develop a presentation on the significance of isometric projections in engineering design.
	SO5.3: Introduction to Computer Aided Drafting (CAD).		CI5.3: Lecture on the benefits and applications of CAD in engineering.	
	SO5.4: Understand the basic commands of CAD software.		CI5.4: Demonstrate basic drafting commands in CAD such as line, circle, polygon.	
	SO5.5: Learn transformations and editing commands in CAD.		CI5.5: Lecture on transformation and editing commands like move, rotate, mirror, array.	
	SO5.6: Apply CAD skills to solve projection		CI5.6: Interactive session on solving projection	

	problems.		problems using CAD.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Draw Isometric view of a cone resting centrally on a cube
	SW5.2 Mini Project	Drawing of different orthographic view of planes and solid by Auto CAD commands

Course duration (in hours) to Attain Course Outcomes

Course Title: Bioprocess Equipment Design **Course Code:**98ME206

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98ME206.1. Get introduced with Engineering Graphics and visual aspects of design.	6	0	2	1	9
CO2-98ME206.2. Know and use common drafting tools with the knowledge of drafting standards.	6	0	2	1	9
CO3-98ME206.3. Apply computer aided drafting techniques to represent line, surface or solid models in different engineering viewpoints.	6	0	2	1	9
CO4-98ME206.4. Produce part models; carry out assembly operation and show working procedure of a designed project work using animation.	6	0	2	1	9
CO5-98ME206.5. To make the student understand the viewing perception of a solid object in Isometric and perspective Projection, Design modulation and simulation by Auto CAD	6	0	2	1	9
Total Hours	30	00	10	5	45

End semester Assessment Scheme for Setting up Question Paper and Assessment to Evaluate the Course Outcome

Course Title: Engineering Drawing **Course Code:**98ME206

Course Outcomes	Marks Distribution				Total Marks
	A	**An**	**E**	**C**	
CO1-98ME206.1. Get introduced with Engineering Graphics and visual aspects of design.	2	1	1	1	5
CO2-98ME206.2. Know and use common drafting tools with the knowledge of drafting standards.	2	4	5	1	12
CO3-98ME206.3. Apply computer aided drafting techniques to represent line, surface or solid models in different engineering viewpoints.	3	5	5	1	14
CO4-98ME206.4. Produce part models; carry out assembly operation and show working procedure of a designed project work using animation.	2	3	5	1	11
CO5-98ME206.5. To make the student understand the viewing perception of a solid object in Isometric and perspective Projection, Design modulation and simulation by Auto CAD	2	4	1	1	10
Total Marks	**11**	**17**	**17**	**05**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

CO, PO and PSO Mapping

Program Name: B.Tech. Biotechnology **Semester:** II Semester

Course Title: Engineering Drawing **Course Code:** 98ME206

Course Outcomes (COs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-98ME206.1. Get introduced with Engineering Graphics and visual aspects of design.	3	2	2	1	2	1	1	1	2	1	1	1	3	2	2
CO2-98ME206.2. Know and use common drafting tools with the knowledge of drafting standards.	3	3	2	1	2	1	1	1	2	1	1	1	3	2	2
CO3-98ME206.3. Apply computer aided drafting techniques to represent line, surface or solid models in different engineering viewpoints.	3	3	3	2	3	2	2	1	2	1	2	2	3	3	3
CO4-98ME206.4. Produce part models; carry out assembly operation and show working procedure of a designed project work using animation.	3	3	3	3	3	3	3	1	3	2	3	2	3	3	3
CO5-98ME206.5. To make the student understand the viewing perception of a solid object in Isometric and perspective Projection, Design modulation and	3	3	3	3	3	2	2	2	3	2	3	2	3	3	3

simulation by Auto CAD																

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum Map

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO1-98ME206.1** Get introduced with Engineering Graphics and visual aspects of design.	SO1.1 SO1.2 SO1.3 SO1.4		1.1,1.2,1.3,1.4,1.5,1.6	**1SL-1,2**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO2-98ME206.2** Know and use common drafting tools with the knowledge of drafting standards.	SO2.1 SO2.2 SO2.3 SO2.4		1.1,1.2,1.3,1.4,1.5,1.6	**2SL-1,2**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO3-98ME206.3** Apply computer aided drafting techniques to represent line, surface or solid models in different engineering viewpoints.	SO3.1 SO3.2		1.1,1.2,1.3,1.4,1.5,1.6	**3SL-1,2**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO4-98ME206.4** Produce part models; carry out assembly operation and show working procedure of a designed project work using animation.	SO4.1 SO4.2 SO4.3		1.1,1.2,1.3,1.4,1.5,1.6	**4SL-1,2**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO5-98ME206.5** To make the student understand the viewing perception of a solid object in Isometric and perspective Projection, Design modulation and simulation by Auto CAD	SO5.1 SO5.2 SO5.3		1.1,1.2,1.3,1.4,1.5,1.6	**5SL-1,2**

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Computer Aided Engg drawing, VTU Belgaum, Visvesvaraya Tech. University
2	Engineering Drawing, Bhatt N.D., Panchal V.M. & Ingle P.R., Charotar Publishing House
3	Engineering Drawing, R.K. Dawan, S. Chand Publication.
4	Engineering Drawing, Agrawal and Agrawal, TMH

(b) Online Resources:

1. Online Resource for Ecology and Environment Ecology and Environmental Science by The Nature Conservancy
2. Online Resource for Ecology and Environment EPA's Environmental Education
3. Online Resource for Ecology and Environment National Geographic's Environment Section

(c) Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Beverage producing plants & Distillery/Fermenter units
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	II	
CourseCode:	98MS207	
Coursetitle:	Mathematics	**Curriculum Developer**: Ms. Arpana Tripathi
Pre-requisite:	Students should have basic knowledge of calculus	
Rationale:	Modeling and Analysis: Engineers use mathematical models to represent real-world systems, whether they are designing structures, optimizing processes, or simulating physical phenomena. Mathematics is a critical aspect of engineering as it provides the tools and techniques necessary for modeling and analyzing complex systems. In engineering, mathematics is used extensively for designing and analyzing structures and machines.	
CourseOutcomes (COs):	**CO1-98BT506-A.1.** Explain the basic concept of vectors and coordinate geometry **CO2-98BT506-A.2.** Apply differentiation and integration in vector &scalar valued functions **CO3-98BT506-A.3.** Classify and solve the ordinary differential equation with constant coefficients **CO4-98BT506-A.4.** Explain the basic concept of Laplace Transforms **CO5-98BT506-A.5.** Apply Basic numerical methods for finding roots differentiation and integration.	

Scheme of Studies:

Board ofStudy	CourseCode	CourseTitle	Scheme ofstudies (Hours/Week)					Total Credits(C) (L: T:P=1:1:0)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
BSC	98MS207	Mathematics	2	0	1	2	5	2

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
BSC	98MS207	Mathematics	15	20	5	5	5	50	50

Course-Curriculum:

<table>
<tr>
<td>This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.</td>
<td>ApproximateHours
<table>
<tr><td>Item</td><td>Cl</td><td>LI</td><td>SW</td><td>SL</td><td>Total</td></tr>
<tr><td>Approx.Hrs</td><td>06</td><td>00</td><td>01</td><td>2</td><td>09</td></tr>
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Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1-56MB205.1: Explain The Concept of Determinant and Matrix	SO1.1: Define Cramer's rule for solving simultaneous equations.		CI1.1: Lecture on the theory of Cramer's rule.	SL1.1: Write a report on solving simultaneous equations using Cramer's rule.
	SO1.2: Explain the solution methods for quadratic equations.		CI1.2: Class activity on solving quadratic equations.	
	SO1.3: Describe the properties and classification of matrices.		CI1.3: Lecture on special types of matrices and their characteristics.	
	SO1.4: Perform basic arithmetic operations on matrices.		CI1.4: Lecture on arithmetic operations involving matrices.	
	SO1.5: Compute the transpose of a matrix and understand its significance.		CI1.5: Practical session on calculating and using matrix transposes.	
	SO1.6: Find the inverse of a matrix and use it to solve simultaneous equations.		CI1.6: Demonstration of matrix inversion and solving equations.	SL1.2: Create a project on real-world applications of matrix inversion and simultaneous equations.

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail about the Determinant of the matrix
	SW1.2 Mini Project	Draw a well labelled diagram of a matrices
	SW1.3 Other Activities (Specify)	Write an article on "Latest research in the field of mathematics"

Item	Cl	LI	SW	SL	Total
Approx.Hrs	06	00	01	2	09

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO2-98BT506-A Define the role of Differentiation of standard function and Integration	SO2.1: Define limits and functions and their role in differentiation.		CI2.1: Lecture on the concept of limits and functions.	SL2.1: Write a report on the significance of limits in differentiation.
	SO2.2: Explain the definition and process of differentiation.		CI2.2: Class activity on differentiating standard functions.	
	SO2.3: Apply the chain rule to differentiate composite functions.		CI2.3: Class exercise on differentiating using the chain rule.	
	SO2.4: Perform implicit differentiation and logarithmic differentiation.		CI2.4: Discussion on practical applications of implicit differentiation.	SL2.2: Create a presentation on the use of logarithmic differentiation in solving real-world problems.
	SO2.5: Understand and apply parametric differentiation and successive differentiation.		CI2.5: Class activity on parametric and successive differentiation.	
	SO2.6: Explain		CI2.6: Lecture on integration	

	integration as the inverse of differentiation and solve integrals.		techniques including parts, substitution, and partial fractions.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	To solve Parametric differentiation, successive differentiation substitution and partial fraction
	SW2.2 Other Activities (Specify)	Attain at least one seminar or online talk on Calculus and its applications

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	00	01	02	09

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
98BT506-A.3. Comprehend the working Equations of first order and first degree, variable separable	SO3.1: Explain the formation of differential equations.		CI3.1: Equations of first order and first degree, variable separable, homogeneous and linear differential equations.	SL3.1: Study and summarize the concepts of equations of first order and first degree.
	SO3.2: Learn the concept of linear differential equations.		CI3.2: Characteristics of equations reducible to linear differential equations.	SL3.2: Research and review homogeneous and linear differential equations.
	SO3.3: Define the working of the integral.		CI3.3: Linear differential equations of order greater than one with constant coefficients.	
	SO3.4: Learn about the complementary function in		CI3.4: Application of linear	

	differential equations.		differential equations.	
	SO3.5: Analyze linear differential equations of order greater than one.		CI3.5: Complementary function and particular integral in linear differential equations.	
	SO3.6: Understand the characteristics of variable separable equations.		CI3.6: Characteristics of variable separable equations.	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	00	01	02	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO4-98BT506-A.4: Introduction transforms of elementary function, properties of linearity	SO4.1: Observe the role of linearity and shifting in Laplace Transforms.		CI4.1: Definition and transforms of elementary functions in Laplace Transforms.	SL4.1: Read and summarize information on elementary functions in Laplace Transforms.
	SO4.2: Explore common applications of inverse Laplace Transforms.		CI4.2: Define and understand the properties of linearity in Laplace Transforms.	SL4.2: Study and review the properties of transforms of elementary functions.
	SO4.3: Analyze the working and applications of Laplace Transforms.		CI4.3: Define and understand the properties of shifting in Laplace Transforms.	

	SO4.4: Recognize various applications of linearity and shifting in Laplace Transforms.		CI4.4: Introduction to inverse Laplace Transforms and their applications.	
	SO4.5: Discover the applications of transforms of elementary functions.		CI4.5: Application of transforms of elementary functions in solving differential equations.	
	SO4.6: Investigate the disadvantages of Laplace Transforms.		CI4.6: Discuss and analyze the disadvantages and limitations of Laplace Transforms.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Write an article on "Role of transforms in elementary function"
	SW4.2 Other Activities (Specify)	Make a presentation on Non-Viral Gene therapy techniques

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	00	01	02	09

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
98BT506-A.5. To Examine Distance between two points area of triangle, a locus of points, straight line, slope	SO5.1: Introduce Analytical Plane Geometry and understand its basic concepts.		CI5.1: Introduction to Analytical Plane Geometry and basic forms (double intercept, normal, slope-point).	SL5.1: Investigate the role of Geometry in practical applications.
	SO5.2: Recognize the		CI5.2: Define and understand	**SL5.2:** Explore various

	limitations of Geometry in real-life applications.		certain coordinates and their significance in Analytical Plane Geometry.	kinds of Geometry and their limitations.
	SO5.3: Analyze principles and concepts of Geometry and their applications.		CI5.3: Calculate distance between two points and area of a triangle using Analytical Plane Geometry.	
	SO5.4: Define the concept of locus of points, straight line, slope, and intercept form.		CI5.4: Understand and apply the concepts of locus of points, straight line, and slope-intercept form.	
	SO5.5: Explore applications of straight lines and slopes in Analytical Plane Geometry.		CI5.5: Apply concepts of straight lines and slopes to solve problems in Analytical Plane Geometry.	
	SO5.6: Understand and use the two-point form and general equation of the first degree.		CI5.6: Learn about and solve problems using the two-point form and general equation of the first degree.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Write an article on "Role of Geometry and its Properties"
	SW5.2 Other Activities (Specify)	Make a presentation on Lab-On-A-Chip technique with applications

Course duration (in hours) to attain Course Outcomes:

Course Title: Mathematics **Course Code:** 98MS207

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Sessional work (SW)	Self-Learning (SL)	Total Hours (Li+CI+SW+SL)
CO1-98MS207**.1:** Explain Determinant and Matrix	6	0	1	2	09
CO2-98MS207**.2:** Apply differentiation and integration in vector &scalar valued functions	6	0	1	2	09
CO3-98MS207**.3:** Classify and solve the ordinary differential equation with constant coefficients	6	0	1	2	09
CO4-98MS207**.4:** Explain the basic concept of Laplace Transforms	6	0	1	2	09
CO5-98MS207**.5:** Apply Basic numerical methods for finding roots differentiation and integration	6	0	1	2	09
Total Hours	30	0	05	10	45

End Semester Assessment Scheme for Setting Up Question Paper and Assessment to Evaluate the Course Outcome

Course Title: Mathematics **Course Code:** 98MS207

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-98MS207**.1:** Explain Determinant and Matrix	2	1	1	1	5
CO2-98MS207**.2:** Apply differentiation and integration in vector &scalar valued functions	3	4	2	1	10
CO3-98MS207**.3:** Classify and solve the ordinary differential equation with constant coefficients	4	5	5	1	15
CO4-98MS207**.4:** Explain the basic concept of Laplace Transforms	3	4	3	0	10
CO5-98MS207**.5:** Apply Basic numerical methods for finding roots differentiation and integration	5	4	1	0	10
Total Marks	**17**	**18**	**12**	**03**	**50**

Legend**: A,** apply; **An,** Analyze**, E-**Evaluate**, C,** Create

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology
Semester: II Semester
Course Title: Mathematics
Course Code: 98MS207

Course Outcome COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-98MS207**.1:** Explain Determinant and Matrix	-	-	-	1	2	2	2	-	1	2	2	3	3	3	1
CO2-98MS207**.2:** Apply differentiation and integration in vector &scalar valued functions	-	-	-	-	-	-	3	-	2	2	3	3	1	1	2
CO3-98MS207**.3:** Classify and solve the ordinary differential equation with constant coefficients	-	1	1	2	-	-	2	-	1	1	1	2	1	3	1
CO4-98MS207**.4:** Explain the basic concept of Laplace Transforms	-	1	1	-	2	2	2	2	-	1	-	-	1	2	2
CO5-98MS207**.5:** Apply Basic numerical methods for finding roots differentiation and integration	1	1	1	-	-	2	3	3	1	2	2	2	1	1	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-**98MS207**.1:** Explain Determinant and Matrix	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5	**LI 1**	1.1,1.2,1.3,1.4,1.5	**1SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-**98MS207**.2:** Apply differentiation and integration in vector &scalar valued functions	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5	**LI 1** **LI 2**	2.1, 2.2, 2.3, 2.4, 2.5	**2SL-1,2,3**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3-**98MS207**.3:** Classify and solve the ordinary differential equation with constant coefficients	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5	**LI 1**	3.1,3.2,3.3,3.4,3.5	**3SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-**98MS207**.4:** Explain the basic concept of Laplace Transforms	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5	**LI 1**	4.1,4.2,4.3,4.4, 4.5	**4SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO5-**98MS207**.5:** Apply Basic numerical methods for finding roots differentiation and integration	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5	**LI 1**	5.1,5.2,5.3,5.4,5.5	**5SL-1,2,3,4,5**

Suggested learning Resources:

(a) Books:

1. Mathematics Part I - Textbook for Class XI, NCERT Publication
2. Mathematics Part II - Textbook for Class XI, NCERT Publication

3. Analytic Geometry - Shantinarayan, HC Sinha, DK Jha, Sharma
4. Ordinary Differential Equations - Golden Series, NP Bali
5. Differential Equations - Chaurasia, V B L, Indus Valley Publications, Jaipur, 2006

(b) Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Demonstration
7. ICT Based teaching Learning
8. Brainstorming

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	II	
CourseCode:	98IKS208	
Coursetitle:	Fundamentals of Indian Knowledge System	**Curriculum Developer**: Ms. Arpana Tripathi
Pre-requisite:	Creating awareness among the youths about the true history and past rich culture of India.	
Rationale:	India has very rich and versatile knowledge system and cultural heritage since antiquity. The Indian Knowledge systems was developed on life science, medical science, literature, drama, art, music, dance, astronomy, mathematics, architecture (Sthapatyaveda), chemistry, aeronautics etc., during ancient period. In this basic course, a special attention is given to the ancient and historical perspective of ideas occurrence in the ancient society, and implication to the concept of material world and religious, social and cultural beliefs. On the closer examination, religion, culture and science have appeared epistemological very rigidly connected in the Indian Knowledge System. This land of Bharat Bhumi has provided invaluable knowledge stuff to the society and the world in all spheres of life.	
Course Outcomes (COs):	**CO-98IKS208.1:** To understand the ancient civilization, Indian knowledge systems, concept of Panch Mahabhuta, origin of the name Bharat Varsha, ancient rivers, ancient universities, and ancient agriculture. **CO-98IKS208.2:** Students will be able to learn about ancient books, religious places, the basic concepts of Indian dance, music, and arts, as well as the fundamental aspects of Sangeeta and Natyashashtra. **CO-98IKS208.3:** Students will be able to gain knowledge on Vedic Science, Astronomy, Astrovastu, Vedic Mathematics, Aeronautics, Metallurgy, Nakhatras, Panchang, and Concepts of Zero, Pi, and Point. **CO-98IKS208.4:** Understanding Ancient Engineering, Science and Technology, Town Planning, Temple Architecture, Chemistry and Metallurgy, and Metal Manufacturing. **CO-98IKS208.5:** Students will be able to understand life, nature, and health through the basic concepts of Ayurveda and Yoga, Traditional Medicinal Systems, Ethnomedicine, Nature Conservation, and World Heritage Sites.	

Scheme of Studies:

Category of Course	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C)
			CI	LI	SW	SL	Total Study Hours CI+LI+SW+SL	
HS	98IKS208	Indian Knowledge System	2	0	1	1	4	2

Legend:
CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Session Work (includes assignment, seminar, mini project etc.),
SL: Self Learning,
C: Credits.

Assessment Scheme: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
HS	98IKS208	Indian Knowledge System	15	20	5	5	5	50	50

Course-Curriculum Detailing: This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	0 0	01	01	08

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO-98IKS208.1: To understand the ancient civilization, Indian knowledge systems, concept of Panch Mahabhuta, origin of the name Bharat Varsha, ancient rivers, ancient universities, and ancient agriculture.	SO1.1: Understand Overview of Indian Knowledge Systems (IKS)		CI1.1: Overview of Indian Knowledge Systems (IKS)	SL1.1 Golden era of India
	SO1.2: Understand Classification of Ancient IKS texts		CI 1.2: Classification of Ancient IKS texts	
	SO1.3: Understand Introduction to Panch Mahabhutas (Earth, Water, Fire, Sky, and Air)		CI 1.3: Introduction to Panch Mahabhutas (Earth, Water, Fire, Sky, and Air)	
	SO1.4: Understand Origin of the name Bharatvarsha: the Land of Natural Endowments		CI 1.4: Origin of the name Bharatvarsha: the Land of Natural Endowments	
	SO1.5: Understand Rivers of ancient India (The Ganga, Yamuna, Godawari, Saraswati, Narmada, Sindhu, and Kaveri)		CI1.5: Rivers of ancient India (The Ganga, Yamuna, Godawari, Saraswati, Narmada, Sindhu, and Kaveri)	
	SO1.6: Understand Ancient Agriculture and ancient Universities: Takshashila and Nalanda,		CI 1.6: Agriculture system in ancient India, Ancient Universities: Takshashila and Nalanda, Gurukul	

	Gurukul system		system	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	00	01	01	08

SW-1 Suggested Sessional Work (SW)	SW1.1 Assignments: Concepts of Panch Mahabhuta, Classification of ancient texts, origin of ancient rivers SW1.2 Mini Project: Ancient Universities: Takshashila and Nalanda, SW1.3 Other Activities (Specify):

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO-98IKS208.2: Students will be able to learn about ancient books, religious places, the basic concepts of Indian dance, music, and arts, as well as the fundamental aspects of Sangeeta and Natyashashtra	SO2.1: Understand the Ancient Indian Books: Vedas, Puranas, Shastras, Upanishads, Mahakavyas (Ramayana & Mahabharata), Smrities, Samhitas		CI2.1: Ancient Indian Books: Vedas, Puranas, Shastras, Upanishads, Mahakavyas (Ramayana & Mahabharata), Smrities, Samhitas	SL1.1Access to texts such as the Vedas, Puranas, and Upanishads.
	SO2.2: Understand the Religious Places: Puries, Dhams, Jyotiralinga, Shaktipeeths, Kumbha Mela		CI 2.2: Religious Places: Puries, Dhams, Jyotiralinga, Shaktipeeths, Kumbha Mela	
	SO2.3: Understand the Legendary Places of Madhya Pradesh: Ujjain, Chitrakoot, Omkareshwar, Bharhut, Maihar		CI 2.3: Legendary Places of Madhya Pradesh: Ujjain, Chitrakoot, Omkareshwar, Bharhut, Maihar	
	SO2.4: Understand the Basic Concept of Indian Art, Music and Dance, Indian Musical Instruments		CI 2.4: Basic Concept of Indian Art, Music and Dance, Indian Musical Instruments	
	SO2.5: Understand the Fundamental Aspects of Sangeeta and Natya Shastra		CI 2.5: Fundamental Aspects of Sangeeta and Natya Shastra	
	SO2.6: Understand the Different		CI 2.6: Different Schools of	

	Schools of Music, Dance, and Painting in Different Regions of India		Music, Dance, and Painting in Different Regions of India	

SW-2 Suggested Sessional Work (SW): anyone	**SW 2.1 Assignments:** Visit of Chitrakoot, Maihar and Bharhuta **SW 2.2 Mini Project:** Kumbhmela, Story of Ramayana and Mahabharata **SW 2.3 Other Activities (Specify):**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	00	01	01	08

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO-98IKS208.3: Students will be able to gain knowledge on Vedic Science, Astronomy, Astrovastu, Vedic Mathematics, Aeronautics, Metallurgy, Nakhatras, Panchang, and Concepts of Zero, Pi, and Point.	SO3.1: Understand Vedic Cosmology		CI 3.1: Vedic Cosmology	SL 3.1 Vedic Astronomy and Mathematics - The Historical Development
	SO3.2: Understand Astronomy, Astrovastu, Vedang Jyotish, Nakshatras, Navagraha, Rashis, Vastushastra and their related plants		CI 3.2: Astronomy, Astrovastu, Vedang Jyotish, Nakshatras, Navagraha, Rashis, Vastushastra and their related plants	
	SO3.3: Understand Time and Calendar, Panchang		CI 3.3: Time and Calendar, Panchang	
	SO3.4: Understand the Concept of Zero, Point, Pi -number system, Pythagoras		CI 3.4: Concept of Zero, Point, Pi -number system, Pythagoras	
	SO3.5: Understand Vedic Mathematics, Vimana-Aeronautics, Basic idea of planetary model of Aryabhatta		CI 3.5: Vedic Mathematics, Vimana-Aeronautics, Basic idea of planetary model of Aryabhatta	
	SO3.6: Understand the Varanamala of Hindi language based on classification of sounds on the basis of their origin, Basic purpose of science of Vyakarana		CI 3.6: Varanamala of Hindi language based on classification of sounds based on their origin, Basic purpose of science of Vyakarana	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	00	01	01	08

SW-3 Suggested Sessional Work (SW)	**SW3.1 Assignments:** Varanamala of Hindi language based on classification of sounds based on their origin **SW3.2 Mini Project:** Nakshatras, Navagraha and their related plants **SW3.3 Other Activities (Specify):**

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO-98IKS208.4: Understanding Ancient Engineering, Science and Technology, Town Planning, Temple Architecture, Chemistry and Metallurgy, and Metal Manufacturing.	SO 4.1: Understand the Engineering Science and Technology in Vedic and Post-Vedic Era		**CI** 4.1: Engineering Science and Technology in Vedic and Post-Vedic Era	SL3.1Temple Architecture of India
	SO 4.2: Understand Town and Home Planning, Sthapatyaveda		**CI** 4.2: Town and Home Planning, Sthapatyaveda	
	SO 4.3: Understand Chemistry and Metallurgy as gleaned from Archaeological Artifacts		**CI** 4.3: Chemistry and Metallurgy as gleaned from Archaeological Artifacts	
	SO 4.4: Understand the Chemistry of Dyes, Pigments used in Paintings, Fabrics, Potteries, and Glass		**CI** 4.4: Chemistry of Dyes, Pigments used in Paintings, Fabrics, Potteries, and Glass	
	SO 4.5: Understand Temple Architecture: Khajuraho, Sanchi Stupa, Chonsath Yogini Temple		**CI** 4.5: Temple Architecture: Khajuraho, Sanchi Stupa, Chonsath Yogini Temple	
	SO 4.6: Understand Mining and Manufacture in India of Iron, Copper, Gold from Ancient Times		**CI** 4.6: Mining and Manufacture in India of Iron, Copper, Gold from Ancient Times	

SW-4 Suggested Sessional Work (SW)	**SW 4.1 Assignments:** Varanamala of Hindi language based on classification of sounds based on their origin **SW4.2 Mini Project:** Nakshatras, Navagraha and their related plants **SW 4.3 Other Activities (Specify):**

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO-98IKS208.5: Students will be able to understand life, nature, and health through the basic concepts of Ayurveda and Yoga, Traditional Medicinal Systems, Ethnomedicine, Nature Conservation, and World Heritage Sites.	SO 5.1: Understand the Fundamentals of Ayurveda (Charaka & Shushruta) and Yogic Science (Patanjali), Ritucharya and Dinacharya		CI 5.1: Fundamentals of Ayurveda (Charaka & Shushruta) and Yogic Science (Patanjali), Ritucharya and Dinacharya	**SL5.1** Ethnobotany and Ethnomedicine of India
	SO 5.2: Understand the Traditional System of Indian Medicines (Ayurveda, Siddha, Unani, and Homoeopathy)		CI 5.2: Traditional System of Indian Medicines (Ayurveda, Siddha, Unani, and Homoeopathy)	
	SO 5.3: Understand Fundamentals of Ethnobotany and Ethnomedicines of India		CI 5.3: Fundamentals of Ethnobotany and Ethnomedicines of India	
	SO 5.4: Understand Nature Conservation in Indian Ancient Texts		CI 5.4: Nature Conservation in Indian Ancient Texts	
	SO 5.5: Understand the Introduction to Plant Science in Vrikshayurveda		CI 5.5: Introduction to Plant Science in Vrikshayurveda	
	SO 5.6: Understand the		CI 5.6: World Heritage	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	00	01	01	08

	World Heritage Sites of Madhya Pradesh: Bhimbetka, Sanchi, Khajuraho		Sites of Madhya Pradesh: Bhimbetka, Sanchi, Khajuraho	

SW-5 Suggested Sessional Work (SW):	**SW 5.1 Assignments:** Visit to world Heritage Site Khajuraho **SW 5.2 Mini Project:** Ritucharya and Dincharya, Ethnomedicinal plants **SW 5.3 Other Activities (Specify):**

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self-Learning (SL)	Total hour (Cl+SW+Sl)
98IKS208. 1: To understand Indian Civilization and Indian Knowledge Systems	6	1	1	8
98IKS208. 2: Students will have the ability to apply the knowledge gained about Indian Art, Literature and Religious Places	6	1	1	8
98IKS208. 3: Student will be able to understand the Ancient Science, Astronomy and Vedic Mathematics	6	1	1	8
98IKS208. 4: Understand the Engineering, Technology and Architecture	6	1	1	8
98IKS208. 5: Understand about the Life, Nature and Health	6	1	1	8
Total	30	5	5	40

Suggestion for End Semester Assessment

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	

CO1-98MS201**.1:** Indian Civilization and Indian Knowledge Systems	2	1	1	1	5
CO2-98MS201**.2:** Indian Art, Literature and Religious Places	3	4	2	1	10
CO3-98MS201**.3:** Ancient Science, Astronomy and Vedic Mathematics	4	5	5	1	15
CO4-98MS201**.4:** Engineering, Technology and Architecture	3	4	3	0	10
CO5-98MS201**.5:** Life, Nature and Health	5	4	1	0	10
Total Marks	**17**	**18**	**12**	**03**	**50**

Legend: A, apply; An, Analyze, E-Evaluate, C, Create

The end of semester assessment for **Indian Knowledge Systems** will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course teacher for above tasks. Teacher can also design different tasks as per requirement, for end semester assessment.

COs, POs and PSOs Mapping

Programme Title: B.Tech-Biotechnology **Semester:** II
Course Title: Fundamentals of Indian Knowledge System **Course Code:** 98IKS208

Course Outcome COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO-1: To understand the ancient civilization, Indian Knowledge Systems, Concept of Panch Mahabhuta, Origin of name Bharat Varsha, Ancient Rivers, Ancient Universities and ancient agriculture.	-	-	-	1	2	2	2	-	1	2	2	3	3	3	1
CO-2: Students will have the ability to learn about ancient books, Religious places, basic concept of Indian dance, music and arts, and fundamental aspects of Sangeeta and Natyashashtra etc.	-	-	-	-	-	-	3	-	2	2	3	3	1	1	2
CO-.3: Student will be able to gain knowledge on Vedic Science, Astronomy, Astrovastu, Vedic Mathematics, Aeronautics, Metallurgy, Nakhatras, Panchang, Concept of Zero, Pi and point etc.	-	1	1	2	-	-	2	-	1	1	1	2	1	3	1

CO- 4: Understanding on ancient Engineering, Science and Technology, Town Planning, Temple architecture, Chemistry and Metallurgy, Metal manufacturing etc.	-	1	1	-	2	2	2	2	-	1	-	-	1	2	2
CO- 5: Student will able to understand about the Life, Nature and Health through basic concept of Ayurveda and Yoga, Traditional Medicinal Systems, Ethnomedicine, Nature conservation, World Heritage Sites etc.	1	1	1	-	-	2	3	3	1	2	2	2	1	1	2

Legend 1–Low,2–Medium, 3–High

Course Curriculum Map

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
PO1,2,3,4,5,6, 7,8,9,10,11,12 PSO 1,2, 3, 4, 5	**CO-1:** To understand the ancient civilization, Indian Knowledge Systems, Concept of Panch Mahabhuta, Origin of name Bharat Varsha, Ancient Rivers, Ancient Universities and ancient agriculture.	SO1.1S O1.2SO 1.3SO1. 4 SO1.5		**Unit-1**: Indian Civilization and Indian Knowledge Systems 1.1,1.2,1.3,1.4,1.5,1.6	As mentioned,
PO1,2,3,4,5,6, 7,8,9,10,11,12 PSO 1,2, 3, 4, 5	**CO-2:** Students will have the ability to learn about ancient books, religious places, basic concept of Indian dance, music and arts, and fundamental aspects of Sangeeta and Natyashashtra etc.	SO2.1S O2.2SO 2.3 SO2.4 SO2.5		**Unit-2:** Indian Art, Literature and Religious Places 2.1,2.2,2.3,2.4,2.5,2.6	

PO1,2,3,4,5,6,7,8, 9,10,11,12 PSO 1,2, 3, 4, 5	**CO-.3:** Student will be able to gain knowledge on Vedic Science, Astronomy, Astrovastu, Vedic Mathematics, Aeronautics, Metallurgy, Nakhatras, Panchang, Concept of Zero, Pi and point etc.	SO3.1S O3.2 SO3.3 SO3.4, SO3.5		**Unit-3**: Ancient Science, Astronomy and Vedic Mathematics 3.1, 3.2,3.3,3.4,3.5,3.6	
PO1,2,3,4,5,6,7,8, 9,10,11,12 PSO 1,2, 3, 4, 5	**CO- 4:** Understanding on ancient Engineering, Science and Technology, Town Planning, Temple architecture, Chemistry and Metallurgy, Metal manufacturing etc.	SO4.1S O4.2SO 4.3SO4. 4 SO4.5		**Unit-4:** Engineering, Technology and Architecture 4.1, 4.2,4.3,4.4,4.5,4.6	
PO1,2,3,4,5,6,7,8, 9,10,11,12 PSO 1,2, 3, 4, 5	**CO- 5:** Student will able to understand about the Life, Nature and Health through basic concept of	SO5.1S O5.2SO 5.3SO5. 4, SO5.5		Unit 5: **Life, Nature and Health** 5.1,5.2,5.3,5.4,5.5,5.6	

	Ayurveda andYoga, Traditional Medicinal Systems, Ethnomedicine, Nature conservation, World Heritage Sites etc.				

Suggested Learning Resources:

(a) Books:

1. An Introduction of Indian Knowledge Systems: Concept and Applications - Mahadevan, B.; Bhat V. R. and Pavana, Nagendra R. N. - Prentice Hall of India, 2022
2. Indian Knowledge Systems: Vol. I and II - Kapoor, Kapil and Singh, A. K. - D.K. Print World Ltd, 2005
3. Science of Ancient Hindus: Unlocking Nature in Pursuit of Salvation - Kumar, Alok - Createpace Independent Publishing, 2014
4. A History of Agriculture in India - Randhava, M.S. - ICAR, New Delhi, 1980
5. Panch Mahabhuta - Yogcharya, Jnan Dev - Yog Satsang Ashram, 2021
6. The Indian Rivers - Singh, Dhruv Sen - Springer, 2018
7. The Wonder That Was India - Basam, Arthur Llewellyn - Sidgwick & Jackson, 1954
8. Ancient Cities, Sacred Skies: Cosmic Geometries and City Planning in Ancient India - Malville, J. MacKim & Gujaral, Lalit M. - IGNCA & Aryan Books International, New Delhi, 2000
9. The Natya Shastra of Bharat Muni - Jha, Narendra - Innovative Imprint, Delhi, 2023
10. Astronomy in India: A Historical Perspective - Padmanabhan, Thanu - Indian National Science Academy, New Delhi & Springer (India), 2010

(b) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Case Method
4. Group Discussion
5. Role Play
6. Visit to Religious places, World Heritage Sites
7. Demonstration
8. ICT Based Teaching Learning (Video Demonstration/Tutorials CBT, Blog, Facebook, Twitter, Whatsapp, Mobile, Online sources)
9. Brainstorming

Curriculum Development Team:

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2. Prof. B.A. Copade, Hon'ble Vice Chancellor, AKS University, Satna (M.P.).
3. Prof. G.C. Mishra, Director, IQAC, AKS University, Satna (M.P.).
4. Prof. R.L.S. Sikarwar, Director, Centre for Traditional Knowledge Research & Application, AKS University, Satna (M.P.).
5. Prof. Kamlesh Chaure, HOD, Department of Biotechnology, AKS University, Satna (M.P.).
6. Dr. Akhilesh Waoo, HoD, Department of Computer Science, AKS University, Satna (M.P.).
7. Dr. Shailendra Yadav, HoD, Department of Chemistry, AKS University, Satna (M.P.).
8. Dr. Kaushik Mukherji, HoD, Department of Management, AKS University, Satna (M.P.).
9. Dr. Neeraj Verma, PG Coordinator, Faculty of Agriculture Science and Technology, AKS University, Satna (M.P.)
10. Dr. Dilip Kumar Tiwari, HoD, Department of Yoga, AKS University, Satna (M.P.).
11. Shri Mirza Shamiullah Beg, Department of Arts, AKS University, Satna (M.P.).
12. Shri Vivek Shrivastava, Examination, AKS University, Satna (M.P.).
13. Shri Manish Agrawal, Department of Mining, AKS University, Satna (M.P.).

Program Name	**B. Tech. Biotech Semester**	
Semester	**III**	
Course Code:	**98BT301**	
Course title:	Computational Biology & Bioinformatics	**Curriculum Developer**: Mr. Piyush Kant Rai, Assistant Professor
Pre-requisite:	Biology fundamentals (molecular biology, genetics), programming (Python), statistics, mathematics, bioinformatics tools, genomics, NGS technologies, Linux/Unix, version control, and effective communication.	
Rationale:	The proposed syllabus integrates essential elements for bioinformatics proficiency. It combines foundational biology with practical programming skills, statistical and mathematical methods, and database management. This comprehensive approach ensures students acquire the necessary tools to analyze biological data, fostering a robust understanding of bioinformatics principles and applications.	
Course Outcomes (COs):	**98BT301.1:** The unit will explain bioinformatics history, homology, and utilize sequence databases (EMBL, GENBANK, Entrez, Unigene). **98BT301.2:** Analyze protein information from PDB, SWISS-PROT, TREMBL databases, mastering their structures for effective utilization in research. **98BT301.3:** Operates diverse data generation techniques, understand bioinformatics challenges, and apply problem-solving skills in biological analyses. **98BT301.4:** Master sequence and phylogeny analysis, detect ORFs, understand sequence assembly, mutation matrices, BLAST usage, and interpret results. **98BT301.5:** Navigate databases, execute similarity searches (BLAST, FASTA), and annotate genomes, integrating pattern finding and gene identification.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L: T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
PC	98BT301	Computational Biology and Bioinformatics	3	2	1	2	8	3+0+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning.

C: Credits.

Note: SW & SL must be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	**Scheme of Assessment (Marks)**						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
PC	**98BT301**	Computational Biology and Bioinformatics	15	20	5	10	50	50	100

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	02	16

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO1-98BT301.1: The unit will explain bioinformatics history,	SO1.1 Understand the concept of computational biology	Li1.1Analyze computational	CI1.1 Lecture on the fundamentals of computational	SL1.1 Read a review article on the evolution of

homology, and utilize sequence databases (EMBL, GENBANK, Entrez, Unigene).		biology case studies	biology and its importance	computational biology
	SO1.2 Introduction to bioinformatics	LI1.2 Hands-on session with bioinformatics tools	CI1.2 Lecture on the basics of bioinformatics and its role in computational biology	SL1.2 Watch an introductory video on bioinformatics tools and techniques
	SO1.3 Review the history of bioinformatics		CI1.3 Classroom discussion on the historical development of bioinformatics	
	SO1.4 Learn basic terminology used in bioinformatics		CI1.4 Lecture on key bioinformatics terms and definitions	
	SO1.5 Understand the scope and applications of bioinformatics		CI1.5 Discuss the various applications of bioinformatics in research and industry	
	SO1.6 Introduction to the National Center for Biotechnology Information (NCBI)		CI1.6 Lecture on the role of NCBI and its resources	
	SO1.7 Define and understand biological sequence databases		CI1.7 Classroom discussion on the importance and uses of biological sequence databases	
	SO1.8 Overview of various primary and secondary biological databases		CI1.8 Lecture on primary databases (e.g., GenBank, EMBL, DDBJ) and secondary databases (e.g., SwissProt, PIR)	
	SO1.9 Introduction to specific databases: GenBank, EMBL, DDBJ, Swiss Prot, PIR, MIPS, TIGR, TAIR		CI1.9 Classroom activity: Explore and compare different databases such as GenBank, SwissProt, and TAIR	

Suggested Sessional	**SW1.1** Assignments	Summarizes the GenBank, EMBL and DDBJ. .

Work (SW): *anyone*	**SW1.2** Mini Project	Demonstrate how to retrieve data from EMBL.
	SW1.3 Other Activities (Specify)	correlate the data redundancy among INSDC databases.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	**09**	04	01	2	**16**

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self Learning (SL)**

CO2-49BT505.2: Analyze protein information from PDB, SWISS-PROT, TREMBL databases, mastering their structures for effective utilization in research.	SO2.1 Define biological databases and their significance	2.1 Create a comparative report on different biological databases	CI 2.1 Lecture on the definition and importance of biological databases	SL2.1 Read articles on the role of biological databases in research
	SO 2.2 Identify and describe different types of biological databases		CI 2.2 Lecture on types of biological databases: primary, secondary, and others	SL2.2 Watch videos explaining various types of biological databases
	SO 2.3 Overview primary and secondary databases	2.2 Explore primary and secondary databases to understand their features	CI 2.3 Classroom discussion on the characteristics of primary and secondary databases	
	SO 2.4 Understand nucleic acid sequence databases (NCBI, EMBL, DDBJ)		CI 2.4 Lecture on nucleic acid sequence databases and their roles	
	SO 2.5 Explore the SWISS-PROT protein sequence database		CI 2.5 Classroom lecture on SWISS-PROT and its significance in protein sequence analysis	
	SO 2.6 Learn database searching techniques using BLAST and FASTA		CI 2.6 Lecture on BLAST and FASTA algorithms and their applications	
	SO 2.7 Perform and interpret BLAST searches		CI 2.7 Classroom activity on interpreting BLAST search results	
	SO 2.8 Perform and interpret FASTA searches		CI 2.8 Classroom discussion on the differences between BLAST and FASTA	
	SO 2.9 Compare results from BLAST and FASTA searches		CI2.9 Case study analysis of BLAST and FASTA results to understand their efficacy	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Justify the role of SwissProt in biotechnology.
	SW2.2 Mini Project	Interpret the TrEMBL result concerning the DNA.
	SW2.3 Other Activities (Specify)	Incorporate some youtube videos based on features of TrEMBL construction.

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO3-49BT505.3 Operates diverse data generation techniques, understand bioinformatics challenges, and apply problem-solving skills in biological analyses.	SO3.1 Understand the concepts of local and global alignments	LI3.1 Perform local and global alignments using alignment tools	CI3.1 Lecture on the difference between local and global alignments	SL3.1 Read articles on the applications of local and global alignments
	SO 3.2 Learn pairwise sequence alignment techniques	LI3.2 Use software to perform pairwise alignments and analyze results	CI3.2 Lecture on pairwise alignment methods and algorithms	SL3.2 Watch tutorials on pairwise sequence alignment techniques
	SO 3.3 Understand substitution scoring and gap penalties		CI3.3 Classroom discussion on scoring systems and the impact of gap penalties	SL3.3 Study different substitution matrices and their use cases
	SO 3.4 Comprehend the statistical significance of sequence alignments		CI3.4 Lecture on the statistical methods for evaluating alignment significance	SL3.4 Explore statistical models used in sequence alignment significance
	SO 3.5 Learn about multiple sequence alignment methods		CI3.5 Classroom discussion on various methods for multiple sequence alignment	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	**09**	**04**	**01**	04	**18**

	SO 3.6 Explore progressive alignment methods		CI 3.6 Lecture on progressive alignment methods and their applications	
	SO 3.7 Understand motifs and patterns in sequences		CI 3.7 Classroom discussion on the identification and significance of motifs and patterns	
	SO 3.8 Compare results from different alignment methods		CI 3.8 Classroom activity analyzing and comparing alignment results from different methods	
	SO 3.9 Apply sequence alignment techniques to real-world data		CI 3.9 Case study analysis of real-world applications of sequence alignment	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Write about Local and global alignment.
	SW3.2 Mini Project	
	SW3.3 Other Activities (Specify)	Search and find the amrita lab and there find alignment methods.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	**09**	**04**	**01**	04	**18**

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO4-49BT505.4 Master sequence and phylogeny analysis, detect ORFs, understand sequence assembly, mutation matrices, BLAST usage, and interpret results.	SO4.1 Understand the elements of a phylogenetic model	LI4.1 Construct a basic phylogenetic model using sample data	CI 4.1 Lecture on the elements and structure of phylogenetic models	SL4.1 Read articles on the development and use of phylogenetic models
	SO4.2 Learn data analysis techniques for phylogenetics	LI4.2 Analyze genetic data for phylogenetic studies using software tools	CI 4.2 Lecture on methods of data analysis in phylogenetics	SL4.2 Watch tutorials on phylogenetic data analysis

	SO4.3 Understand tree building methods		CI 4.3 Classroom discussion on different tree building methods	SL4.3 Research different phylogenetic tree building algorithms
	SO 4.4 Learn tree evaluation techniques		CI 4.4 Lecture on tree evaluation methods and criteria	SL4.4 Study case studies on phylogenetic tree evaluation
	SO 4.5 Explore methods for searching for a phylogenetic tree		CI 4.5 Classroom discussion on techniques for searching phylogenetic trees	
	SO 4.6 Understand the use of phylogenetic software		CI 4.6 Lecture on various phylogenetic software tools	
	SO 4.7 Learn to use CLUSTAL for phylogenetic analysis		CI 4.7 Classroom demonstration on using CLUSTAL for phylogenetic analysis	
	SO 4.8 Learn to use PHYLIP for phylogenetic analysis		CI 4.8 Classroom demonstration on using PHYLIP for phylogenetic analysis	
	SO 4.9 Understand UPGMA for phylogenetic analysis		CI4.9 Lecture on the UPGMA method and its applications	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Write about mathematical associated with phylogenetic analysis.
	SW4.2 Mini Project	
	SW4.3 Other Activities (Specify)	Search and learn via YouTube how to interpret phylogenetic tree.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	**09**	04	01	04	18

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO5-49BT505.5: Navigate databases, execute similarity searches (BLAST, FASTA), and annotate genomes, integrating pattern finding and gene identification.	SO5.1 Understand the physical properties of proteins	LI5.1 Analyze the physical properties of a given protein sample	CI 5.1 Lecture on the physical properties of proteins	SL5.1 Read articles on protein physical properties
	SO 5.2 Learn about secondary structures of proteins	LI5.2 Predict secondary structures using computational tools	CI 5.2 Classroom discussion on alpha and beta structures	SL5.2 Study secondary structure prediction methods
	SO 5.3 Understand alpha and beta structures		CI 5.3 Lecture on the significance of alpha and beta structures	SL5.3 Explore case studies involving alpha and beta structures
	SO 5.4 Learn about protein motifs		CI 5.4 Classroom discussion on common protein motifs	SL5.4 Research different protein motifs and their functions
	SO 5.5 Understand tertiary structures of proteins		CI 5.5 Lecture on the formation and significance of tertiary structures	
	SO 5.6 Explore specialized protein structures		CI 5.6 Classroom discussion on specialized structures and their functions	
	SO 5.7 Learn about protein conformation		CI 5.7 Lecture on protein conformation and its importance	
	SO 5.8 Understand the role of bioinformatics in drug discovery		CI 5.8 Lecture on bioinformatics applications in drug discovery	

	SO 5.9 Learn about docking and prediction of drug quality		CI5.9 Classroom discussion on docking methods and drug quality prediction	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Write about protein function aspect and its properties.
	SW5.2 Mini Project	
	SW5.3 Other Activities (Specify)	Try to learn and apply Rasmol to learn protein structure using virtual lab.

Course duration (in hours) to attain Course Outcomes

Course Title: Computational biology and bioinformatics **Course Code:** 98BT301

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98BT301.1: The unit will explain bioinformatics history, homology, and utilize sequence databases (EMBL, GENBANK, Entrez, Unigene).	9	4	2	1	16
CO2-98BT301.2: Explain Bioinformatics resources, computational tools and associated algorithms	9	4	2	1	16
CO3-98BT301.3: Analyze protein information from PDB, SWISS-PROT, TREMBL databases, mastering their structures for effective utilization in research.	9	4	4	1	18
CO4-98BT301.4: Analyze evolutionary tree to understand evolutionary genetics	9	4	4	1	18
CO5-98BT301.5: Compare sequence alignment tools to predict structures & functions of gene, RNA and Proteins & Predict protein structures and its functional annotations through databases	9	4	4	1	18
Total Hours	45	20	16	5	86

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title Computational biology and bioinformatics **Course Code** 98BT301

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-98BT301.1: The unit will explain bioinformatics history, homology, and utilize sequence databases (EMBL, GENBANK, Entrez, Unigene).	02	03	04	1	10
CO2-98BT301.2: Analyze protein information from PDB, SWISS-PROT, and TREMBL databases, mastering their structures for effective utilization in research.	03	04	02	1	10
CO3-98BT301.3: Analyze protein information from PDB, SWISS-PROT, TREMBL databases, mastering their structures for effective utilization in research.	02	05	02	1	10
CO4-98BT301.4: Analyze evolutionary tree to understand evolutionary genetics	02	05	02	1	10
CO5-98BT301.5: Compare sequence alignment tools to predict structures & functions of gene, RNA and Proteins & Predict protein structures and its functional annotations through databases.	03	04	03	1	11
Total Marks	12	21	13	05	51

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Bioinformatics Thomas Dandekar, Meik Kunz Springer-Verlag GmbH Germany, part of Springer Nature 2023
2	Introduction to bioinformatics, Arthur Lesk Oxford University Press 2023
3	Essential bioinformatics, Jin Xiong, Cambridge University Press 2007

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Research lab (BSL-1)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B.Tech. Biotechnology
Semester: III

Course Title: Computational Biology and Bioinformatics **Course Code:** 98BT301

CO/PO/PSO Mapping															
Course Outcome (Cos)	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	PO1	**PO 2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-98BT301.1: The unit will explain bioinformatics history, homology, and utilize sequence databases (EMBL, GENBANK, Entrez, Unigene).	-	-	-	1	2	2	1	-	1	2	2	3	3	3	1
CO2-98BT301.2: Analyze protein information from PDB, SWISS-PROT, and TREMBL databases, mastering their structures for effective utilization in research.	-	-	-	-	-	-	3	-	2	2	3	3	1	1	2
CO3-98BT301.3: Analyze protein information from PDB, SWISS-PROT, TREMBL databases, mastering their structures for effective utilization in research.	-	1	1	1	-	-	2	-	3	1	1	2	1	1	1
CO4-98BT301.4: Analyze	-	1	1	-	2	2	2	3	-	1	-	-	1	2	3

evolutionary tree to understand evolutionary genetics															
CO5-98BT301.5: Compare sequence alignment tools to predict structures & functions of gene, RNA and Proteins & Predict protein structures and its functional annotations through databases.	1	1	1	-	-	2	3	3	1	2	2	2	1	-	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 4,5,6 7,9,10,11,12 PSO 1,2, 3	**CO1-98BT301.1:** The unit will explain bioinformatics history, homology, and utilize sequence databases (EMBL, GENBANK, Entrez, Unigene).	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	**IL 1** **IL 2**	1.1,1.2,1.3,1.4,1.5,1.6, 1.7 1.8 1.9	**1SL-1,2**
PO 7,9,10,11,12 PSO 1,2, 3	**CO2-98BT301.2:** Analyze protein information from PDB, SWISS-PROT, and TREMBL databases, mastering their structures for effective utilization in research.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	**IL 1** **IL 2**	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7 2.8 2.9	**2SL-1,2**
PO 2,3,4, 7,9,10,11,12	**CO3-98BT301.3:** Analyze protein information from PDB, SWISS-	SO3.1 SO3.2 SO3.3 SO3.4	**IL 1** **IL 2**	3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8, 3.9	**3SL-1,2,3,4**

PSO 1,2, 3	PROT, TREMBL databases, mastering their structures for effective utilization in research.	SO3.5 SO3.6 SO3.7 SO3.8 SO3.9			
PO 2,3,5,6 7,8,10,11,12 PSO 1,2, 3	**CO4-98BT301.4:** Analyze evolutionary tree to understand evolutionary genetics	SO4.1 SO4.2 SO4.3 SO4.4,SO 4.5,SO4.6 SO4.7 SO4.8 SO4.9	**IL 1** **IL 2**	4.1,4.2,4.3,4.4,4.5,4.6, 4.7, 4.8, 4.9	**4SL-1,2,3,4**
PO 1,2,3,6 7,8,9,10,11,12 PSO 1, 3	**CO5-98BT301.5:** Compare sequence alignment tools to predict structures & functions of gene, RNA and Proteins & Predict protein structures and its functional annotations through databases.	SO5.1 SO5.2 SO5.3 SO5.4,SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	**IL 1** **IL 2**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9	**5SL-1,2,3,4**

Program Name	B.Tech. Biotechnology	
Semester	**III**	
Course Code:	**98BT302**	
Course title:	**Principles of Microbiology**	**Curriculum Developer**: Mr. Vivek Kumar Agnihotri, Assistant Professor
Pre-requisite:	To understand and work effectively in microbiology, especially when preparing consortia as you described, it's important to have a strong foundation in the basics of microbiology.	
Rationale:	Understanding the principle of microbiology revolves around microorganisms, their functions, and their roles in various environments, including their interactions with humans, animals, plants, and the ecosystem. The rationale for studying microbiology is multi-faceted, encompassing scientific, medical, environmental, and industrial perspectives.	
Course Outcomes (COs):	**CO1.** Understand the different fields in microbiology. **CO2.** Understand the growth and control of microbes as well as different bacteriological techniques involved in microbiology. **CO3.** Acknowledged about the different types of microorganisms and their significance. **CO4.** How to interact microorganisms with higher organisms. **CO5.** Identify novel microbes by using standard operating procedures used in microbiology.	

Scheme of Studies:

Board of Study	**Course Code**	**Course Title**	**Scheme of studies (Hours/Week)**					**Total Credits (C) (L:T:P=3:0:1)**
			Cl	LI	SW	SL	**Total Study Hours (CI+LI+SW+SL)**	
BSC	**98BT302**	**Principles of Microbiology**	4	0	0	0	4	4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning.

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	**Scheme of Assessment (Marks)**						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
Program Elective (PE)	**98BT302**	Principles of Microbiology		20	5	5	5	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	04	18

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO1: Understand the	**SO1.1** Know about the Microbial World	**LI1.1** Learn how to handle pathogens	**CI1.1** Introduction to the microbial world	**SL1.1** Remember Carriers in Disease Transmission

different fields in microbiology.	**SO1.2** Learn about the History of Microorganisms	**LI1.2** Practice historical resume techniques	**CI1.2** Historical Resume	**SL1.2** Explore the microflora of the university
	SO1.3 Know about the life of Microbes	**LI1.3** Prepare and observe microbial samples	**CI1.3** Microbial life	**SL1.3** Investigate microbial life in local environments
	SO1.4 Know about Prokaryotic & Eukaryotic Microorganisms		**CI1.4** Prokaryotes & Eukaryotes	**SL1.4** Compare prokaryotic and eukaryotic microorganisms
	SO1.5 Learn about the Archea & Protozoa		**CI1.5** Archea & Protozoa	
	SO1.6 Learning of classification of microorganisms		**CI1.6** Classification of microorganisms	
	SO1.7 Know about the Microbial Cell Structure		**CI1.7** Structure of microbial cell	
	SO1.8 Know about the cyanobacteria		**CI1.8** Characteristics of cyanobacteria	
	SO1.9 Know about the actinomycetes		**CI1.9** Characteristics of actinomycetes	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Summarizes classification of microorganism- Bacteria.
	SW1.2 Mini Project	Demonstrate how to isolate microbes from soil.
	SW1.3 Other Activities (Specify)	

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO2: Understand the growth and control of microbes as well as different bacteriological	SO2.1 Understand the basic principles of light microscopy	LI2.1 Prepare sample for light microscopy	CI2.1 Light microscope: basic principles	SL2.1 Create a chart of the parts of a light microscope
	SO2.2 Learn about phase contrast microscopy		CI2.2 Types of phase contrast microscopy	SL2.2 Draw a diagram of phase contrast microscopy

techniques involved in microbiology.	SO2.3 Learn about dark field microscopy		CI2.3 Basic principles of dark field microscopy	
	SO2.4 Learn about fluorescent microscopy		CI2.4 Basic principles and types of fluorescent microscopy	
	SO2.5 Understand the principles of electron microscopy	LI2.2 Prepare sample for electron microscopy	CI2.5 Principles of electron microscope	
	SO2.6 Learn about the working and function of electron microscopy		CI2.6 Working and function of electron microscope	
	SO2.7 Know about electron probe microscopy		CI2.7 Electron probe microscopy	
	SO2.8 Understand the types of electron microscopy (TEM, SEM, STEM)		CI2.8 Types of electron microscopy: TEM, SEM, STEM	
	SO2.9 Learn about sample preparation for electron microscopy	LI2.3 Sample preparation for EM analysis	CI2.9 Sample preparation for EM analysis	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	02	16

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Justify the role of SEM and TEM in biotechnology.
	SW2.2 Mini Project	Differentiate between SEM and TEM.
	SW2.3 Other Activities (Specify)	Incorporate some YouTube videos based on features of how TEM works.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	1	3	**17**

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO3: Acknowledged about the different types of microorganisms and their significance.	SO3.1 Understand the mathematical expression of microbial growth	LI3.1 Calculate microbial growth rates	CI3.1 Mathematical expression of microbial growth	SL3.1 Review and summarize mathematical models of microbial growth
	SO3.2 Learn to interpret growth curves		CI3.2 Growth curve: phases and characteristics	SL3.2 Plot and analyze a growth curve from experimental data
	SO3.3 Measure microbial growth accurately		CI3.3 Methods for measuring microbial growth	
	SO3.4 Understand synchronous culture techniques		CI3.4 Synchronous culture: principles and applications	
	SO3.5 Learn about continuous culture systems		CI3.5 Continuous culture: concepts and methods	
	SO3.6 Understand the cultivation of microorganisms	LI3.2 Practice cultivation techniques	CI3.6 Cultivation of microorganisms: methods and conditions	
	SO3.7 Learn about sterilization techniques		CI3.7 Sterilization methods and their applications	
	SO3.8 Understand biosafety in microbial work		CI3.8 Biosafety guidelines and practices	
	SO3.9 Learn about pure culture techniques		CI3.9 Pure culture techniques and isolation methods	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Write about Sterilization Techniques.
	SW3.2 Mini Project	
	SW3.3 Other	Know about Biosafety Levels.

	Activities (Specify)	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	03	17

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO4: How to interact microorganisms with higher organisms.	SO4.1 Identify different types of pathogens	LI4.1 Identification of pathogens in clinical samples	CI4.1 Types of pathogens and their characteristics	SL4.1 Research and summarize case studies of specific pathogens
	SO4.2 Understand the sources of infection, including carriers and vectors		CI4.2 Sources of infection: carriers and vectors	SL4.2 Explore local carriers and vectors of infectious diseases
	SO4.3 Learn about congenital infections		CI4.3 Congenital infections: causes and effects	
	SO4.4 Understand modes and sources of infection		CI4.4 Modes of infection and sources	
	SO4.5 Study pathogenesis of bacterial infections		CI4.5 Pathogenesis of bacterial infections	
	SO4.6 Study pathogenesis of fungal infections		CI4.6 Pathogenesis of fungal infections	
	SO4.7 Study pathogenesis of viral infections		CI4.7 Pathogenesis of viral infections	
	SO4.8 Study pathogenesis of protozoan infections		CI4.8 Pathogenesis of protozoan infections	
	SO4.9 Learn about prophylaxis and preventive measures	LI4.2 Techniques for testing antimicrobial efficacy	CI4.9 Prophylaxis and preventive measures for infections	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Write about the Morphology and Pathogenesis of Herpes Virus.
	SW4.2 Mini Project	

	SW4.3 Other Activities (Specify)	Search and learn via YouTube how to take Preventive Measures and Chemotherapy for the Papova Virus.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	03	17

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO5: Identify novel microbes by using standard operating procedures used in microbiology.	SO5.1 Understand methods to assess microbial diversity	LI5.1 Use methods to assess microbial diversity	CI5.1 Methods for assessing microbial diversity	SL5.1 Research and summarize various methods of assessing microbial diversity
	SO5.2 Learn about culture-dependent methods and their merits and demerits		CI5.2 Culture-dependent methods: merits and demerits	SL5.2 Compare culture-dependent and culture-independent methods in microbial studies
	SO5.3 Learn about culture-independent methods and their merits and demerits		CI5.3 Culture-independent methods: merits and demerits	
	SO5.4 Understand molecular analysis techniques for bacterial communities	LI5.2 Perform molecular analysis of bacterial communities	CI5.4 Molecular analysis techniques: density gradient, gel electrophoresis	
	SO5.5 Study density gradient centrifugation for bacterial analysis		CI5.5 Density gradient centrifugation: principles and applications	
	SO5.6 Learn about gel electrophoresis for bacterial community analysis		CI5.6 Gel electrophoresis: techniques and interpretation	
	SO5.7 Understand Restriction Fragment Length		CI5.7 RFLP: principles and applications	

	Polymorphism (RFLP)			
	SO5.8 Learn about 16S rRNA gene analysis for microbial diversity		CI5.8 16S rRNA gene analysis: methods and significance	
	SO5.9 Compare and contrast molecular techniques for bacterial community analysis		CI5.9 Comparison of molecular techniques for bacterial analysis	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Write about the Microbial Diversity
	SW5.2 Mini Project	
	SW5.3 Other Activities (Specify)	Try to learn about 16s RNA Sequencing.

Course duration (in hours) to attain Course Outcomes:

Course Title: Principles of Microbiology **Course Code:** 98BT302

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1. Understand the different fields in microbiology.	09	04	04	01	18
CO2. Understand the growth and control of microbes as well as different bacteriological techniques involved in microbiology.	09	04	02	01	16
CO3. Acknowledged about the different types of microorganisms and their significance.	09	04	03	01	17
CO4. How to interact microorganisms with higher organisms.	09	04	03	01	17
CO5. Identify novel microbes by using standard operating procedures used in microbiology	09	04	03	01	17

Total Hours	45	20	15	05	85

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome

Course Title: Principles of Microbiology **Course Code:** 98BT302

Course Outcomes	Marks Distribution				Total Marks
	U	A	An	E	
CO1. Understand the different fields in microbiology.	02	03	04	1	10
CO2. Understand the growth and control of microbes as well as different bacteriological techniques involved in microbiology.	03	04	02	1	10
CO3. Acknowledged about the different types of microorganisms and their significance.	02	05	02	1	10
CO4. How to interact microorganisms with higher organisms.	02	05	02	1	10
CO5. Identify novel microbes by using standard operating procedures used in microbiology	03	03	03	1	10
Total Marks	12	20	13	05	50

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

List of Books	
1	Textbook of Microbiology, R.C. Dubey and D. K. Maheshwari, S. Chand Publications, 5 & 2022
2	Microbiology, M.J. Pelczar, E.C.S Chan and N.R. Kreig, McGraw Hill, 5 & 2002
3	General Microbiology, R. Y. Stanier, E. A. Adelberg, J. L. Ingraham, Mac Millan Press, 1 & 2014
4	General Microbiology, Hans G. Schlegel, Cambridge University Press, 7 & 2000

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Microbiology lab
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO, and PSO Mapping

Program Name: B.Tech. Biotechnology
Semester: IIIrd Sem

Course Title: Principles of Microbiology **Course Code:** 98BT302

CO/PO/PSO Mapping															
Course Outcome (Cos)	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1. Understand the different fields in microbiology.	1	-	-	1	2	2	1	-	1	2	2	3	3	3	1
CO2. Understand the growth and control of microbes as well as different bacteriological techniques involved in microbiology.	1	-	2	-	-	-	3	2	2	2	3	3	1	1	2
CO3. Acknowledged about the different types of microorganisms and their significance.	1	1	1	1	1	-	2	-	3	1	1	2	1	1	1
CO4. How to interact microorganisms with higher organisms.	-	1	1	-	2	2	2	3	-	1	-	-	1	2	3
CO5. Identify novel microbes by using standard operating procedures used in	1	1	1	-	-	2	3	3	1	2	2	2	1	-	2

microbiology															

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 4, 5, 6, 7, 9, 10, 11, 12 PSO 1,2, 3	**CO1**. Understand the different fields in microbiology.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6	IL 1 IL 2	1.1,1.2,1.3,1.4,1.5,1.6	1SL-1,2
PO 7,9,10,11,12 PSO 1,2, 3	**CO2.** Understand the growth and control of microbes as well as different bacteriological techniques involved in microbiology.	SO2.1 SO2.2 SO2.3 SO2.4	IL 1 IL 2	2.1, 2.2, 2.3, 2.4	2SL-1,2
PO 2,3,4, 7,9,10,11,12 PSO 1,2, 3	**CO3.** Acknowledged about the different types of microorganisms and their significance.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6	IL 1 IL 2	3.1,3.2,3.3,3.4,3.5	3SL-1,2
PO 2,3,5,6 7,8,10,11,12 PSO 1,2, 3	**CO4.** How to interact microorganisms with higher organisms.	SO4.1 SO4.2 SO4.3 SO4.4, SO 4.5, SO4.6	IL 1 IL 2	4.1,4.2,4.3,4.4,4.5,4.6	4SL-1,2
PO 1,2,3,6 7,8,9,10,11,12 PSO 1, 3	**CO5.** Identify novel microbes by using standard operating procedures used in microbiology	SO5.1 SO5.2 SO5.3 SO5.4, SO5.5	IL 1 IL 2	5.1,5.2,5.3,5.4,5.5	5SL-1

Program Name	**B.Tech. Biotechnology**	
Semester	III	
CourseCode:	98BT303	
Coursetitle:	Biostatistics	**Curriculum Developer**: KEERTI SAMDARIYA, Assistant Professor
Pre-requisite:	Student should have basic knowledge of biostatistics, their role and application in biological field.	
Rationale:	The paper on BIOSTATISTICS in an B.Tech Biotechnology program explores the role of biostatistics and their activity in biological systems. Biostatistics pertains to the acquisition and interpretation of quantitative information in medical research. Finding the correct mathematical hypotheses, biological models, and statistical tests is essential for adequate study designs as a mandatory prerequisite for useful study outcomes.	
CourseOutcomes (COs):	**98BT303.1:** Describe the roles biostatistics serves in the discipline of public health. **98BT303.2:** Apply basic statistical concepts commonly used in public health and health Sciences **98BT303.3:** Demonstrate basic analytical techniques to generate results **98BT303.4:** Interpret results of commonly used statistical analyses in written summaries **98BT303.5:** Demonstrate statistical reasoning skills accurately and contextually	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L: T:P)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
BSC	98BT303	Biostatistics	2	0	1	1	5	1+1+1= 3

Legend: **CI:** Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)

SW: Sessional Work (includes assignment, seminar, mini project etc.),

SL: Self Learning,

C: Credits.

Note: SW & SL must be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA+CAT+AT)		
BSC	98BT303	Biostatistics	15	20	5	5	5	50	50	100
PC	98BT353	Biostatistics (Lab 3)	15	20	5	5	5	50	50	100

Course-Curriculum Detailing: This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Item	**CI**	**LI**	**SW**	**SL**	**Total**
Approx. Hrs.	**06**	**4**	**01**	**02**	**13**

CO.1 98BT303.1: Describe the roles biostatistics serves in the discipline of public health.	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
	SO1.1 Understand the definitions, historical development, and applications of biostatistics.	LI1.1 Conduct a historical analysis of key developments in biostatistics through a lab presentation.	CI1.1 Lecture: Introduction to biostatistics - Definitions, historical resume, and applications.	SL1.1 Research and write a report on the historical milestones in the field of biostatistics.
	SO 1.2 Identify and apply different methods of sampling.	LI1.2 Perform a simple random sampling and non-random sampling exercise using a dataset.	CI 1.2 Discussion: Methods of sampling - Random sampling and non-random sampling.	SL1.2 Develop a flowchart illustrating the steps involved in different sampling methods.
	SO 1.3 Understand sampling errors and non-sampling errors.		CI 1.3 Case Study: Identify sampling and non-sampling errors in a real-world study.	
	SO 1.4 Learn the types of data and methods for data collection.		CI 1.4 Workshop: Types of data and methods for data collection.	
	SO 1.5 Understand how to organize data into a frequency distribution.		CI 1.5 Practical: Organize a dataset into a frequency distribution.	
	SO 1.6 Develop skills in presenting data effectively.		CI 1.6 Presentation: Effective methods of data presentation.	

SW-1 Suggested Sessional Work (SW): anyone	1.1. Assignments: Differentiate between Random Sampling and Non-random sampling, portance of biostatistics and their applications 1.2 Mini Project: Measures of central Tendency by suitable examples. 1.3 Other Activities (Specify): Find out some you tube videos based on history, methods, and application of biostatistics.

Item	**C I**	**L I**	**SW**	**SL**	**Total**
Approx. Hrs.	**06**	**04**	**01**	**02**	**13**

CO.2 98BT303.2: Apply basic statistical concepts commonly used in public health and health Sciences	**Session-Outcomes (SOs)**	**Laboratory-Instruction (LI)**	**Classroom-Instruction (CI)**	**Self-Learning (SL)**
	SO2.1 Understand the concept and importance of measures of central tendency.	LI2.1 Calculate the mean, median, and mode of a given dataset.	CI2.1 Lecture: Introduction to measures of central tendency.	SL2.1 Research and compare the uses of mean, median, and mode in different fields.
	SO 2.2 Calculate the mean of a dataset accurately.	LI2.2 Perform calculations to find the mean of various datasets.	CI 2.2 Practical: Calculation of mean from provided data.	SL2.2 Research and compare the uses of mean, median, and mode in different fields
	SO 2.3 Calculate the median of a dataset accurately.		CI 2.3 Practical: Calculation of median from provided data.	
	SO 2.4 Calculate the mode of a dataset accurately.		CI 2.4 Practical: Calculation of mode from provided data.	
	SO 2.5 Evaluate the merits and demerits of mean, median, and mode in different scenarios.		CI 2.5 Discussion: Merits and demerits of mean, median, and mode.	
	SO 2.6 Understand the concept and importance of measures of dispersion, including range, mean deviation, and standard deviation.		CI 2.6 Lecture: Introduction to measures of dispersion - Range, mean deviation, and standard deviation.	

SW-2 Suggested Sessional Work (SW)	a. Assignments: Calculate mean median and mode by related questions., write short note on range b. Mini Project: Measures of central Tendency by suitable examples. c. Other Activities (Specify): Find out some you tube videos based on calculation method of mean median and mode.

Item	**CI**	**LI**	**SW**	**SL**	**Total**
Approx. Hrs.	06	04	01	02	13

CO.3 98BT303.3: Demonstrate basic analytical techniques to generate results	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
	SO3.1 Understand the definition and fundamental concepts of probability.	LI3.1 Conduct an experiment to demonstrate basic probability principles using real-life examples.	CI3.1 Lecture: Introduction to probability - Definitions and fundamental concepts.	SL3.1 Research and summarize the historical development and applications of probability theory.
	SO3.2 Apply theorems of probability to solve problems.	LI3.2 Perform calculations using theorems of probability on given datasets.	CI3.2 Discussion: Theorems of probability and their applications.	SL3.2 Develop a set of practice problems involving probability theorems and provide solutions.
	SO3.3 Understand and apply the addition rule in probability.		CI3.3 Practical: Using the addition rule to solve probability problems.	
	SO3.4 Understand and apply the multiplication rule in probability.		CI3.4 Practical: Using the multiplication rule to solve probability problems.	
	SO3.5 Understand the concept and applications of probability distributions, including binomial, Poisson, and normal distributions.		CI3.5 Lecture: Introduction to probability distributions - Binomial, Poisson, and normal distributions.	
	SO3.6 Perform calculations using binomial, Poisson, and normal probability distributions.		CI3.6 Workshop: Solving problems using binomial, Poisson, and normal distributions.	

SW-3 Suggested Sessional Work (SW):	**a. Assignments:** Write about probability distribution and Calculate probability by suitable examples **b. Mini Project:** how probability is important in biological system? **c. Other Activities (Specify):** Find out some you tube videos based on probability theorems.

Item	**CI**	**LI**	**SW**	**SL**	**Total**
Approx. Hrs.	06	04	01	02	13

CO.4 98BT303.4: Interpret results of commonly used statistical analyses in written summaries	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
	SO4.1 Understand the concept and importance of correlation and regression in statistical analysis.	LI4.1 Conduct an experiment to calculate the correlation coefficient between two variables using a given dataset.	CI 4.1 Lecture: Introduction to correlation and regression - Definitions and significance.	SL4.1 Research and write a report on the historical development and applications of correlation and regression analysis.
	SO 4.2 Identify and differentiate between positive and negative correlation.	LI4.2 Perform an analysis to identify positive and negative correlations in various datasets.	CI 4.2 Practical: Identifying types of correlation - Positive and negative.	SL4.2 Develop a set of practice problems involving identification of positive and negative correlations and provide solutions.
	SO 4.3 Calculate the correlation coefficient and interpret its meaning.		CI 4.3 Workshop: Calculation and interpretation of the correlation coefficient.	
	SO 4.4 Understand the principles of linear regression and how to derive the regression equation.		CI 4.4 Lecture: Principles of linear regression and derivation of the regression equation.	
	SO 4.5 Apply linear regression techniques to analyze relationships between variables.		CI 4.5 Practical: Applying linear regression to analyze relationships between variables in given datasets.	
	SO 4.6 Interpret the results of regression analysis to make		CI4.6 Discussion: Interpreting regression	

	predictions and informed decisions.		analysis results for predictions and decision-making.	

SW-4 Suggested Sessional Work (SW):	SW 4.1. Assignments: Illustrating Principles of Correlation and Regression and Explain application of regression equation. SW4.2 Mini Project: how regression equation is important in area of biological research? SW 4.3 Other Activities (Specify): **Find out some you tube videos based on Correlation and Regression.**

Item	**CI**	**LI**	**SW**	**SL**	**Total**
Approx. Hrs.	06	04	01	02	13

CO.5 98BT303.5: Demonstrate statistical reasoning skills accurately and contextually	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
	SO5.1 Understand the concept of significance testing and its importance in hypothesis testing.	LI5.1 Conduct a hypothesis test using a dataset, including the formulation of null and alternative hypotheses.	CI5.1 Lecture: Introduction to significance testing - Concepts of null and alternative hypotheses.	SL5.1 Research and write a report on the historical development and applications of hypothesis testing in statistics.
	SO5.2 Understand the procedure for testing hypotheses.	LI5.2 Perform the procedure for testing hypotheses on sample data, including calculating p-values and making decisions.	CI5.2 Workshop: Procedure of hypothesis testing - Steps and methodologies.	SL5.2 Develop a detailed guide on the steps involved in hypothesis testing, including examples and common pitfalls.
	SO5.3 Understand and apply the T-Test for small samples.		CI5.3 Lecture: Introduction to T-Test - Properties and applications.	
	SO5.4 Calculate and interpret the T-Test results for small sample sizes.		CI5.4 Practical: Applying the T-Test to small samples and interpreting results.	
	SO5.5 Understand the properties of the Chi-Square distribution and its		CI5.5 Lecture: Properties of Chi-Square distribution and its	

	applications.		relevance in statistical testing.	
	SO5.6 Perform Chi-Square tests for independence and homogeneity, including interpretation of results.		CI5.6 Practical: Performing and interpreting Chi-Square tests for independence and homogeneity using sample data.	

SW-5 Suggested Sessional Work (SW):	SW 5.1 Assignments: Differentiate null and alternative hypothesis and explain chi square test. SW 5.2 Mini Project: How T-Test and Chi-Square test are playing important role in biostatistics? SW 5.3 Other Activities (Specify): Find out some you tube videos based on Test of significance.

Brief of hours suggested for the Course Outcome

Course Outcomes (COs)	**Class lecture (Cl)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1. Describe the roles biostatistics serves in the discipline of public health.	**6**	**4**	**2**	**1**	**13**
CO2. Apply basic statistical concepts commonly used in public health and health Sciences	**6**	**4**	**2**	**1**	**13**
CO3. Demonstrate basic analytical techniques to generate results	**6**	**4**	**2**	**1**	**13**
CO4. Interpret results of commonly used statistical analyses in written summaries	**6**	**4**	**2**	**1**	**13**
CO5. Demonstrate statistical reasoning skills accurately and contextually	**6**	**4**	**2**	**1**	**13**
Total Hours	**30**	**20**	**10**	**05**	**65**

Suggestion for End semester Assessment

Course Outcome	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
CO1	Introduction to Biostatistics	03	02	04	09
CO2	Measures of central Tendency	04	05	02	11
CO3	Probability	02	06	02	10
CO4	Correlation and Regression	03	05	02	10
CO5	Test of significance	03	04	03	10
Total		**15**	**22**	**13**	**50**

Legend: R: Remember **U:** understand **A:** Apply

The end of semester assessment for biostatistics will be held with the written examination 50 Marks.

Suggested learning Resources:

(a) Books:

S.no.	Title	Author	Publisher	Edition & Year
1	Biostatistics	P.N.Arora, P.K.Malhan	Himalaya Publishing House	2 & 2005
2	Fundamentals of biostatistics	Khan and khanam	Ukaaz Publication	2 & 2004
3	Elements Of Biostatistics,	Prasad	Rastogi Publication	3& 2009

CO, PO and PSO Mapping

Program Title: B. Tech. Biotechnology
Semester: 3rd

Course Code: 98BT303 **Course Title:**
Biostatistics

CO/PO Mapping															
Course Outcome COs	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
98BT303.1	-	-	-	1	2	2	2	-	1	2	2	3	3	2	1
98BT303.2	-	-	-	-	-	-	3	-	2	2	3	3	2	1	2
98BT303.3	-	1	1	1	-	-	2	-	3	1	1	2	1	2	1
98BT303.4	-	1	1	-	2	2	2	3	-	1	-	-	2	2	3
98BT303.5	1	1	1	-	-	2	3	3	1	2	2	2	2	1	2

Legend: **(1) Low (2) Medium (3) High**

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	98BT303.1 Describe the roles biostatistics serves in the discipline of public health.	SO1.1 SO1.2 SO1.3 SO1.4, SO1.5 SO1.6	**LI 1** **LI 2**	Unit-1 Introduction to Biostatistics 1.1,1.2,1.3,1.4,1.5, 1.6	**1SL-1,2,**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	98BT303.2 Apply basic statistical concepts commonly used in public health and health Sciences	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6	**LI 1** **LI 2**	Unit-2 Measures of central Tendency 2.1, 2.2, 2.3, 2.4, 2.5,2.6	**2SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	98BT303.3 Demonstrate basic analytical techniques to generate results	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6	**LI 1** **LI 2**	Unit-3 Probability 3.1,3.2,3.3,3.4,3.5,3.6	**3SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	98BT303.4 Interpret results of commonly used statistical analyses in written summaries	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6	**LI 1** **LI 2**	Unit-4 Correlation and Regression 4.1,4.2,4.3,4.4,4.5, 4.6	**4SL-1,2**

PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	98BT303.5 Demonstrate statistical reasoning skills accurately and contextually	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6	**LI 1** **LI 2**	Unit-5 Test of significance 5.1,5.2,5.3,5.4,5.5,5.6	**5SL-1,2**

Program Name	**Bachelor of Technology (B Tech) -Biotechnology**	
Semester	III Semester	
Course Code:	98BT304	
Course title:	Biophysical Tools and Techniques	**Curriculum Developer**: Dr. Deepak Mishra, Professor
Pre-requisite:	Student should have basic knowledge of Biotechnology, Biochemistry and Laboratory skills.	
Rationale:	The Bio physical tools and techniques course for B Tech Biotechnology students is integral for equipping them with essential skills in utilizing advanced instruments crucial for biotechnological research. It focuses on bridging biological principles with physical and chemical methodologies, enabling comprehensive study of biomolecules, cellular processes, and environmental interactions. Practical training with instruments such as spectrophotometers, chromatographs, and microscopes enhances students' proficiency in experimental design, data analysis, and interpretation. This hands-on experience not only prepares them for academic research but also for careers in biotechnology, pharmaceuticals, and healthcare industries where such skills are in high demand. Moreover, the course emphasizes ethical considerations in research, ensuring responsible and effective use of bio physical tools. By fostering critical thinking and problem-solving abilities, it cultivates innovation and prepares students to tackle complex challenges in biotechnological applications. Ultimately, the course aims to empower B Tech Biotechnology students with the knowledge and practical expertise needed to contribute meaningfully to advancements in biological sciences and related fields.	
Course Outcomes (COs):	**CO1-98BT304.1:** Familiarization with the basic concept's good laboratory practices, Quality Management and basic instrumentation. **CO2-98BT304.2:** Acquired knowledge and technical Skills of advanced molecular biology Techniques. **CO3-98BT304.3:** Equipped to comprehend the fundamentals of Chromatography Techniques and its application. **CO4-98BT304.4:** Recognize various methods related to Electrophoresis and its applications. **CO5-98BT304.5:** Explore role of centrifugation and physical methods of imaging of biological molecules.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)	Total Credits(C)

			Cl	LI	SW	SL	**Total Study Hours(CI+LI+SW+SL)**	**(L:T:P=3:0:1)**
Program Common (PC)	98BT304	Biophysical Tools and Techniques	3	2	1	3	09	3+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning.

C: Credits.

Note: SW & SL must be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	**Scheme of Assessment (Marks)**							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Activity	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
PC	98BT304	Biophysical Tools and Techniques	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	03	17

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO1-98BT304.1: Familiarization with the basic concept's good laboratory practices, Quality Management and basic instrumentation	SO1.1 Understand the concept of Good Laboratory Practice (GLP)	Li1.1 Demonstrate proper lab notebook documentation practices	CI1.1 Lecture on principles of GLP and its importance in research	SL1.1 Read a chapter on GLP from a designated textbook
	SO1.2 Comprehend quality management in a laboratory setting	Li1.2 Conduct a mock audit of laboratory procedures	CI1.2 Discuss quality control and quality assurance processes in labs	SL1.2 Watch a video on quality management systems
	SO 1.3 Describe the steps involved in analysis		CI 1.3 Outline the steps of qualitative and quantitative analysis	SL1.3 Write a report summarizing an analysis method of choice
	SO1.4 Differentiate between qualitative and quantitative analysis		CI 1.4 Compare and contrast qualitative vs. quantitative analysis in class	
	SO 1.5 Explain biosafety guidelines and handling problems in the lab		CI 1.5 Review biosafety levels and guidelines in biotechnology	

	SO 1.6 Understand the working principle and instrumentation of common biotech lab instruments		CI 1.6 Overview of the principles and uses of key lab instruments	
	SO 1.7 Prepare different types of solutions		CI 1.7 Explain the process of making standard solutions and buffers	
	SO 1.8 Conduct different types of titrations		CI 1.8 Detailed lecture on titration techniques and calculations	
	SO 1.9 Describe the principles of osmosis and diffusion		CI 1.9 Teach the concepts of osmosis and diffusion with examples	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Describe in detail about instruments used in biotechnology lab.
	SW1.2 Mini Project	Prepare list of articles used in your lab and classify them
	SW1.3 Other Activities (Specify)	Preparation of GLP manual for biotechnology laboratory.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	0 9	04	01	03	17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO2-98BT304.2: Acquired knowledge and technical Skills of advanced molecular biology Techniques.	2.1 Understand the principles of DNA isolation	2.1 Perform DNA extraction from plant tissue	2.1 Lecture on the basic principles of DNA isolation	2.1 Read research papers on DNA isolation methods
	2.2 Comprehend the principles of RNA isolation	2.2 Isolate RNA from cultured cells	2.2 Discuss the methodologies of RNA extraction and purification	2.2 Study protocols for RNA isolation from various sources
	2.3 Explain the process of protein isolation		2.3 Overview of protein extraction techniques	2.3 Review articles on protein isolation methods
	2.4 Describe the technique of DNA fingerprinting		2.4 Lecture on DNA fingerprinting and its applications	
	2.5 Understand DNA footprinting methodology		2.5 Explain DNA footprinting and its role in molecular biology	
	2.6 Comprehend the concept of DNA imprinting		2.6 Discuss the principles of DNA imprinting and its biological significance	
	2.7 Understand the use of DNA microarray technology		2.7 Teach the working principle and applications of DNA microarrays	

	2.8 Explain the process of DNA sequencing		2.8 Discuss the various DNA sequencing technologies and their applications	
	2.9 Describe Southern, Northern, and Western blotting techniques		2.9 Detailed lecture on Northern and Western blotting techniques	

Suggested Sessional Work (SW):*anyone*	**SW2.1** Assignments	Assess the role of different blotting techniques
	SW2.2 Mini Project	Designing of poster for molecular biology techniques
	SW2.3 Other Activities (Specify)	To demonstration of protocols for molecular biology techniques.

Course Outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO3-98BT304.3: Equipped to comprehend the fundamentals of Chromatography Techniques and its applications.	**SO3.1** Explain the concept of chromatography	**LI3.1** Perform paper chromatography	**CI3.1** Separation and identification of material: concept of chromatography	**SL3.1** Collection of books and study materials for study chromatography
	SO3.2 Assessing the principle of chromatography		**CI3.2** principle of chromatography	**SL3.2** Study different factors affecting chromatography
	SO3.3 Explaining concept of paper chromatography	**LI3.2** Perform thin layer chromatography	**CI3.3** paper chromatography	**SL3.3** categorization of different types of chromatography
	SO3.4 Assessing thin layer chromatography		**CI3.4** thin layer chromatography	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	05	19

	SO3.5 Describe about column chromatography		**CI3.5** Column chromatography	**SL3.4** Study of role of chromatography for separation
	SO3.6 Assessing the concept of adsorption chromatography		**CI3.6** adsorption chromatography	**SL3.5** Assess application of chromatography
	SO3.7 Describe about gas liquid chromatography		**CI3.7** gas liquid chromatography	
	SO3.8 Describe about affinity chromatography		**CI3.8** affinity chromatography	
	SO3.9 Describe about gel permeation chromatography		**CI3.9** gel permeation chromatography	

Suggested Sessional Work (SW): *anyone*		
	SW3.1 Assignments	Describe in detail about different types of chromatography.
	SW3.2 Mini Project	Describe the role of different chromatography techniques
	SW3.3 Other Activities (Specify)	Standardization of protocol for chromatography.

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO4-98BT304.4: Recognize various methods related to Electrophoresis and its applications.	4.1 Understand the concept and basic principle of electrophoresis	4.1 Perform a basic gel electrophoresis experiment	4.1 Lecture on the concept and principle of electrophoresis	4.1 Read research articles on the history and development of electrophoresis
	4.2 Identify factors affecting electrophoretic mobility	4.2 Test the effects of different buffer pH levels on electrophoretic mobility	4.2 Discuss factors affecting electrophoretic mobility (pH, voltage, etc.)	4.2 Study case studies on troubleshooting electrophoresis experiments
	4.3 Explain free electrophoresis		4.3 Lecture on the principles and applications of free electrophoresis	4.3 Review protocols and papers on free electrophoresis
	4.4 Describe moving boundary electrophoresis		4.4 Detailed lecture on moving boundary electrophoresis	4.4 Watch a video tutorial on moving boundary electrophoresis
	4.5 Understand zone electrophoresis		4.5 Discuss the principles and applications of zone electrophoresis	4.5 Write a report on zone electrophoresis methods
	4.6 Comprehend paper		4.6 Lecture on paper	

Item	CI	LI	SW	SL	Total
Approx.Hrs	09	04	01	05	20

	electrophoresis		electrophoresis and its historical significance	
	4.7 Explain gel electrophoresis		4.7 Overview of gel electrophoresis techniques and applications	
	4.8 Understand capillary electrophoresis		4.8 Teach the working principle and applications of capillary electrophoresis	
	4.9 Describe immunoelectrophoresis and isoelectric focusing		4.9 Lecture on immunoelectrophoresis and isoelectric focusing	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain general characteristics and silent features of centrifugation
	SW4.2 Mini Project	Describe the role of physical methods of imaging biological molecules.
	SW4.3 Other Activities (Specify)	Standardization of protocol of centrifugation used for biological research.

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO4-98BT304.4: Recognize various methods related to Electrophoresis and its applications.	5.1 Understand the basic principle of sedimentation	5.1 Demonstrate sedimentation using a simple centrifuge	5.1 Lecture on the basic principles of sedimentation	5.1 Read research articles on sedimentation in biological systems
	5.2 Identify factors affecting sedimentation	5.2 Investigate the effects of particle size on sedimentation rate	5.2 Discuss factors affecting sedimentation (particle size, density, etc.)	5.2 Study case studies on sedimentation analysis in different materials
	5.3 Explain the use of ultracentrifuge		5.3 Lecture on the principles and applications of ultracentrifugation	5.3 Review protocols for ultracentrifugation experiments
	5.4 Understand the role of analytical centrifuge		5.4 Detailed lecture on analytical centrifugation	5.4 Watch a video tutorial on analytical centrifugation techniques
	5.5 Describe differential centrifugation		5.5 Discuss the principles and steps of differential centrifugation	5.5 Write a report on the applications of differential centrifugation
	5.6 Comprehend density gradient centrifugation		5.6 Lecture on the methodology and applications of density gradient centrifugation	
	5.7 Explain physical methods of imaging intact biological structures		5.7 Overview of X-ray imaging and its applications	
	5.8 Understand the principles of CAT-Scan		5.8 Lecture on the principles and applications of CAT-Scan	
	5.9 Describe the uses of ECG and EEG		5.9 Discuss the working principles and uses of ECG and EEG	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	05	19

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Understanding the Basic Principles and Factors Affecting Sedimentation
	SW5.2 Mini Project	To explore physical methods of imaging intact biological structures using X-ray, CAT-Scan, ECG, and EEG.
	SW5.3 Other Activities (Specify)	To understand the operation and applications of ultracentrifuges and analytical centrifuges.

Course duration (in hours) to attain Course Outcomes:

Course Title: Biophysical Tools and Techniques **Course Code:**98BT304

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98BT304.1: Familiarization with the basic concepts good laboratory practices, Quality Management and basic instrumentation.	9	4	3	1	17
CO2-98BT304.2: Acquired knowledge and technical Skills of advanced molecular biology Techniques.	9	4	3	1	17
CO3-98BT304.3: Equipped to comprehend the fundamentals of Chromatography Techniques and its application.	9	4	5	1	19
CO4-98BT304.4: Recognize various methods related to Electrophoresis and its applications.	9	4	5	1	19
CO5-98BT304.5: Explore role of centrifugation and physical methods of imaging of biological molecules.	9	4	5	1	19
Total Hours	45	20	21	05	91

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain about different factors affecting electrophoresis and its performance.
	SW4.2 Mini Project	Compare different protocols of gel electrophoresis.
	SW4.3 Other Activities (Specify)	Prepare one article on application of electrophoresis for biological research.

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Biophysical Tools and Techniques **Course Code:** 98BT304

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-98BT304.1: Familiarization with the basic concepts good laboratory practices, Quality Management and basic instrumentation.	2	1	1	1	5
CO2-98BT304.2: Acquired knowledge and technical Skills of advanced molecular biology Techniques.	2	3	2	2	9
CO3-98BT304.3: Equipped to comprehend the fundamentals of Chromatography Techniques and its application.	2	4	3	2	11
CO4-98BT304.4: Recognize various methods related to Electrophoresis and its applications.	3	4	4	2	13
CO5-98BT304.5: Explore role of centrifugation and physical methods of imaging of biological molecules.	5	4	2	1	12
Total Marks	**14**	**16**	**12**	**08**	**50**

***Legend*: A,** Apply; **An,** Analyze;v**E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Biochemical Calculations by Irwin H. Segel, John Wiley & Sons (2nd Edition), 1975
2	Practical Biochemistry, Principles and Techniques, Keith Wilson and John Walker
3	Principles of Physical Biochemistry, K.E. Van Holde, Prentice Hall.
4	Principles and Practice of Bioanalysis, Richard F. Venn
5	Biochemical Calculations by Irwin H. Segel

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method

4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B.Tech.. Biotechnology
Semester: III Semester

Course Title: Biophysical Tools and Techniques **Course Code:** 52BT208

Course Outcome (Cos)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-98BT304.1: Familiarization with the basic concepts good laboratory practices, Quality Management and basic instrumentation.	1	2	3	2	2	2	3	2	2	1	2	3	2	2	3
CO2-98BT304.2: Acquired knowledge and technical Skills of advanced molecular biology Techniques.	1	2	2	1	2	3	3	2	1	2	2	2	2	3	3
CO3-98BT304.3: Equipped to comprehend the fundamentals of Chromatography Techniques and its application.	1	2	2	2	1	2	3	1	2	1	2	2	1	2	3
CO4-98BT304.4: Recognize various methods related to Electrophoresis and its	1	1	3	1	1	2	3	1	2	2	1	3	1	2	3

applications.															
CO5-98BT304.5: Explore role of centrifugation and physical methods of imaging of biological molecules.	1	2	3	1	1	2	2	1	1	2	2	3	1	2	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO1-98BT304.1:** Familiarization with the basic concepts good laboratory practices, Quality Management and basic instrumentation.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10	1.1,1.2	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8, 1.9,1.10	1SL-1,2,3
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO2-98BT304.2:** Acquired knowledge and technical Skills of advanced molecular biology Techniques.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9 SO2.10	2.1, 2.2	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	2SL-1,2,3
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO3-98BT304.3:** Equipped to comprehend the fundamentals of Chromatography Techniques and its application.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	3.1,3.2	3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8, 3.9	3SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO4-98BT304.4:** Recognize various methods related to Electrophoresis and its applications.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10	4.1,4.2	4.1,4.2,4.3,4.4, 4.5, 4.6, 4.7, 4.8, 4.9,4.10	4SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12	**CO5-98BT304.5:** Explore role of centrifugation and physical methods of	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6	5.1,5.2	5.1,5.2,5.3,5.4,5.5, 5.6, 5.7, 5.8	5SL-1,2,3,4,5

PSO 1,2,3	imaging of biological molecules.	SO5.7 SO5.8			

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	III	
CourseCode:	**98ME305**	
Coursetitle:	Fluid Mechanics	**Curriculum Developer**: Er. Lokesh Agrawal, Assistant Professor
Pre-requisite:	Students should have a solid foundation in physics, calculus, mechanics, thermodynamics, biology, and chemistry.	
Rationale:	Fluid mechanics is crucial in biotechnology for understanding fluid behaviors in biological systems, such as cell cultures, bioreactors, and drug delivery. Mastery of fluid mechanics enables optimization of processes like fermentation and separation techniques. This knowledge aids in designing efficient biotechnological processes, enhancing productivity and sustainability.	
CourseOutcomes (COs):	**CO1-98ME305.1** Understand fundamental properties of fluids and their practical significance. **CO2: 98ME305.2** Comprehension of fluid motion, kinematics, and various types of fluid flow dynamics **CO3: 98ME305.3** Apply Bernoulli's equation and related principles to solve fluid dynamics problems. **CO4: 98ME305.4** Demonstrate proficiency in material and energy balance calculations in unit operations **CO5: 98ME305.5** Proficiency in Process Equipment Operation, Optimization, and Power Consumption Analysis.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L: T:P=2:0:0)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
OS	98ME305	Fluid Mechanics	2	0	1	2	5	2+0+0=2

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning.

C: Credits.

Note: SW & SL must be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		
OS	98ME305	Fluid Mechanics	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**ApproximateHours**

Item	Cl	LI	SW	SL	Total
Approx.Hrs	06	00	01	04	11

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1-98ME305.1. Understand fundamental properties of fluids and their practical significance.	1.1 Understand the difference between ideal and real fluids		1.1 Lecture on the characteristics of ideal and real fluids	1.1 Read articles on the applications of ideal and real fluids
	1.2 Learn about Newtonian and Non-Newtonian fluids		1.2 Classroom discussion on Newtonian and Non-Newtonian fluids	1.2 Study case studies on Newtonian and Non-Newtonian fluids
	1.3 Understand the properties of fluid (mass density, weight density, etc.)		1.3 Lecture on properties of fluids and their significance	1.3 Research different fluid properties and their industrial applications
	1.4 Learn about viscosity and surface tension		1.4 Lecture on viscosity and surface tension and their effects	1.4 Watch tutorials on measuring viscosity and surface tension
	1.5 Understand gas laws and humidity		1.5 Classroom discussion on gas laws and their	

			applications in fluids	
	1.6 Understand fluid statics (pressure, Pascal's law, hydrostatic law)		1.6 Lecture on fluid statics: pressure, Pascal's law, and hydrostatic law	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Explore and differentiate between Newtonian and non-Newtonian fluids. Provide real-world examples of each type
	SW1.2 Mini Project	Document and observe these scenarios, noting down relevant data such as fluid types, dimensions, and observed behaviors.
	SW1.3 Other Activities (Specify)	Make a power point presentation on "Buoyancy and Floatation"

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	00	01	03	10

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO2-98ME305.2 Comprehension of fluid motion, kinematics, and various types of fluid flow dynamics.	2.1 Understand the description of fluid motion		2.1 Lecture on the basic principles of fluid motion	2.1 Read articles on real-world applications of fluid motion
	2.2 Learn the Lagrangian and Eulerian approaches		2.2 Classroom discussion on Lagrangian and Eulerian approaches	2.2 Study case studies comparing the two approaches
	2.3 Identify different types of fluid flow		2.3 Lecture on types of fluid flow (laminar,	2.3 Research examples of different fluid flow types in

			turbulent, etc.)	nature and industry
	2.4 Understand and apply the continuity equation		2.4 Lecture on the continuity equation and its applications	
	2.5 Learn about the acceleration of a fluid particle		2.5 Classroom discussion on fluid particle acceleration	
	2.6 Understand the motion of fluid particles along a curved path and vortex motion		2.6 Lecture on curved path motion and vortex motion	

Suggested Sessional Work (SW):*anyone*	**SW2.1** Assignments	Define laminar, turbulent, and transitional flow. Compare and contrast these types of flow, highlighting their characteristics and the factors influencing their occurrence. Provide real-world examples for each type of flow.
	SW2.2 Mini Project	Make a project on the continuity equation and its significance in fluid dynamics.
	SW2.3 Other Activities (Specify)	Make Power point presentation on Vortex Motion.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	00	01	03	10

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO3-98ME305.3 Apply Bernoulli's equation and related principles to solve fluid dynamics	3.1 Understand and derive Euler's Equation		3.1 Lecture on the derivation and significance of Euler's Equation	3.1 Read articles on the historical development and applications of Euler's

problems of motion.				Equation
	3.2 Learn the principles and applications of Bernoulli's Equation		3.2 Lecture on Bernoulli's Equation and its practical applications	3.2 Study case studies on Bernoulli's Equation in engineering and natural systems
	3.3 Understand the working and applications of a Venturimeter		3.3 Classroom discussion on the design and use of Venturimeters	3.3 Research various industrial applications of Venturi meters
	3.4 Learn the working principles of a Pitot tube		3.4 Lecture on the Pitot tube and its application in flow measurement	
	3.5 Understand the concepts of kinetic energy and momentum correction factors		3.5 Lecture on kinetic energy and momentum correction factors in fluid flow	
	3.6 Learn about flow through pipelines and flow measurement techniques		3.6 Classroom discussion on flow through pipelines and various flow measurement techniques	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Derive and explain the impulse momentum equation for a control volume. Discuss its significance in analyzing fluid flow problems and provide examples demonstrating its application.
	SW3.2 Mini Project	Collect and compile the data obtained from each flow measurement device.
	SW3.3 Other	Prepare one Power point presentation on "Different flow measurement device"

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	00	01	04	11

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO4-98ME305.4 Demonstrate proficiency in material and energy balance calculations in unit operations	4.1 Understand the basic concepts of material balances		4.1 Lecture on the fundamentals of material balances	4.1 Read chapters on material balances from a chemical engineering textbook
	4.2 Apply material balance concepts to unit operations		4.2 Classroom discussion on material balance applications in unit operations	4.2 Solve practice problems on material balances in various unit operations
	4.3 Learn to solve material balance problems in bioprocesses		4.3 Lecture on material balances in bioprocesses	4.3 Review case studies on material balance applications in bioprocesses
	4.4 Understand the basic concepts of energy balances		4.4 Lecture on the fundamentals of energy balances	4.4 Study examples of energy balances in chemical engineering
	4.5 Learn about sensible and latent heats		4.5 Lecture on sensible and latent heats	

	4.6 Apply thermo chemical calculations using steam tables		4.6 Classroom discussion on thermo chemical calculations and steam tables	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	"Describe the importance of simultaneous material and energy balance in bioprocesses. Provide real-world examples to illustrate its application."
	SW4.2 Mini Project	Utilize energy balance concepts to determine energy inputs (sensible and latent heats) and losses.
	SW4.3 Other Activities (Specify)	Make a Power point presentation on " Energy balance in various bioprocesses"

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	00	01	04	11

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO5-98ME305.5 Proficiency in Process Equipment Operation, Optimization, and Power Consumption Analysis.	5.1 Understand the basic principles of agitation and its applications		5.1 Lecture on the fundamentals of agitation in chemical processes	5.1 Read chapters on agitation and mixing from a chemical engineering textbook
	5.2 Learn about fluid flow through packed columns		5.2 Classroom discussion on the principles of fluid flow through packed columns	5.2 Solve practice problems related to fluid flow in packed columns

	5.3 Understand the concept of fluidization		5.3 Lecture on fluidization and its industrial applications	5.3 Watch tutorials on fluidization processes and their applications
	5.4 Explore different fluid transport mechanisms		5.4 Classroom discussion on fluid transport mechanisms	5.4 Review case studies on fluid transport in various industries
	5.5 Learn about the equipment used for gas movement		5.5 Lecture on gas moving devices and their applications	
	5.6 Calculate power requirements for agitation		5.6 Classroom discussion on the calculation of power requirements for different agitation systems	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain the significance of fluidization in packed columns and its impact on fluid transport efficiency. Provide examples to illustrate.
	SW5.2 Mini Project	Prepare a comprehensive report detailing the project methodology, findings, and recommendations for optimizing fluid dynamics in process equipment.
	SW5.3 Other Activities (Specify)	Prepare one article on the "How Mixing effects the working mechanism of Impellers"

Course duration (in hours) to attain Course Outcomes:

Course Title: Fluid Mechanics **Course Code:**98ME305

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98ME305.1. Understand fundamental properties of fluids and their practical significance.	06	00	04	1	11
CO2-98ME305.2. Comprehension of fluid motion, kinematics, and various types of fluid flow dynamics	06	00	03	1	10
CO3-98ME305.3. Apply Bernoulli's equation and related principles to solve fluid dynamics problems.	06	00	03	1	10

CO4-98ME305.4. Demonstrate proficiency in material and energy balance calculations in unit operations	06	00	04	1	11
CO5-98ME305.5. Proficiency in Process Equipment Operation, Optimization, and Power Consumption Analysis.	06	00	04	1	11
Total Hours	30	00	18	05	53

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Fluid Mechanics **Course Code:** 98ME305

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-98ME305.1. Understand fundamental properties of fluids and their practical significance.	2	1	1	1	5
CO2-98ME305.2. Comprehension of fluid motion, kinematics, and various types of fluid flow dynamics	2	4	5	1	12
CO3-98ME305.3. Apply Bernoulli's equation and related principles to solve fluid dynamics problems.	3	5	5	1	14
CO4-98ME305.4. Demonstrate proficiency in material and energy balance calculations in unit operations	2	3	5	1	11
CO5-98ME305.5. Proficiency in Process Equipment Operation, Optimization, and Power Consumption Analysis.	2	4	1	1	10
Total Marks	**11**	**17**	**17**	**05**	**50**

***Legend*:A,** Apply;**An,** Analyze;**E,** Evaluate;**C,** Create

Suggested learning Resources:

(a) Books

S.No.	**Title/Author/Publisher details**

1	Fluid Mechanics & Hydraulic Machines, S.S. Rattan: Khanna Book Publishing
2	Introduction to Fluid Mechanics, P.J. Pritchard, A.T. McDonald and R.W. Fox, Wiley India
3	Fluid Mechanics- F.M. White – Tata McGraw Hill.
4	Introduction to Fluid Mechanics and Fluid Machines, S. K. Som, G. Biswas and S. Chakraborty, Tata McGraw Hill ”

(b) Online Resources

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Beverage producing plants & Distillery/Fermenter units
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology
Semester: III Semester

Course Title: Fluid Mechanics **Course Code:** 98ME305

CO/PO/PSO Mapping									
Course Outcome (Cos)	**Program Outcomes (POs)**						**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO**	**PSO1**	**PSO2**	**PSO3**

						6			
CO1-98ME305.1. Understand fundamental properties of fluids and their practical significance.	1	1	-	1	2	1	2	2	1
CO2-98ME305.2. Comprehension of fluid motion, kinematics, and various types of fluid flow dynamics	1	1	1	-	-	1	1	1	2
CO3-98ME305.3. Apply Bernoulli's equation and related principles to solve fluid dynamics problems.	1	1	1	1	2	1	1	1	1
CO4-98ME305.4. Demonstrate proficiency in material and energy balance calculations in unit operations	1	-	1	-	-	1	1	1	3
CO5-98ME305.5. Proficiency in Process Equipment Operation, Optimization, and Power Consumption Analysis.	1	-	1	1	2	1	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO1-98ME305.1.** Understand fundamental properties of fluids and their practical significance.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6		1.1,1.2,1.3,1.41.5,1.6	**1SL-1,2,3,4**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO2-98ME305.2.** Comprehension of fluid motion, kinematics, and various types of fluid flow dynamics	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6		2.1, 2.2, 2.3, 2.4,2.5,2.6	**2SL-1,2,3**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO3-98ME305.3.** Apply Bernoulli's equation and related principles to solve fluid dynamics problems.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6		3.1,3.2,3.3,3.4,3.5,3.6	**3SL-1,2,3**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO4-98ME305.4.** Demonstrate proficiency in material and energy balance calculations in unit operations	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO 4.6		4.1,4.2,4.3,4.4, 4.5,4.6	**4SL-1,2,3,4**
PO 1,2,3,4,5,6	**CO5-98ME305.5.** Proficiency in Process Equipment Operation, Optimization, and	SO5.1 SO5.2 SO5.3 SO5.4		5.1,5.2,5.3,5.4,5.5, 5.6	**5SL-1,2,3,4**

PSO 1,2, 3	Power Consumption Analysis.	SO5.5 SO5.6			

Program Name	**Bachelor of Technology B.Tech.-Biotechnology**	
Semester	III Semester	
Course Code:	98EN306	
Course title:	Entrepreneurship Development	**Curriculum Developer**: Mr. Dhirendra Mishra,
Pre-requisite:	Students should have basic knowledge of Entrepreneurship Development	
Rationale:	Entrepreneurs perform a vital function in economic development. They have been referred to as the human agents needed "to mobilize capital, to exploit natural resources, to create markets and to carry on trade". It might well be said that the entrepreneurial input spells the difference between prosperity and poverty among nations. Many economic theories emphasize the significant roles played by individual entrepreneurs as they combine talents, abilities, and drive to transform resources into profitable undertakings. Joseph Schumpeter, the first major writer to highlight the human agent in the process of economic development, believed that the economy was propelled by the activities of persons. Who wanted to promote new goods and new methods of production, or to exploit a new source of materials or new market not merely for profit but also to the purpose of creating?	
Course Outcomes (COs):	**CO1-98EN306** Basic aspects of establishing a business in a competitive environment **CO2-98EN306** Apply the basic understanding to examine the existing business ventures **CO3-98EN306** Examine various business considerations such as marketing, financial and teaming etc. **CO4-98EN306** Assessing strategies for planning a business venture **CO5-98EN306** Create business ideas that can drive the innovative society	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme ofstudies (Hours/Week)					Total Credits(C) (L: T:P=2:1:0)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
HS	98EN306	Entrepreneurship Development	3	0	1	3	7	2+1 = 3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
HS	98EN306	Entrepreneurship Development	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

ApproximateHours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	00	01	02	12

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1-98EN306.1: Basic aspects of establishing a business in a competitive environment	1.1 Understand the meaning and definition of entrepreneurship		1.1 Lecture on the definition and key concepts of entrepreneurship	1.1 Read a book on famous entrepreneurs and their journeys
	1.2 Comprehend the needs and importance of entrepreneurship		1.2 Classroom discussion on the importance of entrepreneurship for economic growth	1.2 Watch TED Talks on entrepreneurship and innovation
	1.3 Identify factors influencing entrepreneurship		1.3 Lecture on internal and external factors influencing entrepreneurship	
	1.4 Describe the promotion of entrepreneurship		1.4 Discuss government and private sector initiatives for promoting entrepreneurship	
	1.5 Understand the characteristics of successful entrepreneurs		1.5 Classroom activity: Group discussion on traits of successful entrepreneurs	
	1.6 Explain the role of innovation in entrepreneurship		1.6 Lecture on the importance of innovation in entrepreneurial success	
	1.7 Understand the challenges faced by entrepreneurs		1.7 Discuss common challenges and obstacles in entrepreneurship	
	1.8 Comprehend the concept of entrepreneurial mindset		1.8 Lecture on developing an entrepreneurial mindset	
	1.9 Understand the features of a successful entrepreneurship ecosystem		1.9 Discuss the components of a supportive entrepreneurship ecosystem	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Interview one successful and one unsuccessful entrepreneur in your place/location. Identify five major characteristics of both
	SW1.2 Mini Project	Meet one or two Government officials involved in the promotion of small enterprise. Ask them about the specific facilities the government offers to entrepreneurs to establish small-scale facilities. Also try to know the extent of use of these facilities by the entrepreneurs and major problems faced by them in this regard.
	SW1.3 Other Activities (Specify)	**Case study –N.R. Narayana Murthy**

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO2-98EN306.2: Know various form of business organization.	2.1 Understand the different forms of business organization		2.1 Lecture on sole proprietorship, partnership, and corporation	2.1 Read case studies on different business organizations
	2.2 Comprehend the characteristics of each business form		2.2 Discuss the advantages and disadvantages of different business forms	2.2 Watch video lectures on business structures
	2.3 Identify the steps in project identification		2.3 Lecture on the process of identifying a business project	
	2.4 Understand the criteria for selecting a product		2.4 Classroom discussion on factors influencing product selection	
	2.5 Describe the stages of project formulation		2.5 Explain the components of project formulation in a detailed lecture	

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	00	01	02	12

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	00	01	02	12

	2.6 Understand how to assess project feasibility		2.6 Lecture on the methods of assessing technical, financial, and market feasibility	
	2.7 Comprehend the importance of feasibility studies		2.7 Discuss the role of feasibility studies in project success	
	2.8 Learn to use project management tools		2.8 Overview of project management software and tools in a classroom setting	
	2.9 Understand the impact of project management on business success		2.9 Discuss real-world examples of successful and failed projects	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Suppose you propose two-three enterprise like travel agency in a tourist place like Nainital. elaborate which form of ownership you will chose and why?
	SW2.2 Mini Project	Selection of the product.
	SW2.3 Other Activities (Specify)	How an entrepreneurs do assessment of project feasibility

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO3-98EN306.3: Correlation among various types of loans and repayment of loans.	3.1 Understand the importance of finance and the role of loans and repayments		3.1 Lecture on the importance of finance and loan management	3.1 Read articles on successful loan management strategies
	3.2 Identify the characteristics of business finance		3.2 Discuss key characteristics of business finance such as risk, return, and liquidity	3.2 Watch webinars on business finance fundamentals
	3.3 Explain sources of fixed capital and their management		3.3 Lecture on various sources of fixed capital and their management	
	3.4 Comprehend working capital management and its sources		3.4 Detailed discussion on working capital management, including sources and strategies	
	3.5 Understand how to apply for loans and manage repayments		3.5 Classroom activity on preparing a loan application and repayment plan	
	3.6 Describe inventory management of direct and indirect raw materials		3.6 Lecture on inventory management practices for direct and indirect raw materials	
	3.7 Understand the importance of inventory management		3.7 Classroom discussion on the impact of inventory management on business operations	
	3.8 Learn techniques for effective inventory management		3.8 Overview of inventory management techniques such as JIT (Just-In-Time) and EOQ (Economic Order Quantity)	
	3.9 Evaluate real-world examples of fixed and working capital management		3.9 Case study analysis of companies fixed and working capital management practices	

Item	CI	LI	SW	SL	Total
Approx. Hrs	09	00	01	02	12

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Issue of debenture is source of short-term loans.
	SW3.2 Mini Project	Visit to an enterprise and find out its financial position whether it is over-capitalized or under –capitalized. Give your suggestion to correct the situation whatever be the case.
	SW3.3 Other Activities (Specify)	Find out some you tube videos based on financing the enterprise.

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO4-98EN306.4 Assessing strategies for planning a business venture	4.1 Understand the meaning and importance of marketing		4.1 Lecture on the fundamental concepts of marketing and its significance	4.1 Read articles on the role of marketing in business success
	4.2 Comprehend the marketing-mix and its components		4.2 Discuss the 4P's (Product, Price, Place, Promotion) and their role in marketing strategy	4.2 Watch videos on the application of the marketing-mix in different industries
	4.3 Explain product management concepts, including product line and product mix		4.3 Lecture on product line, product mix, and their management	
	4.4 Understand the stages of the product life cycle		4.4 Classroom discussion on the product life cycle stages (Introduction, Growth, Maturity, Decline)	
	4.5 Analyze the importance of marketing research and surveys		4.5 Lecture on the role of marketing research and the benefits of surveys	
	4.6 Understand the process of conducting marketing research		4.6 Classroom activity on designing and conducting a marketing survey	
	4.7 Comprehend physical distribution and stock management		4.7 Lecture on physical distribution methods and stock management techniques	
	4.8 Explore strategies for effective stock management		4.8 Discuss inventory control techniques such as Just-In-Time (JIT) and Economic Order Quantity (EOQ)	
	4.9 Evaluate real-world examples of product management and distribution		4.9 Case study analysis of successful product management and distribution strategies	

	SW4.1 Assignments	Explain life cycle of product.
	SW4.2 Mini Project	Meet an entrepreneur running a manufacturing enterprise. Ask him how he/she took decision on marketing mix and prepare systematic report on the same.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	00	01	02	12

Suggested Sessional Work (SW): *anyone*	**SW4.3** Other Activities (Specify)	Find out some you tube videos based on Marketing Management.

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO5-98EN306.5: To compare various government policy for international business and analyzed institutions support for export.	5.1 Understand the meaning and significance of international business		5.1 Lecture on the definition and importance of international business	5.1 Read articles on global business strategies and trends
	5.2 Comprehend the process of selecting a product for international markets		5.2 Discuss criteria for product selection for international markets	5.2 Watch webinars on international product strategies
	5.3 Learn how to select a market for international business		5.3 Lecture on market selection criteria and methods for international expansion	
	5.4 Understand the principles of export financing		5.4 Classroom discussion on various export financing options such as letters of credit and export credit insurance	
	5.5 Explore institutional support available for exports		5.5 Lecture on the roles of export promotion agencies and government institutions in supporting exports	
	5.6 Evaluate real-world examples of successful market entry strategies		5.6 Case study analysis of businesses that have successfully entered international markets	

	5.7 Understand the challenges and risks in international business		5.7 Discuss common challenges such as cultural differences, legal issues, and economic instability	
	5.8 Learn about the documentation and compliance required for international trade		5.8 Lecture on the essential documentation and compliance requirements for international trade	
	5.9 Analyze the impact of global trade policies on international business		5.9 Classroom discussion on the effects of global trade policies, tariffs, and trade agreements	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Write about Institutional support for exports for international business.
	SW5.2 Mini Project	Make a list of financial institutes those support for export and write about their polices for export
	SW5.3 Other Activities (Specify)	Find out some you tube videos based on international business.

Course duration (in hours) to attain Course Outcomes:

Course Title: Entrepreneurship Development **Course Code:** 98EN306

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98EN306.1: Understand basic aspects of establishing a business in a competitive environment.	9	0	2	1	12
CO2-98EN3065.2: Apply the basic understanding to examine the existing business ventures.	9	0	2	1	12
CO3-98EN306.3: Examine various business considerations such as marketing, financial and teaming etc.	9	0	2	1	12
CO4-98EN306.4: Assessing strategies for planning a business venture	9	0	2	1	12
CO5-98EN306.5: Create business ideas that can drive the innovative society	9	0	2	1	12
Total Hours	45	00	10	05	60

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Entrepreneurship Development **Course Code:** 98EN306

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-98EN3065.1: Understand basic aspects of establishing a business in a competitive environment.	2	1	1	1	5
CO2-98EN306.2: Apply the basic understanding to examine the existing business ventures.	2	4	2	2	10
CO3-98EN3065.3: Examine various business considerations such as marketing, financial and teaming.	3	5	5	2	15
CO4-98EN306.4: Assessing strategies for planning a business venture	2	3	3	2	10
CO5-98EN306.5: Create business ideas that can drive the innovative society	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

Legend: **A,** apply; **An,** analyze; **E,** evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	**Title/Author/Publisher details**
1	Holt DH. Entrepreneurship: New Venture Creation.
2	Kaplan JM Patterns of Entrepreneurship.
3	Gupta CB, Khanka SS. Entrepreneurship and Small Business Management, Sultan Chand & Sons

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Industrial Visit
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: Bachelor of Technology-Biotechnology
Semester: III Semester
Course Title: Entrepreneurship Development **Course Code:** 98EN306

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-98EN3065.1: Understand basic aspects of establishing a business in a competitive environment.	2	-	-	1	2	2	2	1
CO2-98EN306.2: Apply the basic understanding to examine the existing business ventures.	-	-	-	-	-	1	1	2
CO3-98EN306.3: Examine various business considerations such as marketing, financial and teaming etc. .	-	1	1	1	-	1	1	1

CO4-98EN306.4: Assessing strategies for planning a business venture.	-	1	1	-	2	1	1	3
CO5-98EN306.5: Create business ideas that can drive the innovative society.	1	1	1	-	-	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-98EN306.1:** Understand basic aspects of establishing a business in a competitive environment	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		1.1,1.2,1.3,1.4,1.5	**1SL-1,2,3,4**
PO 1,2,3,4,5 PSO 1,2,3	**CO2-98EN306.2:** Apply the basic understanding to examine the existing business ventures	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5		2.1, 2.2, 2.3, 2.4, 2.5,	**2SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO3-98EN306.3:** Examine various business considerations such as marketing, financial and teaming etc.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6		3.1,3.2,3.3,3.4,3.5 3.6	**3SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO4-98EN306.4:** Assessing strategies for planning a business venture.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7		4.1,4.2,4.3,4.4,4.5, 4.6,4.7	**4SL-1,2,3**
PO 1,2,3,4,5 PSO 1,2,3	**CO5-98EN306.5:** Create business ideas that can drive the innovative society.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6		5.1,5.2,5.3,5.4,5.5 5.6	**5SL-1,2,3**

Program Name	**B.Tech. Biotechnology**	
Semester	III	
Course Code:	98UHV307	
Course title:	Universal Human Values	**Curriculum Developer**: Dr Ashutosh Pandey, Assistant ProfesCIr
Pre-requisite:	Creating awareness among the students on a holistic perspective about life.	
Rationale:	The purpose is to help develop a holistic perspective about life. A self- reflective methodology of teaching is adopted. It opens the space for the student to explore his/her role (value) in all aspects of living – as an individual, as a member of a family, as a part of the CIciety and as a unit in nature. Through this process of self-exploration, students can discover the values intrinsic in them.	
Course Outcomes (COs):	**98UHV307.1:** To explore the importance of understanding classroom value inputs, skills vs. values, education's needs, foundations, curriculum, and procedure in assessing happiness, prosperity, and CIciety. **98UHV307.2:** Differentiate the Self and Body and grasp Self-Harmony and Self-Body Coexistence. **98UHV307.3:** To explore how trust, respect, and other naturally appropriate feelings in human-human relationships contribute to a peaceful CIciety. **98UHV307.4:** Understand the harmony in nature and existence, and workout their mutually fulfilling participation in nature. **98UHV307.5:** Students will have the ability to apply the gained knowledge in Implications of Holistic Understanding- A Look at Professional Ethics**.**	

Scheme of Studies:

Course Category	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P)
			CI	LI	SW	SL	Total Hours (CI+LI+SW+SL)	
VAC	98UHV307	Universal Human Values	4 (3+1)	0	1	1	1	4

Legend: **CI:** Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini projectetc.),
SL: SelfLearning,
C: Credits

Note: Proposed examination scheme (Marking) as per the recommendation of University Grant Commission (UGC) for Under Graduate Courses in Fundamentals of Universal Human Values 2022-23 onwards SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment: Theory

Course Category	Course Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ESA)
			Class/ Home Assignment 5 number 3 marks each (HA)	Class Test 2 (2 best out of 3)10 marks each (CT)	Seminar one (TSN)	Class Activity anyone (TCA)	Class Attendance (TA)	Total, Marks (HA+CT+TSN+TCA+TA)		
VAC	HSMC	Universal Human Value	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (CIs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Item	**CI**	**LI**	**SW**	**SL**	**Total**
Approx Hrs.	12	0	01	02	15

98UHV307.1: To explores the importance of understanding classroom value inputs, skills vs. values, education's needs, foundations, curriculum, and procedure in assessing happiness, prosperity, and CIciety.	**Session Outcomes (CIs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self Learning (SL)**
	CI1.1 Understand the need for and importance of value education.		CI 1.1 Lecture: Introduction to value education - Need, guidelines, content, and process.	SL1.1 Research and prepare a report on the role of value education in perCInal and professional life.
	CI1.2 Explain the basic guidelines and content for value education.		CI 1.2 Workshop: Basic guidelines and content for value education.	SL1.2 Reflective essay on how value education can influence CIcietal change.
	CI 1.3 Understand the process of self-exploration and its		CI 1.3 Lecture: Self-exploration – Its content and process.	

	significance.			
	CI 1.4 Explain the concepts of 'Natural Acceptance' and 'Experiential Validation' in self-exploration.		CI 1.4 Practical: Exercises on self-exploration using natural acceptance and experiential validation.	
	CI 1.5 Understand the basic human aspirations of continuous happiness and prosperity.		CI 1.5 Discussion: Continuous happiness and prosperity - Basic human aspirations.	
	CI 1.6 Explain the concepts of right understanding, relationships, and physical facilities in fulfilling human aspirations.		CI 1.6 Lecture: Right understanding, relationship, and physical facilities - Their role in human aspirations.	
	CI 1.7 Critically appraise the current scenario of understanding happiness and prosperity.		CI 1.7 Workshop: Understanding happiness and prosperity - A critical appraisal of the current scenario.	
	CI 1.8 Understand the method to fulfill human aspirations by living in harmony at various levels.		CI 1.8 Lecture: Methods to fulfill human aspirations - Living in harmony at various levels.	

	CI 1.9 Develop a perCInal plan for living in harmony with oneself and others.		CI 1.9 Practical: Developing a perCInal plan for living in harmony.	
	CI 1.10 Reflect on the impact of value education on perCInal and CIcietal well-being.		CI 1.10 Discussion: Impact of value education on perCInal and CIcietal well-being.	
	CI 1.11 Explore the relationship between value education and sustainable development.		CI 1.11 Lecture: Value education and its contribution to sustainable development.	
	CI 1.12 Evaluate the role of educational institutions in promoting value education.		CI1.12 Seminar: The role of educational institutions in promoting value education.	

Suggested Sessional Work (SW)	**SW 1.1 Assignments:** Continuous Happiness and Prosperity–the Basic Human Aspirations **SW 1.2 Mini Project:** Relationship and Physical Facility **SW 1.3 Other Activities (Specify):** Quiz, Class Test

Item	**CI**	**LI**	**SW**	**SL**	**Total**
Approx Hrs.	11	0	01	02	14

98UHV307.2:	**Session Outcomes**	**Laboratory**	**Classroom Instruction**	**Self-Learning**

Differentiate the Self and Body and grasp Self-Harmony and Self-Body Coexistence.	**(CIs)**	**Instruction (LI)**	**(CI)**	**(SL)**
	CI2.1 Understand the concept of harmony in the human being and the self.		CI 2.1 Lecture: Introduction to harmony in the human being and the self.	SL2.1 Research and write an essay on different philoCIphical perspectives of self and harmony.
	CI 2.2 Explain the co-existence of the sentient 'I' and the material 'Body'.		CI 2.2 Lecture: Understanding human being as a co-existence of the sentient 'I' and the material 'Body'.	SL2.2 Reflective journal on perCInal experiences of the relationship between 'I' and the body.
	CI 2.3 Differentiate between the needs of Self ('I') and the 'Body' - Sukh and Suvidha.		CI 2.3 Discussion: Needs of Self ('I') and 'Body' - Sukh (happiness) and Suvidha (facilities).	
	CI 2.4 Understand the Body as an instrument of 'I' (I being the doer, seer, and enjoyer).		CI 2.4 Lecture: The Body as an instrument of 'I' - Roles of doer, seer, and enjoyer.	
	CI 2.5 Describe the characteristics and activities of 'I' and harmony in 'I'.		CI 2.5 Workshop: Exploring characteristics and activities of 'I' - Finding harmony within.	
	CI 2.6 Understand the		CI 2.6 Lecture:	

	harmony of 'I' with the Body: Sanyam and Swasthya.		Harmony of 'I' with the Body - Sanyam (self-regulation) and Swasthya (health).	
	CI 2.7 Appraise physical needs correctly in the context of harmony and well-being.		CI 2.7 Practical: Appraising physical needs correctly to maintain harmony and well-being.	
	CI 2.8 Understand the detailed meaning of Prosperity.		CI 2.8 Lecture: Prosperity - Detailed understanding and its implications.	
	CI 2.9 Develop programs for Sanyam (self-regulation) and Swasthya (health).		CI 2.9 Workshop: Developing perCInal programs for Sanyam and Swasthya.	
	CI 2.10 Reflect on perCInal practices and their alignment with the concept of Sanyam and Swasthya.		CI 2.10 Discussion: Reflecting on perCInal practices and their alignment with Sanyam and Swasthya.	
	CI 2.11 Evaluate the impact of Sanyam and Swasthya on overall well-being.		CI 2.11 Lecture: Evaluating the impact of Sanyam and Swasthya on individual and CIcietal well-being.	

Suggested Sessional Work (SW-2)	**SW 2.1: Assignments:** Harmony in the self **SW 2.2: Mini Project:** Body an instrument **SW 2.3: Other Activities (Specify):** Quiz, Class Test.

Item	CI	LI	SW	SL	Total
Approx. Hrs.	13	0	01	05	19

98UHV307.3: To explore how trust, respect, and other naturally appropriate feelings in human-human relationships contribute to a peaceful CIciety.	**Session Outcomes (CIs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
	CI3.1 Understand the concept of harmony in the family and its importance as the basic unit of human interaction.		CI 3.1 Lecture: Introduction to harmony in the family - The basic unit of human interaction.	SL3.1 Research and write an essay on the significance of family harmony in CIcietal development.
	CI 3.2 Explain the values in human-human relationships, including the meanings of Nyaya and Ubhay-tripti.		CI 3.2 Workshop: Understanding values in human-human relationships - Nyaya and Ubhay-tripti.	SL3.2 Reflective journal on perCInal experiences and observations of values in human relationships.
	CI 3.3 Understand the foundational values of trust (Vishwas) and respect (Samman) in relationships.		CI 3.3 Lecture: Trust (Vishwas) and Respect (Samman) as foundational values of relationships.	
	CI 3.4 Differentiate between intention and competence in the context of Vishwas.		CI 3.4 Discussion: Understanding Vishwas - Intention vs. competence.	

	CI 3.5 Explain the meaning of Samman and differentiate between respect and differentiation.		CI 3.5 Lecture: Understanding Samman - Difference between respect and differentiation.	
	CI 3.6 Identify and understand other salient values in relationships.		CI 3.6 Workshop: Exploring other salient values in relationships.	
	CI 3.7 Understand the concept of harmony in CIciety as an extension of the family.		CI 3.7 Lecture: Harmony in CIciety - An extension of the family.	
	CI 3.8 Explain the comprehensive human goals: Samadhan, Samridhi, Abhay, and Sah-astitva.		CI 3.8 Discussion: Comprehensive human goals - Samadhan, Samridhi, Abhay, and Sah-astitva.	
	CI 3.9 Visualize a universal harmonious order in CIciety - Undivided CIciety (Akhand Samaj) and Universal Order (Sarvabhaum Vyawastha).		CI3.9 Seminar: Universal harmonious order in CIciety - Undivided CIciety and Universal Order.	
	CI 3.10 Understand the role of family and educational institutions in promoting harmony in CIciety.		CI 3.10 Lecture: The role of family and educational institutions in CIcietal harmony.	SL3.3 Prepare a report on how educational institutions can contribute to CIcietal harmony.

	CI 3.11 Reflect on the interrelationship between individual actions and CIcietal harmony.		CI3.11 Discussion: Interrelationship between individual actions and CIcietal harmony.	SL3.4 Write a reflective essay on perCInal actions that can promote CIcietal harmony.
	CI 3.12 Evaluate perCInal values and their alignment with the concept of CIcietal harmony.		CI 3.12 Lecture: PerCInal values and their alignment with CIcietal harmony.	SL3.5 Create a perCInal action plan to enhance alignment with CIcietal harmony.
	CI 3.13 Explore the impact of global cultural differences on achieving a universal harmonious order.		CI3.13 Seminar: Impact of global cultural differences on universal harmonious order.	

Suggested Sessional Work (SW-3):	**SW 3.1 Assignments:** Respect their right evaluation **SW 3.2 Mini Project:** Trust is the fundamental value of relationships **SW 3.3 Other Activities (Specify):** Quiz, Class Test.

Item	**CI**	**LI**	**SW**	**SL**	**Total**
Approx. Hrs.	12	0	01	04	17

98UHV307.4:	**Session Outcomes (CIs)**	**Laboratory**	**Classroom Instruction**	**Self-Learning (SL)**

Understand the harmony in nature and existence, and workout their mutually fulfilling participation in nature.		**Instruction (LI)**	**(CI)**	
	CI4.1 Understand the concept of harmony in nature and its significance.		CI 4.1 Lecture: Introduction to harmony in nature.	SL4.1 Research and write a report on the importance of harmony in nature for sustainable living.
	CI4.2 Explain the interconnectedness and mutual fulfillment among the four orders of nature.		CI4.2 Workshop: Exploring interconnectedness and mutual fulfillment in nature.	SL4.2 Reflective journal on perCInal observations of interconnectedness in nature.
	CI4.3 Understand recyclability and self-regulation in nature.		CI4.3 Lecture: Recyclability and self-regulation in nature.	
	CI4.4 Explore the concept of existence as co-existence (Sah-astitva) of mutually interacting units.		CI4.4 Discussion: Understanding existence as co-existence.	
	CI4.5 Understand the holistic perception of harmony at all levels of existence.		CI4.5 Lecture: Holistic perception of harmony at all levels of existence.	
	CI 4.6 Identify examples of mutual fulfillment in nature.		CI4.6 Workshop: Identifying mutual fulfillment in nature.	
	CI 4.7 Analyze the role of natural cycles in maintaining harmony in		CI4.7 Discussion: Natural cycles and their role in	

	nature.		maintaining harmony.	
	CI 4.8 Explore the concept of co-existence in various cultures and philoCIphies.		CI 4.8 Seminar: Co-existence in different cultures and philoCIphies.	SL4.3 Prepare a project proposal for a community-based initiative to promote harmony with nature.
	CI 4.9 Understand the impact of human activities on the harmony in nature.		CI 4.9 Lecture: Human activities and their impact on natural harmony.	
	CI 4.10 Identify ways to restore and maintain harmony in nature through sustainable practices.		CI 4.10 Workshop: Sustainable practices to restore and maintain natural harmony.	
	CI 4.11 Reflect on perCInal actions and their alignment with natural harmony.		CI 4.11 Discussion: PerCInal actions and natural harmony.	SL4.4 Write a reflective essay on perCInal actions that can promote CIcietal harmony.
	CI 4.12 Evaluate the importance of educating others about harmony in nature and existence.		CI4.12Lecture: The importance of education in promoting harmony in nature and existence.	

Suggested Sessional Work (SW-4):	**SW 4.1 Assignments:** Harmony in nature **SW 4.2 Mini Project:** Exploring4 orders of nature **SW 4.3 Other Activities (Specify):** Quiz, Class Test.

Item	CI	L I	SW	S L	Total
Approx. Hrs.	12	0	01	05	18

98UHV307.5: Students will have the ability to apply the gained knowledge in Implications of Holistic Understanding- A Look at Professional Ethics.	**Session Outcomes (CIs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
	CI5.1 Understand the natural acceptance of human values.		CI 5.1 Lecture: Introduction to natural acceptance of human values.	SL5.1 Reflective journal on perCInal values and natural acceptance.
	CI 5.2 Explain the definitiveness of ethical human conduct.		CI 5.2 Workshop: Exploring definitiveness of ethical human conduct.	SL 5.2 Write an essay on the importance of ethical conduct in professional life.
	CI 5.3 Understand the basis for humanistic education.		CI 5.3 Lecture: Basis for humanistic education.	SL 5.3 Interview educators about the challenges and benefits of humanistic education.
	CI 5.4 Explore the concept of a humanistic constitution and humanistic universal		CI 5.4 Seminar: Humanistic constitution and universal order.	SL 5.4 Research and write a paper on the impact of a humanistic

	order.			constitution on CIcietal well-being.
	CI 5.5 Identify the competence in professional ethics required for augmenting the universal human order.		CI 5.5 Lecture: Competence in professional ethics.	
	CI 5.6 Understand the ability to utilize professional competence for promoting people-friendly and eco-friendly production systems.		CI 5.6 Workshop: People-friendly and eco-friendly production systems.	
	CI 5.7 Analyze the scope and characteristics of eco-friendly technologies and management models.		CI 5.7 Discussion: Characteristics of eco-friendly technologies and management models.	
	CI 5.8 Evaluate case studies of typical holistic technologies, management models, and production systems.		CI 5.8 Seminar: Case studies of holistic technologies, management models, and production systems.	
	CI 5.9 Understand the strategy for transitioning from the current state to		CI 5.9 Lecture: Strategy for transitioning to universal human order at the individual	

	a universal human order at the individual level.		level.	
	CI 5.10 Explore the role of CIcially and ecologically responsible engineers, technologists, and managers.		CI 5.10 Workshop: Role of responsible engineers, technologists, and managers.	SL 5.5 Prepare a project proposal for implementing a CIcially responsible engineering practice in your community.
	CI 5.11 Understand the strategy for transitioning to a universal human order at the CIcietal level.		CI 5.11 Lecture: Strategy for transitioning to universal human order at the CIcietal level.	
	CI 5.12 Explore the role of mutually enriching institutions and organizations in achieving a universal human order.		CI5.12 Seminar: Role of enriching institutions and organizations.	

Suggested Sessional Work (SW-5): anyone	**SW 5.1 Assignments:** Human conduct **SW 5.2 Mini Project:** Humanistic constitution **SW 5.3 Other Activities (Specify):** Quiz, Class Test**.**

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Laboratory Instruction (LI)	Sessional Work (SW)	Self-Learning (SL)	Total hour (CI+SW+SL)
98UHV307.1: To explores the importance of understanding classroom value inputs, skills vs. values, education's needs, foundations, curriculum, and procedure in assessing happiness, prosperity, and CIciety.	12	0	01	02	15
98UHV307.2: Differentiate the Self and Body and grasp Self-Harmony and Self-Body Coexistence.	11	0	01	02	14
98UHV307.3: To explore how trust, respect, and other naturally appropriate feelings in human-human relationships contribute to a peaceful CIciety.	13	0	01	05	19
98UHV307.4: Understand the harmony in nature and existence, and workout their mutually fulfilling participation in nature.	12	0	01	04	17
98UHV307.5: Students will have the ability to apply the gained knowledge in Implications of Holistic Understanding- A Look at Professional Ethics.	12	0	01	05	18
Total Hours	60	0	05	18	83

Suggestion for End Semester Assessment: Suggested Specification Table

CO	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
CO-1	**98UHV307.1:** To explores the importance of understanding classroom value inputs, skills vs. values, education's needs, foundations, curriculum, and procedure in assessing happiness, prosperity, and CIciety.	02	04	05	11
CO-2	**98UHV307.2:** Differentiate the Self and Body and grasp Self-Harmony and Self-Body Coexistence.	03	07	04	14
CO-3	**98UHV307.3:** To explore how trust, respect, and other naturally appropriate feelings in human-human relationships contribute to a peaceful CIciety.	02	06	02	10
CO-4	**98UHV307.4:** Understand the harmony in nature and existence, and workout their mutually fulfilling participation in nature.	03	03	02	08
CO-5	**98UHV307.5:** Students will have the ability to apply the gained knowledge in Implications of Holistic Understanding- A Look at Professional Ethics.	03	02	02	07
Total		13	22	15	50

Legend: **R:Remember,** **U:Understand,** **A:Apply**

The end of semester assessment will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can alCI design different tasks as per requirement, for end semester assessment.

Suggested Instructional / Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Case Method
4. Group Discussion
5. Role Play
6. Demonstration
7. ICT Based Teaching Learning (Video Demonstration/Tutorials CBT, Blog, Facebook, Online CIurces)
8. Brainstorming
9. Seminar
10. Workshop

SuggestedLearningReCIurces:

(a) Books:

S. No.	Title	Author	Publisher	Edition&Year
1	Jeevan Vidya: Ek Parichaya	A Nagaraj	Jeevan Vidya Prakashan, Amarkantak	1998
2	Human Values	A.N.Tripath	New AgeIntl. Publishers, New Delhi,	2004
3	Universal Human Values		AICTE	2021
4	Human Values and	R.R. Gaur, R Sangal And G P Bagaria	Excel Book Publisher	2009

	Professional Ethics			
5	Vyavaharvadï Samajshastra	A Nagaraj	Jeevan VidyaPrakashan, Amar kantak	1999
6	Manava Vyavahara Darsana	A Nagaraj	Jeevan Vidya Prakashan, Amarkantak	2003
7	Foundations of Ethics and Management,	BP Banerjee	ExcelBook	2005
8	Fundamentals of Ethicsfor Scientists & Engineers	EGSeebauer& RobertL.Berry	OxfordUniversity Press.	2000
9	Engineering Ethichs (includingHumanValues)	MGovindrajran,S Natrajan and V.S. SenthilKumar	Eastern Economy Edition,PrenticeHall ofIndiaLtd.	-

Curriculum Development Team

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10. Sh V K Singh, Sr Faculty, Dept. Cement Tech. (Former GM M/s Maihar Cement)

<u>COs, POsandPSOs Mapping</u>

Program Title: B.TechCourse Code: 98UHV307; Course Title: Universal Human Values

Course Outcomes	Program Outcomes												ProgramSpecificOutcome			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
	Engineering knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual and team work	Communication	Project management and finance	Life-long learning	The ability to apply technical & engineering knowledge for production	Ability to understand the day to plant operational problems of cement	Ability to understand the latest cement manufacturing technology	Ability to use the research based innovative knowledge for sustainable
98UHV307.1 To understanding Value Education	2	2	3	2	1	1	1	3	2	1	1	2	2	2	2	2
98UHV307.2 Students will have the ability to learn about Harmony in the Human Being	2	2	1	3	1	2	1	3	2	2	2	2	2	2	2	2
98UHV307.3 Student will be able to gain knowledge on Harmony in the Family and Society.	2	1	2	1	1	2	2	3	2	1	2	3	2	2	2	2
98UHV307.4 Understanding Harmony in the Nature/Existence.	1	1	1	2	1	2	1	3	2	1	2	2	2	2	3	3
98UHV307.5: Student will able to understand about Implications of Holistic Understanding- A Look at Professional Ethics.	1	1	1	1	1	2	2	3	1	2	2	2	3	2	3	2

Legend:1–Low,2–Medium,3–High

Course Curriculum Map: Physics-I

POs&PSOsNo.	Cos No.&Titles	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO1,2,3,4	**98UHV307.1** To understanding Value Education	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10 SO1.11 SO1.12		**Unit-1: Understanding Value Education** 1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9 , 1.10, 1.11, 1.12	SL1,2
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO1,2,3,4	**98UHV307.2** Students will have the ability to learn about Harmony in the Human Being	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9 SO2.10 SO2.11		**Unit-2: Harmony in the Human Being** 2.1,2.2,2.3,2.4,2.5,2.6,2.7, 2.8,2.9, 2.10, 2.11	SL1,2
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO1,2,3,4	**98UHV307.3** Student will be able to gain knowledge on Harmony in the Family and Society.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9 SO3.10 SO3.11 SO3.12 SO3.13		**Unit-3: Harmony in the Family and Society** 3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9 3.10 3.11 3.12 3.13	SL1,2,3,4
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO1,2,3,4	**98UHV307.4** Understanding Harmony in the Nature/Existence.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10 SO4.11 SO4.12		**Unit-4: Harmony in the Nature/Existence Implications of Holistic** 4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8,4.9, 4.10 4.11 4.12	SL1,2,3,4,5
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO1,2,3,4	**98UHV307.5** Student will able to understand about Implications of Holistic Understanding- A Look at Professional Ethics.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9 SO5.10 SO5.11 SO5.12		**Unit 5: Understanding- A Look at Professional Ethics** 5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8, 5.9, 5.10 5.11 5.12	SL1,2,3,4

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	IV	
CourseCode:	98BT401	
Coursetitle:	Molecular Biology	**Curriculum Developer**: Shaily Mishra, Assistant Professor
Pre-requisite:	Students should have basic knowledge of genetics, biochemistry of nucleic acids, chromosomes and gene structure.	
Rationale:	The paper on Molecular Biology in a B.Tech Biotechnology program seeks to understand the molecular basis of genetic processes. The students will acquire basic knowledge and explore skills in molecular biology an become aware of the complexity and harmony of cell. The course enlightens the students about the various processes such as DNA replication, transcription, translation, regulation, repair and advances in the topics in recent research. The students will be able design and implement experimental procedures using relevant techniques.	
CourseOutcomes (COs):	**CO1-98BT401.1.** Understand the composition, structure and characteristics of nucleic acids. **CO2-98BT401.2.** Understand molecular phenomena of DNA copying and transmission of information, its damage and repair mechanism. **CO3-98BT401.3.** Students are able to understand the chemical and molecular processes that occur in and between cells. **CO4-98BT401.4.** Gain knowledge about the protein synthesis mechanism and its localization in and between the cells. **CO5-98BT401.5.** The regulation of gene function, respond to environment and associated phenomena.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme ofstudies (Hours/Week)					Total Credits(C) (L:T:P=3:0:1)
			CI	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
ProgramCommon(PC)	98BT401	Molecular Biology	3	2	1	3	9	3+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment:Theory

Board	Couse	Course	Scheme of Assessment (Marks)		
			Progressive Assessment (PRA)	End Semester Assessment	Total Marks

of Study	Code	Title	Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)	(ESA)	(PRA+ ESA)
PC	98BT401	Molecular Biology	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		

			7 marks each (CA)						
PC	98BT451	Molecular Biology lab	35	5	5	5	50	50	50

Course-Curriculum:	
This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**ApproximateHours**

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	04	01	03	17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-98BT401.1 Understand the composition, structure and characteristics of nucleic acids.	**SO1.1** Understand the chemical nature and structure of genetic material.	**LI1.1** Isolation of bacterial genomic DNA.	**Unit-1** **Genetic Material** **CI1.1** Chemical nature,	**SL1.1** Study about prokaryotic and eukaryotic cells.
	SO1.2 Study the structure & properties of genetic material		**CI1.2** Structure & properties of genetic material	
	SO1.3 Explain experimental	**LI1.2** Isolation of plant	**CI1.3** DNA as the genetic	**SL1.2** Learn about

	evidences to show DNA as genetic material.	genomic DNA.	material- experimental evidences	experimental evidences of genetic material.
	SO1.4 Understand structure and forms of DNA		**CI1.4** Structure of DNA,	**SL1.3** Study the Watson and Crick model of DNA.
	SO1.5 Alternative forms of DNA		**CI1.5** Alternative forms of DNA	
	SO1.6 Explain RNA as genetic material		**CI1.6** RNA as genetic material	
	SO1.7 Organization of genetic material into the cell.		**CI1.7** Genomic organization/ packaging of genetic material,.	
	SO1.8 Organization of DNA- Nucleosome model		**CI1.8** Nucleosome model	
	SO1.9 revision and discussion		**CI1.9** revision and discussion	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Diagrammatic representation of experiments to prove DNA as genetic material.
	SW1.2 Mini Project	Differentiate between prokaryotic and eukaryotic genome organization.
	SW1.3 Other Activities (Specify)	Find out some you tube videos based on working model of biological activity associated with DNA.

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-98BT401.2. Understand molecular phenomena of DNA copying and transmission of information, its damage and repair mechanism.	**SO2.1** Understand about the origin site of DNA replication.	**LI2.1** Isolation of bacterial plasmid and their separation to confirm the coiling.	**Unit-2** **DNA replication and repair** **CI2.1** Origin of DNA replication,.	**SL2.1** Study the structure of DNA and its functions.
	SO2.2 Understand about the model of DNA replication in prokaryotes	**Li2.2** To Prepare the setup for gel electrophoresis and PCR	**CI2.2** Replication of bacterial chromosomes-Theta model	
	SO2.3 Understand about the model of DNA replication in eukaryotes		**CI2.3** Replication of eukaryotic chromosomes-Linear model	
	SO2.4 Rolling circle		**CI2.4** Rolling circle replication	**SL2.2** Learn the functions of

Item	Cl	LI	SW	SL	Total
Approx.Hrs	9	04	01	04	18

	mechanism of DNA replication.			telomere
	SO2.5 Understand the function of DNA polymerases		**CI2.5** DNA polymerases	**SL2.3** Study the fundamentals of cell division
	SO2.6 Explain the enzymes and mechanism involved in DNA replication.		**CI2.6** Mechanism of DNA replication and its regulation	
	SO2.7 Define the concept of telomere		**CI2.7** Telomere replication	**SL2.4** Find out the different kinds of DNA damage in the cell
	SO2.8 Explain the role of different repair mechanism of DNA damage		**CI2.8** DNA repair mechanisms: photo reactivation, excision, mismatch, post replication recombination repair, SOS repair	
	SO2.9 Revision and discussion		**CI2.9** Revision and discussion	

Suggested Sessional Work (SW):*anyone*	**SW2.1** Assignments	Write the mechanism of DNA replication in both prokaryotes and eukaryotes.
	SW2.2 Mini Project	Find some research paper on causes of DNA damage in the cell.
	SW2.3 Other Activities (Specify)	Draw a neat labelled diagram of various repair mechanism in the cell

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-98BT401.3 Students are able to understand the chemical and molecular processes that occur in and between cells.	**SO3.1** Understand the process involved in synthesis of RNA molecules from DNA.	**LI3.1** Competent cell preparation using bacterial *E.coli* strain.	**Unit-3 Gene Expression I - Transcription** **CI3.1:** Transcriptional unit	**SL3.1** DNA binding proteins and their interaction with DNA.
	SO3.2 Study the role of bacterial and eukaryotic RNA polymerases		**CI3.2** Bacterial and eukaryotic RNA polymerases	
	SO3.3 Learn the role of sigma factor. Cis-regulatory sequence, enhancers/silencers		**CI3.3** Role of sigma factor. Cis-regulatory sequence, enhancers/silencers	
	SO3.4	**LI3.2**	**CI3.4**	**SL3.2**

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	04	01	03	17

	Factors and enzymes involved in RNA synthesis.	Bacterial transformation	Cognate transcription factors	Functions of different types of RNAs.
	SO3.5 Steps involved in process of transcription		**CI3.5** Initiation, elongation & termination of transcription	
	SO3.6 Role of regulatory proteins in RNA synthesis.		**CI3.6** Role of transcription factors, promoters and enhancers.	**SL3.3** Study the importance of Central Dogma.
	SO3.7 Post transcriptional modification in synthesized RNA.		**CI3.7** Processing of rRNA , tRNA and mRNA, poly-A tailing, 5' capping,	
	SO3.8 Understand the function of RNA editing		**CI3.8** RNA editing	
	SO3.9 Revision and discussion		**CI3.9** Revision and discussion	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe mechanism of transcription in prokaryotes and eukaryotes.
	SW3.2 Mini Project	Diagrammatic representation of process of RNA processing in different types of RNAs.
	SW3.3 Other Activities (Specify)	Write the role of various proteins and enzyme involved in transcription process and RNA processing.

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-98BT401.4 Gain knowledge about the protein synthesis mechanism and its localization in and between the cells.	**SO4.1** Study of genetic code and wobble hypothesis.	**LI4.1** Restriction digestion of plant genomic DNA	**Unit-4 Gene Expression II - Translation** **CI4.1:** Genetic code, wobble hypothesis.	**SL4.1** Structure of protein (primary, secondary and tertiary)
	SO4.2 Role of ribosome and different RNAs	**LI4.2** Restriction digestion of bacterial genomic DNA	**CI4.2:** Ribosomal RNA and ribosome organization, transferRNA,	**SL4.2** Role of protein in biological activities.
	SO4.3 Steps involved in process of protein synthesis in prokaryotes		**CI4.3:** Translation process-initiation, elongation, termination in prokaryotes	**SL4.3** Understand the role of molecular chaperones

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	04	01	04	18

	SO4.4 Steps involved in process of protein synthesis in eukaryotes		**CI4.4:** Translation process- initiation, elongation, termination in eukaryotes	
	SO4.5 Comparison of eukaryotic and prokaryotic protein synthesis systems.		**CI4.5:** Comparison of eukaryotic and prokaryotic protein synthesis systems.	
	SO4.6 Importance Post-translational modifications.		**CI4.6:** Post- translational modifications	**SL4.4** Interaction of proteins in and between the cell.
	SO4.7 Translocation of proteins in and between the cells.		**CI4.7:** Translocation of proteins across ER membrane, protein modifications and folding in ER, transport into mitochondria, chloroplast, nucleus and peroxisomes	
	SO4.8 Learn about role of molecular chaperones		**CI4.8:** Molecular chaperones	
	SO4.9 Revision and discussion		**CI4.9** Revision and discussion	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe the importance of post translation modification.
	SW4.2 Mini Project	Diagrammatic representation of translation process in both prokaryotes and eukaryotes.
	SW4.3 Other	Draw a chart of genetic code and watch you tube videos of models of protein structures.

	Activities (Specify)	

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-98BT401.5 The regulation of gene function, respond to environment and associated phenomena.	**SO5.1** Learn about role of gene regulation in prokaryotes	**LI5.1** Demonstration of DNA amplification using thermal cycler.	**Unit-5 Regulation of Gene Expression** **CI5.1:** Regulation in prokaryotes	**SL5.1** Concept of gene and unit of gene.
	SO5.2 Types of gene regulation	**LI5.2** to check the gene expression using RTPCR	**CI5.2:** Positive and negative gene regulation	
	SO5.3 Understand the operon concept.		**CI5.3:** Operon concept	
	SO5.4 Study the concept of		**CI5.4:** *lac* and *trp operon*	**SL5.2** Study of operon model

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	04	01	03	17

	lac and trp operons in prokaryotes.			and structural genes
	SO5.5 Understand ara operon and glucose effect		**CI5.5:** *ara* operon, catabolite repression, attenuation	
	SO5.6 Control of gene expression in eukaryotes.		**CI5.6:** Regulation in eukaryotes- methylation & acetylation	**SL5.3** Study the role of regulatory proteins in gene regulation.
	SO5.7 Hormonal regulation of gene expression		**CI5.7:** Hormonal control of gene expression	
	SO5.8 Mechanism of RNA silencing		**CI5.8:** RNA silencing	
	SO5.9 Revision and discussion		**CI5.9** Revision and discussion	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Describe mechanism of gene regulation in prokaryotic and eukaryotic organism.
	SW5.2 Mini Project	Diagrammatic representation of positive and negative regulation in prokaryotes.
	SW5.3 Other Activities (Specify)	Read research paper related to gene regulation in both prokaryotic and eukaryotic organisms.

Course duration (in hours)to attain Course Outcomes:

Course Title: Molecular Biology **Course Code:**98BT401

Course Outcomes(COs)	**Class lecture (CI)**	**Laboratory Instruction(LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-98BT401.1. Understand the composition, structure and characteristics of nucleic acids.	9	4	3	1	17
CO2-98BT401.2. Understand molecular phenomena of DNA copying and transmission of information, its damage and repair mechanism.	9	4	4	1	18
CO3-98BT401.3. Students are able to understand the chemical and molecular processes that occur in and between cells.	9	4	3	1	17
CO4-98BT401.4. Gain knowledge about the protein synthesis mechanism and its localization in and between the cells.	9	4	4	1	18
CO5-98BT401.5. The regulation of gene function, respond to environment and associated phenomena.	9	4	3	1	17
Total Hours	45	20	17	5	87

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Molecular Biology **Course Code:**98BT401

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-98BT401.1. Understand the composition, structure and characteristics of nucleic acids.	2	1	1	1	5
CO2-98BT401.2. Understand molecular phenomena of DNA copying and transmission of information, its damage and repair mechanism.	2	4	5	1	12
CO3-98BT401.3. Students are able to understand the chemical and molecular processes that occur in and between cells.	3	5	5	1	14
CO4-98BT401.4. Gain knowledge about the protein synthesis mechanism and its localization in and between the cells.	2	3	5	1	11
CO5-98BT401.5. The regulation of gene function, respond to environment and associated phenomena.	5	4	1	0	10
Total Marks	**14**	**17**	**17**	**04**	**52**

***Legend*:A,** Apply;**An,** Analyze;**E,** Evaluate;**C,** Create

Suggested learning Resources:

(a) Books:

S.No.	**Title/Author/Publisher details**
1	Genes V by Benjamin Lewin, Oxford University Press, New York, 1994.
2	Gene IX, Benjamin Lewin Oxford University Press, New York, 2006.
3	Principles of Genetics, Snustad and Simmons, Seventh Edition, John Wiley and Sons, Inc.,2015.

4	Molecular Cell Biology, Lodish et.al., W. H. Freeman and Company,Eighth Edition,2016.
5	Genomes 5 by T.A. Brown, John Wiley and sons (Asia)PTE LTD, New York, Fifth Edition2023

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Waste water/Effluent Treatment plant and downstream pharmaceutical plants
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: IV Semester

Course Title: Molecular Biology

Course Code: 98BT401

CO/PO Mapping	

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1-98BT401.1. Understand the composition, structure and characteristics of nucleic acids.	-	-	-	-	2	2	3	-	3	3	3	3	2	2	1
CO2-98BT401.2. Understand molecular phenomena of DNA copying and transmission of information, its damage and repair mechanism.	-	-	-	-	-	-	3	-	3	2	3	3	2	1	2
CO3-98BT401.3. Students are able to	-	-	-	-	-	-	3	-	3	1	3	3	1	1	3

understand the chemical and molecular processes that occur in and between cells.															
CO4-98BT401.4. Gain knowledge about the protein synthesis mechanism and its localization in and between the cells.	**-**	**-**	**-**	**-**	**2**	**2**	**3**	**3**	**-**	**1**	**3**	**3**	**1**	**1**	**3**
CO5-98BT401.5. The regulation of gene function, respond to environment and associated phenomena.	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**3**	**-**	**2**	**3**	**3**	**1**	**3**	**2**

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	**COs**	**SOs No.**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-98BT401.1.** Understand the composition, structure and characteristics of nucleic acids.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	**LI 1** **LI 2**	1.1,1.2,1.3,1.4,1.5 , 1.6,1.7,1.8, 1.9	**1SL-1,2,3**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-98BT401.2.** Understand molecular phenomena of DNA copying and transmission of information, its damage and repair mechanism.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	**LI 1** **LI2**	2.1, 2.2, 2.3, 2.4, 2.5,2.6,2.7,2.8, 2.9	**2SL-1,2,3,4**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3-98BT401.3.** Students are able to understand the chemical and molecular processes that occur in and between cells.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	**LI 1** **LI2**	3.1,3.2,3.3,3.4,3.5, 3.6,3.7,3.8, 3.9	**3SL-1,2,3**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-98BT401.4.** Gain knowledge about the protein synthesis mechanism and its localization in and between the cells.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	**LI 1** **LI2**	4.1,4.2,4.3,4.4.4.5, 4.6,4.7,4.8, 4.9	**4SL-1,2,3,4**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO5-98BT401.5.** The regulation of gene function, respond to environment and associated phenomena.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	**LI 1** **LI2**	5.1,5.2,5.3,5.4,5.5, 5.6,5.7,5.8, 5.9	**5SL-1,2,3**

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	IV	
Course Code:	98BT402	
Course title:	Biochemical Engineering	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of basic mathematical calculations, and fermentation.	
Rationale:	Biochemical engineering provides information in bioprocess engineering, bioinformatics, and biotechnology for students. In India and outside, there is a lot of opportunity for biochemical engineers. Across a range of industries, biochemical engineers can find work. They work in the food industry, nuclear industry, healthcare industry, chemical manufacturing firms, pharmaceutical industry, research labs, and other sectors. Biochemical engineers develop novel products and manufacturing methods from biological materials by utilizing cutting-edge technology and their expertise in biology, chemistry, and engineering. They frequently collaborate in a laboratory setting with scientists and other engineers to evaluate material interactions in order to generate product concepts.	
Course Outcomes (COs):	**CO1-98BT402.1.** Illustrate the basic mechanism of Biochemical Engineering & Mass Balance **CO2-98BT402.2.** Discuss the role of Energy Balance in bioprocessing **CO3-98BT402.3.** Comprehend & distinguish among the working mechanism of Heat transfer **CO4-98BT402.4.** Interpretate the mechanism of Biochemical Kinetics **CO5-98BT402.5.** Examine and demonstrate the mechanism of Cellular Metabolism and Kinetics	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=2:0:1)
			CI	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Common (PC)	98BT402	Biochemical Engineering	2	2	1	3	8	3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of	Couse	Course Title	Scheme of Assessment (Marks)		
			Progressive Assessment (PRA)	End Semester Assessment	Total Marks

Study	Code		Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)	(ESA)	(PRA+ ESA)
PC	98BT402	Biochemical Engineering	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PC	98BT452	Biochemical Engineering	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	05	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-98BT402.1 Illustrate the basic mechanism of Biochemical Engineering & Mass Balance	**SO1.1** Explain concept of Biochemical engineering	**LI1.1** To determine the biomass yield	**Unit-1** **CI1.1** Outline of Biochemical Engineering	**SL1.1** Practice to operate scientific calculator
	SO1.2 Define Basic terminology, scope and application	**LI1.2** To determine the consumption of substrate	**CI1.2** Significance of Biochemical Engineering	**SL1.2** Solve numerical problems related to Mass Balance
	SO1.3 Elaborate the scientific applications of Mass balance		**CI1.3** Thermodynamic preliminaries, law of conservation of mass	**SL1.3** Write down few points on Microbial growth kinetics
	SO1.4 Define the mechanism of Conservation of Mass in biochemical engineering		**CI1.4** Types of material balances, Procedure of material balance	**SL1.4** Learn to calculate the mass balance based numerical
	SO1.5 Describe Material balance and its significance		**CI1.5** Material balance with: recycle, bypass, and purge stream	**SL1.5** Understand the basic problem solving related to biomass-substate based yield

	SO1.6 Interpret and solve stoichiometry of growth and product formation, Derive Biomass yield, Theoretical yield, Oxygen demand, Max. possible Yield		**CI1.6** Derive and Solve numerical related to stoichiometry of growth and product formation Derive Biomass yield, Theoretical yield, Oxygen demand, Max. possible Yield	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	05	16

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail about the role of Biochemical Engineering in Product development
	SW1.2 Mini Project	Differentiate between Upstream and Downstream processing
	SW1.3 Other Activities (Specify)	Draw a flowchart compiling all procedures used in Mass Balance equations

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-98BT402.2. Discuss the role of Energy Balance in bioprocessing	**SO2.1** Explain concept of Energy balance	**LI2.1** Demonstrate the working of Energy balance in fermentation process	**Unit-2** **CI2.1** Basic energy concepts, units, Energy balance equations	**SL2.1** Find out the role of Kinetic, Potential and Internal energy in biochemical engineering
	SO2.2 Distinguish between Adiabatic process, Steady state process	**LI2.2** To perform the experiment of production of microbial biomass	**CI2.2** Adiabatic process, Steady state process	**SL2.2** Read the difference between Adiabatic process, Steady state process
	SO2.3 Outline the mechanism of		**CI2.3** Enthalpy change in Non-	**SL2.3** Write down few points on

	Enthalpy change in Non-Reactive process		Reactive process	Enthalpy change in Non-Reactive process
	SO2.4 Define the mechanism of biological separations		**CI2.4** Procedure for energy balance calculation	**SL2.4** Solve all numerical related to energy balance equations
	SO2.5 Explain the role of Rotary vacuum filtration unit		**CI2.5** Enthalpy change due to Reaction	
	SO2.6 Illustrate the mechanism of change in Phase due to energy, critical mechanism of Energy and Mass Balance equation, Solve numerical problem related to energy balance and phase changes		**CI2.6** Change of Phase, Energy and Mass Balance equation corelation, Fermentation Energy	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	04	15

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Solve numerical on the basis of energy balance equation
	SW2.2 Mini Project	Make a project on Adiabatic process and Steady State process
	SW2.3 Other Activities (Specify)	Make a Power point presentation on Energy mass balance

				Self-Learning (SL)

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Derive the equations for Heat Transfer for conduction, convection in fermentation technology
	SW3.2 Mini Project	Describe the role of heat Transfer coefficients
	SW3.3 Other Activities (Specify)	Prepare one Power point presentation on "Double Pipe Heat Exchangers and its mechanism"

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-98BT402.4. Interpretate the mechanism of Biochemical Kinetics	**SO4.1** Elucidate the Fundamental Reaction Kinetics	**LI4.1** To perform the kinetics of enzyme using graphical method	**Unit-4** **CI4.1** Fundamental Reaction Kinetics	**SL4.1** Find out the Fundamental Reaction Kinetics
	SO4.2 Distinguish among Rates of Chemical Reaction, Elementary Reaction and Equilibrium	**LI4.2** To check the enzyme kinetics of the bacterial microbes	**CI4.2** Rates of Chemical Reaction, Elementary Reaction and Equilibrium	**SL4.2** Understand how the rate of chemical reaction occurs

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	05	16

	SO4.3 Analyse the Temperature Dependence of Reaction Rate Constant k		**CI4.3** Temperature Dependence of Reaction Rate Constant k	**SL4.3** Evaluate and derive Temperature Dependence of Reaction Rate Constant k
	SO4.4 Distinguish among the Rate Equations for First- and Second-Order Reactions		**CI4.4** Rate Equations for First- and Second-Order Reactions	**SL4.4** Derive different kinds of enzyme reaction kinetic study
	SO4.5 Discuss Enzyme Reaction Kinetics		**CI4.5** Enzyme Reaction Kinetics	
	SO4.6 Evaluate Enzyme Reaction Kinetics		**CI4.6** Evaluation of Enzyme Reaction Kinetics	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Determine the working mechanism and applications of enzymes
	SW4.2 Mini Project	Derive the MM Equation for ES complex theory
	SW4.3 Other Activities (Specify)	Make a project on “Inhibitors for enzyme reactions”

Item	C l	LI	SW	SL	Total
Approx. Hrs	6	04	01	04	15

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-98BT402.5. Examine and demonstrate the mechanism of Cellular Metabolism and Kinetics	**SO5.1** Elucidate Carbohydrate Metabolism, Glycolysis	**LI5.1** To determine the ATPs produced in Glycolysis	**Unit-5** **CI5.1** Carbohydrate Metabolism, Glycolysis	**SL5.1** Find out the role of glycolysis
	SO5.2 Discuss the role of TCA cycle	**LI5.2** To determine the protein 3D structure, function and annotations using Protein Data Bank (PDB database)	**CI5.2** Metabolic Pathway of TCA cycle	**SL5.2** List down various kinds of metabolites produced in TCA cycle
	SO5.3 Analyse the working of Electron transport system		**CI5.3** Electron transport system	**SL5.3** Draw the flow chart for ETC
	SO5.4 Discuss Oxidative Phosphorylation		**CI5.4** Oxidative Phosphorylation	**SL5.4** Draw the flow chart for Oxidative

				Phosphorylation
	SO5.5 Describe Microbial growth curve		**CI5.5** Microbial Growth curve	**SL5.5** Draw the graph for Microbial Growth curve
	SO5.6 Derive Cell Growth kinetics in Batch culture		**CI5.6** Cell Growth kinetics in Batch culture	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general mechanism of Cell Growth kinetics
	SW5.2 Mini Project	Describe the Biomass and Product based yield factors
	SW5.3 Other Activities (Specify)	Write metabolic pathway for TCA cycle

Course duration (in hours) to attain Course Outcomes:

Course Title: Biochemical Engineering **Course Code:** 98BT402

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO5-98BT402.5. Examine and demonstrate the mechanism of Cellular Metabolism and Kinetics	6	4	5	1	16
CO2-98BT402.2. Discuss the role of Energy Balance in bioprocessing	6	4	5	1	16
CO3-98BT402.3. Comprehend & distinguish among the working mechanism of Heat transfer	6	4	4	1	15

CO4-98BT402.4. Interpretate the mechanism of Biochemical Kinetics	6	4	5	1	16
CO5-98BT402.5. Examine and demonstrate the mechanism of Cellular Metabolism and Kinetics	6	4	4	1	15
Total Hours	30	20	23	05	78

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Biochemical Engineering **Course Code:** 98BT402

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO5-98BT402.5. Examine and demonstrate the mechanism of Cellular Metabolism and Kinetics	2	1	1	1	5
CO2-98BT402.2. Discuss the role of Energy Balance in bioprocessing	2	4	5	1	12
CO3-98BT402.3. Comprehend & distinguish among the working mechanism of Heat transfer	3	5	5	1	14
CO4-98BT402.4. Interpretate the mechanism of Biochemical Kinetics	2	3	5	1	11
CO5-98BT402.5. Examine and demonstrate the mechanism of Cellular Metabolism and Kinetics	5	4	1	0	10
Total Marks	**14**	**17**	**17**	**04**	**52**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

(b)

S.No.	Title/Author/Publisher details
1	Pauline M. Doran, “Bioprocess engineering principles”: Academic press
2	James E. Bailey & David F. Ollis- Biochemical engineering fundamentals
3	Peter F. Stanbury, Allan Whitaker “Principles of fermentation technology”
4	Fundamentals of Biochemistry. Author, JL Jain et al. Edition, reprint. Publisher, S. Chand Publishing, 2004.
5	Biotechnology-Questioning The Reasons: 2^{nd} Edition, Book Rivers Publication

(c) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Waste water/Effluent Treatment plant and downstream pharmaceutical plants
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: IV Semester

Course Title: Biochemical Engineering

Course Code: 98BT402

CO/PO Mapping															
Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO5-98BT402.5.	-	1	-	1	2	2	3	-	3	2	2	3	1	2	1

Examine and demonstrate the mechanism of Cellular Metabolism and Kinetics															
CO2-98BT402.2. Discuss the role of Energy Balance in bioprocessing	**-**	**1**	**-**	**-**	**-**	**-**	**3**	**-**	**2**	**2**	**3**	**3**	**3**	**-**	**2**
CO3-98BT402.3. Comprehend & distinguish among the working mechanism of Heat transfer	**-**	**1**	**1**	**1**	**-**	**-**	**3**	**-**	**3**	**1**	**1**	**2**	**1**	**2**	**-**
CO4-98BT402.4. Interpretate the mechanism of Biochemical Kinetics	**-**	**-**	**1**	**-**	**2**	**2**	**3**	**3**	**-**	**1**	**3**	**3**	**2**	**1**	**3**
CO5-98BT402.5. Examine and demonstrate the mechanism of Cellular Metabolism and Kinetics	**1**	**-**	**1**	**-**	**-**	**2**	**3**	**3**	**1**	**2**	**2**	**2**	**1**	**1**	**2**

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO5-98BT402.1.** Examine and demonstrate the mechanism of Cellular Metabolism and Kinetics	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6	**LI 1** **LI 2**	1.1,1.2,1.3,1.4,1.5,1.6	**1SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-98BT402.2.** Discuss the role of Energy Balance in bioprocessing	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6	**LI 1** **LI 2**	2.1, 2.2, 2.3, 2.4, 2.5, 2.6	**2SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3-98BT402.3.** Comprehend & distinguish among the working mechanism of Heat transfer	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6	**LI 1** **LI 2**	3.1,3.2,3.3,3.4,3.5, 3.6	**3SL-1,2,3,4**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-98BT402.4.** Interpretate the mechanism of Biochemical Kinetics	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6	**LI 1** **LI 2**	4.1,4.2,4.3,4.4, 4.5, 4.6	**4SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12	**CO5-98BT402.5.** Examine and demonstrate the mechanism of Cellular Metabolism and Kinetics	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6	**LI 1** **LI 2**	5.1,5.2,5.3,5.4,5.5, 5.6	**5SL-1,2,3,4**

PSO 1,2, 3					

Program Name	**Bachelor of Technology - Biotechnology**	
Semester	IV	
Course title:	Genetic Engineering and Molecular Diagnostics	**Curriculum Developer**: Shaily Mishra, Assistant Professor
Pre-requisite:	Students should have basic knowledge of biology, biochemistry of nucleic acids, immune system related biological processes.	
Rationale:	The paper on Molecular biology and diagnostic techniques in a B.Sc. Biotechnology program provides students with an understanding of the basic principles and clinical significance of laboratory testing in the field of molecular diagnostics. Students will gain insights about the basic principles of DNA replication and how to perform basic molecular diagnostic techniques and their applications in the identification of genetic diseases and diseases caused by microorganisms.	
Course Outcomes (COs):	**CO1-:** Understand the basic structure of DNA and RNA, modes of DNA replication and its damage and repair mechanism. **CO2-:** Students are able to understand the chemical and molecular processes that occur in and between cells. **CO3-:** Gain knowledge about the protein synthesis mechanism and regulation of gene expression in prokaryotes. **CO4-:** Demonstrate an understanding of basic molecular diagnostic techniques. **CO5-:** Apply molecular diagnostic techniques to the identification and diagnosis of diseases.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme ofstudies (Hours/Week)					Total Credits(C) (L:T:P=3:0:1)
			CI	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
Program Common (PC)	98BT403	Genetic Engineering and Molecular Diagnostics	3	2	1	3	9	4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board	Couse	Course Title		Scheme of Assessment (Marks)		
					End Semester Assessm	Total Marks

of Study	Code			Progressive Assessment (PRA)					ent (ESA)	(PRA+ ESA)
			Class/ Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Class Activity (CAT)	Seminar (SA)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA +AT)		
PC	**98BT403**	Genetic Engineering and Molecular Diagnostics	**15**	**20**	**05**	**05**	**05**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	**Scheme of Assessment (Marks)**						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		

			(CA)						
PC	98BT453	Genetic Engineering and Molecular Diagnostics	35	5	5	5	50	50	50

Course-Curriculum:

<table>
<tr>
<td>This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.</td>
<td>ApproximateHours
<table>
<tr><td>Item</td><td>Cl</td><td>LI</td><td>SW</td><td>SL</td><td>Total</td></tr>
<tr><td>Approx. Hrs</td><td>9</td><td>04</td><td>01</td><td>3</td><td>17</td></tr>
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Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1- Understand the basic structure of DNA and RNA, modes of DNA replication and its damage and repair mechanism.	**SO1.1** Learn about DNA as genetic material	**LI1.1** Preparation of solutions for Molecular biology experiments.	**Unit-1 DNA structure and replication** **CI1.1** DNA as genetic material,	**SL1.1** Study experiments that proves DNA as genetic material
	SO1.2 Understand the structure of DNA		**CI1.2** Structure of DNA	
	SO1.3 Study about different forms of DNA		**CI1.3** Types of DNA	
	SO1.4	**LI1.2**	**CI1.4**	**SL1.2**

	Understand the experimental proof of semi conservative DNA replication.	DNA isolation from different sources	Semi conservative nature of DNA replication	Understand the role of proteins and enzymes in DNA replication
	SO1.5 Role of replicon and polymerases in prokaryotes		**CI1.5** Replicon and DNA polymerases in prokaryotes	
	SO1.6 Role of replicon and polymerases in eukaryotes		**CI1.6** Replicon and DNA polymerases in eukaryotes	
	SO1.7 Study the process of replication in prokaryotes		**CI1.7** Replication of DNA in prokaryotes	
	SO1.8 Role of telomere in termination of replication		**CI1.8** Telomere and end replication problem	
	SO1.9 Study the process of replication in eukaryotes		**CI1.9** Replication of DNA in eukaryotes	**SL1.3** Study about various factors responsible for DNA Damage

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Describe in detail the function of machinery involved in DNA replication.
	SW1.2 Mini Project	Diagrammatic representation of repair mechanism of damaged DNA.
	SW1.3 Other Activities (Specify)	Search research papers related to DNA damage.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	9	04	01	03	17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2- Students are able to understand the chemical and molecular processes that occur in and between cells.	**SO2.1** Understand the structure of RNA	**LI2.1** Isolation of bacterial plasmid and their separation to confirm the coiling.	**Unit-2 Transcription** **CI2.1** RNA structure	**SL2.1** Function of different types of RNA.
	SO2.2 Types of RNA		**CI2.2** Types of RNA	
	SO2.3 Study the role of RNA polymerase enzyme in transcription	**LI2.2** Agarose gel electrophoresis	**CI2.3** Transcription in prokaryotes: Prokaryotic RNA polymerase	**SL2.2** Study the interaction of DNA and proteins.
	SO2.4 Learn about importance of different promoters		**CI2.4** Role of sigma factor and promoter	
	SO2.5 Understand the		**CI2.5** Initiation, elongation	

	mechanism of transcription in prokaryotes		and termination of RNA chains in prokaryotes	
	SO2.6 Study the role of RNA polymerase enzyme in eukaryotes		**CI2.6** Transcription in eukaryotes: Eukaryotic RNA polymerases,	**SL2.3** Understand the role of regulatory proteins.
	SO2.7 Study the role of transcription factors, promoters and enhancers		**CI2.7** Transcription factors, promoters, enhancers	
	SO2.8 Understand the mechanism of DNA replication in prokaryotes		**CI2.8** Mechanism of transcription in eukaryotes	
	SO2.9 Learn about RNA processing		**Cl2.9** RNA splicing and processing	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Differentiate between structure of RNA polymerase in prokaryotes and eukaryotes.
	SW1.2 Mini Project	Diagrammatic representation of mechanism of different types of RNA splicing.
	SW1.3 Other Activities (Specify)	Make a PowerPoint presentation on mechanism of transcription in prokaryotes.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	9	04	01	03	17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3- Gain knowledge about the protein synthesis mechanism and regulation of gene expression in prokaryotes.	**SO3.1** Study about genetic code	**LI3.1** Demonstration of AMES test or reverse mutation for carcinogenicity	**Unit-3 Translation & Gene Expression** **CI3.1** Genetic code and its characteristics	**SL4.1** Structure of protein (primary, secondary and tertiary)
	SO3.2 Study the role of ribosome in translation.	**LI3.2** Kirby-Bauyer method (disc-diffusion method) to study antibiotic sensitivity of a bacterial culture	**CI3.2** Prokaryotic translation: ribosome structure and assembly,	**SL4.2** Role of protein in biological activities.
	SO3.3 Role of charging of aminoacyl tRNA in translation		**CI3.3** Charging of tRNA, aminoacyl tRNA synthetases	
	SO3.4 Structure and function of mRNA		**CI3.4** Polycistronic and monocistronic mRNA	
	SO3.5 Steps involved in process of protein synthesis in prokaryotes		**CI3.5** Mechanism of initiation, elongation and termination of polypeptides	**SL4.3** Understand the role of molecular chaperones
	SO3.6		**CI3.6**	**SL4.3**

	Steps involved in process of protein synthesis in eukaryotes		Mechanism of initiation, elongation and termination of polypeptides	Understand the role of molecular chaperones
	SO3.7 Post-translational modifications		**CI3.7** Post-translational modifications of proteins	**SL4.4** Study the role of regulatory proteins in gene regulation.
	SO3.8 Learn about types of post-translational modifications		**CI3.8** Types of Post-translational modifications of proteins	
	SO3.9 Understand the mechanism of protein modifications		**CI3.9** Mechanism of protein modifications	

Suggested Sessional Work (SW):*anyone*	**SW3.1** Assignments	Describe the importance of post translation modification of proteins.
	SW3.2 Mini Project	Diagrammatic representation of *lac* and *trp* operon.
	SW3.3 Other Activities (Specify)	Draw a chart of genetic code and watch you tube videos of models of protein structures.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	9	04	01	03	17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4- Demonstrate an understanding of basic molecular diagnostic techniques.	**SO4.1** Understand about molecular diagnostic techniques.	**LI4.1** A kit-based detection of a microbial infection (Widal test).	**Unit-4** **Molecular Diagnostics Techniques-I** **CI4.1** Introduction to molecular Diagnostics	**SL4.1** Study different molecular techniques
	SO4.2 Explain PCR and DNA sequencing	**LI4.2** Demonstration of PCR	**CI4.2** PCR and its applications	**SL4.2** Gain insights of DNA replication mechanism
	SO4.3 Learn about the function of different types of PCR		**CI4.3** Types of PCR	
	SO4.4 Application of DNA sequencing		**CI4.4** DNA sequencing and its method	
	SO4.5 Different types of DNA sequencing methods		**CI4.5** Types of DNA sequencing	
	SO4.6 Understand difference among different blotting technique		**CI4.6** Blotting Techniques-Southern Blotting	**SL4.3** Learn about DNA,RNA and protein
	SO4.7 Concept of Blotting Techniques		**CI4.7** Northern Blotting	

	SO4.8 Applications of blotting techniques		**CI4.8** Southern Blotting	
	SO4.9 Demonstrate about the diagnosis of genetic diseases.		**CI4.9** Diagnosis of genetic diseases,	**SL4.4** Study about molecular basis of genetic diseases.

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Differentiate between different blotting techniques used in molecular biology.
	SW4.2 Mini Project	Diagrammatic representation of PCR and DNA sequencing methods.
	SW4.3 Other Activities (Specify)	Find out some you tube videos related to detection of genetic diseases and mutation in DNA.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	9	04	01	03	17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5- Apply molecular diagnostic techniques to the identification and diagnosis of diseases.	**SO5.1** Describe the techniques for testing microbial susceptibility	**LI5.1** Perform any one immune-diagnostic test (Typhoid, Malaria, and Dengue).	**Unit-5 Molecular Diagnostics Techniques-II** **CI5.1** Susceptibility tests- Micro-dilution and macro-dilution broth procedures	**SL5.1** Study about effect of different antibiotics on microbial cell
	SO5.2 Learn about types and applications of susceptibility test		**CI5.2** Diffusion test procedures.	
	SO5.3 Study the tests for bactericidal activity.	**LI5.2** Demonstration of ELISA	**CI5.3** Tests for bactericidal activity	**SL5.2** List out antibiotics that have bactericidal effect
	SO5.4 Understand the application of bactericidal		**CI5.4** Application of bactericidal activity	

	activity			
	SO5.5 Elucidate enzyme immuno assay technique		**CI5.5** Enzyme Immuno assay	**SL5.3** Learn about role of enzyme-substrate complex in immunological diagnostics.
	SO5.6 Recognize the application of enzyme in immunodiagnostic tests		**CI5.6** Applications of enzyme immunoassays in diagnostic microbiology	
	SO5.7 Learn about Immunodiagnostic tests		**CI5.7** Immunodiagnostic tests	
	SO5.8 Understand the application of immunodiagnostic tests		**CI5.8** Application of immunodiagnostic tests	
	SO5.9 Explain different immune assays techniques		**CI5.9** Immuno florescence	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Draw a ray diagram to show different immuno assay methods used in molecular diagnostics.
	SW5.2 Mini Project	Make a power point presentation on immune fluorescence.
	SW5.3 Other Activities (Specify)	Search research paper on microbial susceptibility test.

Course duration (in hours) to attain Course Outcomes:

Course Title: Genetic Engineering and M D

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1- Understand the basic structure of DNA and RNA, modes of DNA replication and its damage and repair mechanism.	9	04	03	01	17
CO2- Students are able to understand the chemical and molecular processes that occur in and between cells.	9	04	03	01	17
CO3- Gain knowledge about the protein synthesis mechanism and regulation of gene expression in prokaryotes.	9	04	03	01	17
CO4- Demonstrate an understanding of basic molecular diagnostic techniques.	9	04	03	01	17
CO5- Apply molecular diagnostic techniques to the identification and diagnosis of diseases.	9	04	03	01	17
Total Hours	45	20	15	05	85

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Molecular biology and diagnostic techniques

Course Outcomes	Marks Distribution	Total

					Marks
	A	**An**	**E**	**C**	
CO1- Understand the basic structure of DNA and RNA, modes of DNA replication and its damage and repair mechanism.	2	1	1	0	4
CO2- Students are able to understand the chemical and molecular processes that occur in and between cells.	2	4	2	0	08
CO3- Gain knowledge about the protein synthesis mechanism and regulation of gene expression in prokaryotes.	3	5	4	1	13
CO4- Demonstrate an understanding of basic molecular diagnostic techniques.	2	3	3	2	10
CO5- Apply molecular diagnostic techniques to the identification and diagnosis of diseases.	4	4	2	2	12
Total Marks	**13**	**17**	**12**	**05**	**47**

***Legend*:A,** Apply;**An,** Analyze;**E,** Evaluate;**C,** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Genes V by Benjamin Lewin, Oxford University Press, New York, 1994.
2	Gene IX, Benjamin Lewin Oxford University Press, New York, 2006.
3	Principles of Genetics, Snustad and Simmons, Seventh Edition, John Wiley and Sons, Inc.,2015.
4	Molecular Cell Biology, Lodish et.al., W. H. Freeman and Company,Eighth Edition,2016.
5	Genomes 5 by T.A. Brown, John Wiley and sons (Asia)PTE LTD, New York, Fifth Edition2023
6	Genes V by Benjamin Lewin, Oxford University Press, New York, 1994.

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Industrial plant of fermentation industries
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: IV Semester

Course Title: Genetic Engineering and Molecular Diagnostics

CO/PO Mapping															
Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1- Understand the basic structure of DNA and RNA, modes of DNA replication and its damage and repair mechanism.	-	-	-	-	2	2	3	-	3	3	3	3	2	2	1
CO2- Students are able to understand the chemical and molecular processes that occur in and between cells.	-	-	-	-	-	-	3	-	3	2	3	3	2	1	2

CO3- Gain knowledge about the protein synthesis mechanism and regulation of gene expression in prokaryotes.	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**-**	**3**	**1**	**3**	**3**	**1**	**1**	**3**
CO4- Demonstrate an understanding of basic molecular diagnostic techniques.	**-**	**-**	**-**	**-**	**2**	**2**	**3**	**3**	**-**	**1**	**3**	**3**	**1**	**1**	**3**
CO5- Apply molecular diagnostic techniques to the identification and diagnosis of diseases.	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**3**	**-**	**2**	**3**	**3**	**1**	**3**	**2**

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO1-** Understand the basic structure of DNA and RNA, modes of DNA replication and its damage and repair mechanism.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1,8 SO1.9	**LI 1** **LI 2**	1.1,1.2,1.3,1.4,1.5, 1.6,1.7,1.8,1.9	**1SL-1,2,3**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO2-** Students are able to understand the chemical and molecular processes that occur in and between cells.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	**LI 1** **LI 2**	2.1,2.2,2.3,2.4,2.5,2.6, 2.7,2.8,2.9	**2SL-1,2,3**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO3-** Gain knowledge about the protein synthesis mechanism and regulation of gene expression in prokaryotes.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	**LI 1** **LI 2**	3.1,3.2,3.3,3.4,3.5, 3.6,3.7,3.8,3.9	**3SL-1,2,3**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO4-** Demonstrate an understanding of basic molecular diagnostic techniques.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	**LI 1** **LI 2**	4.1,4.2,4.3,4.4, 4.5, 4.6.4.7,4.8,4.9	**4SL-1,2,3**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO5-** Apply molecular diagnostic techniques to the identification and diagnosis of diseases.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	**LI 1** **LI2**	5.1,5.2,5.3,5.4,5.5, 5.6,5.7,5.8,5.9	**5SL-1,2,3**

Program name	**Bachelor of Technology (B. Tech) Biotechnology**	
Semester	IV	
CourseCode:	**98BT404**	
Coursetitle:	Immunology and Immuno Technology	Developer: Mr. PARAS KOSHE
Pre-requisite:	Student should have basic knowledge about Physiology and biology and various system of our body	
Rationale:	The paper on “Immunology and Immuno Technology” in B.tech. Biotechnology program allow predicting the working principle and application of numerous cells involved in defense responses. This subject will build up the basic and advanced mechanism of immune responses during the different stresses. This subject offers the students the opportunity to advance their knowledge of immunology.	
CourseOutcomes (COs):	**98BT404.1:** The immune system, including its organs, cells, and receptors, will be covered in class. **98BT404.2:** Comparative study of immunogen and antigen and descriptive study of structure of antibody and its production. **98BT404.3:** Understand the mechanism of generation of B and T cell responses and study the their relationship with MHC, Cytokines and complement system **98BT404.4:** The molecular foundations of antigen recognition, hypersensitivity reactions, and antigen-antibody interactions will be thoroughly understood by the students. **98BT404.5:** The student gains an understanding of the fundamentals of immunology and how it can be used to treat diseases of humans as a result of the course.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme ofstudies (Hours/Week)					Total Credits(C) (L: T: P=3:0:1)
			CI	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
Program Core(PCC)	98BT404	Immunology and Immuno Technology	3	2	1	1	7	4

*Legends:*CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial(T) and others);
LI: Laboratory Instruction(Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number	Class Test 2 (2 best out	Seminar one	Clas sActivityanyone	Class Attendance (AT)	Total Marks (CA+CAT+CT+SA+AT)		

			3 marks each (CA)	of 3) 10 marks each (CT)	(SA)	(CAT)				
PCC	98BT404	Immunology and Immuno Technology	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PC	98BT454	Immunology and Immuno Technology	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	04	01	04	18

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO 1: Understand the essential of immune system cells to the organism	SO1.1: Able to define the immune system	LI1.1 Prepare a detailed report on the various components of the immune system	CI 1.1: **Introduction**: overview of the immune system	SL 1.1: Study about the basic of immune systems
	SO1.2: Understanding fundamental of immune system and Lymphatic system.	LI1.2 Dissect a model of the thymus and spleen to understand their structure and function.	CI 1.2: Lymphatic system	SL 1.2: Learn about defence mechanism in lower organism
	SO1.3: Understanding fundamental of lymphoid organs and their structure and functions.		CI 1.3: Lymphoid organs	SL 1.3: Read the working principle of the non-specific immune system
	SO1.4: In depth study		CI 1.4: Cells of the immune	SL 1.4: Compare the B-

	about the specific immune systems and their cells.		system and their functions	cells and T-cells
	SO1.5 Able to know innate and acquired immunity and their role in human life,		CI 1.5: Innate and Acquired immunity	
	SO1.6 Focus on the cells and processes of innate immunity.		CI 1.6: Cells and processes of Innate immunity	
	SO1.7: To know the cells and organs and their functions in acquired immunity.		CI 1.7: Cells and organs of the Acquired immunity-	
	SO1.8: Basic and advanced understanding of Anatomical and Physiological barriers of innate immunity.		CI 1.8: Anatomical and Physiological barriers;	
	SO1.9 Students will able to learn innate immune responses and their mechanism how these responses help in pathogen elimination.		CI 1.9 Innate immune response and their recognition structures; Pathogen elimination.	

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Describe in details about the immune system and lymphatic system.
	SW1.2 Mini Project	Draw well labelled diagram of different lymphoid organs and mention their functions.
	SW1.3 Other Activities (Specify)	Watch animation on mode of action of first line of defence. And various anatomical and physiological barriers,

Item	Cl	LI	S W	SL	Total
Approx.Hrs	09	06	01	03	19

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO 2: Know the fundamentals of immunoglobulins, antigens, and their classifications	SO2.1: Discuss the properties of antigens	LI 2.1: Demonstration of Antibody-antigen interaction	CI 2.1: Antigens: Properties and types, Haptens and Adjuvants	SL 2.1: Fundamental structure of immunoglobins
	SO2.2: Discuss the types of antigens	LI2.2 Determination of bleeding time of an individual	CI 2.2: Antigens: Properties and types, Haptens and Adjuvants	SL 2.2: Read the working principle of non-specific immune system

	SO2.3 explain Haptens and Adjuvants	LI2.3 Determination of Clotting time of an individual	CI 2.3: Haptens and Adjuvants	SL 2.3: Read in details about the monoclonal and polyclonal antibody
	SO2.4: Build up the concept about the antibody's structures and classes		CI 2.4: Antibodies: Types, Molecular structure of Immuno-globulins, allotypes & idiotypes	
	SO2.5: Build up the concept about the antibody's structures and classes		CI 2.5: Antibodies: Types, Molecular structure of Immuno-globulins, allotypes & idiotypes	
	SO2.6: Summarizing the mode of monoclonal Antibody		CI 2.6: monoclonal Antibody	
	SO2.7: Learn how body functions under the pathogen attack		CI 2.7: organization and expression of immunoglobulin genes.	
	SO 2.8: Learn the concept of generation of antibody diversity and its importance.		CI 2.8: generation of Ab diversity	
	SO 2.9 Summarizing the mode of action and mechanism of class switching of antibodies.		CI 2.9 class switching	

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Discuss about cytokines and their role in immune responses
	SW1.2 Mini Project	Draw well labelled diagram of immunoglobin and mention their types
	SW1.3 Other Activities (Specify)	Watch animation on Antibody-antigen interaction mechanism

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	02	01	02	14

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO 3: In-depth study about action of immune responses and their genetic regulations	SO3.1: Discuss about how immune cell are activated and Summarizing the mode of action of B-cells and T-Cells in defence	LI3.1 Determination of Haemoglobin % of given human blood	CI 3.1: Generation of B-Cell and T-Cell Responses	SL3.1: Figure out the fundamental differences between humoral and cell-mediated immune responses
	SO3.2: Learn the structure and function of MHC molecules.		CI3.2: Major histocompatibility complex	SL 3.2: Advance the knowledge of the regulation of B & T cells on exposure to the antigens
	SO3.3: Able to visualize Activation of MHC I and II by peptide binding.		CI3.3: peptide binding by class I and class II molecules,	
	SO 3.4 Focus on antigen processing and presentation and their role in antibody production and immunity		CI 3.4: antigen processing and presentation	

	SO 3.5: Summarizing the mode of action of B-cells and T-Cells in defence.		CI 3.5: -Cell receptor, B- and T-cell activation and differentiation.	
	SO 3.6: Learn about various types of signalling pathways and molecules involved in it..		CI 3.6: signaling pathways	
	SO 3.7 Learn how body functions under the pathogen attack		CI 3.7 Cytokines: properties	
	SO 3.8 Elaborate and describe the role of T helper cells in cytokine production.		CI 3.8 Role of T-helper cells in cytokine production	
	SO 3.9 Describe about the pathways types functions and role of complement system in immunity.		CI 3.9 complement system	

Suggested Sessional Work (SW): *anyone*	Assignments:	Describe in detail about cytokines and their functions.
	Mini Project:	Elaborate the structure and function of MHC molecules.

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction	Class room Instruction (CI)	Self-Learning (SL)

		(LI)		
CO 4: Elaborate the various immunodeficiency related diseases and functionality of immune system	SO4.1: Discuss about principles and types of Antigen antibody Interactions	LI3.1 Determination of blood group of an individual	CI4.1: Antigen antibody Interactions	SL4.1: Study the MHCs
	SO 4.2: To know the mechanism and examples of precipitation reaction.		CI 4.2: Precipitation reaction	SL 4.2: Learn what are the CD4 & CD8
	SO4.3: Focus on the mechanism and examples of agglutination reaction		CI4.3: agglutination reactions	
	SO 4.4: Discus about Antibody affinity and activity		CI 4.4: Antibody affinity and activity	SL 4.3: Study the nature of HIV and why is it not curable so far
	SO4.5: Explain isolation of lymphoid cells from blood and lymphoid organs,	LI3.2 Determination of Rh factor of an individual	CI 4.5: isolation of lymphoid cells from blood and lymphoid organs,	
	SO4.6: Discuss principles types and applications of RIA		CI4.6: Radioimmunoassay	
	SO 4.7: Explain the procedure and applications of western blot.	LI3.3 To perform ELISA test (KIT method)	CI 4.7: Western blot	
	SO 4.8: Discuss Immunoprecipitation – Immunoflouroscence , flow cytometry		CI 4.8: Immunoprecipitation – Immunoflouroscence , flow cytometry	
	SO 4.9 Describe various types of diagnostic method like ELISA and Rocket immunoelectrophoresis.		CI 4.9 Diagnostics methods: Immunodiffussion, immunoelectrophoresis. ELISA	

Suggested Sessional Work (SW): *anyone*	Assignments:	Elaborate the Principle and types of ELISA and RIA
	Mini Project:	Describe the mechanism and types of antigen antibody interactions
	Other Activities (Specify):	Make a poster explaining how pathogen make fool and escape from host immune machineries

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	06	01	03	19

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	02	01	02	14

Course outcome (COs)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO 5: Basic principles and applications of various immunization techniques as well as the various vaccinations	SO 5.1: Explain Vaccinology- Active immunization	Li5.1 to perform the antibiotic sensitive test of microbes	CI 5.1: Molecular Immunology	SL 5.1: Apply the idea of Infection to suppress the immunity to human health
	SO 5.2: Explain Vaccinology- passive immunization		CI 5.2: Preparation of vaccines	SL 5.2: Revise the ELSIA for several diseases' diagnosis.
	SO5.3: Illustrate thevaccine technology and application		CI 5.3: Vaccines & Vaccination	

	SO5.4 Explain application of recombinant DNA technology for the study of the immune systems		CI 5.4: application of recombinant DNA technology for the study of the immune systems	
	SO5.5 Explain the role and action of catalytic antibodies in -immunotherapy with genetically engineered antibodies		CI 5.5: catalytic antibodies-immunotherapy with genetically engineered antibodies	
	SO5.6: Discuss about Hypersensitivity-Delayed hypersensitivity and immediate		CI 5.6 Hypersensitive reactions	
	SO5.7: Describe about Immune responses to infectious diseases		CI 5.7: Immune responses to infectious diseases	
	SO5.8: Demonstrate about Tumor Immunology with focusing the role of Vaccines		CI 5.8 Tumor Immunology-Vaccines	
	SO5.9Explain		CI 5.9 Autoimmunity, tissue	

	autoimmunity and their role in tissue and organ transplantation.		and organ transplant	

Suggested Sessional Work (SW): Anyone	Assignments:	Detail explanation of principle of vaccine production
	Mini Project:	Discuss about the western blotting techniques and it application in infection detection
	Other Activities (Specify):	How ELISA functioning differs from RIA.

Course duration (in hours) to attain Course Outcomes:

Course Title: Immunology and Immuno- Technology **Course Code:98BT404**

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
98BT404.1: The immune system, including its organs, cells, and receptors, will be covered in class.	9	4	4	1	18
98BT404.2: comprehensive understanding of innate immunity and the cell types involved.	9	6	3	1	19
98BT404.3: Understand the structure and operation of antibodies.	9	2	2	1	14
98BT404.4: The molecular foundations of antigen recognition, hypersensitivity reactions, and antigen-antibody interactions will be thoroughly understood by the students.	9	6	3	1	19
98BT404.5: The student gains an understanding of the fundamentals of immunology and how it can be used to treat diseases of humans as a result of the course.	9	2	2	1	14
Total Hours	45	20	14	05	84

End-semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Immunology and Immuno- Technology **Course Code: 98BT404**

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
98BT404.1: The immune system, including its organs, cells, and receptors, will be covered in class.	2	1	1	1	5
98BT404.2: comprehensive understanding of innate immunity and the cell types involved.	2	4	2	2	10
98BT404.3: Understand the structure and operation of antibodies.	3	5	5	2	15
98BT404.4: The molecular foundations of antigen recognition, hypersensitivity reactions, and antigen-antibody interactions will be thoroughly understood by the students.	2	3	3	2	10
98BT404.5: The student gains an understanding of the fundamentals of immunology and how it can be used to treat diseases of humans as a result of the course.	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

***Legend*:A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	**Title/Author/Publisher details**
1	Roitt I.M, Brostoff, J., Male D.K., Immunology (Illustrated Publisher, Mosby).
2	T. J. Kindt, R.A. G. B. A. Osborne, J. Kuby. Immunology (W.H. Freeman and Company, New York).
3	Paul, W.E. (2008). Fundamental immunology (Lippincott Williams & Wilkins).
4	T.G. Parslow, D.P. Stites, A.I. Terr. Medical immunology (Lange Medical Books/McGraw-Hill).

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B.Tech. Biotechnology

Semester: IV Semester

Course Title: Immunology and Immuno- Technology

Course Code: 98BT404

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
98BT404.1: The immune system, including its organs, cells, and receptors, will be covered in class.	1	2	2	3	1	2	2	1
98BT404.2: comprehensive understanding of innate immunity and the cell types involved.	1	2	3	2	1	1	1	2
98BT4041.3: Understand the structure and operation of antibodies.	1	2	3	2	1	1	1	1
98BT404.4: The molecular foundations of antigen recognition, hypersensitivity reactions, and antigen-antibody interactions will be thoroughly understood by the students.	-	1	1	-	2	1	1	3
98BT404.5: The student gains an understanding of the fundamentals of immunology and how it can be used to treat diseases of humans as a result of the course.	1	1	1	-	-	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High,

Course Curriculum:

POs & PSOs No.	**COs**	**SOs No.**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
PO 1,2,3,4,5	**98BT404.1:** The immune system, including its organs,	SO1.1, SO1.2 SO1.3,	**LI 1** **LI 2**	1.1,1.2,1.3,1.4, 1.5,1.6,1.7,1.8,1.9	**1SL-1,2,3,4,**

PSO 1,2,3	cells, and receptors, will be covered in class.	SO1.4SO1.5, SO1.6, SO1.7, SO1.8, SO1.9			
PO 1,2,3,4,5 PSO 1,2,3	**98BT404.2:** comprehensive understanding of innate immunity and the cell types involved.	SO2.1 SO2.2 SO2.3 SO2.4, SO2.5 SO2.6, SO2.7, SO2.8, SO2.9	**LI 1** **LI 2** **LI 3**	2.1, 2.2, 2.3, 2.4,2.5, 2.6,2.7,2.8,2.9	**2SL-1,2,3**
PO 1,2,3,4,5 PSO 1,2,3	**98BT404.3:** Understand the structure and operation of antibodies.	SO3.1 SO3.2 SO3.3 SO3.4, SO3.5, SO3.6, SO3.7, SO3.8, SO3.9	**LI 1**	3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9	**3SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**98BT404.4:** The molecular foundations of antigen recognition, hypersensitivity reactions, and antigen-antibody interactions will be thoroughly understood by the students.	SO4.1 SO4.2 SO4.3 SO4.4, SO4.5, SO4.6, SO4.7 SO4.8, SO4.9	**LI 1** **LI 2** **LI 3**	4.1,4.2,4.3,4.4,4.5,4.5,4.6,4.7,4.8,4.9	**4SL-1,2,3**
PO 1,2,3,4,5 PSO 1,2,3	**98BT404.5:** The student gains an understanding of the fundamentals of immunology and how it can be used to treat diseases of humans as a result of the course.	SO5.1 SO5.2 SO5.3, SO5.4, SO5.5, SO5.6, SO5.7, SO5.8, SO5.9	**LI 1**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9	**5SL-1,2**

Program Name	**Bachelor of Technology (B Tech) -Biotechnology**	
Semester	IV	
Course Code:	98BT405	
Course title:	Biosafety, Bioethics and IPRs	**Curriculum Developer**: Dr. Deepak Mishra, Professor
Pre-requisite:	Student should have basic knowledge of Biotechnology, Genetic Engineering and Research.	
Rationale:	The paper on Biosafety, Bioethics and IPRs in a B Tech Biotechnology program is interconnected concepts that serve to ensure the responsible and ethical use of biotechnology and biological resources. They encompass various aspects, from safety and ethics in research to the protection of intellectual property. The primary goal biosafety is to ensure the safe handling, transport, and disposal of biological materials, especially those with hazardous potential. This is crucial in laboratories, research facilities, and industrial settings where biological research is conducted. Bioethics guides decision-making, ensuring that scientific progress respects human rights, dignity, and welfare. It covers informed consent, privacy, research ethics, animal welfare, and issues surrounding emerging technologies like genetic engineering and cloning. IPRs incentivize innovation by allowing researchers and inventors to profit from their work.	
Course Outcomes (COs):	**CO1-98BT405.1:** Familiarization with the basic concepts, key principles and regulations of biosafety in biotechnological research. **CO2-98BT405.2:** Acquired Skills to analyze and address ethical, legal, and socioeconomic, health and safety implications of biotechnology. **CO3-98BT405.3:** Equipped to comprehend the fundamentals of IPRs, including the legal frameworks and laws. **CO4-98BT405.4:** Recognize various methods related to patents and the patenting process law and regulations in India. **CO5-98BT405.5:** Explore role of regulatory framework for recombinant DNA research, Biotechnology and food safety laws.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits(C (L: T: P=2:0:1
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
PC	98BT405	Biosafety, Bioethics and IPRs	2	2	1	3	8	3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)		
			Progressive Assessment (PRA)	End Semester Assessment (ESA)	Total Marks

			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Activity	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		(PRA+ ESA)
PC	**98BT405**	Biosafety, Bioethics and IPRs	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: practical

Board of Study	Course Code	Course Title	**Scheme of Assessment (Marks)**						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PC	**98BT455**	Biosafety, Bioethics and IPRs	35	5	5	5	50	50	50

Course-Curriculum:

<table>
<tr><td>This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.</td><td>Approximate Hours<table><tr><td>Item</td><td>Cl</td><td>LI</td><td>SW</td><td>SL</td><td>Total</td></tr><tr><td>Approx. Hrs</td><td>06</td><td>04</td><td>01</td><td>04</td><td>15</td></tr></table></td></tr>
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Course outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction(CI)	Self-Learning(SL)
CO1-98BT405.1: Familiarization with the basic concepts, key principles and regulations of biosafety in biotechnological research.	**SO1.1** Define and Describe concept of Biosafety	**LI1.1** Case study on Biosafety	**Unit-1** **CI1.1** Biosafety: Introduction	**SL1.1** Search various reference books and study material to start the learning of Biosafety
	SO1.2 Explain History of biosafety		**CI1.2** Historical prospective	
	SO1.3 Explain objectives of biosafety		**CI1.3** objectives,	**SL1.2** Examine biosafety in your institution's lab
	SO1.4 Study of risk assessment and its regulation	**LI1.2** To do the Case study on risk assessment of lab	**CI1.4,** risk assessment in biotechnological research and their regulation	
	SO1.5 Study the concept of		**CI1.5** physical and	**SL1.3** Classify your lab based on biosafety level

	containment		biological contaminants	
	SO1.6 Study planned introduction of GMOs		**CI1.6** field trial and planned introduction of GMOs,	**SL1.4** To implement guideline in biotech laboratory.

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Describe in detail biosafety guidelines for regulation of RDT research in India.
	SW1.2 Mini Project	Prepare biosafety symbols and implement in your laboratory.
	SW1.3 Other Activities (Specify)	Preparation of biosafety manual for biotechnology laboratory.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	05	16

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-98BT405.2: Acquired Skills to analyze and address ethical, legal, and socioeconomic, health and safety implications of biotechnology.	**SO2.1** Explore the concept bioethics	**LI2.1** Case Study on Women Health Ethics	**Unit-II** **CI2.1** Bioethics: Introduction	**SL2.1** Search various books and resources for study the bioethics.
	SO2.2 Describe the ethical issue of biotechnology	**LI2.2** Case Study on Medical Negligence	**CI2.2** Ethical issues related to biotechnology	**SL2.2** study about failure of biotech products- case study

	SO2.3 Reflecting impact of biotech research in society		**CI2.3** legal and socioeconomic impacts of biotechnology	
	SO2.4 Explain health and safety issues of biotech		**CI2.4** health and safety issues	**SL2.3** to learn about control measures for biotech research
	SO2.5 Assessing the benefits of cloning		**CI2.5** possible benefits of successful cloning	**SL2.4** standardize the protocol for successful cloning
	SO2.6 Explaining the ethical concern of cloning		**CI2.6** Ethical concerns of gene cloning	**SL2.5** to learn hazards of cloning

Suggested Sessional Work (SW):*anyone*	**SW2.1** Assignments	Assess the impact on RDT research on human and environment.
	SW2.2 Mini Project	Designing of poster for showing benefits of cloning
	SW2.3 Other Activities (Specify)	To perform case studies on GMOs and their impact.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	06	04	01	05	16

Course Outcome (CO)	**Session Outcomes(Sos)**	**Laboratory Instruction(LI)**	**Class room Instruction (CI)**	**Self-Learning(SL)**

CO3-98BT405.3: Equipped to comprehend the fundamentals of IPRs, including the legal frameworks and laws.	**SO3.1** Explain the role of IPRs.	**LI3.1** Case Study on clinical trial of drugs	**Unit-III** **CI3.1** Intellectual Property Rights-: Introduction	**SL3.1** Collection of books and study materials for IPRs
	SO3.2 Assessing the concept of Intellectual Property		**CI3.2** intellectual property: trade secret	**SL3.2** Study different types of intellectual property
	SO3.3 Explaining concept of Patent and copy right	**LI3.2** preparation of business plan	**CI3.3** patent, copyright	**SL3.3** categorization of different types of intellectual property
	SO3.4 Assessing different plant varieties		**CI3.4** plant variety protection	
	SO3.5 Describe about WIPO GATT and Trips		**CI3.5** WIPO, GATT, TRIPs,:	**SL3.4** Study of role of WIPO for IPR protection
	SO3.6 Assessing the concept of PBR act		**CI3.6** plant breeder's rights	**SL3.5** Assess law and legislation for IPRs

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail about different types of intellectual properties.
	SW3.2 Mini Project	Describe the role of different Laws for protection of intellectual property.
	SW3.3 Other Activities (Specify)	Prepare a list of plant varieties protected through PBR Act and PPVFR Act.

Course Outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Classroom Instruction(CI)**	**Self-Learning(SL)**
CO4-98BT405.4: Recognize various methods related to patents and the patenting process law and	**SO4.1** Exploring the concept of Patents and Patenting	**LI4.1** Proxy Filling of Process Patent	**Unit-IV** **CI4.1** Patents and patent processing: Introduction	**SL4.1** Learn about different categories of Patents

Item	Cl	LI	SW	SL	Total
Approx. Hrs	0 6	04	01	05	16

regulations in India.	process			
	SO4.2 Assessing role of Patenting	**LI4.2** Proxy filling of Product Patent	**CI4.2** Essential requirements	
	SO4.3 Explaining the concept of patent law		**CI4.3** International scenario of patents	**SL4.2** Compare Rules of different countries
	SO4.4 Explaining the role of patent for biologics.		**CI4.4** patenting of biological materials	**SL4.3** Learn about various criteria for patentnig
	SO4.5 Evaluate impact of patent in india		**CI4.5** significance of patents in India	**SL4.4** Case studies related to patenting in India
	SO4.6 evaluate impact of patenting` of biological items		**CI4.6** protection of biotechnological inventions	**SL4.5** Case studies related to biological patents

Item	Cl	LI	SW	SL	Total
Approx.Hrs	06	04	01	04	15

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain about patent and patent processing procedure.
	SW4.2 Mini Project	Study the silent features of different law of patenting worldwide
	SW4.3 Other Activities (Specify)	Prepare one article on international status of patenting.

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO5-98BT405.5: Explore role of regulatory framework for recombinant DNA research, Biotechnology and food safety laws.	**SO5.1** Define the concept of regulation of RDNA research	**LI5.1** Demonstration of regulation of GM Products	**Unit-V** **CI5.1** Regulatory framework in Biotechnology	**SL5.1** learn about basic concept & requirement of GMOs development
	SO5.2 Able to execute role of Regulation of RDT Research		**CI5.2** Regulation of RDT research;	**SL5.2**Review concept of RDT research
	SO5.3 Apply the role of Regulation of Food products	**LI5.2** case study on Regulation of food	**CI5.3** Regulation of food and food ingredients	**SL5.3**learn how to apply Law to regulate food products
	SO5.4 Apply the Role of Regulatory framework of RDT		**CI5.4** Regulatory framework in India governing GMOs	
	SO5.5 Study the Recombinant DNA Guideline 1990		**CI5.5** Recombinant DNA Guidelines (1990)	
	SO5.6 Elaborate Revised Guideline for Research in Transgenic Plants (1998)		**CI5.6** Revised Guidelines for Research in Transgenic Plants (1998)	**SL5.4** Learn about novel characters of GM Plants

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general characteristics and silent features of RDNA laws.
	SW5.2 Mini Project	Describe the role of Law and legislations for development of new varieties.
	SW5.3 Other Activities (Specify)	Prepare a detail document on international Food law and regulations

Course duration (in hours) to attain Course Outcomes:

Course Title: Biosafety, Bioethics and IPRs **Course Code:**98BT405

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98BT405.1: Familiarization with the basic concepts, key principles and regulations of biosafety in biotechnological research.	6	4	4	1	15
CO2-98BT405.2: Acquired Skills to analyze and address ethical, legal, and socioeconomic, health and safety implications of biotechnology	6	4	5	1	16
CO3-98BT405.3: Equipped to comprehend the fundamentals of IPRs, including the legal frameworks and laws.	6	4	5	1	16
CO4-98BT405.4: Recognize various methods related to patents and the patenting process law and regulations in India	6	4	5	1	16
CO5-98BT405.5: Explore role of regulatory framework for recombinant DNA research, Biotechnology and food safety laws.	6	4	4	1	15
Total Hours	30	20	23	05	78

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Biosafety, Bioethics and IPRs **Course Code:**98BT405

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-98BT405.1: Familiarization with the basic concepts, key principles and regulations of biosafety in biotechnological research.	2	1	1	1	5

CO2-98BT405.2: Acquired Skills to analyze and address ethical, legal, and socioeconomic, health and safety implications of biotechnology	2	4	2	2	10
CO3-98BT405.3: Equipped to comprehend the fundamentals of IPRs, including the legal frameworks and laws.	2	3	3	2	10
CO4-98BT405.4: Recognize various methods related to patents and the patenting process law and regulations in India	3	5	5	2	15
CO5-98BT405.5: Explore role of regulatory framework for recombinant DNA research, Biotechnology and food safety laws.	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

***Legend*:A,** Apply;**An,** Analyze;**E,** Evaluate;**C,** Create

Suggested learning Resources:

(a) Books:

(b)

S.No.	Title/Author/Publisher details
1	Sateesh MK (2010) Bioethics and Bio safety, I. K. International Pvt Ltd.
2	Sree Krishna V (2007) Bioethics and Bio safety in Biotechnology, New age international publishers
3	The law and strategy of Biotechnological patents by Sibley. Butterworth publications.
4	Intellectual property rights – Ganguli – Tat McGraw-Hill
5	Biotechnology-B. D. Singh- Kalyani Publications

(c) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B.Tech. Biotechnology

Semester: 4th Semester

Course Title: Biosafety, Bioethics and IPRs

Course Code: 98BT405

Course Outcome (Cos)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-98BT405.1: Familiarization with the basic concepts, key principles and regulations of biosafety in biotechnological research.	1	1	2	2	3	1	2	3	2	1	2	3	2	2	3
CO2-98BT405.2: Acquired Skills to analyze and address ethical, legal, and socioeconomic, health and safety implications of biotechnology	1	1	1	1	2	1	2	2	1	2	2	2	2	3	3
CO3-98BT405.3: Equipped to comprehend the fundamentals of IPRs, including the legal frameworks and laws.	1	1	2	2	2	1	3	2	2	1	2	2	1	2	3
CO4-98BT405.4: Recognize various methods related to patents and the patenting process law and regulations in India	1	1	2	1	3	1	3	3	2	2	1	3	1	2	3
CO5-98BT405.5: Explore role of regulatory framework for recombinant DNA research, Biotechnology and food safety laws.	1	1	2	1	3	1	3	3	1	2	2	3	1	2	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	**COs**	**SOs No.**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO1-98BT405.1:** Familiarization with the basic concepts, key principles and regulations of biosafety in biotechnological research.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6	**LI1** **LI2**	1.1,1.2,1.3,1.4,1.5, 1.6	1SL-1,2,3,4
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO2-98BT405.2:** Acquired Skills to analyze and address ethical, legal, and socioeconomic, health and safety implications of biotechnology	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6	**LI1** **LI2**	2.1, 2.2, 2.3, 2.4, 2.5, 2.6	2SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO3-98BT405.3:** Equipped to comprehend the fundamentals of IPRs, including the legal frameworks and laws.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6	**LI1** **LI2**	3.1,3.2,3.3,3.4,3.5, 3.6	3SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO4-98BT405.4:** Recognize various methods related to patents and the patenting process law and regulations in India	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6	**LI1** **LI2**	4.1,4.2,4.3,4.4, 4.5, 4.6	4SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO5-98BT405.5:** Explore role of regulatory framework for recombinant DNA research, Biotechnology and food safety laws.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6	**LI1** **LI2**	5.1,5.2,5.3,5.4,5.5, 5.6	5SL-1,2,3,4

Program Name	**B. Tech. Biotechnology**	
Semester	IV	
Course Code:	98BT406	
Course title:	Industrial Fermentation	**Curriculum Developer**: Sonal Gupta
Pre-requisite:	Students should have basic knowledge of microbiology and fermentation	
Rationale:	Industrial microbiology assists industrial production processes using variety of microbial strains. They may examine microbial growth found in the pipes of a chemical factory, monitor the impact industrial waste has on the local ecosystem, or oversee the microbial activities used in cheese production to ensure quality. Fermentation is frequently used for the cultivation of biomass and in the production of enzymes, pharmaceuticals, energy, food and feedstock, bioactive compounds, biopolymers, etc., in which different microorganisms, and including filamentous fungi, are involved. The overall objective of this subject is to make student more relative about their best career opportunity in this field.	
Course Outcomes (COs):	**CO1-98BT406.1.** Describe the fundamentals of Industrial Microbiology and Fermentation Technology **CO2-98BT406.2.** Define the role of microbiology for the production of desired bioproducts **CO3-98BT406.3.** Derive the working mechanism of upstream and downstream processing **CO4-98BT406.4.** Interpretate the mechanism of fermentation process in industry **CO5-98BT406.5.** Examine the mechanism of biological product development using microbes	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=2:0:1)
			CI	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Common (PC)	98BT406	Industrial Fermentation	2	2	1	3	8	3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)		
			Progressive Assessment (PRA)	End Semester Assessment	Total Marks

			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)	(ESA)	(PRA+ ESA)
PC	98BT406	Industrial Fermentation	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	**Scheme of Assessment (Marks)**						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PC	98BT456	Industrial Fermentation lab	35	5	5	5	50	50	50

Course-Curriculum:

<table>
<tr><td rowspan="3">This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.</td><td colspan="6">Approximate Hours</td></tr>
<tr><td>Item</td><td>Cl</td><td>LI</td><td>SW</td><td>S
L</td><td>Total</td></tr>
<tr><td>Approx. Hrs</td><td>06</td><td>0
4</td><td>01</td><td>05</td><td>16</td></tr>
</table>

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-98BT406.1. Describe the fundamentals of Industrial Microbiology and Fermentation Technology	**SO1.1** Explain the concept of Fermentation	**LI1.1** To Demonstrate the working of a Bench Top bioreactor	**Unit-1** **CI1.1** Introduction, fermentation and fermenters	**SL1.1** Search various reference books and study material to start the learning of microorganisms
	SO1.2 Elaborate the historical perspective of fermentation	**LI1.2** To perform the isolation of microorganisms from different kinds of samples	**CI1.2** Brief history and developments in industrial microbiology	**SL1.2** Find out the literature showing use of fermentation technology in ancient India

	SO1.3 Differentiate between Solid-state and liquid-state (stationary and submerged) fermentations		**CI1.3** Solid-state and liquid-state (stationary and submerged) fermentations	**SL1.3** Derive the equation representing various mode of fermentations
	SO1.4 Derive the equations based on Batch, fed-batch and continuous fermentations		**CI1.4** Batch, fed-batch and continuous fermentations	**SL1.4** Explore different bioproducts manufacture in laboratory
	SO1.5 Explain & compare the components of a typical bioreactor, types of bioreactors-Laboratories, pilot- scale and production fermenters		**CI1.5** Components of a typical bioreactor, types of bioreactors-Laboratories, pilot- scale and production fermenters	**SL1.5** Draw a well labelled diagram of a bioreactor
	SO1.6 Examine the difference and working of various types of reactors		**CI1.6** Continuous stirred tank fermenter, tower fermenter, fixed bed, fluidized bed bioreactors and air-lift fermenter	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	6	06	01	05	18

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail "Applications of Microorganisms in various Sectors"
	SW1.2 Mini Project	Draw various types of Fermenters with specifications
	SW1.3 Other Activities (Specify)	List down the tables of different domains of microorganisms which are industrially important

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-98BT406.2. Define the role of microbiology for the production of desired bioproducts	**SO2.1** Explain the role of industrial scope of fermentation	**LI2.1** To Demonstrate the working of a pH electrode	**Unit-1** **CI2.1** Overview on industrial fermentation- measurement of parameters	**SL2.1** Search various reference books and study material to start the learning of microorganisms
	SO2.2 Derive the roles of Isolation of strains, media and ingredients: pH, temperature, dissolved oxygen, foaming and aeration	**LI2.2** To perform the primary and secondary of microorganisms from different kinds of samples	**CI2.2** Isolation of strains, media and ingredients: pH, temperature, dissolved oxygen, foaming and aeration	**SL2.2** Find out the literature showing use of fermentation technology in ancient India
	SO2.3 Compare different identification, screening & preservation techniques	**LI2.3** To prepare the different kinds of nutrient media for microbial culture	**CI2.3** Primary and secondary screening, strain development, preservation and maintenance of industrial strains	**SL2.3** Derive the equation representing various mode of fermentations
	SO2.4 Differentiate among different kinds of media used in industrial microbiology		**CI2.4** Crude and synthetic media; molasses, corn-steep liquor, sulphite waste liquor, whey and yeast extract	**SL2.4** Explore different bioproducts manufacture in laboratory
	SO2.5 Describe the Downstream processing: Filtration, centrifugation		**CI2.5** Downstream processing: Filtration, centrifugation	**SL2.5** Draw a well labelled diagram of a bioreactor
	SO2.6 Examine the difference and working of various types of reactors		**CI2.6** Cell disruption, solvent extraction, precipitation and ultrafiltration	

	SW1.1 Assignments	Write down any 5 kinds of Unit Operations used in Downstream Processing

Suggested Sessional Work (SW): *anyone*	**SW1.2** Mini Project	Draw a well labelled diagram of Bacterial Cell Wall showing gram+/- staining
	SW1.3 Other Activities (Specify)	Watch animation related to working of different kinds of bioreactor used in various industries

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	0 6	01	05	17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-98BT406.3 Derive the working mechanism of upstream and downstream processing	**SO3.1** Explain the role of Metabolic pathways	**LI3.1** To Demonstrate the working of a pH electrode	**Unit-3** **CI3.1** Metabolic pathways and metabolic control mechanisms	**SL3.1** Search various reference books and study material to start the learning of microorganisms
	SO3.2 Define the concept of biological product production	**LI3. 2** To perform the primary and secondary Screening of microorganisms from different kinds of samples	**CI3.2** Industrial production of citric acid, lactic acid	**SL3.2** Find out the literature showing use of Lactic Acid in industries
	SO3.3 Understand the steps of ABE fermentation	**LI3. 3** To prepare the different kinds of nutrient media for microbial culture	**CI3.3** Industrial production of Enzymes (alpha-amylase, lipase, xylase, pectinases, proteases)	**SL3.3** Derive the mechanism for fermentation of ethanol
	SO3.4 Comprehend the concept of microbial production of enzymes		**CI3.4** ABE Fermentation	**SL3.4** Write about different bioproducts manufacture in laboratory

	SO3.5 Examine the role of metabolic pathways in prokaryotes and eukaryotes		**CI3.5** Microbial Production of Lysine and Glutamic acid	**SL3.5** Find out the applications of enzymes in industries
	SO3.6 Revision and assessment		**CI3.6** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail cultivation of microorganisms
	SW3.2 Mini Project	Prepare a flowchart showing industrial production of biological products using fermentation
	SW3.3 Other Activities (Specify)	Make a Power Point Presentation on "Different Types of Microbial Culture Media"

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	0 4	01	05	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-98BT406.4 Interpretate the mechanism of fermentation process in industry	**SO4.1** Define the Microbial production of therapeutic compounds	**LI4.1** To perform the antibiotic production using fungi	**Unit-4** **CI4.1** Importance and production of Beta-lactam, aminoglycosides, (Rifamycin)	**SL4.1** Find out more antibiotics and their production process
	SO4.2	**LI4.2**	**CI4.2**	**SL4.2**

	Understand the production of antibiotics	To perform the microbial growth kinetics by observing the biomass produced and representation on graph	Microbial production of Peptide antibiotics Quinolinones	List out the role of Antibiotic Resistance Genes
	SO4.3 Classify the difference between different classes of antibiotics		**CI4.3** Biotransformation of steroids and its microbial production	**SL4.3** Explore the medical applications of Steroids
	SO4.4 Recognize the various applications of Lactamase enzyme		**CI4.4** Vitamin B12 and Riboflavin production through fermentation	**SL4.4** Make a flowchart showing metabolic pathway for Vitamin B_{12} and Vitamin B_2
	SO4.5 Derive the production of Vitamins through microbes		**CI4.5** Production of Biogas; Anaerobic digestion	**SL4.5** Explore how Biogas is produced in rural areas of India
	SO4.6 revision and discussion		**CI4.6** revision and discussion	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain the role of Antibiotics and its disadvantages
	SW4.2 Mini Project	Describe how therapeutics being produced in biotech-based industries
	SW4.3 Other Activities (Specify)	Make a list of “Biogas producing centres in India”

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	0 2	01	03	12

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-98BT406.5 Examine the mechanism of biological product development using microbes	**SO5.1** Identify Modern trends in microbial production of bioplastics	**LI5.1** To perform the growth of Algae using a photobioreactor column	**Unit-5** **CI5.1** Modern trends in microbial production of bioplastics (PHA, PHB)	**SL5.1** Explore the various kinds of biopolymers and their applications
	SO5.2 Recognize the production mechanism of different polymer		**CI5.2** Production of bioinsectices (Thuricide), Biopolymer (Dextran, Alginate, Xanthan, Pullulan)	**SL5.2** Read research on advancement in production of biofertilizers
	SO5.3 Explain the role of biofertilizers in agriculture		**CI5.3** Biofertilizers (Nitrogen fixer Azotobacter, Phosphate solubilizing microorganisms)	**SL5.3** Find out different centres where Single Cell Proteins are used
	SO5.4 Comprehend the role of Azotobacter in biofertilizer		**CI5.4** Microbial production of Single Cell Protein	
	SO5.5 Production mechanism and importance of Single cell protein		**CI5.5** Production of biological weapons with reference to anthrax	
	SO4.6 Revision and discussion		**CI5.6** Revision and discussion	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general characteristics of Biopolymers & their applications
	SW5.2 Mini Project	Describe the production process of Single Cell Production
	SW5.3 Other Activities (Specify)	Prepare one article on Applications of Biofertilizers

Course duration (in hours) to attain Course Outcomes:

Course Title: Industrial Fermentation **Course Code:** 98BT406

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98BT406.1: Describe the fundamentals of Industrial Microbiology and Fermentation Technology	6	4	5	1	16
CO2-98BT406.2: Define the role of microbiology for the production of desired bioproducts	6	6	5	1	18
CO3-98BT406.3: Elaborate the working mechanism of upstream and downstream processing	6	4	5	1	16
CO4-98BT406.4: Interpretate the mechanism of fermentation process in industry	6	4	5	1	16
CO5-98BT406.5: Examine the mechanism of biological product development using microbes	6	2	3	1	12
Total Hours	30	20	18	05	78

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Industrial Fermentation **Course Code:** 98BT406

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-98BT406.1: Describe the fundamentals of Industrial Microbiology and Fermentation Technology	2	1	1	1	5

CO2-98BT406.2: Define the role of microbiology for the production of desired bioproducts	2	4	2	2	10
CO3-98BT406.3: Elaborate the working mechanism of upstream and downstream processing	3	5	5	2	15
CO4-98BT406.4: Interpretate the mechanism of fermentation process in industry	2	3	3	2	10
CO5-98BT406.5: Examine the mechanism of biological product development using microbes	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:
(b)

S.No.	Title/Author/Publisher details
1	Textbook of Microbiology by Ananthnarayanan and Paniker's, eighth edition, Universities Press
2	Microbiology; Lansing M Prescott, John P. Harley, Donald A Klein, Sixth edition, Mc Graw Hill Higher education.
3	J.E. Bailey and D.F. Ollis, Biochemical Engineer-ing Fundamentals, McGraw-Hill, New York
4	Industrial Microbiology and Biotechnology, Pradeep Verma, Springer, 2022
5	An Introduction to Industrial Microbiology, Sivakumar, K. Sukesh and Joe, S. Chand Publications, 2010

(c) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Industrial plant of Biotech-based organizations
7. Demonstration
8. ICT Based teaching Learning

9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: IV Semester

Course Title: Industrial Fermentation

Course Code: 98BT406

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-98BT406.1: Describe the fundamentals of Industrial Microbiology and Fermentation Technology	2	-	-	1	2	2	2	1
CO2-98BT406.2: Define the role of microbiology for the production of desired bioproducts	-	1	1	-	-	1	1	2
CO3-98BT406.3: Elaborate the working mechanism of upstream and downstream processing	1	1	1	1	-	1	1	1
CO4-98BT406.4: Interpretate the mechanism of fermentation process in industry	1	1	1	-	2	1	1	3
CO5-98BT406.5: Examine the mechanism of biological product development using microbes	1	1	1	-	-	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-98BT406.1:** Describe the fundamentals of Industrial Microbiology and Fermentation Technology	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6	**LI 1** **LI 2**	1.1,1.2,1.3,1.4,1.5 1.6	**1SL-1,2,3,4,5**
PO 1,2,3,4,5 PSO 1,2,3	**CO2-98BT406.2:** Define the role of microbiology for the production of desired bioproducts	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7	**LI 1** **LI 2** **LI 3**	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7	**2SL-1,2,3,4,5**
PO 1,2,3,4,5 PSO 1,2,3	**CO3-98BT406.3:** Elaborate the working mechanism of upstream and downstream processing	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5	**LI 1** **LI 2** **LI 3**	3.1,3.2,3.3,3.4,3.5	**3SL-1,2,3,4,5**
PO 1,2,3,4,5 PSO 1,2,3	**CO4-98BT406.4:** Interpretate the mechanism of fermentation process in industry	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5	**LI 1** **LI 2**	4.1,4.2,4.3,4.4, 4.5	**4SL-1,2,3,4,5**
PO 1,2,3,4,5 PSO 1,2,3	**CO5-98BT406.5:** Examine the mechanism of biological product development using microbes	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5	**LI 1**	5.1,5.2,5.3,5.4,5.5	**5SL-1,2,3**

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	V	
Course Code:	**98BT501**	
Course title:	Plant Biotechnology	**Curriculum Developer**: Kamlesh Kumar Soni
Pre-requisite:	Student should have basic knowledge of Molecular Biology and Biotechnology	
Rationale:	The paper on Plant Biotechnology in B. Tech. Biotech Semester-V program is a rather most important discipline. Nevertheless, the subject Plant Biotechnology has become demanding subject for the last few years that universities at all rankings have introduced or are going to introduce Plant Biotechnology teaching programs. The course will provide an overview over Plant Biotechnology. It will in understanding the basic and advance application in tissue culture and transgenic based plant development. Applications of Plant Biotechnology, as they are already in use today or as they are planned for the future, will be discussed	
Course Outcomes (COs):	**98BT501.1.** Explain fundamentals of Plant Biotechnology **98BT501.2.** Define the role of tissue culture media and its constituents in micropropagation of ex-plants **98BT501.3.** Understand the working mechanism of callus culture **98BT501.4.** Interpretate the mechanism of plant-based vector and plasmids **98BT501.5.** Examine the mechanism of gene transfer in plants	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Common (PC)	**98BT501**	Plant Biotechnology	3	2	1	3	9	3+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks
			Class/Home Assignment	Class Test 2 (2 best out	Seminar one	Class Activity (CAT)	Class Attendance	Total Marks (CA+CT+CAT+SA+AT)		(PRA+ ESA)

			5 number 3 marks each (CA)	of 3) 10 marks each (CT)	(SA)		(AT)			
PC	98BT501	Plant Biotechnology	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Couse Code	Course Title		**Scheme of Assessment (Marks)**						
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		
PC	98BT551	Plant Biotechnology	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Course-Curriculum:

<table>
<tr><td colspan="2">Unit-I: Basics of Plant tissue culture</td></tr>
<tr><td>This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.</td><td>Approximate Hours
<table>
<tr><td>Item</td><td>Cl</td><td>LI</td><td>SW</td><td>S L</td><td>Total</td></tr>
<tr><td>Approx. Hrs</td><td>08</td><td>02</td><td>01</td><td>05</td><td>16</td></tr>
</table></td></tr>
</table>

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-98BT501.1: Explain fundamentals of Plant Biotechnology	1.1: Learning of history of Plant Tissue Culture	1.1: Media Preparation	1.1: Introduction, Historical perspective	1.1: How tissue culture came into picture
	1.2: Basic knowledge of tissue culture techniques	1.2: Working with laminar airflow	1.2: Tissue culture lab and organization	1.2: Tissue culture lab organization of materials
	1.3: Importance of concentration of media preparation		1.3: Preparation of stock solution, sterilization techniques	1.3: Learning of solution preparation calculation
	1.4: Importance of Plant Tissue Culture Media		1.4: Types of nutrient media and media composition	1.4: Importance of sterilization
	1.5: How explant is prepared for the tissue culture		1.5: Sterilization and preparation of explants, initiation of culture.	1.5: Nutrient media preparation and initiation tissue culture

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Briefly explain "Sterilization menthids: why it is important"
	SW1.2 Mini Project	Preparation of different types of media
	SW1.3 Other Activities (Specify)	Look the animated video about agrobacterium transformation from internet sources

Unit-II: Plant Tissue Culture Methods

Course-Curriculum:
This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	01	01	05	15

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-98BT501.2: Define the role of tissue culture media and its constituents in micropropagation of ex-plants	2.1: Study the importance of totipotency	2.1: Micropropagation	2.1: Totipotency	2.1: Understand the fundamental differences between totipotency and pluripotency
	2.2: Understanding the organ culture		2.2: Tissue and organ culture	2.2: Role of hormone in callus culture
	2.3: Can differentiate between callus and suspension culture: their applications		2.3: Establishment and maintenance of callus culture, organogenesis, cell suspension cultures	2.3: Study the importance of suspension culture
	2.4: Important of single cell		2.4: Single cell clones and methods of single cell culture	2.4: Economic importance of single cell
	2.5: How embryo is used in plant tissue culture to make complete plant: its application		2.5: Embryo culture and embryo rescue.	2.5: Learn the development of embryo invitro

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Write about the totipotency and pluripotency
	SW1.2 Mini Project	Use leaf as explant to make callus
	SW1.3 Other Activities (Specify)	Some text book to understand about the embryo and its culture: applications

Unit-III: Protoplast Culture	
Course-Curriculum: This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	01	01	05	15

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO3-98BT501.3: Understand the working mechanism of callus culture	3.1: Explain the importance of Protoplast	3.1: Protoplast Isolation	3.1: Protoplast isolation, culture regeneration	3.1: Importance of protoplast isolation
	3.2: Fundamental differences between somatic hybrid and cybrid		3.2: Protoplast fusion, somatic hybrids, cybrids, production of haploid plants, soma-clonal variations	3.2: Learn why protoplast fusion is important
	3.3: Importance of somatic embryogenesis and variation during micropropagation		3.3: Somatic embryogenesis	3.3: Learn principle behind the somatic embryogenesis
	3.4: understanding of generation of virus free plant		3.4: Production of virus free plants	3.4: Learn about meristematic tissues
	3.5: Conservation of seed germplasm and their preservation		3.5: Germplasm conservation and cryopreservation, transfer and establishment of whole plants in soil (hardening)	3.5: Find out the seed conservation institute and their role in conservations

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Write 5 applications protoplasts in plant biotechnology
	SW1.2 Mini Project	How somatic hybrid is different from cytoplasmic hybrid; their applications in plant biotechnology
	SW1.3 Other Activities (Specify)	Find out hardening methods and why is important

Unit-IV: Genetic engineering in plants

Course-Curriculum: This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	03	01	05	17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-98BT501.4: Interpretate the mechanism of plant-based vector and plasmids	4.1: Fundamental information on plant transformation	4.1: Culture Preparation of *Agrobacterium tumifacians*	4.1: Introduction	4.1: Study about the competent cells
	4.2: Basic understanding of *Agrobacterium tumifacians,* binary vector system	4.2: *Agrobacterium* competent cells preparation	4.2: Transformation vectors- *Agrobacterium tumifacians*, Ti and Ri Plasmid, structure of T-DNA	4.2: Read the biology of *Agrobacterium*
	4.3: Detail knowledge about Ti-Plasmid and is application on plant transformation	4.3: Bacterial (*Agrobacterium*) cells transformation	4.3: Ti plasmid derived vector systems	4.3: Study the vectors and their types
	4.4: Understand the various direct plant transformation methods		4.4: Physical methods of transferring genes to plants - Microprojectile bombardment,	4.4: History of different techniques discovered and applied in plant biotechnology

			Electroporation	
	4.5: Importance of viral based vector		3.5: Viral vector system, Recombinant selection	4.5: Learnt eh mode of action of viruses to infect the plant

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Details on *Agrobacterium tumefaciens* and Ti-Plasmid
	SW1.2 Mini Project	Selection of transformed plant; how is it done?
	SW1.3 Other Activities (Specify)	Look some videos on *Agrobacterium* mediated plant transformation

Unit-V: Application of transgenic technology

Course-Curriculum:
This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	02	01	05	16

Course outcome (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-98BT501.5: Socioeconomic importance of transgenics	5.1: One will understand the importance of transgenics	5.1: Shoot Initiation invitro	5.1: Development of new qualities in transgenic plants i.e. herbicide tolerance, insect/pest resistance, disease resistance, drought resistance	5.1: Importance of resistant plant
	5.2: Understand the Cry gene technology	5.2: Plant transformation by indirect methods	5.2: Bt-cotton, production of Therapeutic proteins and compounds	5.2: Various biotic and abiotic stresses
	5.3: Fundamental of vaccine production		5.3: Oral vaccines	5.3: Lean about Bt-gene and its application
	5.4: Hybrid seed production		5.4: Improvement in seed quality	5.4: Functional principle of vaccine
	5.5: Application of biomarker in plant biotechnology		5.5: Introduction to genetic markers: RFLP, RAPD, AFLP, QTLs, ISSR	5.5: DNA makers and their applications in plant breeding programs

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Briefly explain Bt-Cotton, mode of action and its application
	SW1.2 Mini Project	Treat plant with salt and drought stress and record some physiology parameters and morphology of the plant
	SW1.3 Other Activities (Specify)	Application of various markers: read in depth to understand the differences among the biomarkers

Course duration (in hours) to attain Course Outcomes **(Course Title:** Plant Biotechnology) (**Course Code: 98BT501**)					
Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-98BT501.1: Explain fundamentals of Plant Biotechnology	8	2	5	1	16
CO2-98BT501.2: Define the role of tissue culture media and its constituents in micropropagation of ex-plants	8	1	5	1	15
CO3-98BT501.3: Understand the working mechanism of callus culture	8	1	5	1	15
CO4-98BT501.4: Interpretate the mechanism of plant-based vector and plasmids	8	3	5	1	17
CO5-98BT501.5. Examine and demonstrate the mechanism of product purification	8	2	5	1	16
Total Hours	40	9	25	05	79

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome: **(Course Title:** Plant Biotechnology) (**Course Code: 98BT501**)					
Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-98BT501.1: Explain fundamentals of Plant Biotechnology	2	1	1	1	5
CO2-98BT501.2: Define the role of tissue culture media and its constituents in micropropagation of ex-plants	2	4	5	1	12
CO3-98BT501.3: Understand the working mechanism of callus culture	3	5	5	1	14
CO4-98BT501.4: Interpretate the mechanism of plant-based vector and plasmids	2	3	5	1	11

CO5-98BT501.5. Examine and demonstrate the mechanism of product purification	5	4	1	0	10
Total Marks	**14**	**17**	**17**	**04**	**52**
***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create					

Suggested learning Resources:

(a) Books:

S.no.	Title	Author	Publisher	Edition & Year
1	Plant Tissue Culture	K.K. De	New Central Book Agency	1 & 2018 (reprint)
2	Plant Biotechnology: The Genetic manipulation of plants	Adrian Slater, Nigel Scott, and Mark Fowler	Oxford University Press	2 & 2008
3	Plant Biotechnology	B.D. Singh	Kalyani Publication	4 & 2022
4	Principle of Plant Biotechnology	S.S. Purohit	Agrobios (India)	1 & 2015

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Waste water/Effluent Treatment plant and downstream pharmaceutical plants
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: V Semester

Course Title: Plant Biotechnology

Course Code: 98BT501

CO/PO Mapping															
Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-98BT501.1: Explain fundamentals of Plant Biotechnology	1	1	1	-	-	-	1	-	-	2	1	2	2	2	-
CO2-98BT501.2: Define the role of tissue culture media and its constituents in micropropagation of ex-plants	1	1	1	2	2	-	1	1	-	2	3	2	2	2	1
CO3-98BT501.3: Understand the working mechanism of callus culture	-	1	1	1	-	-	2	-	3	1	1	2	1	1	1
CO4-98BT501.4: Interpretate the mechanism of plant-based vector and plasmids	3	3	3	2	2	3	2	2	1	2	-	1	2	2	3
CO5-98BT501.5. Examine and demonstrate the mechanism of product purification	2	2	2	-	-	2	3	3	1	2	1	2	2	1	3

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Program Name: B. Tech. Biotechnology

Semester: V Semester

Course Title: Plant Biotechnology

Course Code: 98BT501

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-98BT501.1:** Explain fundamentals of Plant Biotechnology	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5	**LI 1** **LI 2**	1.1,1.2,1.3,1.4,1.5	**1SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-98BT501.2:** Define the role of tissue culture media and its constituents in micropropagation of ex-plants	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5	**LI 1**	2.1, 2.2, 2.3, 2.4, 2.5	**2SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3-98BT501.3:** Understand the working mechanism of callus culture	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5	**LI 1**	3.1,3.2,3.3,3.4,3.5	**3SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-98BT501.4:** Interpretate the mechanism of plant-based vector and plasmids	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5	**LI 1** **LI 2** **LI 3**	4.1,4.2,4.3,4.4,4.5	**4SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12	**CO5-98BT501.5.** Examine and demonstrate the mechanism of product purification	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5	**LI 1** **LI 2**	5.1,5.2,5.3,5.4,5.5	**5SL-1,2,3,4,5**

PSO 1,2, 3					

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	V	
Course Code:	**98BT502**	
Course title:	Enzyme engineering	**Curriculum Developer**: Mr. Piyush Kant rai, Assistant Professor
Pre-requisite:	Student should have basic knowledge of Molecular Biology and Biotechnology	
Rationale:	The paper on Enzyme engineering in B. Tech. Biotech Semester-V program is a rather most important discipline. Nevertheless, the subject Enzyme engineering has become demanding subject for the last few years that universities at all rankings have introduced or are going to introduce Enzyme engineering teaching programs. The course will provide an overview over Enzyme engineering. It will in understanding the basic and advance application in enzyme structure and its function. Applications of Enzyme engineering, as they are already in use today or as they are planned for the future, will be discussed.	
Course Outcomes (COs):	**CO1-98BT502.1:** Understand the structure, classification, and factors affecting enzyme activity, and explore enzyme-substrate complex formation, coenzymes, and metal-activated enzymes in biological reactions. **CO2-98BT502.2:** Apply enzyme kinetic models such as Michaelis-Menten, Lineweaver-Burk, and explore multisubstrate kinetics, including allosteric enzymes and reaction mechanisms. **CO3-98BT502.3:** Examine the types and kinetics of enzyme inhibition, mechanisms of enzyme catalysis, and the principles of protein-ligand binding and cooperativity. **CO4-98BT502.4:** Learn the methods, applications, and reactor designs for enzyme immobilization, including enzyme extraction and purification techniques. **CO5-98BT502.5:** Understand enzyme engineering concepts, including structure prediction, genetic and protein engineering, and their applications in molecular biology, nutrition, and biosensors.	

Scheme of Studies:

<table>
<tr><th rowspan="2">Board of Study</th><th rowspan="2">Course Code</th><th rowspan="2">Course Title</th><th colspan="5">Scheme of studies (Hours/Week)</th><th rowspan="2">Total Credits (C)
(L:T:P=3:0:1)</th></tr>
<tr><th>Cl</th><th>LI</th><th>SW</th><th>SL</th><th>Total Study Hours (CI+LI+SW+SL)</th></tr>
<tr><td>Program Common (PC)</td><td>98BT502</td><td>Enzyme engineering</td><td>3</td><td>2</td><td>1</td><td>3</td><td>9</td><td>3+1=4</td></tr>
</table>

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

<table>
<tr><th rowspan="3">Board of Study</th><th rowspan="3">Couse Code</th><th rowspan="3">Course Title</th><th></th><th colspan="7">Scheme of Assessment (Marks)</th></tr>
<tr><th colspan="6">Progressive Assessment (PRA)</th><th rowspan="2">End Semester Assessment
(ESA)</th><th rowspan="2">Total Marks
(PRA+ ESA)</th></tr>
<tr><th>Class/Home Assignment</th><th>Class Test 2
(2 best out</th><th>Seminar one</th><th>Class Activity (CAT)</th><th>Class Attendance</th><th>Total Marks
(CA+CT+CAT+SA+AT)</th></tr>
</table>

			5 number 3 marks each (CA)	of 3) 10 marks each (CT)	(SA)		(AT)			
PC	98BT502	Enzyme engineering	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessmen t (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		
PC	98BT552	Enzyme engineering	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Course-Curriculum:

Unit-I: Introduction to Enzymes	
This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	04	01	03	16

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-98BT502.1: Understand the structure, classification, and factors affecting enzyme activity, and explore enzyme-substrate complex formation, coenzymes, and metal-activated enzymes in biological reactions.	SO1.1: Understand the historical perspective of enzyme research	LI1.1: Preparing enzyme solutions for lab experiments	CI1.1: Introduction to enzymes, history of enzyme research	SL1.1: How enzymes were discovered and their importance in biotechnology
	SO1.2: Learn the nomenclature and classification of enzymes	LI1.2: Enzyme classification exercises using real examples	CI1.2: Classification of enzymes: Based on function, structure, and mechanism	SL1.2: Study enzyme classifications and learn examples for each type
	SO1.3: Study the factors affecting enzyme activity		CI1.3: Explanation of how temperature, pH, and concentration affect enzyme activity	SL1.3: Investigate how environmental factors influence enzyme performance
	SO1.4: Explore the theories of enzyme-		CI1.4: Theories of enzyme action: Lock	

	substrate complex formation		and Key model, Induced Fit model	
	SO1.5: Understand catalytic RNA and its role in enzyme catalysis		CI1.5: Introduction to catalytic RNA and ribozymes	
	SO1.6: Learn about metal-activated enzymes and metalloenzymes		CI1.6: Introduction to metalloenzymes and their role in biological reactions	SL1.6: Study the importance of metal ions in enzyme structure and function
	SO1.7: Understand coenzymes used in biological reactions		CI1.7: Coenzymes in biological reactions: NAD+, FAD, coenzyme A, etc.	SL1.7: Research the role of coenzymes in metabolic processes like glycolysis and the citric acid cycle
	SO1.1: Understand the historical perspective of enzyme research		CI1.1: Introduction to enzymes, history of enzyme research	SL1.1: How enzymes were discovered and their importance in biotechnology

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Briefly explain "enzyme research: why it is important"
	SW1.2 Mini Project	Preparation of different types of enzyme media
	SW1.3 Other Activities (Specify)	Look the animated video about enzyme action from internet sources

Unit-II: Enzyme kinetics

Course-Curriculum:
This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	04	01	02	15

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-98BT502.2: Apply enzyme kinetic models such as Michaelis-Menten, Lineweaver-Burk, and explore multisubstrate kinetics, including allosteric enzymes and reaction mechanisms	SO2.1: Understand the kinetics of uncatalyzed reactions	LI2.1: Conduct experiments to measure the rate of uncatalyzed reactions under different conditions	CI2.1: Introduction to reaction rates and the factors affecting uncatalyzed reactions	SL2.1: Study the basics of reaction kinetics and compare uncatalyzed reactions with catalyzed reactions
	SO2.2: Learn the Michaelis-Menten equation	LI2.2: Use experimental data to derive the Michaelis-Menten equation	CI2.2: Derivation and explanation of the Michaelis-Menten equation	SL2.2: Research the significance of Km and Vmax in enzyme kinetics
	SO2.3: Understand the Briggs-Haldane modification of the Michaelis-Menten model		CI2.3: Introduction to the Briggs-Haldane modification and its application to enzyme kinetics	
	SO2.4: Learn the Lineweaver-Burk plot and its significance		CI2.4: Lineweaver-Burk transformation and interpretation of results	
	SO2.5: Explore the Eadie-Hofstee and Hanes plots		CI2.5: Derivation and use of the Eadie-Hofstee and Hanes plots in enzyme kinetics	
	SO2.6: Classify BiBi (Biphasic Biphasic) reactions		CI2.6: Classification and discussion of BiBi reactions, including sequential and ping-pong mechanisms	
	SO2.7: Understand the Ping Pong BiBi mechanism	LI2.7: Study and identify the Ping Pong mechanism in enzyme-catalyzed reactions	CI2.7: Introduction to Ping Pong BiBi mechanism and its implications for enzyme catalysis	

	SO2.8: Learn the Alberty and Dalziel equation	LI2.8: Use experimental data to derive and apply the Alberty and Dalziel equation	CI2.8: Explanation of the Alberty and Dalziel equation and its applications	SL2.8: Study the applications of the Alberty and Dalziel equation in enzyme kinetics

Suggested Sessional Work (SW): *anyone*	SW2.1 Assignments	Write about the totipotency and pluripotency
	SW2.2 Mini Project	Extract enzyme from bacteria using suitable media
	SW2.3 Other Activities (Specify)	Some text book to understand about the enzyme kinetics

Unit-III: Mechanisms of Enzyme Catalysis

Course-Curriculum:
This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	04	01	02	15

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-98BT502.3: Examine the types and kinetics of enzyme inhibition, mechanisms of enzyme catalysis, and the principles of protein-ligand binding and cooperativity.	SO3.1: Understand the concept of enzyme inhibition	LI3.1: Investigate the effect of inhibitors on enzyme activity	CI3.1: Introduction to enzyme inhibition and its significance in metabolic control	SL3.1: Study the different types of enzyme inhibitors and their biological relevance
	SO3.2: Learn the types of enzyme inhibition	LI3.2: Perform experiments to identify competitive, non-competitive, and uncompetitive inhibition	CI3.2: Overview of competitive, non-competitive, and uncompetitive inhibition	SL3.2: Compare the effects of different types of enzyme inhibition on reaction rates

	SO3.3: Understand the kinetics of enzyme inhibition		CI3.3: Enzyme inhibition kinetics: Michaelis-Menten vs. inhibited reactions	
	SO3.4: Explore the mechanisms of enzyme catalysis		CI3.4: Mechanisms of enzyme catalysis: Transition state theory, acid-base catalysis, covalent catalysis	
	SO3.5: Study the enzyme catalysis mechanism of chymotrypsin		CI3.5: Chymotrypsin as a model for enzyme catalysis	
	SO3.6: Study the enzyme catalysis mechanism of ribonuclease		CI3.6: Ribonuclease as an example of enzyme catalysis in nucleic acid metabolism	
	SO3.7: Understand the principles of protein-ligand binding		CI3.7: Introduction to protein-ligand interactions and their biological importance	
	SO3.8: Learn about cooperativity in protein-ligand binding		CI3.8: Cooperativity in protein-ligand binding and its impact on function	

Suggested Sessional Work (SW): *anyone*	SW3.1 Assignments	Write 5 applications protoplasts in Enzyme engineering
	SW3.2 Mini Project	
	SW3.3 Other Activities (Specify)	Find out enzyme isolation methods ?

Unit-IV: Enzyme Immobilization

Course-Curriculum:
This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	04	01	04	17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-98BT502.4: Learn the methods, applications, and reactor designs for enzyme immobilization, including enzyme extraction and purification techniques.	SO4.1: Understand the basic concept of enzyme immobilization	LI4.1: Conduct experiments on enzyme immobilization using different techniques	CI4.1: Introduction to enzyme immobilization and its applications in biocatalysis	SL4.1: Research the significance of enzyme immobilization in industrial applications
	SO4.2: Learn the different methods of enzyme immobilization	LI4.2: Experiment with various immobilization methods like adsorption, covalent binding, and entrapment	CI4.2: Methods of immobilization: Adsorption, covalent binding, entrapment, and cross-linking	SL4.2: Compare the advantages and disadvantages of different enzyme immobilization methods
	SO4.3: Study the applications of immobilized enzymes		CI4.3: Applications of immobilized enzymes in food, pharmaceutical, and chemical industries	SL4.3: Explore case studies where immobilized enzymes are used in large-scale production
	SO4.4: Learn about the design of immobilized		CI4.4: Reactor design for immobilized enzymes:	SL4.4: Study various reactor designs and their efficiency

	enzyme reactors		Packed bed reactors, fluidized bed reactors, and membrane reactors	in industrial enzyme processes
	SO4.5: Understand the working principles of packed bed reactors		CI4.5: Explanation of packed bed reactors and their application in enzyme catalysis	
	SO4.6: Study fluidized-bed membrane reactors		CI4.6: Principles and advantages of fluidized-bed and membrane reactors for enzyme immobilization	
	SO4.7: Learn the process of extracting soluble and membrane-bound enzymes		CI4.7: Methods of enzyme extraction: Soluble and membrane-bound enzymes	
	SO4.8: Understand the purification of enzymes		CI4.8: Techniques for enzyme purification: Affinity chromatography, ion-exchange chromatography, and gel filtration	

Suggested Sessional Work (SW): *anyone*	SW4.1 Assignments	Details on *affinity chromatography*
	SW4.2 Mini Project	
	SW4.3 Other Activities (Specify)	Look some videos on purification of enzymes

Unit-V: Enzyme Engineering Concepts

Course-Curriculum:
This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	04	01	03	16

Course outcome (COs)	Session Outcomes (SOs)	Laboratory	Class room Instruction	Self-Learning (SL)

		Instruction (LI)	(CI)	
CO5-98BT502.5: Understand enzyme engineering concepts, including structure prediction, genetic and protein engineering, and their applications in molecular biology, nutrition, and biosensors.	SO5.1: Understand the concept of enzyme engineering	LI5.1: Conduct experiments on enzyme engineering applications	CI5.1: Introduction to enzyme engineering: Role in biotechnology and industrial applications	SL5.1: Research the history and development of enzyme engineering and its current applications
	SO5.2: Learn the prediction of enzyme structure	LI5.2: Use bioinformatics tools to predict the structure of enzymes	CI5.2: Methods for predicting enzyme structure: Sequence analysis and 3D modeling	SL5.2: Study how enzyme structure prediction aids in understanding enzyme function
	SO5.3: Study site-directed mutagenesis and its role in enzyme engineering		CI5.3: Site-directed mutagenesis as a technique for enzyme engineering	SL5.3: Explore case studies where site-directed mutagenesis has been used to improve enzyme properties
	SO5.4: Understand protein engineering techniques		CI5.4: Overview of protein engineering: Methods and applications	
	SO5.5: Learn about genetic engineering techniques in enzyme technology		CI5.5: Genetic engineering in enzyme technology: Cloning, expression, and optimization	
	SO5.6: Study polyfunctional enzymes and their applications		CI5.6: Polyfunctional enzymes: Definition, examples, and their significance in	

			biotechnology	
	SO5.7: Understand solvent engineering and its effect on enzyme activity		CI5.7: Solvent engineering: Effects of solvents on enzyme structure and function	
	SO5.8: Explore applications of enzyme engineering in molecular biology		CI5.8: Enzyme engineering applications in molecular biology: PCR, sequencing, and gene editing	

Suggested Sessional Work (SW): *anyone*	SW5.1 Assignments	Briefly explain enzyme engineering
	SW5.2 Mini Project	Perform transformation experiment on bacteria
	SW5.3 Other Activities (Specify)	

Course duration (in hours) to attain Course Outcomes
(Course Title: Enzyme engineering) (**Course Code: 98BT502**)

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-98BT502.1: Explain fundamentals of Enzyme engineering	8	4	3	1	16
CO2-98BT502.2: Define the role of tissue culture media and its constituents in micropropagation of ex-plants	8	4	2	1	15
CO3-98BT502.3: Understand the working mechanism of callus culture	8	4	2	1	15
CO4-98BT502.4: Interpretate the mechanism of plant-based vector and plasmids	8	4	4	1	17
CO5-98BT502.5. Examine and demonstrate the mechanism of product purification	8	4	3	1	16

Total Hours	40	20	14	05	79

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome: **(Course Title:** Enzyme engineering) (**Course Code: 98BT502**)					
Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-98BT502.1: Understand the structure, classification, and factors affecting enzyme activity, and explore enzyme-substrate complex formation, coenzymes, and metal-activated enzymes in biological reactions.	2	1	1	1	5
CO2-98BT502.2: Apply enzyme kinetic models such as Michaelis-Menten, Lineweaver-Burk, and explore multisubstrate kinetics, including allosteric enzymes and reaction mechanisms.	2	4	5	1	12
CO3-98BT502.3: Examine the types and kinetics of enzyme inhibition, mechanisms of enzyme catalysis, and the principles of protein-ligand binding and cooperativity.	3	5	5	1	14
CO4-98BT502.4: Learn the methods, applications, and reactor designs for enzyme immobilization, including enzyme extraction and purification techniques.	2	3	5	1	11
CO5-98BT502.5: Understand enzyme engineering concepts, including structure prediction, genetic and protein engineering, and their applications in molecular biology, nutrition, and biosensors.	5	4	1	0	10
Total Marks	**14**	**17**	**17**	**04**	**52**
***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create					

Suggested learning Resources:

(a) Books:

S.no.	Title	Author	Publisher	Edition & Year
1	Enzymes	Palmer	Horwood Publishing Series.	2018 (reprint)
2	Fundamentals of Enzymology	Price and Stevens	Oxford University Press	2 & 2008
3	Enzyme Technology	Helmut uhling	John Wiley	2014

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Waste water/Effluent Treatment plant and downstream pharmaceutical plants
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: V Semester

Course Title: Enzyme engineering

Course Code: 98BT502

CO/PO Mapping															
Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-98BT502.1: Understand the structure, classification, and factors affecting enzyme activity, and explore enzyme-substrate complex formation, coenzymes, and metal-activated enzymes in biological reactions.	1	1	1	-	-	-	1	-	-	2	1	2	2	2	-
CO2-98BT502.2: Apply enzyme kinetic models such as Michaelis-Menten, Lineweaver-Burk, and	1	1	1	2	2	-	1	1	-	2	3	2	2	2	1

explore multisubstrate kinetics, including allosteric enzymes and reaction mechanisms.															
CO3-98BT502.3: Examine the types and kinetics of enzyme inhibition, mechanisms of enzyme catalysis, and the principles of protein-ligand binding and cooperativity.	-	1	1	1	-	-	2	-	3	1	1	2	1	1	1
CO4-98BT502.4: Learn the methods, applications, and reactor designs for enzyme immobilization, including enzyme extraction and purification techniques.	3	3	3	2	2	3	2	2	1	2	-	1	2	2	3
CO5-98BT502.5: Understand enzyme engineering concepts, including structure prediction, genetic and protein engineering, and their applications in molecular biology, nutrition, and biosensors.	2	2	2	-	-	2	3	3	1	2	1	2	2	1	3
Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3															

Program Name: B. Tech. Biotechnology

Semester: V Semester

Course Title: Enzyme engineering

Course Code: 98BT502

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6	**CO1-98BT502.1:** Understand the structure, classification, and factors affecting enzyme	SO1.1 SO1.2	**LI 1**	1.1,1.2,1.3,1.4,1.5,	**1SL-1,2,3**

7,8,9,10,11,12 PSO 1,2, 3	activity, and explore enzyme-substrate complex formation, coenzymes, and metal-activated enzymes in biological reactions.	SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8	**LI 2**	1.6 1.7 1.8	
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-98BT502.2:** Apply enzyme kinetic models such as Michaelis-Menten, Lineweaver-Burk, and explore multisubstrate kinetics, including allosteric enzymes and reaction mechanisms.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8	**LI 1** **LI 2**	2.1, 2.2, 2.3, 2.4, 2.5, 2.6 2.7 2.8	**2SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3-98BT502.3:** Examine the types and kinetics of enzyme inhibition, mechanisms of enzyme catalysis, and the principles of protein-ligand binding and cooperativity.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8	**LI 1** **LI 2**	3.1,3.2,3.3,3.4,3.5, 3.6 ,3.7 3.8	**3SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-98BT502.4:** Learn the methods, applications, and reactor designs for enzyme immobilization, including enzyme extraction and purification techniques.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8	**LI 1** **LI 2**	4.1,4.2,4.3,4.4,4.5, 4.6 4.7 4.8	**4SL-1,2,3,4**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO5-98BT502.5:** Understand enzyme engineering concepts, including structure prediction, genetic and protein engineering, and their applications in molecular biology, nutrition, and biosensors.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8	**LI 1** **LI 2**	5.1,5.2,5.3,5.4,5.5, 5.6 5.7 5.8	**5SL-1,2,3**

Program name	Bachelor of Technology (B. Tech.)- Biotechnology	
Semester	Vth	
Course Code:	98BT503	
Course title:	Animal Biotechnology	**Curriculum Developer**: Dr. Monika Soni, Assistant Professor
Pre-requisite:	Students should have basic knowledge of animal biotechnology	
Rationale:	Animal Biotechnology explores genetic manipulation, reproductive technologies, and molecular biology applications in animals. The subject aims to enhance livestock production, develop disease-resistant breeds, and advance medical research through transgenic animals. It encompasses ethical considerations, environmental impact assessment, and regulatory frameworks. This multidisciplinary field contributes to food security, medical breakthroughs, and sustainable agriculture. The focus is on innovative techniques for genetic enhancement, disease prevention, and biopharmaceutical production in animals. As a dynamic field, Animal Biotechnology integrates biology, genetics, and technology to address global challenges while promoting responsible and sustainable practices in animal science.	
Course Outcomes (COs):	**CO1-98BT503.1**: To explain about fundamentals of animal biotechnology and define the role of tissue culture media and their constituents. **CO2-98BT503.2**: To understand the role of different cell lines in animal cell culture. **CO3-98BT503.3**: To study about cell cloning and cell selection process and analysis of cytotoxicity and viability of cells. **CO4-98BT503.4**: To study the method of monoclonal antibody production and its application. **CO5-98BT503.5**: To describe the recent research in the field of animal biotechnology.	

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)	Total Credits(C)

			CI	LI	SW	SL	**Total Study Hours(CI+LI+SW+SL)**	**(L:T:P=3:0:1)**
Program Common(PC)	98BT503	Animal Biotechnology	3	2	1	2	8	3+1=4

Scheme of Studies:

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	**Scheme of Assessment (Marks)**							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA+CAT+AT)		
PC	98BT503	Animal Biotechnology	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA+CAT+AT)		
PC	98BT553	Animal Biotechnology -lab	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Course-Curriculum:

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Item	CI	LI	SW	SL	Total
Approx. Hours	12	2	1	5	20

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO1-98BT503.1: To explain about fundamentals of animal biotechnology and define the role of tissue culture media and their constituents.			**Unit-1**	
	SO1.1 Explain in detail about history of animal biotechnology.		**CI1.1** Brief detail of animal biotechnology history.	**SL1.1** Search vario reference books and oth study material to start th learning about animal tissu culture and anim biotechnology.
	SO1.2 Explain in detail to specific goals & future of animal biotechnology.		**CI1.2** Describe the scope, and future of animal biotechnology.	
	SO1.3 Explain the basic requirements in laboratory.	**LI1.1** Demonstration of basic requirements (Instruments, Glasswares and others) in animal tissue culture laboratory.	**CI1.3** Basic requirements use in animal tissue culture laboratory.	**SL1.2** Learn about a requirements for anim biotechnology laboratory.
	SO1.4 Describe the application & function of basic requirements in ATC laboratory.		**CI1.4** Define the Application & function of requirements in laboratory.	
	SO1.5 Describe and define the cell culture media.		**CI1.5** Different components involves in cell culture media.	**SL1.3** Learn about a components involves to th preparation of cell cultu media.
	SO1.6 Describe the different cell culture media & their components in ATC laboratory.		**CI1.6** Different cell culture media & their components.	

	SO1.7 Explain the general use of ingredients in cell culture media.		**CI1.7** Different ingredients like organic salts, vitamins, hormones etc. use in cell culture media for media preparation.	**SL1.4** Practice to th preparation of media.
	SO1.8 Explain the pros &cons of different ingredients in cell culture media.		**CI1.8** Study the Pros & cons of cell culture media's ingredients.	
	SO1.9 Describe about some growth factors use in cell culture media.		**CI1.9** Some growth factors like hormones, antibiotics etc. use in media.	
	SO1.10 Describe the application of growth factors in cell culture media.		**CI1.10** Application of different growth factors involves in cell culture media.	
	SO1.11 Explain the general process of preparation and sterilization of media.	**LI1.2** Demonstration of media preparation and sterilization.	**CI1.11** Different sterilization techniques for sterilization of media.	**SL1.5** Learn about differe sterilization techniques t sterilize the cell cultu media.
	SO1.12 Explain the advantages of sterilization of media.		**CI1.12** Study the advantage of Sterilization of media.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignment	Describe in detail about animal tissue culture.
	SW1.2 Mini Project	Define cell culture medium & explain about various factors for the growth of animal cells/tissues.
	SW1.3 Other Activities (Specify)	Explain the process of media preparation and sterilization.

Course-Curriculum:

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Item	CI	LI	SW	SL	Total
Approx. Hours	12	2	1	5	20

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO2-98BT503.2: To understand the role of different cell lines in animal cell culture.			**Unit-2**	
	SO2.1 Explain in detail about different types of tissue culture techniques.		**CI2.1** Brief details of different tissue culture technique.	**SL2.1** Search variou reference books and oth study material to start th learning about differe cell/tissue cultu techniques.
	SO2.2 Explain in detail about future prospects into tissue culture technique.		**CI2.2** Study the scope and application of tissue culture technique.	
	SO2.3 Define the primary cell culture and its types.		**CI2.3** Types of primary cell culture and methods for preparation of primary cells.	**SL2.2** Learn in detail typ of primary and seconda cell culture.
	SO2.4 Explain the advantages of primary cell culture.		**CI2.4** Study the advantages of primary cell culture.	
	SO2.5 Describe different examples to culture chicken embryo	**LI2.1** Demonstration of chicken embryo fibroblast culture.	**CI2.5** Preparation and culture of chicken embryo fibroblast, liver and kidney.	

	fibroblast, liver and kidney.			
	SO2.6 Explain in detail about application of fibroblast, liver, and kidney cells.		**CI2.6** Study the application of fibroblast, liver, and kidney cells.	
	SO2.7 Define the secondary cell culture and study about different cell lines.		**CI2.7** Types of secondary cell culture and preparation of cell lines.	**SL2.3** Practice to th preparation of cell lines.
	SO2.8 Explain in detail to application of secondary cell culture.		**CI2.8** Study the application of secondary cell culture.	
	SO2.9 Define the cell separation and explain its techniques.	**LI2.2** To isolate the animal cells by using fluorescence activated cell shorter (FACs) technique.	**CI2.9** Isolation/ Separation of cells using different techniques.	**SL2.4** Learn about differe cell separation techniqu for the sorting of cells.
	SO2.10 Explain in detail to application of cell separation techniques.		**CI2.10** Study the application of cell separation techniques.	
	SO2.11 Define the Organ culture and its application.		**CI2.11** Different methods using for culture of organ and its application and limitations.	**SL2.5** Learn in detail o organ culture and i development by usin different methods.
	SO2.12 Explain in detail to pros & cons of organ culture.		**CI2.12** Study the pros & cons of organ culture.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignment	Describe about different cell culture techniques.
	SW2.2 Mini Project	Detail study about cell lines.
	SW2.3 Other Activities (Specify)	Study one review article on cell separation using any techniques from animal cells.

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Item	CI	LI	SW	SL	Total
Approx. Hours	12	2	1	6	21

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO3-98BT503.3: To study about cell cloning and cell selection process and analysis of cytotoxicity and viability of cells.			**Unit-3**	
	SO3.1 Explain in detail of contamination in cell culture.	**LI3.1** Demonstration of contaminants and decontaminants in animal tissue culture laboratory/medium.	**CI3.1** Brief details of different contaminants in cell culture.	**SL3.1** Search vario reference books and oth study material to start th learning about differe contaminants.
	SO3.2 Explain in detail to removal of contamination in cell culture.		**CI3.2** Removal of contamination in cell culture.	
	SO3.3 Describe/Study about Cell cloning and selection.		**CI3.3** Various methods of cloning and selection of cell.	**SL3.2** Learn in deta cloning and selection cell.
	SO3.4 Explain in detail to pros & cons of cell		**CI3.4** Study the pros & cons of cell cloning.	

	cloning.			
	SO3.5 Explain in detail about scale up technique for development of cell culture.		**CI3.5** Different scale-up techniques for cell culture development.	**SL3.3** Learn about scale-u technique.
	SO3.6 Explain in detail to application of scale-up technique.		**CI3.6** Study the application of scale-up technique.	
	SO3.7 Describe the characterization and preservation of animal cells.	**LI3.2** To preserve the animal cells by using cryopreservation technique.	**CI3.7** Various techniques for characterization and preservation of animal cells.	**SL3.4** Learn in deta characterization ar preservation of animal cell
	SO3.8 Explain in detail to application of cryopreservation technique.		**CI3.8** Study the application of cryopreservation techniques.	
	SO3.9 Analysis of samples by cytotoxicity and viability test methods.		**CI3.9** Various test methods of cytotoxicity and viability of cells.	**SL3.5** Learn in deta cytotoxicity and viability cells.
	SO3.10 Explain in detail to application of cell cytotoxicity & viability.		**CI3.10** Study the application of cell cytotoxicity & viability.	
	SO3.11 Define the stem cells and explain about their properties.		**CI3.11** Types of stem cells and their properties.	**SL3.6** Learn in detail ste cells.
	SO3.12 Explain in detail to application of stem cells.		**CI3.12** Study the application of stem cells.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignment	Describe cloning and selection of cells and characterization and preservation methods for animal cells.
	SW3.2 Mini Project	Describe the methods to scale up of animal cell culture.
	SW3.3 Other Activities (Specify)	Prepare one review article on cytotoxicity and viability of cells.

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Item	CI	LI	SW	SL	Total
Approx. Hours	12	2	1	5	20

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO4-98BT503.4: To study the method of monoclonal antibody production and its application.			**Unit-4**	
	SO4.1 Describe and define the transgene and transgenic animal production.		**CI4.1** Brief details of transgenic animal production.	**SL4.1** Search variou reference books and oth study material to start th learning about transgen animals.
	SO4.2 Explain in detail to scope & application of transgenic animal		**CI4.2** Study the scope and application of transgenic animal production.	

	production.			
	SO4.3 Explain in detail the methods of foreign gene transfer and their validation.	**LI4.1** Demonstration of foreign gene transfer in animal cells by using any method.	**CI4.3** Various methods of gene transfer.	
	SO4.4 Explain in detail to advantage & disadvantage of gene transfer methods.		**CI4.4** Study the advantage & disadvantage of gene transfer methods.	
	SO4.5 Explain in detail about transgenesis and organ transplantation.		**CI4.5** Different steps of transgenesis and organ transplantation.	**SL4.2** Learn in detail orga transplantation.
	SO4.6 Explain in detail to application, advantage, & disadvantage of transgenesis & organ transplantation.		**CI4.6** Study the application, advantage, & limitation of transgenesis & organ transplantation.	
	SO4.7 Describe in detail about gene therapy.		**CI4.7** Various methods and application of gene therapy.	**SL4.3** Learn in detail ger therapy.
	SO4.8 Explain in detail to pros & cons of gene therapy.		**CI4.8** Study the pros & cons of gene therapy.	
	SO4.9 Explain in detail In Vitro Fertilization and embryo transfer technique.		**CI4.9** Detail in IVF and embryo transfer technique.	**SL4.4** Learn to the proce of IVF and embryo transf in animal cells.
	SO4.10 Explain in detail to application & limitation		**CI4.10** Study the application & limitation of IVF & embryo	

	of IVF & embryo transfer technique.		transfer technique.	
	SO4.11 Describe in detail about monoclonal antibody production.	**LI4.2** To prepare monoclonal antibody from animal cells.	**CI4.11** Detail about monoclonal antibody, & methods of their production.	**SL4.5** Learn to the metho of monoclonal antibo production.
	SO4.12 Explain in detail to application of monoclonal antibody in animal biotechnology.		**CI4.12** Study the application of monoclonal antibody.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignment	Describe the transgenesis process and production of transgenic animal.
	SW4.2 Mini Project	Describe in the detail of gene therapy and its application.
	SW4.3 Other Activities (Specify)	Study one research article on IVF and embryo transfer technique.

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Item	CI	LI	SW	SL	Total
Approx. Hours	12	1	1	4	18

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO5-98BT503.5: To			**Unit-5**	

describe the recent research in the field of animal biotechnology.	**SO5.1** Describe and define the vaccine.		**CI5.1** Brief details of vaccine.	**SL5.1** Search vario reference books and oth study material to start th learning about vacci production.
	SO5.2 Explain in detail to scope of vaccine in animal biotechnology.		**CI5.2** Study the scope of vaccine.	
	SO5.3 Explain in detail the vaccine production.	**LI5.1** Demonstration of cell culture based vaccine to control of various diseases.	**CI5.3** Detail the vaccine production, & their methods.	
	SO5.4 Explain in detail to application & limitation of vaccine production.		**CI5.4** Study the application, & limitation of vaccine production.	
	SO5.5 Explain in detail about cell culture use for diagnosis and treatment of disease.		**CI5.5** Detail of cell culture in diagnosis and treatment of disease.	**SL5.2** Learn in detail abo cell culture for disea diagnosis.
	SO5.6 Explain in detail to application of cell culture diagnosis methods.		**CI5.6** Study the application of cell culture diagnosis methods.	
	SO5.7 Explain in detail to pros & cons of cell culture diagnosis methods.		**CI5.7** Study the pros & cons of cell culture diagnosis methods.	
	SO5.8 Describe in detail recent research in animal biotechnology.		**CI5.8** Detail in recent research in the field of animal biotechnology.	**SL5.3** Learn in deta current research in anim biotechnology to solve th problems.
	SO5.9 Describe in detail		**CI5.9** Study the scope of current	

	scope of recent research in animal biotechnology.		research in animal biotechnology field.	
	SO5.10 Explain in detail application & limitation of recent research in animal biotechnology field.		**CI5.10** Study the application & limitation of recent research in animal biotechnology field.	
	SO5.11 Explain in detail ethical issues in animal biotechnology.		**CI5.11** Detail in ethical issues/challenges in animal biotechnology field.	**SL5.4** Learn to th challenges in anim biotechnology field.
	SO5.12 Explain in detail to overcome the challenges in animal biotechnology field.		**CI5.12** Overcome the challenges in animal biotechnology.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignment	Explain in detail about vaccine production and their application.
	SW5.2 Mini Project	Describe in the detail of cell culture to diagnosis and treatment of disease.
	SW5.3 Other Activities (Specify)	Study review articles on the current research in the field of biotechnology.

Course duration (in hours) to attain Course Outcomes:

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98BT503.1: To explain about fundamentals of animal biotechnology and define the role of tissue culture media and their constituents.	12	2	5	1	20

CO2-98BT503.2: To understand the role of different cell lines in animal cell culture.	12	2	5	1	20
CO3-98BT503.3: To study about cell cloning and cell selection process and analysis of cytotoxicity and viability of cells.	12	2	6	1	21
CO4-98BT503.4: To study the method of monoclonal antibody production and its application.	12	2	5	1	20
CO5-98BT503.5: To describe the recent research in the field of animal biotechnology.	12	1	4	1	18
Total Hours	60	9	25	05	99

Course Title: Animal Biotechnology **Course Code:** 98BT503

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcomes:

Course Title: Animal Biotechnology **Course Code:** 98BT503

***Legend*:R,** Remember; **U,** Understand; **A,** Apply

Course Outcomes	Marks Distribution			Total Marks
	R	**U**	**A**	
CO1-98BT503.1: To explain about fundamentals of animal biotechnology and define the role of tissue culture media and their constituents.	2	3	4	9
CO2-98BT503.2: To understand the role of different cell lines in animal cell culture.	2	4	4	10
CO3-98BT503.3: To study about cell cloning and cell selection process and analysis of cytotoxicity and viability of cells.	3	4	4	11
CO4-98BT503.4: To study the method of monoclonal antibody production and its application.	3	3	4	10
CO5-98BT503.5: To describe the recent research in the field of animal biotechnology.	3	4	3	10

Total Marks	**13**	**18**	**19**	**50**

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1.	Ranga M.M., Animal Biotechnology. Agrobios India Limited, 2002.
2.	Ramadass P, Meera Rani S., Text Book of Animal Biotechnology. Akshara Printers, 1997.
3.	R. Ian Freshney, Culture of Animal cells, A Manual of basic technique 4th Edition 2002.
4.	Masters J.R.W., Animal Cell Culture: Practical Approach. Oxford University Press,2000.

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to animal biotechnology lab
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: Vth Semester

Course Title: Animal Biotechnology

Course Code: 98BT503

CO/PO/PSO Mapping															
Course Outcome (Cos)	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-98BT503.1: To explain about fundamentals of animal biotechnology and define the role of tissue culture media and their constituents.	-	1	-	1	2	2	2	-	3	1	3	-	2	2	1
CO2-98BT503.2: To understand the role of different cell lines in animal cell culture.	-	1	-	-	-	-	3	-	3	2	3	2	1	1	2
CO3-98BT503.3: To study about cell cloning and cell selection process and analysis of cytotoxicity and viability of cells.	1	1	1	1	-	-	2	-	3	1	2	3	1	1	1
CO4-98BT503.4: To study the method of monoclonal antibody production and its application.	1	-	1	-	2	2	3	3	-	1	3	2	1	1	3
CO5-98BT503.5: To describe the recent research in the field of animal biotechnology.	1	-	1	-	-	2	2	3	-	2	2	3	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO1-98BT503.1**: To explain about fundamentals of animal biotechnology and define the role of tissue culture media and their constituents.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10 SO1.11 SO1.12	LI 1 LI 2	1.1,1.2,1.3,1.4,1.5 1.6,1.7,1.8,1.9,1.1 0,1.11,1.12	1SL-1,2,3,4,5
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO2-98BT503.2**: To understand the role of different cell lines in animal cell culture.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9 SO2.10 SO2.11 SO2.12	LI 1 LI 2	2.1, 2.2, 2.3, 2.4, 2.5,2.6,2.7,2.8,2.9, 2.10,2.11,2.12	2SL-1,2,3,4,5
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO3-98BT503.3**: To study about cell cloning and cell selection process and analysis of cytotoxicity and viability of cells.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9 SO3.10 SO3.11 SO3.12	LI 1 LI 2	3.1,3.2,3.3,3.4,3.5, 3.6,3.7,3.8,3.9,3.1 0,3.11,3.12	3SL-1,2,3,4,5,6
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO4-98BT503.4**: To study the method of monoclonal antibody production and its application.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10 SO4.11 SO4.12	LI 1 LI 2	4.1,4.2,4.3,4.4,4.5, 4.6,4.7,4.8,4.9,4.1 0,4.11,4.12	4SL-1,2,3,4,5
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO5-98BT503.5**: To describe the recent research in the field of animal biotechnology.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9 SO5.10 SO5.11 SO5.12	LI 1	5.1,5.2,5.3,5.4,5.5, 5.6,5.7,5.8,5.9,5.1 0,5.11,5.12	5SL-1,2,3,4

Program Name	**B. Tech. Biotechnology**	
Semester	V	
Course Code:	98BT504	
Course title:	Distillates and Fermentation	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of microbiology and fermentation	
Rationale:	Distillates and Fermentation study and solve problems related to industrial production processes. They may examine microbial growth found in the pipes of a chemical factory, monitor the impact industrial waste has on the local ecosystem, or oversee the microbial activities used in cheese production to ensure quality. Fermentation is frequently used for the cultivation of biomass and in the production of enzymes, pharmaceuticals, energy, food and feedstock, bioactive compounds, biopolymers, etc., in which different microorganisms, and including filamentous fungi, are involved.	
Course Outcomes (COs):	**CO1-98BT504.1.** Describe the fundamentals of Distillates and Fermentation Technology **CO2-98BT504.2.** Define the role of microbiology for the production of desired bioproducts **CO3-98BT504.3.** Derive the working mechanism of upstream and downstream processing **CO4-98BT504.4.** Interpretate the mechanism of fermentation process in industry **CO5-98BT504.5.** Examine the mechanism of biological product development using microbes	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=3:0:1)
			CI	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Common (PC)	98BT504	Distillates and Fermentation	3	2	1	3	9	3+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of	Couse	Course Title	Scheme of Assessment (Marks)		
				End Semester Assessmen	Total Marks

Study	Code		Progressive Assessment (PRA)					t (ESA)	(PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
PC	98BT504	Distillates and Fermentation	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Couse Code	Course Title	**Scheme of Assessment (Marks)**						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each	Seminar (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		

				(CT)					
PC	98BT554	Distillates and Fermentation	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Course-Curriculum:

<table>
<tr><td>This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.</td><td>Approximate Hours
<table><tr><td>Item</td><td>Cl</td><td>LI</td><td>SW</td><td>SL</td><td>Total</td></tr><tr><td>Approx. Hrs</td><td>06</td><td>04</td><td>01</td><td>05</td><td>18</td></tr></table></td></tr>
</table>

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-98BT504.1. Describe the fundamentals of Distillates and Fermentation Technology	**SO1.1** Explain the concept of Fermentation	**LI1.1** To Demonstrate the working of a Bench Top bioreactor	**Unit-1 Introduction to Fermentation** **CI1.1** Introduction, fermentation and fermenters	**SL1.1** Search various reference books and study material to start the learning of microorganisms
	SO1.2 Elaborate the historical perspective of fermentation	**LI1.2** To perform the isolation of microorganisms from different kinds of samples	**CI1.2** Brief history and developments in industrial microbiology	**SL1.2** Find out the literature showing use of fermentation technology in ancient India

	SO1.3 Differentiate between Solid-state and liquid-state (stationary and submerged) fermentations		**CI1.3** Solid-state and liquid-state (stationary and submerged) fermentations	**SL1.3** Derive the equation representing various mode of fermentations
	SO1.4 Derive the equations based on Batch, fed-batch and continuous fermentations		**CI1.4** Batch, fed-batch and continuous fermentations	**SL1.4** Explore different bioproducts manufacture in laboratory
	SO1.5 Explain & compare the components of a typical bioreactor, types of bioreactors-Laboratories, pilot- scale and production fermenters		**CI1.5** Components of a typical bioreactor, types of bioreactors-Laboratories, pilot- scale and production fermenters	**SL1.5** Draw a well labelled diagram of a bioreactor
	SO1.6 Examine the difference and working of various types of reactors		**CI1.6** Continuous stirred tank fermenter, tower fermenter, fixed bed, fluidized bed bioreactors and air-lift fermenter	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail "Applications of Microorganisms in various Sectors"
	SW1.2 Mini Project	Draw various types of Fermenters with specifications
	SW1.3 Other Activities (Specify)	List down the tables of different domains of microorganisms which are industrially important

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	06	01	05	20

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**

CO1-98BT504.2. Define the role of microbiology for the production of desired bioproducts	**SO2.1** Explain the role of industrial scope of fermentation	**LI2.1** To Demonstrate the working of a pH electrode	**Unit-1 Unit-2 Overview different fermentation parameters** **CI2.1** Overview on industrial fermentation- measurement of parameters	**SL2.1** Search various reference books and study material to start the learning of microorganisms
	SO2.2 Derive the roles of Isolation of strains, media and ingredients: pH, temperature, dissolved oxygen, foaming and aeration	**LI2.2** To perform the primary and secondary of microorganisms from different kinds of samples	**CI2.2** Isolation of strains, media and ingredients: pH, temperature, dissolved oxygen, foaming and aeration	**SL2.2** Find out the literature showing use of fermentation technology in ancient India
	SO2.3 Compare different identification, screening & preservation techniques	**LI2.3** To prepare the different kinds of nutrient media for microbial culture	**CI2.3** Primary and secondary screening, strain development, preservation and maintenance of industrial strains	**SL2.3** Derive the equation representing various mode of fermentations
	SO2.4 Differentiate among different kinds of media used in industrial microbiology		**CI2.4** Crude and synthetic media; molasses, corn-steep liquor, sulphite waste liquor, whey and yeast extract	**SL2.4** Explore different bioproducts manufacture in laboratory
	SO2.5 Describe the Downstream processing: Filtration, centrifugation		**CI2.5** Downstream processing: Filtration, centrifugation	**SL2.5** Draw a well labelled diagram of a bioreactor
	SO2.6 Examine the difference and working of various types of reactors		**CI2.6** Cell disruption, solvent extraction, precipitation and ultrafiltration	
	SO2.7 Analyse the difference between Lyophilization and Spray Drying		**CI2.7** Lyophilization and Spray drying	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Write down any 5 kinds of Unit Operations used in Downstream Processing
	SW1.2 Mini Project	Draw a well labelled diagram of Bacterial Cell Wall showing gram+/- staining
	SW1.3 Other Activities (Specify)	Watch animation related to working of different kinds of bioreactor used in various industries

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	05	06	01	05	20

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-98BT504.3 Derive the working mechanism of upstream and downstream processing	**SO3.1** Explain the role of Metabolic pathways	**LI3.1** To Demonstrate the working of a pH electrode	**Unit-3 Microbial Fermentations Metabolic pathways** **CI3.1** Metabolic pathways and metabolic control mechanisms	**SL3.1** Search various reference books and study material to start the learning of microorganisms
	SO3.2 Define the concept of biological product production	**LI3.2** To perform the primary and secondary of microorganisms from different kinds of samples	**CI3.2** Industrial production of citric acid, lactic acid	**SL3.2** Find out the literature showing use of Lactic Acid in industries
	SO3.3 Understand the steps of ABE fermentation	**LI3.3** To prepare the different kinds of nutrient media for microbial culture	**CI3.3** Industrial production of Enzymes (alpha-amylase, lipase, xylase, pectinases, proteases)	**SL3.3** Derive the mechanism for fermentation of ethanol

	SO3.4 Comprehend the concept of microbial production of enzymes		**CI3.4** ABE Fermentation	**SL3.4** Write about different bioproducts manufacture in laboratory
	SO3.5 Examine the role of metabolic pathways in prokaryotes and eukaryotes		**CI3.5** Microbial Production of Lysine and Glutamic acid	**SL3.5** Find out the applications of enzymes in industries

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail cultivation of microorganisms
	SW3.2 Mini Project	Prepare a flowchart showing industrial production of biological products using fermentation
	SW3.3 Other Activities (Specify)	Make a Power Point Presentation on “Different Types of Microbial Culture Media”

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	05	02	01	05	16

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO4-98BT504.4 Interpretate the mechanism of fermentation process in industry	**SO4.1** Define the Microbial production of therapeutic compounds	**LI4.1** To perform the antibiotic production using fungi	**Unit-4** **Microbial production of therapeutic compounds** **CI4.1**	**SL4.1** Find out more antibiotics and their production process

			Importance and production of Beta-lactam, aminoglycosides, (Rifamycin)	
	SO4.2 Understand the production of antibiotics		**CI4.2** Microbial production of Peptide antibiotics Quinolinones	**SL4.2** List out the role of Antibiotic Resistance Genes
	SO4.3 Classify the difference between different classes of antibiotics		**CI4.3** Biotransformation of steroids and its microbial production	**SL4.3** Explore the medical applications of Steroids
	SO4.4 Recognize the various applications of Lactamase enzyme		**CI4.4** Vitamin B12 and Riboflavin production through fermentation	**SL4.4** Make a flowchart showing metabolic pathway for Vitamin B_{12} and Vitamin B_2
	SO4.5 Derive the production of Vitamins through microbes		**CI4.5** Production of Biogas; Anaerobic digestion	**SL4.5** Explore how Biogas is produced in rural areas of India

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain the role of Antibiotics and its disadvantages
	SW4.2 Mini Project	Describe how therapeutics being produced in biotech-based industries
	SW4.3 Other Activities (Specify)	Make a list of “Biogas producing centres in India”

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	05	02	01	05	16

progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-98BT504.5 Examine the mechanism of biological product development using microbes	**SO5.1** Identify Modern trends in microbial production of bioplastics	**LI5.1** To perform the growth of Algae using a photobioreactor column	**Unit-5** **Modern trends in microbial production** **CI5.1** Modern trends in microbial production of bioplastics (PHA, PHB)	**SL5.1** Explore the various kinds of biopolymers and their applications
	SO5.2 Recognize the production mechanism of different polymer		**CI5.2** Production of bioinsectices (Thuricide), Biopolymer (Dextran, Alginate, Xanthan, Pullulan)	**SL5.2** Read research on advancement in production of biofertilizers
	SO5.3 Explain the role of biofertilizers in agriculture		**CI5.3** Biofertilizers (Nitrogen fixer Azotobacter, Phosphate solubilizing microorganisms)	**SL5.3** Find out different centres where Single Cell Proteins are used
	SO5.4 Comprehend the role of Azotobacter in biofertilizer		**CI5.4** Microbial production of Single Cell Protein	
	SO5.5 Production mechanism and importance of Single cell protein		**CI5.5** Production of biological weapons with reference to anthrax	

Suggested Sessional Work	**SW5.1** Assignments	Explain general characteristics of Biopolymers & their applications

(SW): *anyone*	**SW5.2** Mini Project	Describe the production process of Single Cell Production
	SW5.3 Other Activities (Specify)	Prepare one article on Applications of Biofertilizers

Course duration (in hours) to attain Course Outcomes:

Course Title: Distillates and Fermentation **Course Code:** 98BT504

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98BT504.1: Describe the fundamentals of Distillates and Fermentation Technology	6	4	5	1	18
CO2-98BT504.2: Define the role of microbiology for the production of desired bioproducts	6	6	5	1	20
CO3-98BT504.3: Elaborate the working mechanism of upstream and downstream processing	5	6	5	1	20
CO4-98BT504.4: Interpretate the mechanism of fermentation process in industry	5	2	5	1	16
CO5-98BT504.5: Examine the mechanism of biological product development using microbes	5	2	5	1	16
Total Hours	27	20	18	05	70

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Distillates and Fermentation **Course Code:** 98BT504

Course Outcomes	Marks Distribution				Total Marks
	A	**An**	**E**	**C**	

CO1-98BT504.1: Describe the fundamentals of Distillates and Fermentation Technology	2	1	1	1	5
CO2-98BT504.2: Define the role of microbiology for the production of desired bioproducts	2	4	2	2	10
CO3-98BT504.3: Elaborate the working mechanism of upstream and downstream processing	3	5	5	2	15
CO4-98BT504.4: Interpretate the mechanism of fermentation process in industry	2	3	3	2	10
CO5-98BT504.5: Examine the mechanism of biological product development using microbes	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

(b)

S.No.	Title/Author/Publisher details
1	Textbook of Microbiology by Ananthnarayanan and Paniker's, eighth edition, Universities Press
2	Microbiology; Lansing M Prescott, John P. Harley, Donald A Klein, Sixth edition, Mc Graw Hill Higher education.
3	J.E. Bailey and D.F. Ollis, Biochemical Engineer-ing Fundamentals, McGraw-Hill, New York
4	Industrial Microbiology and Biotechnology, Pradeep Verma, Springer, 2022
5	An Introduction to Industrial Microbiology, Sivakumar, K. Sukesh and Joe, S. Chand Publications, 2010

(c) **Online Resources:**

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Industrial plant of Biotech-based organizations
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: M. Sc. Microbiology

Semester: III Semester

Course Title: Distillates and Fermentation Technology

Course Code: 98BT504

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-98BT504.1: Describe the fundamentals of Distillates and	2	-	-	1	2	2	2	1

Fermentation Technology								
CO2-98BT504.2: Define the role of microbiology for the production of desired bioproducts	-	-	-	-	-	1	1	2
CO3-98BT504.3: Elaborate the working mechanism of upstream and downstream processing	-	1	1	1	-	1	1	1
CO4-98BT504.4: Interpretate the mechanism of fermentation process in industry	-	1	1	-	2	1	1	3
CO5-98BT504.5: Examine the mechanism of biological product development using microbes	1	1	1	-	-	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-98BT504.1:** Describe the fundamentals of Distillates and Fermentation Technology	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6	**LI 1** **LI 2**	1.1,1.2,1.3,1.4,1.5 1.6	**1SL-1,2,3,4,5**
PO 1,2,3,4,5 PSO 1,2,3	**CO2-98BT504.2:** Define the role of microbiology for the production of desired bioproducts	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7	**LI 1** **LI 2** **LI 3**	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7	**2SL-1,2,3,4,5**
PO 1,2,3,4,5 PSO 1,2,3	**CO3-98BT504.3:** Elaborate the working mechanism of upstream and downstream processing	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5	**LI 1** **LI 2** **LI 3**	3.1,3.2,3.3,3.4,3.5	**3SL-1,2,3,4,5**
PO 1,2,3,4,5 PSO 1,2,3	**CO4-98BT504.4:** Interpretate the mechanism of fermentation process in industry	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5	**LI 1**	4.1,4.2,4.3,4.4, 4.5	**4SL-1,2,3,4,5**

PO 1,2,3,4,5 PSO 1,2,3	**CO5-98BT504.5:** Examine the mechanism of biological product development using microbes	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5	**LI 1**	5.1,5.2,5.3,5.4,5.5	**5SL-1,2,3**

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	V	
Course Code:	98BT505	
Course title:	Bioseparations	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of fermentation and downstream processing	
Rationale:	Bioseparation is refers to the recovery and the purification of biosynthetic products. Downstream processing or bioseparation constitutes a critical step in manufacturing of pharmaceuticals such as antibiotics, hormones, antibodies and vaccines and enzymes with regards to product purity, cost, and environmental impact. This course offers the importance of downstream processing in biotechnology and its problems associated with product purification. The objective of this course is to impart knowledge and skills on different separation, purification, recovery and processing techniques.	
Course Outcomes (COs):	**CO1-98BT505.1.** Illustrate the basic mechanism of Bioseparations **CO2-98BT505.2.** Discuss the role of Downstream processing in bioprocessing **CO3-98BT505.3.** Comprehend & distinguish among the working mechanism of unit operators used in bioseparations **CO4-98BT505.4.** Interpretate the mechanism of isolation of products through analytical methods **CO5-98BT505.5.** Examine and demonstrate the mechanism of product purification	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Common (PC)	98BT505	Bioseparations	3	2	1	3	9	3+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/ Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA +AT)		
PC	98BT505	Bioseparations	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks
			Class/	Class Test 2	Seminar	Class Activity	Class Attendance	Total Marks		

			Home Assignment 5 number 3 marks each (CA)	(2 best out of 3) 10 marks each (CT)	one (SA)	(CAT)	(AT)	(CA+CT+CAT+SA +AT)		(PRA+ ESA)
PC	98BT555	Bioseparations	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	04	01	05	18

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-98BT505.1 Illustrate the basic mechanism of Bioseparations	**SO1.1** Explain concept of Bioseparations	**LI1.1** Basic instruments used in bioseparation techniques	**Unit-1 Introduction and Overview CI1.1** History and scope of	**SL1.1** Find out some examples of natural bioseparations

			downstream processing in biotechnology	
	SO1.2 Define Basic terminology, scope and application	**LI1.2** To Demonstrate different filtration units	**CI1.2** Problems, requirement of purification	**SL1.2** Explore conventional papers on Bioseparations
	SO1.3 Elaborate the scientific applications of Bioseparation		**CI1.3** Overview of a bioprocess including upstream and downstream processing	**SL1.3** Write down few points on biological product's properties
	SO1.4 Define the mechanism of biological separations		**CI1.4** Characteristics of biotechnology products, classes of bioproducts	**SL1.4** Write down few points on classes of bioproducts
	SO1.5 Describe Bioseparations tools and techniques		**CI1.5** Physicochemical basis of bio-separation	**SL1.5** Collect information on career in bioseparations

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail about the role of Bioseparation in Product development
	SW1.2 Mini Project	Differentiate between Upstream and Downstream processing
	SW1.3 Other Activities (Specify)	Draw a flowchart compiling all procedures used in bioseparation/downstream processing

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	0 4	01	05	18

the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-98BT505.2. Discuss the role of Downstream processing in bioprocessing	**SO2.1** Explain concept of downstream processing	**LI2.1** Demonstrate the working of Cell Disruption technique	**Unit-2** **Physical methods of separation** **CI2.1** Cell disruption for product release–mechanical, enzymatic and chemical methods	**SL2.1** Find out more conventional cell disruption techniques
	SO2.2 Relate the concept of how physical and biological separation can be done	**LI2.2** To perform the experiment of production of microbial biomass	**CI2.2** Pretreatment and stabilization of byproducts	**SL2.2** Read the latest research in bioseparations methods
	SO2.3 Outline difference between physical, chemical and biological method of separation		**CI2.3** Filtration –principles, conventional and cross flow filtration	**SL2.3** Write down few points on biological product’s properties
	SO2.4 Define the mechanism of biological separations		**CI2.4** Filter media; membrane fouling	**SL2.4** Find out the different kinds of filter aids and their role
	SO2.5 Explain the role of		**CI2.5** Rotary vacuum	

	Rotary vacuum filtration unit		filtration-equipment details	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe Filteration and its application in bioseparation techniques
	SW2.2 Mini Project	Make a project on Rotatory Drum Vaccum Filter and its applications
	SW2.3 Other Activities (Specify)	Make Power point presentation on production of biomass

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	02	01	04	15

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-98BT505.3 Comprehend & distinguish among the working mechanism of unit operators used in bioseparations	**SO3.1** Elucidate the application of various kinds of separation process	**LI3.1** To perform the Centrifugation process as Unit Operation	**Unit-3** **CI3.1** Aqueous two-phase extraction principles, phase separation	**SL3.1** Find out the process of Aqueous two-phase extraction, instrument setup
	SO3.2 Derive the mathematical expression for centrifugal sedimentation		**CI3.2** Plate extraction column and centrifugal extractors	**SL3.2** Read the process of protein precipitation and its application in healthcare

	SO3.3 Analyze the partition coefficient associated with phase extraction		**CI3.3** Membrane separation, ultra filtration and dialysis	**SL3.3** Find out the process of Ultracentrifugation and its application
	SO3.4 Distinguish among the working mechanism of Precipitation of proteins by different methods sedimentation		**CI3.4** Precipitation of proteins by different methods sedimentation	
	SO3.5 Explain the role of Sedimentation in Centrifugation		**CI3.5** Principles sedimentation coefficient; centrifugation–tubular and disk centrifuges	
	SO3.6 Elaborate the role of Ultracentrifugation & Flocculation		**CI3.6** Ultracentrifugation–sedimentation at low accelerations; flocculation-principles	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Derive the equations for Centrifugation using sedimentation, terminal velocity and gravity
	SW3.2 Mini Project	Describe the role of Ultracentrifuge in industries
	SW3.3 Other Activities (Specify)	Prepare one Power point presentation on "Different types of Centrifuge and their applications"

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	02	01	05	16

instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-98BT505.4 Interpretate the mechanism of isolation of products through analytical methods	**SO4.1** Elucidate the application & working mechanism of Chromatography	**LI4.1** To perform the Column Chromatography process as Unit Operation for extraction of different compounds	**Unit-4 Product purification by chromatography** **CI4.1** Chromatography principles, chromatography equipment and detectors	**SL4.1** Find out the industrial applications of Chromatography
	SO4.2 Distinguish among Ion-exchange, size exclusion, hydrophobic interactions		**CI4.2** Ion-exchange, size exclusion, hydrophobic interaction	**SL4.2** List down various kinds of Chromatographic columns used in analysis
	SO4.3 Analyze the working of Bioaffinity chromatography		**CI4.3** Bioaffinity chromatography	**SL4.3** List down various kinds of Solvents used in Chromatographic technique
	SO4.4 Distinguish among the working mechanism of Pseudo affinity Chromatographic techniques		**CI4.4** Pseudo affinity Chromatographic techniques	**SL4.4** List down the various kinds of Detectors associated with chromatography

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Determine the working mechanism and applications of different kind of chromatographic techniques
	SW4.2 Mini Project	Derive the Qualitative and Quantitative data optimization and retrieval through chromatographic detectors and equations associated with it
	SW4.3 Other Activities (Specify)	Perform the extraction of different compounds and calculate the Retention time for each compound in laboratory

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	04	01	04	20

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-98BT505.5 Interpretate the mechanism of isolation of products through analytical methods	**SO5.1** Elucidate the application & working mechanism of Chromatography	**LI5.1** To determine the AA sequences comparison on the basis of peptide mapping using ProteoMapper (Server/tool)	**Unit-5 Final product formulation and finishing operations** **CI5.1** Analysis of the final product - Protein-based contaminants	**SL5.1** Find out the industrial applications of Chromatography
	SO5.2 Distinguish among Ion-exchange, size exclusion, hydrophobic	**LI5.2** To determine the protein 3D structure, function and	**CI5.2** Removal of altered forms of the protein of interest from the product stream	**SL5.2** List down various kinds of Chromatographic columns used in analysis

	interactions	annotations using Protein Data Bank (PDB database)		
	SO5.3 Analyze the working of Bioaffinity chromatography		**CI5.3** NMR and X-Ray Crystallography (protein structure determination)	**SL5.3** List down various kinds of Solvents used in Chromatographic technique
	SO5.4 Distinguish among the working mechanism of Pseudo affinity Chromatographic techniques		**CI5.4** Determination of protein concentration (all the major protein assays – principles)	**SL5.4** List down the various kinds of Detectors associated with chromatography
	SO5.5 Describe and draw Amnio acid's structure and functions		**CI5.5** Amino acid analysis, Peptide mapping	**SL5.5** List down the various bioinformatics-based server/tool that assist in study of protein/proteomics
	SO5.6 Explain the process of Protein sequencing		**CI5.6** N-terminal sequencing, Analysis of secondary and tertiary structure	
	SO5.7 Define the protein-based product impurities		**CI5.7** Detection of protein-based product impurities	
	SO5.8 Explain the Rapid methods for detection		**CI5.8** Rapid methods for detection of specific	

	of specific organisms and toxins (ELISA/RIA)		organisms and toxins	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general mechanism of ELISA and RIA
	SW5.2 Mini Project	Describe the RIPP model by giving an example from microbial production of any product from therapeutic domain
	SW5.3 Other Activities (Specify)	Prepare one article on the "Structure and Bonds associated with Proteins"

Course duration (in hours) to attain Course Outcomes:

Course Title: Bioseparations **Course Code:** 98BT505

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98BT505.1. Illustrate the basic mechanism of Bioseparations	8	4	5	1	18
CO2-98BT505.2. Discuss the role of Downstream processing in bioprocessing	8	4	5	1	18
CO3-98BT505.3. Comprehend & distinguish among the working mechanism of unit operators used in bioseparations	8	2	4	1	15
CO4-98BT505.4. Interpretate the mechanism of isolation of products through analytical methods	8	2	5	1	16
CO5-98BT505.5. Examine and demonstrate the	10	4	5	1	20

mechanism of product purification					
Total Hours	40	20	18	05	87

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Bioseparations **Course Code:** 98BT505

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-98BT505.1. Illustrate the basic mechanism of Bioseparations	2	1	1	1	5
CO2-98BT505.2. Discuss the role of Downstream processing in bioprocessing	2	4	5	1	12
CO3-98BT505.3. Comprehend & distinguish among the working mechanism of unit operators used in bioseparations	3	5	5	1	14
CO4-98BT505.4. Interpretate the mechanism of isolation of products through analytical methods	2	3	5	1	11
CO5-98BT505.5. Examine and demonstrate the mechanism of product purification	5	4	1	0	10
Total Marks	**14**	**17**	**17**	**04**	**52**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

(b)

S.No.	**Title/Author/Publisher details**
1	Roger G.Harrison, Paul Todd, Scott R.Rudge and Demetri P. Pterides – Biosepartions Science and Engineering – Oxford University Press - 2003

2	R.O. Jenkins, (Ed.) – Product Recovery In Bioprocess Technology – Biotechnology By Open Learning Series, Butterworth-Heinemann (1992).
3	J.C. Janson And L. Ryden, (Ed.) – Protein Purification – Principles, High Resolution Methods And Applications, VCH Pub. 1989.
4	Fundamentals of Biochemistry. Author, JL Jain et al. Edition, reprint. Publisher, S. Chand Publishing, 2004.
5	Bioseparations: Principles and Techniques; Sivasankar, B; PHI Publications, 2009

(c) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Waste water/Effluent Treatment plant and downstream pharmaceutical plants
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: V Semester

Course Title: Bioseparations

Course Code: 98BT505

CO/PO Mapping															
Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1-98BT505.1. Illustrate the basic mechanism of Bioseparations	**-**	**1**	**-**	**1**	**2**	**2**	**3**	**-**	**3**	**2**	**2**	**3**	**1**	**2**	**1**
CO2-98BT505.2. Discuss the role of Downstream processing in bioprocessing	**-**	**1**	**-**	**-**	**-**	**-**	**3**	**-**	**2**	**2**	**3**	**3**	**3**	**-**	**2**
CO3-98BT505.3. Comprehend & distinguish	**-**	**1**	**1**	**1**	**-**	**-**	**3**	**-**	**3**	**1**	**1**	**2**	**1**	**2**	**-**

among the working mechanism of unit operators used in bioseparations															
CO4-98BT505.4. Interpretate the mechanism of isolation of products through analytical methods	**-**	**-**	**1**	**-**	**2**	**2**	**3**	**3**	**-**	**1**	**3**	**3**	**2**	**1**	**3**
CO5-98BT505.5. Examine and demonstrate the mechanism of product purification	**1**	**-**	**1**	**-**	**-**	**2**	**3**	**3**	**1**	**2**	**2**	**2**	**1**	**1**	**2**

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-98BT505.1.** Illustrate the basic mechanism of Bioseparations	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5	**LI 1** **LI 2**	1.1,1.2,1.3,1.4,1.5	**1SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-98BT505.2.** Discuss the role of Downstream processing in bioprocessing	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5	**LI 1** **LI 2**	2.1, 2.2, 2.3, 2.4, 2.5	**2SL-1,2,3,4**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3-98BT505.3.** Comprehend & distinguish among the working mechanism of unit operators used in bioseparations	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6	**LI 1**	3.1,3.2,3.3,3.4,3.5, 3.6	**3SL-1,2,3**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-98BT505.4.** Interpretate the mechanism of isolation of products through analytical methods	SO4.1 SO4.2 SO4.3 SO4.4	**LI 1**	4.1,4.2,4.3,4.4	**4SL-1,2,3,4**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO5-98BT505.5.** Examine and demonstrate the mechanism of product purification	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8	**LI 1** **LI 2**	5.1,5.2,5.3,5.4,5.5, 5.6, 5.7, 5.8	**5SL-1,2,3,4,5**

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	V	
Course Code:	98BT506-A	
Course title:	Nanotechnology and Engineering	**Curriculum Developer**: Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of Physical & Biological Science	
Rationale:	Nanotechnology is a rather young discipline, which came up in the nineties. Nevertheless, Nanotech has gained so much importance within the last years that universities at all rankings have introduced or are going to introduce Nanotechnology teaching programs. Predictions say that NT will change our lives and society more than computer technology and electricity have done together. The course will provide an overview over NT. It will show that the nano regime is so different from other regimes because both classical and quantum effects can be active thus leading to unique properties of nano devices. It is a highly interdisciplinary science, which will be reflected in the course by making reference to chemistry, physics, biology, pharmacy, and engineering. Applications of Nanotechnology, as they are already in use today or as they are planned for the future, will be discussed.	
Course Outcomes (COs):	**CO1-98BT506-A.1.** Explain fundamentals of Nanotechnology **CO2-98BT506-A.2.** Define the role of biotechnology in nanoscience **CO3-98BT506-A.3.** Comprehend the working mechanism of nanoparticles in cancer treatment **CO4-98BT506-A.4.** Interpretate the mechanism of drug delivery and designing **CO5-98BT506-A.5.** Examine the mechanism of nano-sensors & demonstrate the significance of biosensors in industries.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Elective (PE)	98BT506-A	Nanotechnology and Engineering	3	2	1	1	7	3+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)		
			Progressive Assessment (PRA)	End Semester Assessment (ESA)	Total Marks

			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		(PRA+ ESA)
PE	98BT506-A	Nanotechnology and Engineering	15	20	5	5	5	50	50

Scheme of Assessment: Practical

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		

			(CA)						
PE	98BT556-A	Nanotechnology and Engineering	15	20	5	5	5	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	02	01	05	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-56MB205.1: Explain fundamentals of Nanotechnology	**SO1.1** Summarize concept of Nanotechnology	**LI1.1** Basic instruments used in nanotechnology	**Unit-1 Fundamental Concepts** **CI1.1** Concept of Nanoscience, introduction to Nanotechnology	**SL1.1** Nanoscale comparison
	SO1.2 Define Basic terminology, scope and application		**CI1.2** Nanomechanics-Nanotribology Scanning probe microscopy	**SL1.2** Other Nanodevices around you
	SO1.3		**CI1.3**	**SL1.3**

	Provide use of nanotechnology		Nanomaterials and its handling, nanobots	Use of nanoscience in biology
	SO1.4 Overviewing of various tools of nanotechnology		**CI1.4** Nanofuture, nano-fying Electronics	**SL1.4** Nanotechnology natural occurrence.
	SO1.5 Overviewing nano assisted techniques		**CI1.5** Nanofibres,nanopore and nanotubes	**SL1.5** Use of different nano assisted devices

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail about the Nanoparticles
	SW1.2 Mini Project	Draw a well labelled diagram of a microscope
	SW1.3 Other Activities (Specify)	Write an article on "Latest research in the field of Nanotechnology"

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	04	01	05	18

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-98BT506-A Define the role of biotechnology in nanoscience	**SO2.1** Expalin Concept of nanomaterials	**LI2.1** Working of a microscope	**Unit-1 Production and characterization of nanoparticles** **CI2.1** Introduction to Nanoscience Techniques used in Nanobiotechnology	**SL2.1** List down the nanoparticle which is present around you
	SO2.2	**LI2.2**	**CI2.2**	**SL2.2**

	Relate the concept of how nanomaterials been categorized.	Study of Electron Microscope database (EMD) and retrieve macromolecular structure obtained from the database	Optical Microscopy, Atomic Force, Microscopy, SEM	Find some literature on Atomic Force Microscopy applications in biological sciences
	SO2.3 Outline difference between silver and gold nanoparticles		**CI2.3** MALDI-TOF, Production of nanoparticles.	**SL2.3** List down the various kinds of nano-fertilizers used in India
	SO2.4 Analyzing the working of Electron microscope and Atomic Force Microscopy		**CI2.4** Nanoparticles agglomeration and applications	
	SO2.5 Describe the physicochemical properties and working of nano-aerogels		**CI2.5** Nano-aerogels; Nano-fertilizers	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Make a table to distinguish different nanoparticles with their biological applications
	SW2.2 Mini Project	Write down the protocol for the production of Nanoparticle in laboratory
	SW2.3 Other Activities (Specify)	Attain at least one seminar or online talk on Nanotechnology and its applications

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	02	01	05	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
98BT506-A.3. Comprehend the working mechanism of nanoparticles in Cancer treatment	**SO3.1** Explain the role of Nanotechnology in cancer	**LI3.1** To retrieve the oncological based data from Cancer Genome Atlas	**Unit-3 Nanoparticles for Cancer Drug Delivery** **CI3.1** Cancer and current approach to its cure through nanoparticles (CDDS, Cancer Drug Delivery System)	**SL3.1** Explore the research of Nano-oncology
	SO3.2 Learn the concept of cancer drug delivery		**CI3.2** Characteristics of tumor tissues, drug delivery to tumor	**SL3.2** Learn novel nano-tools used in drug delivery
	SO3.3 Define the working of anti-cancerous drugs		**CI3.3** Physio-chemical properties of nanoparticles in cancer therapy	**SL3.3** Find out new nanomaterials with biocompatibility
	SO3.4 Elaborate the working of nanomaterial as carrier molecule		**CI3.4** Site specific delivery of therapeutic drugs	**SL3.4** Learn the basic mechanism of tumor formation
	SO3.5 Analyse the role of nanomaterial in site specific drug delivery		**CI3.5** Technique to deliver chemotherapeutic agents using nanoparticles	**SL3.5** Find out the disadvantages associated with chemotherapy

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Make a table to distinguish different nanoparticles with their biological applications
	SW3.2 Mini Project	Write down the protocol for the production of Nanoparticle in laboratory
	SW3.3 Other Activities (Specify)	Attain at least one seminar or online talk on Nanotechnology and its applications

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	02	01	05	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-98BT506-A.4: Interpretate the mechanism of drug delivery and nanoparticle-based designing	**SO4.1** Observing the role of Viral and Non-viral gene therapy	**LI4.1** To retrieve the oncological based data from Cancer Genome Atlas	**Unit-4 Non-viral Gene Therapy with nanoparticles** **CI4.1** Non-viral Gene Therapy with nanoparticles: Introduction	**SL4.1** Read the novel papers relevant to Non-viral gene therapy
	SO4.2 Comprehend the working of novel Non-Viral gene therapy		**CI4.2** Hyperthermia, controlled delivery of chemotherapeutic drugs	**SL4.2** Find out the microorganims becoming lethal due to MDR conditions
	SO4.3 Analyze the working of anti-cancerous drugs		**CI4.3** Nanoparticles to circumvent MDR	**SL4.3** Find out new nanomaterials with biocompatibility
	SO4.4 Recognize the various applications of nanotechnology in other fields		**CI4.4** Potential problems using nanoparticles	**SL4.4** Discover out disadvantages associated with nanoparticles
	SO4.5		**CI4.5**	**SL4.5**

	Discover the applications of Nanotechnology in Agriculture, Medicine, Communication technology, Biotechnology and Bioinformatics		Application of Nanotechnology in Agriculture, Medicine, Communication technology, Biotechnology and Bioinformatics	Explore common application of nanotechnology in given fields

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Write an article on "Role of Nanoparticles in Non-Viral Gene Therapy"
	SW4.2 Mini Project	List down the conditions of MDR, XDR and TDR in microbes
	SW4.3 Other Activities (Specify)	Make a presentation on Non-Viral Gene therapy techniques

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	02	01	05	13

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
98BT506-A.5. To Examine the mechanism of nano-sensors & demonstrate the significance of biosensors in industries.	**SO5.1** Identify different classes of biosensors and describe their functioning principles	**LI5.1** To retrieve the oncological based data from Cancer Genome Atlas	**Unit-5** **Biosensors and Nanosensors** **CI5.1** Introduction to Biosensors, types and working of biosensors	**SL5.1** Find out the role of Biosensors
	SO5.2 Recognize limitations of		**CI5.2** Importance of biosensors,	**SL5.2** Explore the various kinds

	biosensors in real-life applications		parts of biosensors and its function, Channel Gating Biomimetic Membranes	of biosensors
	SO5.3 Analyze the principles and concepts of transducers and their application in biosensor design		**CI5.3** Membrane Biosensors Based on Ion Channel Gating	**SL5.3** Read research on advancement in biosensors
	SO5.4 Define the fundamentals of diagnostic devices and biomarker testing in biological fluids		**CI5.4** Nanofabrication, medicine-Potential Biomedical Applications	**SL5.4** Observe the natural biosensors around us
	SO5.5 Discover the technical and societal factors involved in point-of-care diagnostics and wearable sensors		**CI5.5** Applications of Polymer Nanostructures, Types of nanosensors, LAB-On-A-CHIP, Applications of Biosensors	**SL5.5** Find out the meaning of Biomimicry

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Write an article on "Role of Biosensors and its mechanism"
	SW5.2 Mini Project	List down the principles of biosensors and Nanosensors
	SW5.3 Other Activities (Specify)	Make a presentation on Lab-On-A-Chip technique with applications

Course duration (in hours) to attain Course Outcomes:

Course Title: Nanotechnology and Engineering **Course Code:** 98BT506.A

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Sessional work (SW)	Self-Learning (SL)	Total Hours (Li+CI+SW+SL)
CO1-98BT506-A.1: Explain fundamentals of	8	2	1	5	16

Nanotechnology					
CO2-98BT506-A.2: Define the role of biotechnology in nanoscience	8	4	1	5	18
CO3-98BT506-A.3: To Comprehend the working mechanism of nanoparticles in Cancer treatment	8	2	1	5	16
CO4-98BT506-A.4: Interpretate the mechanism of drug delivery and nanoparticle-based designing	8	2	1	5	16
CO4-98BT506-A.5: To Examine the mechanism of nano-sensors & demonstrate the significance of biosensors in industries.	8	2	1	5	16
Total Hours	40	12	05	25	82

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Nanotechnology and Engineering **Course Code:** 98BT506.A

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-98BT506-A.1: Explain fundamentals of Nanotechnology	2	1	1	1	5
CO2-98BT506-A.2: Define the role of biotechnology in nanoscience	3	4	2	1	10
CO3-98BT506-A.3: To Comprehend the working mechanism of nanoparticles in Cancer treatment	4	5	5	1	15
CO4-98BT506-A.4: Interpretate the mechanism of drug delivery and nanoparticle-based designing	3	4	3	0	10
CO4-98BT506-A.5: To Examine the mechanism of nano-sensors & demonstrate the significance of biosensors in industries.	5	4	1	0	10
Total Marks	**17**	**18**	**12**	**03**	**50**

Legend: **A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

Books:

S.No.	Title/Author/Publisher details
1	Bharat Bhushan., Nanotribology and Nanomechanics - An introduction, Springer.
2	Mark, Ratner Daniel Ratner, Nanobiotechnology- next big idea.
3	Challa S.S.R.Kumar, Joseph Hornes, Carola Leuschner, Nanofabrication towards Biomedical applications.
4	Pharmaceutical Nanobiotechnology for Targeted Therapy, Hamed Barabadi, Ebrahim Mostafavi, Muthupandian Saravanan, Springer 2022
5	Charles P. Poole, Jr., Frank J. Owens; "Introduction to Nanotechnology", John Wiley& Sons, 2003,

(a) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Demonstration
7. ICT Based teaching Learning
8. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: V Semester

Course Title: Nanotechnology and Engineering

Course Code: 98BT506-A

CO/PO Mapping															
Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-98BT506-A.1: Explain fundamentals of Nanotechnology	-	-	-	1	2	2	2	-	1	2	2	3	3	3	1
CO2-98BT506-A.2: Define the role of biotechnology in nanoscience	-	-	-	-	-	-	3	-	2	2	3	3	1	1	2
CO3-98BT506-A.3: To Comprehend the working mechanism of nanoparticles in Cancer treatment	-	1	1	1	-	-	2	-	3	1	1	2	1	1	1
CO4-98BT506-A.4: Interpretate the mechanism of drug delivery and nanoparticle-based	-	1	1	-	2	2	2	3	-	1	-	-	1	2	2

designing														
CO4-98BT506-A.5: To Examine the mechanism of nano-sensors & demonstrate the significance of biosensors in industries.	**1**	**1**	**1**	**-**	**-**	**2**	**3**	**3**	**1**	**2**	**2**	**2**	**1**	**1**	**2**

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	**COs**	**SOs No.**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-98BT506-A.1:** Explain fundamentals of Nanotechnology	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5	**LI 1**	1.1,1.2,1.3,1.4,1.5	**1SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-98BT506-A.2:** Define the role of biotechnology in nanoscience	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5	**LI 1** **LI 2**	2.1, 2.2, 2.3, 2.4, 2.5	**2SL-1,2,3**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3-98BT506-A.3:** To Comprehend the working mechanism of nanoparticles in Cancer treatment	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5	**LI 1**	3.1,3.2,3.3,3.4,3.5	**3SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-98BT506-A.4:** Interpretate the mechanism of drug delivery and nanoparticle-based designing	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5	**LI 1**	4.1,4.2,4.3,4.4, 4.5	**4SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12	**CO4-98BT506-A.5:** To Examine the mechanism of nano-sensors & demonstrate the significance of	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5	**LI 1**	5.1,5.2,5.3,5.4,5.5	**5SL-1,2,3,4,5**

PSO 1,2, 3	biosensors in industries.				

Program Name	**B.Tech. Biotechnology**	
Semester	V	
Course Code:	**98BT506-B**	
Course title:	Pharmaceutical Biotechnology	**Curriculum Developer**: Mrs. Keerti Samdariya, Assistant Professor
Pre-requisite:	Students should have basic knowledge of pharmaceutical biotechnology	
Rationale:	The paper on Pharmaceutical Biotechnology in B.tech. Biotechnology program explores the role of biotechnology in drug discovery, development, and production, including the use of recombinant DNA technology and biopharmaceutical manufacturing. Students need to develop practical skills in laboratory techniques and methods used in producing, purifying, and analyzing pharmaceutical biotechnology products. **Course Outcomes (COs):** **CO1-98BT506-B:** Understand the role of biotechnology in drug discovery, development, and production, including recombinant DNA technology and biopharmaceutical manufacturing. **CO2-98BT506-B**: Extend practical skills in laboratory techniques and methods used in producing, purifying, and analyzing pharmaceutical biotechnology products. **CO3-98BT506-B**: Evaluate knowledge of regulatory frameworks and quality control practices specific to pharmaceutical biotechnology. **CO4-98BT506-B**: Understand the application of biotechnology in the pharmaceutical industry. Apply regulatory aspects, ethical considerations, and safety requirements associated with pharmaceutical biotechnology. **CO5-98BT506-B**: Apply the knowledge of GLP and GMP in the Pharmaceutical laboratory.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L: T: P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Common (PC)	**98BT506-B**	Pharmaceutical Biotechnology	3	2	1	3	9	3+1=4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of	Couse	Course Title	Scheme of Assessment (Marks)		
				End Semester Assessme	Total Marks

Study	Code		Progressive Assessment (PRA)					nt (ESA)	(PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
PC	**98BT506-B**	Pharmaceutical Biotechnology	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number	Class Test 2 (2 best out	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		

			3 marks each (CA)	of 3) 10 marks each (CT)					
PC	98BT556-B	Pharmaceutical Biotechnology	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Course-Curriculum:

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Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1 -98BT506-B: Understand the role of biotechnology in drug	**SO1.1** Define and describe Antibiotics and	**LI1.1** Demonstration of antibiotic action with	**Unit 1** **CI1.1** A brief outline of the	**SL1.1** Explore the various kinds of biopolymers and their

discovery, development, and production, including recombinant DNA technology and biopharmaceutical manufacturing.	synthetic antimicrobial agents.	bacterial strain.	discovery of antibiotics.	applications
	SO1.2 Define and describe synthetic antimicrobial agents.	**LI1.2** Diagrammatic presentation of types of antibiotics.	**CI1.2** Define and describe Antibiotics and synthetic antimicrobial agents.	
	SO1.3 Differentiate antifungal antibiotics, antitumor substances	.	**CI1.3** The general structure of beta-lactam antibiotics.	**SL1.2** Read research on advancement in the production of biofertilizers
	SO1.4 Differentiate Chemical disinfectants, antiseptics, and preservatives.		**CI1.4** Classification and Explanation of Antifungal antibiotics, antitumor substances, Peptide antibiotics, Chloramphenicol, Sulphonamides, and Quinolinone antimicrobial agents.	**SL1.3** Find out different centers where Single Cell Proteins are used
	SO1.5		**CI1.5**	

	Classification and Explanation of Antifungal antibiotics		Classification and mechanism of action of antimicrobial agents.	
	SO1.6 Classification and Explanation of antitumor substances,		**CI1.6** Classification and mechanism of action of antimicrobial agents	
	SO1.7 Classification and Explanation of Peptide antibiotics, Chloramphenicol, Sulphonamides, and Quinolinone antimicrobial agents.		**CI1.7** Classification and mechanism of action of antimicrobial agents	
	SO1.8 Classification and Explanation of Chloramphenicol, Sulphonamides, and Quinolinone antimicrobial agents.		**CI1.8** Classification and mechanism of action of antimicrobial agents	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail about Antibiotics and their classification.
	SW3.2 Mini Project	Describe the role of antibiotics in medical system
	SW3.3 Other Activities	Prepare a diagrammatic poster for different antiviral ,antibacterial and antifungal drug and their role in health .

	(Specify)	

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	0 4	01	05	18

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO1 -98BT506-B: Extend practical skills in laboratory techniques and methods for producing, purifying, and analyzing pharmaceutical biotechnology products	**SO2.1** To explain the Mechanism of action of antibiotics inhibitors of cell wall synthesis.	**LI2.1** To perform the Mode of action of antibiotic antimicrobial agents.	**Unit 2** **CI1.1** Mechanism of action of antibiotics (inhibitors of cell wall synthesis, nucleic acid and protein synthesis)	**SL2.1** Read the Mode of action of antibiotics.
	SO2.2 Mechanism of action of antibiotics (inhibitors of nucleic acid synthesis)	**LI2.2** To perform the Mode of action of non-antibiotic antimicrobial agents. .	**CI1.2** Mechanism of action of antibiotics (inhibitors of cell wall synthesis, nucleic acid and protein synthesis)	**SL2.2** Various assays were used for bacterial susceptibility.
	SO2.3 Mechanism of action of antibiotics (inhibitors of protein synthesis		**CI1.3** Mechanism of action of antibiotics (inhibitors of cell wall synthesis, nucleic acid and protein synthesis)	**SL2.3** Learn Molecular principles of drug targeting.

	SO2.4 To describe Molecular principles of drug targeting.		**CI2.4** Molecular principles of drug targeting.	**SL2.3** Read about inhibitors of cell wall synthesis, nucleic acid, and protein synthesis.
	SO2.5 To describe the Mode of action of bacterial killing by quinolinones.		**CI2.5** Mode of action of bacterial killing by quinolinones, Bacterial resistance to quionolinones.	
	SO2.6 To explain the cellular permeability barrier.		**CI2.6** How the antimicrobial agents reach the targets (cellular permeability barrier, cellular transport system and drug diffusion	
	SO2.7 To elaborate on drug diffusion		**CI2.7** How the antimicrobial agents reach the targets (cellular permeability barrier, cellular transport system and drug diffusion	
	SO2.8 To explain the Drug delivery system in gene therapy.		**CI2.8** How the antimicrobial agents reach the targets (cellular permeability barrier, cellular transport system and drug diffusion	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe in detail Mechanism of action of antibiotics .
	SW2.2 Mini Project	Various Mode of action of Bacterial resistance to quionolinones..
	SW2.3 Other Activities (Specify)	How the antimicrobial agents reach the targets (cellular permeability barrier, cellular transport)

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Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	04	01	05	18

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO3-98BT506-B: Evaluate knowledge of regulatory frameworks and quality control practices specific to pharmaceutical biotechnology.	**SO3.1** Explain the Microbial contamination.	**LI3.1** Demonstrate the sterilization process.	**Unit 3** **CI3.1** Microbial contamination and spoilage of pharmaceutical products and their sterilization.	**SL3.1** Discuss various types of vaccines involved in health system
	SO3.2 Define and differentiate sterile injectibles, and non-	**LI3.2** Perform the production of	**CI3.2** Read about various Microbial contamination and	**SL3.2** Read the sterilization

	injectibles.	microbial culture.	spoilage of pharmaceutical products and their sterilization.	process in industrial production of drugs.
	SO3.3 Describe the sterilization process used in the pharmaceutical industry.		**CI3.3** Manufacturing procedures and in process control of pharmaceuticals	
	SO3.4 Describe Manufacturing procedures and in process control of pharmaceuticals		**CI3.4** pharmaceuticals produced by microbial fermentations (streptokinase, streptodornase).	
	SO3.5 Explain pharmaceuticals produced by microbial fermentations (streptokinase, streptodornase)		**CI3.5** New vaccine technology, DNA vaccines, synthetic peptide vaccines, multivalent subunit vaccines.	
	SO3.6 Explain pharmaceuticals produced by microbial fermentations (streptokinase, streptodornase)		**CI3.6** New vaccine technology, DNA vaccines, synthetic peptide vaccines, multivalent subunit vaccines.	

	so3.7 illustrates New vaccine technology, DNA vaccines, synthetic peptide vaccines,		**CI3.7** New vaccine technology, DNA vaccines, synthetic peptide vaccines, multivalent subunit vaccines.	
	SO3.8 illustrates New vaccine technology, multivalent subunit vaccines.		**CI3.8** New vaccine technology, DNA vaccines, synthetic peptide vaccines, multivalent subunit vaccines.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail on New vaccine technology, DNA vaccines, synthetic peptide vaccines.
	SW3.2 Mini Project	Describe the role of different vaccines.
	SW3.3 other activity	Prepare one article on different types of diseases and their vaccines.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	04	01	05	18

Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.				
Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO4-98BT506-B: Understand the application of biotechnology in the pharmaceutical industry. Apply regulatory aspects, ethical considerations, and safety requirements associated with pharmaceutical biotechnology	**SO4.1** Describe the classification of pharmacopeia.	**LI4.1** To analyze the Immobilization process.	**Unit-4** **CI4.1** Financing R&D capital and market outlook	**SL4.1** Learn about the Government regulatory practices and policies.
	SO4.2 Explain the Government regulatory practices and policies.	**LI4.2**To develop a model of the application of microbial enzymes in pharmaceuticals.	**CI4.2** IP, BP, USP. Government regulatory practices and policies, FDA perspective	**SL4.2** Learn about various types of Immobilization procedures for pharmaceutical applications. .
	SO4.3 Describe IP, BP, USP. Government regulatory practices and policies, FDA perspective		**CI4.3** IP, BP, USP. Government regulatory practices and policies, FDA perspective	
	SO4.4 Evaluate reimbursement of		**CI4.4** Reimbursement of drugs and biologicals,	

	drugs and biologicals.		legislative perspective. Rational drug design.	
	SO4.5 Define and describe Immobilization procedures for pharmaceutical applications.		**CI4.5** Immobilization procedures for pharmaceutical applications (liposomes). Macromolecular, cellular and synthetic drug carriers.	
	SO4.6 Explain pharmaceuticals produced by microbial fermentations streptokinase.		**CI4.6** Explain pharmaceuticals produced by microbial fermentations streptokinase	
	SO4.7 Explain pharmaceuticals produced by microbial fermentations streptodornase		**CI4.7** Explain pharmaceuticals produced by microbial fermentations streptokinase.	
	SO4.8 Biosensors in pharmaceuticals. Application of microbial enzymes in pharmaceuticals		**CI4.8** Biosensors in pharmaceuticals. Application of microbial enzymes in pharmaceuticals	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain Biosensors and their application in the pharmaceutical industry.
	SW4.2 Mini Project	Describe the various types of Pharmacopeias.

	SW4.3 Other Activities (Specify)	Prepare one article on the IP, BP, USP. Government regulatory practices and policies, FDA perspective.

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Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	04	01	05	18

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO5-98BT506-B: Apply the knowledge of Quality Assurance and Validation, GLP, and GMP in the Pharmaceutical laboratory.	**SO5.1** Explain Good Manufacturing Practices (GMP) in the pharmaceutical industry.	**LI5.1** Use of Good Laboratory Practices (GLP)	**Unit-5** **CI5.1** Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in the pharmaceutical industry.	**SL5.1** Find out the role of Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in the pharmaceutical industry.
	SO5.2 Define quality control. in		. **CI5.1** Good Manufacturing	

	pharmaceuticals.		Practices (GMP) and Good Laboratory Practices (GLP) in the pharmaceutical industry.	.
	SO5.3 Define Quality assurance and quality management in pharmaceuticals.		**CI5.2** Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in the pharmaceutical industry.	
	SO5.3 Elaborate ISO, WHO, and US certification		**CI5.3** ISO, WHO and US certification	
	SO5.4 Evaluate the Sterilization control and sterility testing.		**CI5.4** Sterilization control and sterility testing (heat sterilization, D value, z value, survival curve, Radiation, gaseous and filter sterilization)	
	SO5.5 Elaborate Chemical and biological indicators		**CI5.5** Chemical and biological indicators.	
	SO5.6 Design and layout of sterile product manufacturing unit. (Designing of Microbiology		**CI5.6** Design and layout of sterile product manufacturing unit. (Designing of Microbiology laboratory), Safety in	

	laboratory), Safety in the microbiology laboratory.		the microbiology laboratory.	
	SO5.7 Design and layout of sterile product manufacturing unit. (Designing of Microbiology laboratory), Safety in the microbiology laboratory.		**CI5.7** Design and layout of sterile product manufacturing unit. (Designing of Microbiology laboratory), Safety in the microbiology laboratory.	
	SO5.8 Design and layout of sterile product manufacturing unit. (Designing of Microbiology laboratory), Safety in the microbiology laboratory.		**CI5.8** Design and layout of sterile product manufacturing unit. (Designing of Microbiology laboratory), Safety in the microbiology laboratory.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain Sterilization control and sterility testing.
	SW5.2 Mini Project	Describe the Design and layout of the sterile product manufacturing unit.

	SW5.3 Other Activities (Specify)	Prepare one article on ISO, WHO, and US certification.

Course duration (in hours) to attain Course Outcomes:

Course Title: Pharmaceutical Biotechnology **Course Code: 98BT506-BE**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98BT506-B: Understand the role of biotechnology in drug discovery, development, and production, including recombinant DNA technology and biopharmaceutical manufacturing.	8	4	5	1	18
CO2-98BT506-B: Extend practical skills in laboratory techniques and methods used in producing, purifying, and analyzing pharmaceutical biotechnology products.	8	4	4	1	17
CO3-98BT506-B: Evaluate knowledge of regulatory frameworks and quality control practices specific to pharmaceutical biotechnology.	8	4	4	1	17
CO4-98BT506-B: Understand the application of biotechnology in the pharmaceutical industry. Apply regulatory aspects, ethical considerations, and safety requirements associated with pharmaceutical biotechnology.	8	4	4	1	17

CO5-98BT506-B: Apply the knowledge of GLP and GMP in the Pharmaceutical laboratory.	8	2	3	1	14
Total Hours	40	18	20	05	83

End-semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Pharmaceutical Biotechnology **Course Code: 98BT506-BE**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-98BT506-B: Understand the role of biotechnology in drug discovery, development, and production, including recombinant DNA technology and biopharmaceutical manufacturing.	2	1	1	1	5
CO2-98BT506-B: Extend practical skills in laboratory techniques and methods used in producing, purifying, and analyzing pharmaceutical biotechnology products.	2	4	2	2	10
CO3-98BT506-B: Evaluate knowledge of regulatory frameworks and quality control practices specific to pharmaceutical biotechnology.	3	5	5	2	15
CO4-98BT506-B: Understand the application of biotechnology in the pharmaceutical industry. Apply regulatory aspects, ethical considerations, and safety requirements associated with pharmaceutical biotechnology.	2	3	3	2	10

CO5-98BT506-B: Apply the knowledge of GLP and GMP in the Pharmaceutical laboratory.	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Pharmaceutical Microbiology – Edt. By W.B.Hugo & A.D.Russell Sixth edition. Blackwell scientific Publications.
2	Analytical Microbiology –Edt by Frederick Kavanagh Volume I & II. Academic Press New York.
3	Quinolinone antimicrobial agents – Edt. by David C. Hooper, John S.Wolfson .ASM Washington DC.
4	Pharmaceutical Microbiology – Edt. By W.B.Hugo & A.D.Russell Sixth edition. Blackwell scientific Publications.
5	Analytical Microbiology –Edt by Frederick Kavanagh Volume I & II. Academic Press New York.

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial

3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B.Tech. Biotechnology

Semester: V Semester

Course Title: Pharmaceutical Biotechnology

Course Code: 98BT506-B

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-98BT506-B: Understand the role of biotechnology in drug discovery, development, and production, including recombinant DNA technology and biopharmaceutical manufacturing.	1	2	2	3	1	2	2	1
CO298BT506-B-: Extend practical skills in laboratory techniques and methods used in producing, purifying, and analyzing pharmaceutical biotechnology products.	1	2	3	2	1	1	1	2

CO3-98BT506-B: Evaluate knowledge of regulatory frameworks and quality control practices specific to pharmaceutical biotechnology.	1	2	3	2	1	1	1	1
CO4-98BT506-B: Understand the application of biotechnology in the pharmaceutical industry. Apply regulatory aspects, ethical considerations, and safety requirements associated with pharmaceutical biotechnology.	-	1	1	-	2	1	1	3
CO5-98BT506-B: Apply the knowledge of GLP and GMP in the Pharmaceutical laboratory.	1	1	1	-	-	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-98BT506-B**: Understand the role of biotechnology in drug discovery, development, and production, including recombinant DNA technology and biopharmaceutical manufacturing.	SO1.1 SO1.2 SO1.3, SO1.4, SO1.5, SO1.6, SO1.7, SO1.8	**LI 1** **LI 2**	1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8	**1SL-1,2,3**
PO 1,2,3,4,5 PSO 1,2,3	**CO2-98BT506-B**: Extend practical skills in laboratory techniques and methods used in producing, purifying, and analyzing pharmaceutical biotechnology products.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5, SO2.6, SO2.7, SO2.8	**LI 1** **LI 2**	2.1, 2.2, 2.3, 2.4,2.5,2.6,2.7,2.8	**2SL-1,2,3,4**
PO 1,2,3,4,5 PSO 1,2,3	**CO3-98BT506-B**: Evaluate knowledge of regulatory frameworks and quality control practices specific to pharmaceutical biotechnology.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5, SO3.6, SO3.7 SO3.8	**LI 1** **LI 2**	3.1,3.2,3.3,3.4,3.5, 3.6,3.7,3.8	**3SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO498BT506-B -**: Understand the application of biotechnology in the pharmaceutical industry. Apply regulatory aspects, ethical considerations, and	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5,	**LI 1** **LI 2**	4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8	**4SL-1,2**

	safety requirements associated with pharmaceutical biotechnology.	SO4.6, SO4.7, SO4.8			
PO 1,2,3,4,5 PSO 1,2,3	**CO5-98BT506-B**: Apply the knowledge of GLP and GMP in the Pharmaceutical laboratory.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5, SO5.6, SO5.7, SO5.8	**LI 1**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8	**5SL-1**

Program Name	**B. Tech. Biotech Semester-**	
Semester	**Vth**	
Course Code:	98BT506-C	
Course title:	**Molecular modeling and Drug designing (MMDD)**	**Curriculum Developer**: Mr. Piyush Kant Rai, Teaching associate
Pre-requisite:	Students must have knowledge of Molecular models and their structures which is important in drug designing.	
Rationale:	The paper on MMDD in B. Tech. Biotech Semester-Vth program explores the critical role of specialized mechanisms of protein 2D and 3D structure modeling and in analyzing microbial evolution and diversity. It delves into the use of tools for understanding mutation, evolution, and databases to learn more about how these data are generated and what biological mystery can be solved by using these data and tools.	
Course Outcomes (COs):	**98BT506-C1: Explain the various stages of drug discovery** **98BT506-C2: Define the concept of receptor and ligand binding** **98BT506-C3: Describe physicochemical Properties and the techniques involved in QSAR** **98BT506-C4: Learn introduction to Bioinformatics and Cheminformatics** **98BT506-C5: Learn methods in molecular and quantum mechanics and Explain various structure-based drug design methods**	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Elective (PE)	98BT506-C	**Molecular modeling and Drug designing (MMDD)**	3	0	1	1	5	3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of	Couse	Course Title	Scheme of Assessment (Marks)		
				End Semester Assessmen	Total Marks

Study	Code		Progressive Assessment (PRA)					t (ESA)	(PRA+ ESA)
			Class/ Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
Program Elective (PE)	98BT506-C	**Molecular modeling and Drug designing (MMDD)**	16	19	5	5	5	50	50

Scheme of Assessment: Practical

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/ Home Assignment	Class Test 2 (2 best out of 3)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		

			5 number 3 marks each (CA)	10 marks each (CT)					
Program Elective (PE)	98BT556-C	**Molecular modeling and Drug designing (MMDD)**	16	19	5	5	5	50	50

Course-Curriculum:

<table>
<tr>
<td>This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.</td>
<td>Approximate Hours
<table>
<tr><td>Item</td><td>Cl</td><td>LI</td><td>SW</td><td>SL</td><td>Total</td></tr>
<tr><td>Approx. Hrs</td><td>05</td><td>01</td><td>02</td><td>02</td><td>10</td></tr>
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Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-98BT506C1: Explain the various stages of drug discovery	**SO1.1** bond length, bond angle, torsion angle and non-covalent interactions.	**LI1.1** Learn how to use any browser efficiently and what are the features of the computers	**CI1.1** Introduction to bond length, bond angle, torsion angle and non-covalent interactions.	**SL1.1** Bond length, Different types of force fields.
	SO1.2 What is Energy minimization of small molecules –		**CI1.2** Energy minimization of small molecules	**SL1.2** Schrodinger wave equation
	SO1.3 How Empirical representation of molecular energies works		**CI1.3** Empirical representation of molecular energies	
	SO1.4 Can answer Use and types of force fields.		**CI1.4** Use and types of force fields.	
	SO1.5 Role and algorithm of molecular mechanics method		**CI1.5** molecular mechanics method	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Write about the Schrodinger wave equation and its improvement
	SW1.2 Mini Project	Learn different types of force fields.
	SW1.3 Other Activities (Specify)	Which force field is the most stable and frequently used for biologically active molecule

Item	Cl	LI	SW	SL	Total
Approx. Hrs	**05**	2	2	2	**11**

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
CO2-98BT506-C2: Define the concept of receptor and ligand binding	SO2.1 Rational basis of drug designing.	LI2.1 To learn Basics of bond length and bond angle	**CI2.1** Rational basis of drug designing	**SL2.1** Explore Pubchem
	SO2.2 What is Drug designing approaches	LI2.2 To search and explore various drug databases.	**CI2.2** Drug designing approaches	**SL2.2** Explore PDB database
	SO2.3 How structure-based drug design process.		**CI2.3** Structure-based drug design process.	

	SO2.4 Understanding the structure-based drug design process.		**CI2.4** Drug designing using known receptor structure	
	SO2.5 Drug designing using known receptor structure.		**CI2.5** Drug designing using known receptor structure.	

Item	CI	LI	SW	SL	Total
Approx. Hrs	**05**	1	**1**	2	09

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Write about the Lipinski rule of five
	SW2.2 Mini Project	Write about lead and target optimization.
	SW2.3 Other Activities (Specify)	Find out some you tube videos based on how a drug works in the system.

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-98BT506-C3: Describe physicochemical Properties and the techniques involved in QSAR	**SO3.1** What is Ludi, Ludi/CAP, auto dock	**LI3.1** Apply ADMET properties to any lead compound	**CI3.1** Concept of Ludi, Ludi/CAP, auto dock	**SL3.1** Remember Lipinski's rule of five
	SO3.2 Learn the concept of Scoring and Docking.		**CI3.2** the concept of Scoring and Docking	**SL3.2** Understand AMDET properties
	SO3.3 Practice QSAR principles and methods in drug designing		**CI3.3** The QSAR principles and methods in drug designing	

	SO3.4 how to perform drug design by receptor site fit		**CI3.4** drug design by receptor site fit	
	SO3.5 Estimate homology modelling.		**CI3.5** The homology modelling.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Write about the minimum and maximum range and its significance with respect to ADMET properties
	SW3.2 Mini Project	
	SW3.3 Other Activities (Specify)	Employ the virtual lab for docking basics.

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO4-98BT506-C4: Learn introduction to Bioinformatics and Cheminformatics	**SO4.1** Answer the Basic principles of molecular dynamics.	**LI4.1** Perform one basic molecular dynamics simulation using any online platform.	**CI4.1** The Basic principles of molecular dynamics.	**SL4.1** learn newton equation of motion and its relevance with the monte-Carlo algorithm
	SO4.2 Adapt ab initio – Density-Functional Theory		**CI4.2** Adapt ab initio – Density-Functional Theory	
	SO4.3 Combine Organized drug discovery		**CI4.3** Combine Organized drug discovery	
	SO4.4 how development of Pharmacology -Microbial		**CI4.4** development of Pharmacology -Microbial	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	**06**	1	2	1	**10**

	SO4.5 What is Alternative strategies inlead		**CI4.5** Introduction to Alternative strategies inlead	
	SO4.6 How to do Identification – Lead optimization.		**CI4.6** Identification – Lead optimization.	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	**04**	1	1	2	08

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	prepare a flow chart of drug discovery and development.
	SW4.2 Mini Project	
	SW4.3 Other Activities (Specify)	Relate the force field and Newton equation of motion for a biological system

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO5-98BT506-C5: Learn methods in molecular and quantum mechanics and Explain various structure-	**SO5.1** What is Rational design of enzyme inhibitors.	**LI5.1** How to do the lead findings	**CI5.1** Rational design of enzyme inhibitors.	**SL5.1** Revise structural and rational drug design

based drug design methods.	**SO5.2** What Recapitulation affinity labels – Illustrative examples.		**CI5.2** Recapitulation affinity labels – Illustrative examples.	**SL5.2** Role of structure in drug discovery process
	SO5.3 Distinguish theories of enzyme inhibition		**CI5.3** Theories of enzyme inhibition	
	SO5.4 Convey structural bioinformatics in drug discovery		**CI5.4** Structural bioinformatics in drug discovery	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	illustrate the theories of enzyme inhibition
	SW5.2 Mini Project	
	SW5.3 Other Activities (Specify)	Rewrite the Scope and limitations of Enzyme background

Course duration (in hours) to attain Course Outcomes:

Course Title: Molecular modeling and Drug designing (MMDD) **Course Code: 98BT506-C**

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-98BT506C1: Explain the various stages of drug discovery	5	01	2	2	10
CO2-98BT506-C2: Define the concept of receptor and ligand binding	5	2	2	2	11

CO3-98BT506-C3: Describe physicochemical Properties and the techniques involved in QSAR	5	1	2	1	09
CO4-98BT506-C4: Learn introduction to Bioinformatics and Cheminformatics	6	1	1	2	10
CO5-98BT506-C5: Learn methods in molecular and quantum mechanics and Explain various structure-based drug design methods.	4	1	2	1	08
Total Hours	25	06	09	8	48

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Computational biology and bioinformatics **Course Code: 98BT506-C**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-98BT506-C1: Explain the various stages of drug discovery	02	03	04	1	10
CO2-98BT506-C2: Define the concept of receptor and ligand binding	02	05	02	1	10
CO3-98BT506-C3: Describe physicochemical Properties and the techniques involved in QSAR	04	04	01	1	10
CO4-98BT301-A.4 Learn Introduction to Bioinformatics and Cheminformatics	03	04	02	1	10
CO5-98BT301-A.5 Learn methods in molecular and quantum mechanics and Explain various structure-based drug design methods	04	03	02	1	11
Total Marks	15	19	11	05	51

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

(b)

S.No.	Title/Author/Publisher details
1	MOLECULAR MODELLING AND DRUG DESIGN K. Anand Solomon Mjp Publishers 2011
2	Guidebook On Molecular Modeling In Drug Design Cohen Claude Elsevier India 2014
3	Molecular Modeling in Drug Design Rebecca Wade and Outi Salo-Ahen MDPI 2019

(c) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Research lab (BSL-1)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: 5th Sem

Course Title: Molecular modeling and Drug designing (MMDD)

Course Code: 98BT506-C

CO/PO/PSO Mapping														
Course Outcome (Cos)	**Program Outcomes (POs)**												**Program Speci Outcomes (PS**	
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1-98BT506-C1: Explain the various stages of drug discovery	-	-	-	1	2	2	2	-	1	2	2	3	-	-
CO2-98BT506-C2: Define the concept of receptor and ligand binding	-	-	-	-	-	-	-	-	2	2	3	3	-	-
CO3-98BT506-C3:Describe physicochemical Properties and the techniques involved in QSAR	-	1	1	1	-	-	2	-	3	1	1	2	-	1
CO4-98BT301-A.4 Learn Introduction to Bioinformatics and Cheminformatics	1	1	1	-	2	2	2	3	-	1	-	-	1	1
CO5-98BT301-A.5 Learn methods in molecular and quantum mechanics and Explain various structure-based drug design methods	-	1	1	-	-	2	-	3	1	2	2	2	-	1

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 4,5,6 7,9,10,11,12 PSO 1,2, 3	**CO1-98BT506-C1: Explain the various stages of drug discovery**	SO1.1 SO1.2 SO1.3 SO1.4,SO1.5	**IL 1**	1.1,1.2,1.3,1.4 ,1.5	**1SL-1,2**
PO 9,10,11,12 PSO 1,2, 3	**CO2-98BT506-C2: Define the concept of receptor and ligand binding**	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5	**IL 1** **IL 2**	2.1, 2.2, 2.3, 2.4,2.5	**2SL-1,2**
PO 2,3,4,5, 7,9,10,11,12 PSO 1,2, 3	**CO3-98BT506-C3:Describe physicochemical Properties and the techniques involved in QSAR**	SO3.1 SO3.2 SO3.3 SO3.4 ,3.5	**IL 1**	3.1,3.2,3.3,3.4.3.5	**3SL-1,2**
PO 1,2,3,5,6 7,8,10 PSO 1,2, 3	**CO4-98BT301-A.4 Learn Introduction to Bioinformatics and Cheminformatics**	SO4.1 SO4.2 SO4.3 SO4.4 ,SO4.5,SO4.6	**IL 1**	4.1,4.2,4.3,4.4,4.5,4.6	**4SL-1**
PO 2,3,4,5,6 7,8,10,11,12 PSO 1,2, 3	**CO5-98BT301-A.5** **Learn methods in molecular and quantum mechanics and Explain various structure-based drug design methods**	SO5.1 SO5.2 SO5.3 SO5.4	**IL 1**	5.1,5.2,5.3,5.4	**5SL-1,2**

Program Name	**Bachelor of Technology (B. Tech)- Biotechnology**	
Semester	VI	
Course Code:	98BT601	
Course title:	Advance Bioanalytical Techniques	**Curriculum Developer**: Dr. Ashwini A. Waoo, Professor
Pre-requisite:	Student should have foundational knowledge in biology, chemistry, and analytical instrumentation. Additionally, familiarity with basic bioanalytical methods	
Rationale:	Students have acquired fundamental knowledge in biotechnology and related sciences. Introducing advanced bioanalytical techniques in the 6th semester allows students to deepen their understanding of analytical methods crucial for biotechnological research and industry applications. It equips them with practical skills necessary for addressing complex biological challenges and fosters their readiness for professional roles in biotechnology, pharmaceuticals, and research.	
Course Outcomes (COs):	**98BT601CO1-.1:** Students will be proficient in employing various microscopy techniques for detailed sample analysis and understand the principles behind high-throughput screening methods, **98BT601CO1-.2:** Students will grasp sequencing technology evolution and gain proficiency in diverse genomics research applications. **98BT601CO1-.3:** Students will master a diverse range of spectroscopic techniques, enhancing their analytical capabilities across scientific disciplines. **98BT601CO1-.4:** Students will develop expertise in chromatographic techniques, specifically GCMS and LCMS, enabling precise separation and analysis of complex mixtures in various fields **98BT601CO1-.5:** Students will grasp flow cytometry fundamentals, including fluorochromes, experimental design, and fluorescence quantitation. They will also learn electrophoresis techniques	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Core (PCC)	98BT601	Advance Bioanalytical Techniques	3	2	1	1	7	4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

<table>
<tr><td rowspan="3">Board of Study</td><td rowspan="3">Couse Code</td><td rowspan="3">Course Title</td><td colspan="7">Scheme of Assessment (Marks)</td></tr>
<tr><td colspan="5">Progressive Assessment (PRA)</td><td rowspan="2">End Semester Assessment
(ESA)</td><td rowspan="2">Total Marks
(PRA+</td></tr>
<tr><td>Class/Home</td><td>Class Test 2</td><td>Seminar</td><td>Class Attendance</td><td>Total Marks</td></tr>
</table>

			Assignment 5 number 3 marks each (CA)	(2 best out of 3) 10 marks each (CT)	one (SA)	(AT)	(CA+CT+SA+AT)		ESA)
Program Core (PCC)	98BT601	Advance Bioanalytical Techniques	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
Program Core (PCC)	98BT651	Advance Bioanalytical Techniques lab	35	5	5	5	50	50	50

Course-Curriculum:

<table>
<tr>
<td>This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.</td>
<td>Approximate Hours
<table>
<tr><td>Item</td><td>Cl</td><td>LI</td><td>SW</td><td>SL</td><td>Total</td></tr>
<tr><td>Approx. Hrs</td><td>09</td><td>04</td><td>01</td><td>05</td><td>19</td></tr>
</table>
</td>
</tr>
</table>

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-.1: Students will be proficient in employing various microscopy techniques for detailed sample analysis and understand the principles behind high-throughput screening methods,	Understand working of live cell imaging		**Unit-1** **CI1.1** Live cell imaging,	Study videos on live cell imaging

	Illustrate the mechanism of confocal microscopy		**CI1.2** Confocal microscopy and	What are various components of confocal Microscope
	Understand fluorescence microscopy		**CI1.3** sample preparation for fluorescence microscopy	Write applications of fluorescence microscopy
	Understand need of High content/throughput screening		**CI1.4** High content/throughput screening -	Study videos of High content/throughput screening
	Describe basics of SEM	**LI1.1** Virtual demonstration of SEM	**CI1.5** Basics of SEM &	
	Illustrate the technique of Specimen preparation for SEM		**CI1.6** Specimen preparation for SEM -	
	Learn Basics of TEM	**LI1.2** Virtual demonstration of TEM	**CI1.7** Basics of TEM &	
	Knowledge about Specimen preparation for TEM		**CI1.8** Specimen preparation for TEM.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Enlist differences between SEM and TEM
	SW1.2 Mini Project	Describe mode of action of High content/throughput screening .
	SW1.3 Other Activities (Specify)	Find out DNA extraction protocol for insect cell.

	Revision and assessment		**CI1.9** Revision and assessment	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	05	19

Item		Cl	LI	SW	SL	Total
Approx. Hrs		09	0 4	01	05	19

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-.3: Students will master a diverse range of spectroscopic techniques, enhancing their analytical capabilities across scientific disciplines.	Demonstrate the UV-Visible light spectroscopy	**LI3.1** Demonstration of Beer Lambert Law	**Unit-III** Introduction to UV, Visible light spectroscopy,	Read about types of spectroscopy
	SO3.2 Illustration of Fluorescence spectroscopy,	**LI 3.2** Demonstration of UV visible spectrophotometer	Flouroscence spectroscopy,	Draw a fluorescence spectroscopy
	SO3.3 Apply and analyze CD spectroscopy and luminometry		luminometry, CD spectroscopy,	Explain luminometry and CD spectroscopy
	SO3.4 Evaluate Light scattering, Atomic spectroscopy,		Light scattering, Atomic spectroscopy,	
	SO3.5 Describe IR and Raman		IR and Raman spectroscopy,	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	06	01	05	21

	spectroscopy,			
	SO3.6 Demonstrate the use of surface plasmone resonance ,		surface plasmone resonance ,	Write a note on CI3.6 surface plasmone resonance
	SO3.7 Describe Electron paramagnetic resonance,		Electron paramagnetic resonance,	
	SO3.8 Describe X-ray diffraction techniques		X-ray diffraction techniques.	Diagrammatically explain X ray diffraction
	SO3.9 Revision and assessment		Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe principles and types of spectroscopies
	SW3.2 Mini Project	Describe the significance of UV visible spectroscopy
	SW3.3 Other Activities (Specify)	Prepare list of compounds analysed by NMR, IR and UV Visible spectrophotometer

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1-.4: Students will develop expertise in chromatographic techniques, specifically GCMS and LCMS, enabling precise separation and analysis of complex mixtures in various fields	Develop understanding of GCMS	LI 4.1 Virtual Demonstration of GCMS	Gas chromatography with mass spectrometric detection (GC-MS),	Learn about GC MS
	Illustrate mechanism of LC MS	LI4.2 Virtual Demonstration of LCMS	liquid chromatography with mass spectrometric detection (LC-MS),	Discuss challenges LC MS
	Ananlyze key features ICPMS	LI4.3 Virtual Demonstration of ICPMS	inductively coupled plasma with mass spectrometric detection (ICP-MS).	Video for ICPMS
	Evaluate strategies and analysis of HPLC data		Metal analysis by ICP-MS; Analysis of data: HPLC	**SL4.4** Study heavy metals and its Metal analysis

			chromatograms,	
	Evaluate the need of Adsorption Chromatography, partition chromatography		Chromatographic performance parameters, Adsorption Chromatography,	
	Evaluate the need of partition chromatography		partition chromatography,	**SL4.5** Evaluate the technique of adsorption and partition chromatography
	Apply Ion exchange chromatography in appropriate samples		Ion exchange chromatography,	
	Explain Molecular exclusion chromatography		Molecular exclusion chromatography	
	Revision and assessment		Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe principles and strategies of GC MS and LC MS
	SW4.2 Mini Project	Describe the techniques of heavy metal analysis

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	2	01	05	18

	SW4.3 Other Activities (Specify)	Prepare list of samples and their state for analysis in GC MS, LC MS, ICP MS

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1-.5: Students will grasp flow cytometry fundamentals, including fluorochromes, experimental design, and fluorescence quantitation. They will also learn electrophoresis techniques	SO5.1: Learn the principles of flow cytometry	LI5.1: Perform electrophoresis of DNA	CI5.1: Introduction to flow cytometry: Principles and instrumentation	SL5.1: Study the principles and working mechanism of flow cytometers
	SO5.2: Understand the basics of fluorochromes and fluorescence		CI5.2: Fluorochromes and fluorescence: Applications and examples	SL5.2: Research the significance of fluorochromes in flow cytometry
	SO5.3: Evaluate the importance of fluorescence quantitation		CI5.3: Experimental design and fluorescence quantitation	SL5.3: Investigate the role of fluorescence quantitation in

				biological research
	SO5.4: Learn about compensation, gating, and normalization in flow cytometry		CI5.4: Compensation, gating, and normalization techniques	SL5.4: Study the importance of compensation and gating in flow cytometry
	SO5.5: Analyze the techniques of electrophoresis for proteins and nucleic acids		CI5.5: Electrophoresis of proteins and nucleic acids: Techniques and advantages	SL5.5: Learn precautions during electrophoresis runs for accurate results
	SO5.6: Describe the principles of capillary electrophoresis		CI5.6: Capillary electrophoresis: Techniques and applications	
	SO5.7: Evaluate the applications of microchip electrophoresis		CI5.7: Microchip electrophoresis: Principles and advantages	
	SO5.8: Understand the types of microchips used in electrophoresis		CI5.8: Types of microchips used in biological applications	
	SO5.9: Perform revision and assessment for flow cytometry and		CI5.9: Revision and assessment of key topics	

	electrophoresis			

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Describe principles and mechanism of flow cytometry
	SW5.2 Mini Project	Describe the applications of electrophoresis
	SW5.3 Other Activities (Specify)	Describe PAGE and SDS PAGE

Course duration (in hours) to attain Course Outcomes:

Course Title: Advance Bioanalytical Techniques **Course Code:** 98BT601

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-.1: Students will be proficient in employing various microscopy techniques for detailed sample analysis and understand the principles behind high-throughput screening methods,	9	4	5	1	19
CO1-.2: Students will grasp sequencing technology evolution and gain proficiency in diverse genomics research applications.	9	4	5	1	19

CO1-.3: Students will master a diverse range of spectroscopic techniques, enhancing their analytical capabilities across scientific disciplines.	9	4	5	1	19
CO1-.4: Students will develop expertise in chromatographic techniques, specifically GCMS and LCMS, enabling precise separation and analysis of complex mixtures in various fields	9	6	5	1	21
CO1-.5: Students will grasp flow cytometry fundamentals, including fluorochromes, experimental design, and fluorescence quantitation. They will also learn electrophoresis techniques	9	2	5	1	17
Total Hours	45	20	25	05	83

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Advance Bioanalytical Techniques **Course Code:98BT601**

Course Outcomes					
	A	**A**	**E**	**C**	**Total Marks**
98BT601CO1-.1: Students will be proficient in employing various microscopy techniques for detailed sample analysis and understand the principles behind high-throughput screening methods,	03	01	01	01	06
98BT601CO1-.2: Students will grasp sequencing technology evolution and gain	02	04	02	02	10

proficiency in diverse genomics research applications.					
98BT601CO1-.3: Students will master a diverse range of spectroscopic techniques, enhancing their analytical capabilities across scientific disciplines.	03	05	05	01	14
98BT601CO1-.4: Students will develop expertise in chromatographic techniques, specifically GCMS and LCMS, enabling precise separation and analysis of complex mixtures in various fields	02	03	05	00	10
98BT601CO1-.5: Students will grasp flow cytometry fundamentals, including fluorochromes, experimental design, and fluorescence quantitation. They will also learn electrophoresis techniques	05	04	00	01	10
Total Marks	15	17	13	05	50

Legend: A: Apply, A: Analyze E: Evaluate, C: Create

Suggested learning Resources:

Books:

S. No.	Title
1	Skoog, D.A., Crouch, S.R., and Holler, F.J. *"Principles of Instrumental Analysis",* 6th edition, Brooks/Cole, USA, 2006.
2	Williams, D. and Fleming, I. "*Spectroscopic Methods in Organic Chemistry",* 6th edition, McGraw-Hill Higher Education, Maidenhead, UK, 2008.
3	Freifelder D., Physical Biochemistry, "*Application to Biochemistry and Molecular Biology*", 2nd

	Edition, W.H. Freeman & Company, San Fransisco, 1982.
4	Keith Wilson and John Walker, “Principles and Techniques of Practical Biochemistry”, 5th Edition, Cambridge University Press, 2000.

Online Resources:

Suggested instructions/Implementation strategies:

Improved lecture
Tutorial
Case method
Group Discussion
Role play
Visit to virology lab (BSL-3)
Demonstration
ICT Based teaching Learning
Brainstorming

CO, PO and PSO Mapping

Program Title: B. Tech. Biotechnology

Semester: VI

Course Code: 98BT601

Course Title: Advance Bioanalytical Techniques

CO/PO Mapping	

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-.1: Students will be proficient in employing various microscopy techniques for detailed sample analysis and understand the principles behind high-throughput screening methods,	**-**	**-**	**1**	**2**	**2**	**2**	**2**	**-**	**2**	**2**	**2**	**3**	**3**	**-**	**-**
CO1-.2: Students will grasp sequencing technology evolution and gain proficiency in diverse genomics research applications.	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**2**	**3**	**3**	**2**	**-**	**1**

CO1-.3: Students will master a diverse range of spectroscopic techniques, enhancing their analytical capabilities across scientific disciplines.	**-**	**1**	**2**	**2**	**-**	**2**	**2**	**-**	**3**	**3**	**3**	**1**	**2**	**2**	**1**
CO1-.4: Students will develop expertise in chromatographic techniques, specifically GCMS and LCMS, enabling precise separation and analysis of complex mixtures in various fields	**-**	**1**	**2**	**2**	**2**	**2**	**2**	**3**	**-**	**2**	**2**	**2**	**2**	**2**	**2**
CO1-.5: Students will grasp flow cytometry fundamentals, including	**1**	**1**	**1**	**-**	**-**	**3**	**3**	**3**	**1**	**2**	**3**	**2**	**2**	**2**	**1**

fluorochromes, experimental design, and fluorescence quantitation. They will also learn electrophoresis techniques															

Legend: **(1) Low (2) Medium (3) High**

Course Curriculum:

POs & PSOs No.	**COs**	**SOs No.**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2,3	**CO1-.1:** Students will be proficient in employing various microscopy techniques for detailed sample analysis and understand the principles behind high-throughput screening methods,	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	LI 1, LI 2	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8,1.9	1SL-1,2,3,4,5
PO 1,2,3,4,5,6,7,8,9,10,11,12	**CO1-.2:** Students will grasp sequencing technology evolution and gain proficiency in diverse genomics	SO2.1 SO2.2 SO2.3	LI 1, LI 2	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7,2.8, 2.9	2SL-1,2,3,4,5

PSO 1,2,3	research applications.	SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9			
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2,3	**CO1-.3:** Students will master a diverse range of spectroscopic techniques, enhancing their analytical capabilities across scientific disciplines.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	LI 1, LI 2	3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8, 3.9	3SL-1,2,3,4,5
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2,3	**CO1-.4:** Students will develop expertise in chromatographic techniques, specifically GCMS and LCMS, enabling precise separation and analysis of complex mixtures in various fields	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	LI 1, LI 2, LI 3	4.1,4.2,4.3,4.4, 4.5, 4.6, 4.7, 4.8, 4.9	4SL-1,2,3,4,5
PO 1,2,3,4,5,6,7,8,9,10,11,12	**CO1-.5:** Students will grasp flow cytometry fundamentals, including fluorochromes, experimental design, and fluorescence quantitation. They	SO5.1 SO5.2 SO5.3 SO5.4	LI1	5.1,5.2,5.3,5.4,5.5, 5.6, 5.7, 5.8, 5.9	5SL-1,2,3,4,5

PSO 1,2,3	will also learn electrophoresis techniques	SO5.5 SO5.6 SO5.7 SO5.8 SO5.9			

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	VI	
Course Code:	98BT602	
Course title:	Metabolic Engineering	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of biochemistry and metabolism	
Rationale:	Metabolic engineering is an emerging field of biotechnology/bioprocess engineering which aims towards purposeful modification of cellular (metabolic, gene regulatory, and signaling) processes/networks to achieve desirable goals such as enhanced production of metabolites including pharmaceuticals, biofuels and biochemicals and other biotechnology products. This course aims to provide fundamental and advanced knowledge in the development of microbial strain for bio production through metabolic engineering	
Course Outcomes (COs):	**CO1-98BT602.1.** Explain the basic principles and fundamentals of metabolic engineering **CO2-98BT602.2.** Discuss the role of comprehensive cellular reaction models **CO3-98BT602.3.** Design and describe metabolic flux analysis to determine metabolic pathway utilization **CO4-98BT602.4.** Design effective strategies to implement metabolic flux to determine metabolic pathways **CO5-98BT602.5.** Describe combinatorial metabolic engineering strategies to illustrate metabolic control analysis	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=2:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Common (PC)	98BT602	Metabolic Engineering	2	2	1	3	8	3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks
			Class/ Home	Class Test 2 (2 best	Seminar one	Class Activity	Class Attendance	Total Marks		

			Assignment 5 number 3 marks each (CA)	out of 3) 10 marks each (CT)	(SA)	(CAT)	(AT)	(CA+CT+CAT+SA +AT)		(PRA+ ESA)
PC	98BT602	Metabolic Engineering	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: practical

Board of Study	Course Code	Course Title	**Scheme of Assessment (Marks)**						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PC	98BT652	Metabolic Engineering	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	06	01	05	22

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-98BT602.1. Explain the basic principles and fundamentals of metabolic engineering	**SO1.1** Explain concept of metabolic engineering	**LI1.1** Draw the steps followed in prokaryotic /eukaryotic glycolysis metabolic pathways	**Unit-1** **CI1.1** Metabolic Engineering and its importance	**SL1.1** Find out some examples of metabolic engineering
	SO1.2 Define Basic terminology, scope and application for ME	**LI1.2** Draw the steps followed in prokaryotic /eukaryotic TCA metabolic pathways	**CI1.2** Terminologies of Metabolic Engineering	**SL1.2** Explore conventional papers on metabolic engineering
	SO1.3 Elaborate the scientific Flux, Flux Split Ratio, flux analysis	**LI1.3** To understand the production and consumption of ATPs involve in glycolysis	**CI1.3** Flux, Flux Split Ratio, flux analysis	**SL1.3** Write down few points on applications of metabolic engineering

		and TCA cycle		
	SO1.4 Define metabolism and types		**CI1.4** Overview of Cellular Metabolism, Ana/Catabolism	**SL1.4** Write down few points on flux
	SO1.5 Describe types of cellular reactions		**CI1.5** Polymerization, Fuel reactions, Assembling Reactions with examples	**SL1.5** Collect information on career in metabolic engineering field
	SO5.6 Revision and Assessment		**CI1.6** Revision and Assessment	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail about the role of "Metabolic Engineering in synthesis of bioproduct"
	SW1.2 Mini Project	Elaborate the role of Flux and Fluxomics
	SW1.3 Other Activities (Specify)	Draw a flowchart compiling all procedures used in performing metabolic engineering

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	0 4	01	04	19

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-98BT602.2. Discuss the role of comprehensive cellular reaction models	**SO2.1** Explain concept of downstream processing	**LI2.1** Demonstrate the working of Cell Disruption technique	**Unit-2** **CI2.1** Anapleoritic, Mixed Fermentation, Fermentative Metabolism of yeast	**SL2.1** Find out more conventional cell disruption techniques
	SO2.2 Relate the concept of how physical and biological separation can be done	**LI2.2** To perform the experiment of production of microbial biomass	**CI2.2** Stoichiometry of Cellular Reactions, (Glucose to Acetate)	**SL2.2** Read the latest research in bioseparations methods
	SO2.3 Outline the steps of coverting		**CI2.3** Glucose to Ethanol, Metabolic	**SL2.3** Write down few points on biological

	glucose to ethanol		products	product's properties
	SO2.4 Define the mechanism of biomass		**CI2.4** Biomass Constituents, Intracellular Metabolites	**SL2.4** Find out the different kinds of filter aids and their role
	SO2.5 Explain the role of Modelling Metabolism		**CI2.5** Modelling Metabolism (Graph Theory)	
	SO2.6 Revision and assessment		**CI2.6** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe the role of Biomass in metabolism
	SW2.2 Mini Project	Make a project on bioconversion of Glucose to Ethanol
	SW2.3 Other Activities (Specify)	Make Power point presentation on Metabolism modelling

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	04	01	03	18

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO3-98BT602.3. Design and describe metabolic flux analysis to determine metabolic pathway utilization	**SO3.1** Define the Regulation of Enzymatic Activity, Models of Feedback inhibition	**LI3.1** To perform the Centrifugation process as Unit Operation	**Unit-3** **CI3.1** Regulation of Enzymatic Activity, Models of Feedback inhibition	**SL3.1** Find out the process of Enzyme inhibition in human metabolism
	SO3.2 Derive the mathematical expression for Enzyme Kinetics, Inhibition system	**LI3.2** To do the enzyme assay using spectrophotometric method	**CI3.2** Overview of Enzyme Kinetics, Inhibition system with slopes, Steady state approach, BH equation	**SL3.2** Read the process of how Michalis Menten equation was derived

	SO3.3 Analyze the Substrates, Competitive Inhibition with slopes		**CI3.3** Substrates, Competitive Inhibition with slopes	**SL3.3** Write down the steps followed in Lac operon model
	SO3.4 Distinguish among the working mechanism of Regulation of Enzyme concentration & Operon		**CI3.4** Regulation of Enzyme concentration; Transcription: Lac Operon Model	
	SO3.5 Explain the role of Global control and Enzyme Substrate binding		**CI3.5** Global Control at Whole Cell Level, Enzyme Substrate Binding theory	
	SO3.6 Revision and assessment		**CI3.6** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Derive the equations for Michalis Menten theory of Enzyme Substrate complex
	SW3.2 Mini Project	Write an article on Global Control at whole Cell level
	SW3.3 Other Activities (Specify)	Prepare one Power point presentation on “Different types of Centrifuge and their applications”

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-98BT602.4 Design effective strategies to implement metabolic flux to determine metabolic pathways	**SO4.1** Distinguish among different nodes and branches in MFA	**LI4.1** To perform the Column Chromatography process as Unit Operation for extraction of different compounds	**Unit-4** **CI4.1** Branch Point Classification, Nodes Analysis (Weak, Strong and Rigid), Introduction to Metabolic Flux Analysis	**SL4.1** Find out the the types of classifications of nodes in MFA
	SO4.2 Distinguish among different theories of MFA		**CI4.2** Theories of MFA, Tissue Dynamics, Sensitivity Analysis	**SL4.2** Write down some more examples of Tissue dynamics
	SO4.3 Analyze the working of		**CI4.3** Isotope Labelling;	**SL4.3** List down the role of MFA

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	0 2	01	04	17

	isotopic labelling and fractional labelling		Fractional Label enrichment in MFA	in metabolism
	SO4.4 Derive the metabolism reaction for lysine biosynthesis and carbon balancing		**CI4.4** Lysine Biosynthesis; Carbon balancing	**SL4.4** List down the steps involve in Lysine biosynthesis
	SO4.5 Derive the Atom mapping metrices based equations		**CI4.5** Atom mapping matrices	
	SO4.6 Revision and assessment		**CI4.6** Revision and assessment	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	0 4	01	05	20

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Determine the working mechanism and applications of Tissue Dynamics
	SW4.2 Mini Project	Derive the Qualitative and Quantitative data optimization and retrieval through MFA in isotopic labelling
	SW4.3 Other Activities (Specify)	Make a presentation on Lysine biosynthesis and its importance in metabolism

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-98BT602.5 Describe combinatorial metabolic engineering strategies to illustrate metabolic control analysis	**SO5.1** Elucidate Amino Acid Metabolism	**LI5.1** To determine the AA sequences comparison on the basis of peptide mapping using ProteoMapper (Server/tool)	**Unit-5** **CI5.1** Amino Acid Metabolism; Metabolism types in biomolecules	**SL5.1** Explore amino acid metabolism in eukaryotes
	SO5.2 Distinguish among different metabolic core carbon pathways with glycolysis	**LI5.2** To determine the protein 3D structure, function and annotations using Protein Data Bank (PDB database)	**CI5.2** Glycolysis and Core Carbon metabolism	**SL5.2** Write down the enzymes associated in glycolysis
	SO5.3 Analyze the metabolism of aromatic amino acids		**CI5.3** Aromatic amino acid metabolism	**SL5.3** List down various kinds of amino acids and their structures
	SO5.4 Describe the entire role of CRISPR and its mechanism		**CI5.4** CRISPR-CAS9; Introduction; fundamentals and mechanism	**SL5.4** List down the applications of CRISPR
	SO5.5 Describe metabolic reconstruction		**CI5.5** Metabolic Reconstruction and Remodelling	**SL5.5** List down the various bioinformatics-based server/tool that assist in

				study of metabolism
	SO5.6 Explain the mechanism of MCA and network modelling of MCA		**CI5.6** MCA (metabolic Control analysis); fundamentals and mechanism; Metabolic networks	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general mechanism of negative Charge Amino acids
	SW5.2 Mini Project	Describe the applications of CRISP-Cas9 in detail
	SW5.3 Other Activities (Specify)	Prepare one article on the "Metabolic Control Analysis"

Course duration (in hours) to attain Course Outcomes:

Course Title: Metabolic Engineering **Course Code:** 98BT602

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98BT602.1. Explain the basic principles and fundamentals of metabolic engineering	10	6	5	1	22
CO2-98BT602.2. Discuss the role of comprehensive cellular reaction models	10	4	4	1	19
CO3-98BT602.3. Design and describe metabolic flux analysis to determine metabolic pathway utilization	10	4	3	1	18
CO4-98BT602.4. Design	10	2	4	1	17

effective strategies to implement metabolic flux to determine metabolic pathways					
CO5-98BT602.5. Describe combinatorial metabolic engineering strategies to illustrate metabolic control analysis	10	4	5	1	20
Total Hours	50	20	21	05	96

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Metabolic Engineering **Course Code:** 98BT602

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-98BT602.1. Explain the basic principles and fundamentals of metabolic engineering	2	1	1	1	5
CO2-98BT602.2. Discuss the role of comprehensive cellular reaction models	2	4	5	1	12
CO3-98BT602.3. Design and describe metabolic flux analysis to determine metabolic pathway utilization	3	5	5	1	14
CO4-98BT602.4. Design effective strategies to implement metabolic flux to determine metabolic pathways	2	3	5	1	11
CO5-98BT602.5. Describe combinatorial metabolic engineering strategies to illustrate metabolic control analysis	5	4	1	0	10
Total Marks	**14**	**17**	**17**	**04**	**52**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

Books:

S.No.	Title/Author/Publisher details
1	Gregory N. Stephanopoulos, Aristos A. Aristidou, Jens Nielsen; Metabolic Engineering; Academic Press 1998
2	R.O. Jenkins, (Ed.) – Product Recovery in Bioprocess Technology – Biotechnology By Open Learning Series, Butterworth-Heinemann (1992).
3	J.C. Janson And L. Ryden, (Ed.) – Protein Purification – Principles, High Resolution Methods And Applications, VCH Pub. 1989.
4	Fundamentals of Biochemistry. Author, JL Jain et al. Edition, reprint. Publisher, S. Chand Publishing, 2004.
5	Nielsen, J., Eggeling, L., Dynesen, J., Gárdonyi, M., Gill, R. T., de Graaf, A. A., van Zyl, W. H. (Eds.). (2001). Metabolic Engineering. Advances in Biochemical Engineering/Biotechnology.

Online Resources:

Suggested instructions/Implementation strategies:

Improved lecture
Tutorial
Case method
Group Discussion
Role play
Visit to Waste water/Effluent Treatment plant and downstream pharmaceutical plants
Demonstration
ICT Based teaching Learning
Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: VI Semester

Course Title: Metabolic Engineering

Course Code: 98BT602

CO/PO Mapping															
Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**	**PSO 1**	**PSO 2**	**PSO 3**
CO1-98BT602.1. Explain the basic principles and fundamentals of metabolic engineering	**-**	**1**	**-**	**1**	**2**	**2**	**3**	**-**	**3**	**2**	**2**	**3**	**1**	**2**	**1**
CO2-98BT602.2. Discuss the	**-**	**1**	**-**	**-**	**1**	**-**	**3**	**1**	**2**	**2**	**3**	**3**	**2**	**-**	**2**

role of comprehensive cellular reaction models															
CO3-98BT602.3. Design and describe metabolic flux analysis to determine metabolic pathway utilization	**-**	**1**	**1**	**1**	**-**	**-**	**1**	**-**	**2**	**1**	**1**	**2**	**3**	**2**	**-**
CO4-98BT602.4. Design effective strategies to implement metabolic flux to determine metabolic pathways	**-**	**-**	**1**	**-**	**2**	**2**	**3**	**3**	**-**	**1**	**3**	**3**	**2**	**1**	**3**
CO5-98BT602.5. Describe combinatorial	**1**	**-**	**1**	**2**	**-**	**2**	**3**	**3**	**1**	**2**	**2**	**2**	**1**	**1**	**2**

metabolic engineering strategies to illustrate metabolic control analysis															

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	**COs**	**SOs No.**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-98BT602.1.** Explain the basic principles and fundamentals of metabolic engineering	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6	**LI 1** **LI 2** **LI 3**	1.1,1.2,1.3,1.4,1.5,1.6	**1SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-98BT602.2.** Discuss the role of comprehensive cellular reaction models	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6	**LI 1** **LI 2**	2.1, 2.2, 2.3, 2.4, 2.5, 2.6	**2SL-1,2,3,4**
PO	**CO3-98BT602.3.** Design and	SO3.1 SO3.2	**LI 1**	3.1,3.2,3.3,3.4,3.5,	**3SL-1,2,3**

1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	describe metabolic flux analysis to determine metabolic pathway utilization	SO3.3 SO3.4 SO3.5 SO3.6	**LI 2**	3.6	
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-98BT602.4.** Design effective strategies to implement metabolic flux to determine metabolic pathways	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6	**LI 1**	4.1,4.2,4.3,4.4, 4.5, 4.6	**4SL-1,2,3,4**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO5-98BT602.5.** Describe combinatorial metabolic engineering strategies to illustrate metabolic control analysis	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6	**LI 1** **LI 2**	5.1,5.2,5.3,5.4,5.5, 5.6	**5SL-1,2,3,4,5**

Program Name	**Bachelors of Technology (B. Tech.)- Biotechnology**	
Semester	VI	
Course Code:	98BT603	
Course title:	Bioreactor Design	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of fermentation and biochemical engineering	
Rationale:	Bioreactor Design covers a wide range of topics, from the design and research of bioreactors (including their physical architecture, instrumentation, and operational mode) to the development of kinetic models. Across a range of industries, biochemical engineers can find work. They work in the food industry, nuclear industry, healthcare industry, chemical manufacturing firms, pharmaceutical industry, research labs, and other sectors. This course gives us information on various living things, including bacteria, fungus, plants, and animals. However, bioprocess engineering aids in the development of the necessary abilities needed to use these living things for the benefit of both humans and the natural world.	
Course Outcomes (COs):	**CO1-98BT603.1.** Illustrate the terminologies associated with Bioreactor Design **CO2-98BT603.2.** Explain the kinetics and mechanism of various types of reactors **CO3-98BT603.3.** Interpretate the different experimental data on reaction rate related to reactor engineering principles **CO4-98BT603.4.** Analyse the Transfer of Heat and Mass with its kinetics **CO5-98BT603.5.** Evaluate & Design numerical values for development of heterogenous reaction	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=2:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Common (PC)	98BT603	Bioreactor Design	2	2	1	3	8	3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number	Class Test 2 (2 best out of 3)	Seminar one	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		

			3 marks each (CA)	10 marks each (CT)	(SA)					
PC	98BT603	Bioreactor Design	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PC	98BT653	Bioreactor Design	35	5	5	5	50	50	50

Course-Curriculum:

<table>
<tr><td rowspan="3">This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.</td><td colspan="6">Approximate Hours</td></tr>
<tr><td>Item</td><td>Cl</td><td>LI</td><td>SW</td><td>SL</td><td>Total</td></tr>
<tr><td>Approx. Hrs</td><td>10</td><td>08</td><td>01</td><td>03</td><td>22</td></tr>
</table>

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-98BT603.1 Illustrate the terminologies associated with Bioreactor Design	**SO1.1** Explain concept of Basic design and construction, materials of construction of reactor's vessels	**LI1.1** To Demonstrate the working of a Bench Top bioreactor with all its parts	**CI1.1** Basic design and construction, materials of construction	**SL1.1** Find out some examples of bioprocess technique used in ancient India
	SO1.2 Determine the basic Vessel geometry, Bearing assemblies	**LI1.2** To perform the isolation of microorganisms from different kinds of samples	**CI1.2** Vessel geometry, Bearing assemblies	**SL1.2** Search various reference books and study material to start the learning of microorganisms
	SO1.3 Elaborate the working mechanism of Motor drives, Aseptic seals,	**LI1.3** To evaluate the theoretical and observable yield of biological	**CI1.3** Motor drives, Aseptic seals, flow measuring device	**SL1.3** Draw a flow chart showing upstream and

	flow measuring device	products from fermentation process		fermentation processing
	SO1.4 Define the Fundamental mechanism of Valves, Agitator, and Sparger Design	**LI1.4** To evaluate the numerical data on overall mass transfer associated with bioprocessing in a given reactor	**CI1.4** Valves, Agitator & Numerical Problems	
	SO1.5 Define Sparger Design & types		**CI1.5** Sparger Design & types	
	SO1.6 Revision and assessment		**CI1.6** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail "Applications of Microorganisms in various Sectors"
	SW1.2 Mini Project	Draw various types of Fermenters with specifications and parts
	SW1.3 Other Activities (Specify)	Make a power point presentation on "Role of Fermentations in Ancient India"

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	06	01	03	20

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-98BT603.2. Explain the kinetics and mechanism of various types of reactors	**SO2.1** Explain the Operational Mode of Reactors: Batch, Fed batch, Continuous cultivation	**LI2.1** To perform the experiment on the microbial production of Acetic Acid	**CI2.1** Operational Mode of Reactors: Batch, Fed batch, Continuous cultivation	**SL2.1** Find out more conventional cell disruption techniques
	SO2.2 Explain the working mechanism of Stirred Tank, Airlift Bioreactor, Airlift Pressure, cycle Bioreactor, Loop Bioreactor, Bubble column Bioreactor, Packed bed and hollow fibre membrane bioreactor	**LI2.2** To perform the experiment of microbial production of Amino acids	**CI2.2** Novel Bioreactor Stirred Tank, Airlift Bioreactor, Airlift Pressure, cycle Bioreactor, , Packed bed and hollow fibre membrane bioreactor	**SL2.2** Read the latest research in bioseparations methods
	SO2.3 Explain the working mechanism of CSTRs fermenter, Monod equation for chemostat, Monod Kinetics	**LI2.3** To perform the cell disruption technique using physical, chemical and biological methods	**CI2.3** Design equation for CSTRs fermenter	**SL2.3** Write down few points on biological product's properties
	SO2.4 Explain Monod equation for chemostat		**CI2.4** Monod equation for chemostat	
	SO2.5 Explain Monod		**CI2.5**	

	Kinetics		Monod Kinetics	
	SO2.6 Explain Loop Bioreactor, Bubble column Bioreactor		**CI2.6** Loop Bioreactor, Bubble column Bioreactor	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe Biosynthetic pathway for Acetone, Butanol and Ethanol derived fermentation
	SW2.2 Mini Project	Make a project on different kinds of Amino acids, their structure and functions
	SW2.3 Other Activities (Specify)	Make Power point presentation on Distillation as Unit operations

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	0 6	01	02	19

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-98BT603.3 Interpretate the different experimental data on reaction rate related to reactor engineering principles	**SO3.1** Elucidate the application of various kinds of separation process	**LI3.1** To perform the microbial production of Secondary metabolites using shake flask fermentation method	**CI3.1** Law of mass action, Rate equation, elementary, non elementary reaction and their mechanism	**SL3.1** Derive the numerical problems associated with Elementary and Non-Elementary reactions
	SO3.2 Derive the mathematical	**LI3.2** To observe the growth of	**CI3.2** Theories of reaction rate	**SL3.2** Derive the numerical

	expression for centrifugal sedimentation	microbial biomass and calculate its kinetics using graph	and temperature dependency	problems associated with experimental reactor data
	SO3.3 Analyze the partition coefficient associated with phase extraction	**LI3.3** To determine the production of weak organic acids through fermentation	**CI3.3** Analysis of experimental reactor data	
	SO3.4 Evaluation of rate equation, Integral and differential analysis for constant and variable volume system		**CI3.4** Evaluation of rate equation, Integral and differential analysis for constant and variable volume system	
	SO3.5 Evaluate Numerical problem associated with rate of reaction		**CI3.5** Fitting of data to complex reaction mechanism, Numerical problems	
	SO3.6 Revision and assessment		**CI3.6** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Derive the equations for Rate of Reaction and 1^{st} Order, 2^{nd} Order reactions
	SW3.2 Mini Project	Describe the role of mass and heat transfer and its kinetics
	SW3.3 Other	Prepare one Power point presentation on “Reaction Kinetics of Various Fermentation Operations”

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	00	01	03	14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-98BT603.4 Analyse the Transfer of Heat and Mass with its kinetics	**SO4.1** Elucidate the Mechanism of heat transfer, Equipment of heat transfer		**CI4.1** Mechanism of heat transfer, Equipment of heat transfer	**SL4.1** List down the different kinds of equipment used in heat exchangers
	SO4.2 Derive the Conduction, Heat transfer between fluids, Heat transfer coefficients, Overall Hear transfer coefficients		**CI4.2** Conduction, Heat transfer between fluids, Heat transfer coefficients, Overall Hear transfer coefficients	**SL4.2** Read the process of Heat transfer
	SO4.3 Analyze the Design equation for Heat transfer, Calculations of Heat transfer coefficients		**CI4.3** Design equation for Heat transfer, Calculations of Heat transfer coefficients	**SL4.3** Find out the role of oxygen transfer in reactors

	SO4.4 Describe the Oxygen transfer methodologies in fermenter, Determination of oxygen transfer coefficient (Kla) Liquid –Liquid Mass transfer		**CI4.4** Oxygen transfer methodologies in fermenter, Determination of oxygen transfer coefficient (Kla) Liquid –Liquid Mass transfer	
	SO4.5 Interpretate the Factor affecting mass transfer and oxygen transfer		**CI4.5** Factor affecting mass transfer and oxygen transfer	
	SO4.6 Revision and assessment		**CI4.6** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Determine the working mechanism and applications of different kind of Vectors used in RDT
	SW4.2 Mini Project	Derive the Plant and Animal Cell Culture based metabolites having therapeutic applications
	SW4.3 Other Activities (Specify)	Make a Power point presentation for description of "Role of Host-vector system" in RDT for Bioprocessing

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	00	01	05	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-98BT603.5. Evaluate & Design numerical values for development of homogeneous reaction	**SO5.1** Elucidate the Internal mass transfer and steady state shell mass balance (assumption and derivation)		**CI5.1** Internal mass transfer and steady state shell mass balance (assumption and derivation)	**SL5.1** Find out the industrial applications of Chromatography
	SO5.2 Describe the Concentration profile for first order kinetics and spherical geometry		**CI5.2** Concentration profile for first order kinetics and spherical geometry	**SL5.2** Solve the numerical problems associated with Thiele Modulus
	SO5.3 Analyze the Concentration profile for zero order kinetics and spherical geometry		**CI5.3** Concentration profile for zero order kinetics and spherical geometry	**SL5.3** Solve the numerical problems associated with rate of reactions
	SO5.4 Analyze the Concentration profile for Michles-menten kinetics and spherical geometry		**CI5.4** Concentration profile for Michles-menten kinetics and spherical geometry	**SL5.4** Solve the numerical problems associated with Michalis-Menton kinetics
	SO5.5 Evaluate the Thiele modulus and effectiveness factor for first order, Zero order		**CI5.5** Thiele modulus and effectiveness factor for first order, Zero order	**SL5.5** Solve the numerical problems associated with heterogeneous reactions

	SO5.6 Evaluate the Michles-menten Kinetics, External mass transfer, Minimizing mass transfer effect (internal and external		**CI5.6** , External mass transfer, Minimizing mass transfer effect (internal and external	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Derive the numerical problems for Thiele modulus
	SW5.2 Mini Project	Describe the Michalis-Menton kinetics
	SW5.3 Other Activities (Specify)	Prepare one article on the "Heterogeneous Reactions and its Significance"

Course duration (in hours) to attain Course Outcomes:

Course Title: Bioreactor Design **Course Code:** 98BT603

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98BT603. Illustrate the terminologies associated with Bioreactor Design	10	8	3	1	22
CO2-98BT603. Explain the kinetics and mechanism of various types of reactors	10	6	3	1	20

CO3-98BT603.3. Interpretate the different experimental data on reaction rate related to reactor engineering principles	10	6	2	1	19
CO4-98BT603.4. Analyse the Transfer of Heat and Mass with its kinetics	10	0	3	1	14
CO5-98BT603.5. Evaluate & Design numerical values for development of heterogenous reaction	10	0	5	1	16
Total Hours	50	20	16	05	91

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Bioreactor Design **Course Code:** 98BT603

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-98BT603.1. Illustrate the terminologies associated with Bioreactor Design	2	1	1	1	5
CO2-98BT603.2. Explain the kinetics and mechanism of various types of reactors	2	4	5	1	12
CO3-98BT603.3. Interpretate the different experimental data on reaction rate related to reactor engineering principles	3	5	5	1	14
CO4-98BT603.4. Analyse the Transfer of Heat and Mass with its kinetics	2	3	5	1	11
CO5-98BT603.5. Evaluate & Design numerical values for development of heterogenous reaction	2	4	1	1	10
Total Marks	**11**	**17**	**17**	**05**	**50**

Legend: **A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

Books:

S.No.	Title/Author/Publisher details
1	Pauline M. Doran, "Bioprocess engineering principles" : Acedemic press
2	James E. Bailey & David F. Ollis- Biochemical engineering fundamentals
3	J.C. Janson And L. Ryden, (Ed.) – Protein Purification – Principles, High Resolution Methods and Applications, VCH Pub. 1989.
4	Peter F. Stanbury, Allan Whitekar, "Principles for fermentation technology"

Online Resources:

Suggested instructions/Implementation strategies:

Improved lecture
Tutorial
Case method
Group Discussion
Role play
Visit to Beverage producing plants & Distillery/Fermenter units
Demonstration
ICT Based teaching Learning
Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: 6th Semester

Course Title: Bioreactor Design

Course Code: 98BT603

CO/PO/PSO Mapping									
Course Outcome (Cos)	**Program Outcomes (POs)**						**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1-56MB303.1: Describe the fundamentals of Industrial Microbiology and Fermentation Technology	2	-	-	1	2	1	2	2	1
CO2-56MB303.2: Define the role of microbiology for the production of desired bioproducts	-	-	1	1	-	1	1	1	2
CO3-56MB303.3: Elaborate the working mechanism of upstream and downstream processing	1	1	1	1	-	1	1	1	1
CO4-56MB303.4: Interpretate the mechanism of fermentation process in industry	-	1	1	-	2	1	1	1	3
CO5-56MB303.5: Examine the mechanism of biological product development using microbes	1	1	1	-	-	1	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO1-98BT603.1.** Illustrate the terminologies associated with Bioreactor Design	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6	**LI 1** **LI 2** **LI 3** **LI 4**	1.1,1.2,1.3,1.4,1.5, 1.6	**1SL-1,2,3**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO2-98BT603.2.** Explain the kinetics and mechanism of various types of reactors	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6	**LI 1** **LI 2** **LI 3**	2.1, 2.2, 2.3,2.4,2.5,2.6	**2SL-1,2,3**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO3-98BT603.3.** Interpretate the different experimental data on reaction rate related to reactor engineering principles	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6	**LI 1** **LI 2** **LI 3**	3.1,3.2,3.3,3.4,3.5, 3.6	**3SL-1,2**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO4-98BT603.4.** Analyse the Transfer of Heat and Mass with its kinetics	SO4.1 SO4.2 SO4.3 SO4.4 SO5.5 SO5.6		4.1,4.2,4.3,4.4, 4.5, 4.6	**4SL-1,2,3**
PO 1,2,3,4,5,6	**CO5-98BT603.5.** Evaluate & Design numerical values for development of heterogenous reaction	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6		5.1,5.2,5.3,5.4,5.5, 5.6	**5SL-1,2,3,4,5**

PSO 1,2, 3					

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	VI	
Course Code:	98BT604	
Course title:	Waste Treatment	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of environmental science	
Rationale:	The course content aims to make the student understand how biotechnology can help in monitoring or removing the pollutants and developing an understanding of new trends such as biofuels, renewable energy sources, or development of stress-tolerant plants which can minimize the harmful impact of pollutants thereby making the planet earth a better dwelling place. Students will gain knowledge about how to maintain the environment. They will also gain the knowledge to use biotechnology for waste management, bioremediation, and green energy.	
Course Outcomes (COs):	**CO1-98BT604.1.** Identify different strategies of Waste treatment and its management **CO2-98BT604.2.** Apply technical methods to get best out of waste **CO3-98BT604.3.** Analyze various equipment used in anaerobic waste treatment **CO4-98BT604.4.** Design effective strategies to implement metabolic flux to determine metabolic pathways **CO5-98BT604.5.** Describe, design and develop systematic approach to remediate waste using technical advancement	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L: T: P=2:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Common (PC)	98BT604	Waste Treatment	2	2	1	3	8	3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number	Class Test 2 (2 best out of 3)	Seminar one	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		

			3 marks each (CA)	10 marks each (CT)	(SA)					
PC	98BT604	Waste Treatment	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PC	98BT654	Waste Treatment	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	0 6	01	05	22

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-98BT604.1. Identify different strategies of Waste treatment and its management	**SO1.1** Explain concept of waste treatment	**LI1.1** To make a report on Waste treatment and management plan for any district of your choice	**Unit-1** **CI1.1** Waste; Treatment of waste and its importance	**SL1.1** Find out some examples of waste
	SO1.2 Define Basic terminology, scope and application for waste	**LI1.2** Identify the types of pollutants present in drinking water	**CI1.2** Types and Sources of solid and hazardous wastes	**SL1.2** Explore conventional papers on waste management
	SO1.3 Elaborate the scientific applications of hazardous waste	**LI1.3** Prepare a report on different types of agricultural waste produces in your surrounding	**CI1.3** hazardous wastes, and biomedical wastes; other types of waste	**SL1.3** Write down few points on applications of waste treatment
	SO1.4 Define waste generation rates		**CI1.4** Waste generation rates, Composition; Characteristics	**SL1.4** Write down few points on recycle

	SO1.5 Elaborate the process of waste generation in food industries		**CI1.5** Waste generation from food industries	**SL1.5** Collect information on career in waste treatment
	SO1.6 Revision and assessment		**CI1.6** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail about the role of "Generation of Waste in India"
	SW1.2 Mini Project	Elaborate the role of 3Rs
	SW1.3 Other Activities (Specify)	Draw a flowchart compiling all procedures used in waste management

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	0 4	01	04	19

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**

CO2-98BT604.2. Apply technical methods to get best out of waste	**SO2.1** Explain concept of downstream processing	**LI2.1** Demonstrate the working of waste segregation and handling	**Unit-2** **CI2.1** Handling, Segregation, Storage and collection of waste	**SL2.1** Find out the process followed in your district for waste handling and segregation
	SO2.2 Relate the concept of how physical and biological separation can be done	**LI2.2** To perform the experiment of production of microbial biomass	**CI2.2** Treatment of biomedical waste	**SL2.2** Read the latest research in innovations in composting
	SO2.3 Outline the steps of converting glucose to ethanol		**CI2.3** Composting, thermal conversion technologies, energy recovery	**SL2.3** Write down few points on energy recovery from waste
	SO2.4 Define the mechanism of biomass		**CI2.4** Incineration, solidification and stabilization of hazardous wastes	**SL2.4** Find out the different kinds of incinerators and write about them
	SO2.5 Explain the role of Modelling Metabolism		**CI2.5** Biological and chemical conversion technologies	
	SO2.6 Revision and assessment		**CI2.6** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe the role of agricultural Biomass in Energy recovery
	SW2.2 Mini Project	Make a project on bioconversion of agricultural waste for the production of waste

	SW2.3 Other Activities (Specify)	Make a Power point presentation on Composting and Thermal conversion of waste

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	04	01	03	18

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO3-98BT604.3. Analyz various equipment used in anaerobic waste treatment	**SO3.1** Define the the role of landfills	**LI3.1** To design a landfill with all details and labelling	**Unit-3** **CI3.1** Design and operation of sanitary landfills, secure landfills and landfill bioreactors	**SL3.1** Find out how many landfills are present in your district and of which type they are
	SO3.2 Derive the process of landfill monitoring	**LI3.2** To determine the BOD of various water samples	**CI3.2** Landfill closure and environmental monitoring; remediation	**SL3.2** Read the process of BOD is calculated for a given sample
	SO3.3 Distinguishes the types of landfills and its working		**CI3.3** Landfills; types; mechanism; site selection	**SL3.3** Write down the steps followed in Effluent Treatment Plant

	SO3.4 Derive the mathematical modelling of BOD		**CI3.4** Mathematical modelling of BOD & kinetics	
	SO3.5 Explain the treatment process in ETP		**CI3.5** Waste Water Treatment (ETP)	
	SO3.6 Revision and assessment		**CI3.6** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Derive the equations for Michalis Menten theory of Enzyme Substrate complex
	SW3.2 Mini Project	Write an article on Global Control at whole Cell level
	SW3.3 Other Activities (Specify)	Prepare one Power point presentation on "Effluent Treatment Plant"

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	02	01	04	17

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO4-98BT604.4	**SO4.1**	**LI4.1**	**Unit-4**	**SL4.1**

Design effective strategies to implement waste management	Distinguish among different types of waste water	To perform the Oil separation method using aqueous two-phase extraction method	**CI4.1** Sources and types of industrial wastewater, Environmental impacts	Find out the methods to separate oil from water
	SO4.2 Distinguish among different methodologies used in waste treatment		**CI4.2** Neutralization, Oil separation, Flotation, Precipitation	**SL4.2** Write down some more examples of Heavy metals contamination
	SO4.3 Analyze the working of Heavy metal Removal, adsorption, Chemical oxidation		**CI4.3** Heavy metal Removal, adsorption, Chemical oxidation	**SL4.3** List down the different organic pollutants present in natural substances
	SO4.4 Derive the process of ozonation, evaporation and other methods		**CI4.4** Ozonation, Photocatalysis, Wet Air Oxidation – Evaporation	**SL4.4** List down the steps involve in membrane separations
	SO4.5 Derive the mechanism of ion exchange, membrane processing		**CI4.5** Ion Exchange, Membrane Technologies	
	SO4.6 Revision and assessment		**CI4.6** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Determine the working mechanism and applications of Photocatalysis
	SW4.2 Mini Project	Derive the working mechanism of membrane separation technologies
	SW4.3 Other Activities (Specify)	Make a presentation on heavy metal contamination and its bioremediation processing

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-98BT604.5. Describe, design and develop systematic approach to remediate waste using technical advancement	**SO5.1** Elucidate Anaerobic process of digestion	**LI5.1** To perform the process of anaerobic digestion	**Unit-5** **CI5.1** Fundamentals of anaerobic treatments; Anaerobic digestion	**SL5.1** Explore Anaerobic digestion
	SO5.2 Distinguish among Sedimentation and thickening in waste treatment	**LI5.2** To remediate the contaminatio ns from water sample using natural adsorbents	**CI5.2** Sedimentation and Thickening	**SL5.2** Write a report on gravity-based separation of waste
	SO5.3 Analyz the working of anaerobic lagoons		**CI5.3** Anaerobic lagoons	**SL5.3** Prepare a report on air pollution in your locality and the air quality index
	SO5.4 Describe the Waste generation from different		**CI5.4** Waste generation from different industries	**SL5.4** List down the surrounding industries and type of waste

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	04	01	05	20

	industries			they generate
	SO5.5 Interpret design considerations of Anaerobic reactors		**CI5.5** General design considerations, of Anaerobic reactors	**SL5.5** List down the various types of anaerobic lagoons found in India
	SO5.6 Revision and assessment		**CI5.6** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general mechanism of Anaerobic digestion and products associated with it
	SW5.2 Mini Project	Describe the applications of Anaerobic reactors and its design
	SW5.3 Other Activities (Specify)	Prepare one article on the "Biogas Production mechanism and its distribution in India"

Course duration (in hours) to attain Course Outcomes:

Course Title: Waste Treatment **Course Code:** 98BT604

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-98BT604.1. Identify different strategies of Waste treatment and its management	10	6	5	1	22
CO2-98BT604.2. Apply technical methods to get best out of waste	10	4	4	1	19
CO3-98BT604.3. Analyze various equipment used in anaerobic waste treatment	10	4	3	1	18
CO4-98BT604.4. Design effective strategies to implement waste	10	2	4	1	17

management					
CO5-98BT604.5. Describe, design and develop systematic approach to remediate waste using technical advancement	10	4	5	1	20
Total Hours	50	20	21	05	96

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Waste Treatment **Course Code:** 98BT604

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-98BT604.1. Identify different strategies of Waste treatment and its management	2	1	1	1	5
CO2-98BT604.2. Apply technical methods to get best out of waste	2	4	5	1	12
CO3-98BT604.3. Analyze various equipment used in anaerobic waste treatment	3	5	5	1	14
CO4-98BT604.4. Design effective strategies to implement waste management	2	3	5	1	11
CO5-98BT604.5. Describe, design and develop systematic approach to remediate waste using technical advancement	5	4	1	0	10
Total Marks	**14**	**17**	**17**	**04**	**52**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

Books:

S.No.	Title/Author/Publisher details
1	S.K.Garg (2004) Environmental Engineering (Vol I & II) Khanna publishers
2	Marcos Von Sperling (2007), Waste Water Characteristics, Treatment and Disposal, Biological Waste Water Treatment, Serie I, Iwa Publishing (Intl water Association).
3	Eckenfelder, W.W., (1999). Industrial Water Pollution Control, (3rd Ed) McGraw-Hill.

Online Resources:

Suggested instructions/Implementation strategies:

Improved lecture
Tutorial
Case method
Group Discussion
Role play
Visit to Waste water/Effluent Treatment plant and downstream pharmaceutical plants
Demonstration
ICT Based teaching Learning
Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: VI Semester

Course Title: Waste Treatment

Course Code: 98BT604

CO/PO Mapping	

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-98BT604.1. Identify different strategies of Waste treatment and its management	-	1	-	1	2	2	3	-	3	2	2	3	1	1	2
CO2-98BT604.2. Apply technical methods to get best out of waste	-	1	-	-	1	-	3	1	2	2	3	3	2	-	2
CO3-98BT604.3. Analyze various equipment used in anaerobic waste treatment	-	1	1	1	-	1	1	-	2	1	1	2	3	2	-
CO4-98BT604.4. Design effective strategies to implement waste management	1	-	1	-	2	2	2	3	-	1	3	3	2	1	3
CO5-98BT604.5. Describe, design and develop systematic approach to remediate waste using technical advancement	1	-	1	2	-	2	3	2	1	2	2	2	1	2	1

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-98BT604.1.** Identify different strategies of Waste treatment and its management	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6	**LI 1** **LI 2** **LI 3**	1.1,1.2,1.3,1.4,1.5, 1.6	**1SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-98BT604.2.** Apply technical methods to get best out of waste	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6	**LI 1** **LI 2**	2.1, 2.2, 2.3, 2.4, 2.5, 2.6	**2SL-1,2,3,4**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3-98BT604.3.** Analyze various equipment used in anaerobic waste treatment	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6	**LI 1** **LI 2**	3.1,3.2,3.3,3.4,3.5, 3.6	**3SL-1,2,3**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-98BT604.4.** Design effective strategies to implement waste management	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5,SO4.6	**LI 1**	4.1,4.2,4.3,4.4, 4.5,4.6	**4SL-1,2,3,4**
PO 1,2,3,4,5,6 7,8,9,10,11,12	**CO5-98BT604.5.** Describe, design and develop systematic approach to remediate waste using technical	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6	**LI 1**	5.1,5.2,5.3,5.4,5.5,5.6	**5SL-1,2,3,4,5**

PSO 1,2, 3	advancement		**LI 2**		

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	VI	
Course Code:	**98BT605**	
Course title:	Genomics and Proteomics	**Curriculum Developer**: Sonal Gupta, Assistant Professor
Pre-requisite:	Students should have basic knowledge of biochemistry, molecular biology and bioinformatics	
Rationale:	Genomics is an entry point for looking at the other 'omics' sciences. Genomics provides an overview of the complete set of genetic instructions provided by the DNA, while transcriptomics looks into gene expression patterns. Proteomics studies dynamic protein products and their interactions. An application of proteomics is known as protein "expression profiling" where proteins are identified at a certain time in an organism as a result of the expression to a stimulus. Proteomics can also be used to develop a protein-network map where interaction among proteins can be determined for a particular living system.	
Course Outcomes (COs):	**CO1 98BT605**. Understand about the fundamentals of genomics and proteomics **CO2 98BT605** Outline the next-generation sequencing techniques **CO3 98BT605**. Apply analytical approach to identify protein structures **CO4 98BT605**. Analyse vaccine designing and protein-ligand interactions for drug discovery **CO5 98BT605**. Compare various databases and software used in proteomics	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Common (PC)	98BT605	Genomics and Proteomics	3	2	1	3	9	4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	**Scheme of Assessment (Marks)**							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number	Class Test 2 (2 best out of 3)	Seminar one	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		

			3 marks each (CA)	10 marks each (CT)	(SA)					
PC	98BT605	Genomics and Proteomics	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: practical

Board of Study	Couse Code	Course Title		**Scheme of Assessment (Marks)**						
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		
PC	98BT655	Genomics and Proteomics	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Course-Curriculum:

<table>
<tr>
<td rowspan="3">This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.</td>
<td colspan="6">Approximate Hours</td>
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<td>Item</td><td>Cl</td><td>LI</td><td>SW</td><td>SL</td><td>Total</td>
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<tr>
<td>Approx. Hrs</td><td>09</td><td>04</td><td>01</td><td>05</td><td>19</td>
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Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-98BT605.1 Understand about the fundamentals of genomics	**SO1.1** An introduction of genomics	**LI1.1** List the basic software used for genomic study	**Unit-1** **Introduction of genomics** **CI1.1** Genomics: History, types and scope in modern biotechnology	**SL1.1** Find out some examples softwares used for genome assembly
	SO1.2 Describe various DNA sequencing methods: Manual methods	**LI1.2** Make a comparative chart of various DNA sequencing methods	**CI1.2** Elaborate Sanger and Maxam Gilbert method of DNA sequencing	**SL1.2** Explain the manual methods of DNA sequencing

	SO1.3 Elaborate the automated methods of DNA sequencing		**CI1.3** Study pyrosequencing and other next generation platforms of automated DNA sequencing	**SL1.3** Write down stepwise methodology of shotgun sequencing method of genome sequencing
	SO1.4 Define the shot gun method of genome sequencing		**CI1.4** Explain the detailed principle and methodology of shot gen method of whole genome sequencing	**SL1.4** Write an overview on genomics and its types
	SO1.5 Describe hierarchical method of genome sequencing		**CI1.5** Explain the principle and stepwise methodology of hierarchical method of genome sequencing	**SL1.5** Collect information on next generation sequencing methods
	SO1.6 Elaborate various computational tool used for genome sequencing		**CI1.6** Study the software or computational platform used for genome sequencing	
	SO1.7 Explain Genome sequence assembly software		**CI1.7** Study various software used for alignment of genome sequences during whole genome projects	

	SO1.8 Revision		**CI1.8** Revision	
	SO1.9 Assessment		**CI1.9** Assessment	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe the role of bioinformatics and computational biology in genomics
	SW1.2 Mini Project	Differentiate between shot gun and hierarchical method of genome sequencing
	SW1.3 Other Activities (Specify)	Draw a flowchart compiling all steps of Sanger and Maxam Gilbert methods of DNA sequencing

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	04	18

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-98BT605.2. Outline the next-generation sequencing techniques	**SO2.1** Explain web-based server	**LI2.1** Make a list of various browsers used for genome analysis	**Unit-2** **Managing and Distributing Genome Data** **CI2.1** Describe web-based servers and softwares	**SL2.1** Find out all the browser used to search genomic database

			used for genome analysis: ENSEMBL, VISTA, UCSC	
	SO2.2 Describe various browser used for genome analysis	**LI2.2** Make a chart of first, second and next generation sequencing platforms	**CI2.2** Explain different Genome Browser, NCBI genome	**SL2.2** Read the latest research in genome sequencing
	SO2.3 Describe various genomic database		**CI2.3** Biological database: definition, types, databases for genomic studies	**SL2.3** Write down a note on genome database
	SO2.4 Define the model organisms used for genomic studies		**CI2.4** Elaborate various model organisms	**SL2.4** Find out the different kinds of platforms used for genome sequencing projects
	SO2.5 Explain the first-generation sequencing platforms		**CI2.5** Describe different platforms used for first generation sequencing: Sanger DNA sequencing	
	SO2.6 Explain second generation sequencing platforms		**CI2.6** Elaborate second generation sequencing platform: Roche 454	

			FLX system – Illumina Solexa and SoLiD	
	SO2.7 Describe Next generation sequencing platforms		**CI2.7** Explain next generation sequencing and various platforms used for NGS	
	SO2.8 different types of NGS platforms		**CI2.8** different types of NGS platforms	
	SO2.9 Revision and assessment		**CI2.9** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe browsers and servers used for genomic studies
	SW2.2 Mini Project	Make a comparative chart on genomic databases
	SW2.3 Other Activities (Specify)	Make a power point presentation on "Next Generation Sequencing".

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	03	17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-98BT505.3 Apply analytical approach to identify protein structures	SO3.1: Understand the basic structure of proteins	LI3.1: SDS-PAGE for Protein Size Determination	CI3.1: Introduction to Protein Structure	SL3.1: Study of protein structures
	SO3.2: Learn about the chemical properties of proteins	LI3.2: Native PAGE for Protein Structure Analysis	CI3.2: Chemical Properties of Proteins	SL3.2: Research on chemical properties of proteins
	SO3.3: Understand the role of physical interactions in proteins		CI3.3: Physical Interactions in Proteins	SL3.3: Study of protein physical interactions
	SO3.4: Learn about short-range interactions in proteins		CI3.4: Short-Range Interactions in Proteins	
	SO3.5: Understand electrostatic forces in proteins		CI3.5: Electrostatic Forces in Proteins	
	SO3.6: Study Van der Waals interactions in proteins		CI3.6: Van der Waals Interactions in Proteins	

	SO3.7: Learn about hydrogen bonds in proteins		CI3.7: Hydrogen Bonds in Proteins	
	SO3.8: Understand hydrophobic interactions in proteins		CI3.8: Hydrophobic Interactions in Proteins	
	SO3.9: Learn methods for determining protein sizes		CI3.9: Methods for Determining Protein Sizes	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe the properties of proteins
	SW3.2 Mini Project	Describe the role of SDS PAGE in proteomic studies
	SW3.3 Other Activities (Specify)	Prepare one Power point presentation on “Proteomics”

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	03	17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-98BT605.4 Compare various databases and software used in proteomics	SO4.1: Understand the introduction and scope of proteomics	LI4.1: Two-dimensional PAGE for Proteome Analysis	CI4.1: Introduction and Scope of Proteomics	SL4.1: Study of various applications of proteomics
	SO4.2: Learn about ion-exchange chromatography	LI4.2: Isoelectric Focusing (IEF) of Proteins	CI4.2: Protein Separation Techniques: Ion-Exchange Chromatography	SL4.2: Research on ion-exchange chromatography
	SO4.3: Understand size-exclusion chromatography		CI4.3: Protein Separation Techniques: Size-Exclusion Chromatography	SL4.3: Study of size-exclusion chromatography
	SO4.4: Learn about affinity chromatography techniques		CI4.4: Protein Separation Techniques: Affinity Chromatography	
	SO4.5: Understand polyacrylamide gel electrophoresis		CI4.5: Polyacrylamide Gel Electrophoresis (PAGE)	
	SO4.6: Learn about isoelectric focusing (IEF)		CI4.6: Isoelectric Focusing (IEF)	
	SO4.7: Study two-dimensional PAGE for proteome analysis		CI4.7: Two-Dimensional PAGE for Proteome Analysis	

	SO4.8: Understand image analysis of 2D gels		CI4.8: Image Analysis of 2D Gels	
	SO4.9: Learn about in-silico analysis of proteins		CI4.9: In-Silico Analysis of Proteins	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe the working principle of chromatographic techniques and their applications in protein studies
	SW4.2 Mini Project	Read research articles on recent advancements in proteomics
	SW4.3 Other Activities (Specify)	Make a presentation on 2D PAGE

Item	Cl	LI	SW	SL	Total
Approx. Hrs	9	04	01	05	19

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO5-98BT605.5 Design novel proteins and predict their annotative functionality through NMR	**SO5.1** Introduction to mass spectrometry.	**LI5.1** Make a list of protein databases used for proteomic studies	**Unit-5** **CI5.1** Mass spectrometery: principle, instrumentation and application in proteome study	**SL5.1** Find out the industrial applications of functional proteomics
	SO5.2 Explain	**LI5.2** To perform the	**CI5.2** Describe various	**SL5.2** List down

	strategies for protein identification	SDS-PAGE analysis of the given protein	techniques used for protein identification	various steps of protein engineering
	SO5.3 Explain Protein sequencing		**CI5.3** Describe different methods of protein sequencing	**SL5.3** An overview on Mass spectrometery
	SO5.4 Elaborate Protein modifications		**CI5.4**	**SL5.4** Explain different kinds of protein modifications
	SO5.5 Elaborate Protein-protein interaction (Two hybrid interaction screening)		**CI5.5** Describe protein-protein interaction and two hybrid method to detect protein-protein interaction	**SL5.5** List down the various bioinformatics-based server/tool and databases that assist in study of protein/proteomics
	SO5.6 Proteomics and Applications of proteomics		**CI5.6** Define functional proteomics; Clinical and biomedical application of proteomics, proteome analysis for drug designing	
	SO5.7 Describe different proteome database		**CI5.8** Study the various databases used for proteomic studies	
	SO5.8 Describe Protein engineering		**CI5.8** Elaborate detailed strategy of protein engineering	
	SO5.9 What is protein chip and its role in proteomic studies		**CI5.9** Explain Protein chips	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general strategy of protein engineering
	SW5.2 Mini Project	Describe various applications of proteomic studies
	SW5.3 Other Activities (Specify)	Prepare one article on the "Mass spectrometery"

Course duration (in hours) to attain Course Outcomes:

Course Title: Genomics and Proteomics **Course Code:** 98BT605

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1 98BT605. Understand about the fundamentals of genomics and proteomics	9	04	05	01	19
CO2 98BT605 Outline the next-generation sequencing techniques	9	04	04	01	18
CO3 98BT605. Apply analytical approach to identify protein structures	9	04	03	01	17
CO4 98BT605. Analyse vaccine designing and protein-ligand interactions for drug discovery	9	04	03	01	17
CO5 98BT605. Compare various databases and software used in proteomics	9	04	03	01	17
Total Hours	45	20	18	5	88

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Genomics and Proteomics **Course Code:** 98BT605

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1 98BT605. Understand about the fundamentals of genomics and proteomics	2	1	1	1	5

CO2 98BT605 Outline the next-generation sequencing techniques	2	4	5	1	12
CO3 98BT605. Apply analytical approach to identify protein structures	3	5	5	1	14
CO4 98BT605. Analyse vaccine designing and protein-ligand interactions for drug discovery	2	3	5	1	11
CO5 98BT605. Compare various databases and software used in proteomics	5	4	1	0	10
Total Marks	**14**	**17**	**17**	**04**	**52**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

Books:

S.No.	Title/Author/Publisher details
1	Genes IX by Benjamin Lewin, Johns and Bartlett Publisher, 2006.
2	Modern Biotechnology, 2nd Edition, S.B. Primrose, Blackwell Publishing, 1987.
3	Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th Edition, B.R. Glick, J.J. Pasternak and C.L. Patten, 2010.
4	Molecular Cloning: A Laboratory Manual (3rd Edition) Sambrook and Russell Vol. I to III, 1989.
5	Principles of Gene Manipulation 6th Edition, S.B.Primrose, R.M.Twyman and R.W. Old. Blackwell Science, 2001.
6	Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
7	Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX Edition. Benjamin Cummings.

Online Resources:

Suggested instructions/Implementation strategies:

Improved lecture
Tutorial
Case method
Group Discussion
Role play
Visit to Waste water/Effluent Treatment plant and downstream pharmaceutical plants
Demonstration
ICT Based teaching Learning
Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: VI Semester

Course Title: Genomics and Proteomics

Course Code: 98BT605

CO/PO Mapping		
Course Outcome	**Program Outcomes (POs)**	**Program Specific Outcomes (PSOs)**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1 98BT605. Understand about the fundamentals of genomics and proteomics	**-**	**1**	**-**	**1**	**2**	**2**	**3**	**-**	**3**	**3**	**3**	**3**	**1**	**2**	**1**
CO2 98BT605 Outline the next-generation sequencing techniques	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**-**	**3**	**2**	**3**	**3**	**3**	**-**	**2**
CO3 98BT605. Apply analytical approach to identify protein structures	**-**	**-**	**1**	**1**	**-**	**-**	**3**	**-**	**3**	**1**	**-**	**-**	**1**	**2**	**-**
CO4 98BT605. Analyse vaccine designing and protein-ligand interactions for drug discovery	**1**	**-**	**1**	**-**	**2**	**-**	**2**	**3**	**-**	**1**	**-**	**1**	**2**	**1**	**3**
CO5 98BT605. Compare various databases and software used in proteomics	**1**	**1**	**1**	**-**	**-**	**2**	**3**	**3**	**1**	**2**	**3**	**3**	**1**	**1**	**2**

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1 98BT605**. Understand about the fundamentals of genomics and proteomics	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	**LI 1** **LI 2**	1.1,1.2,1.3,1.4,1.5 1.6, 1.7, 1.8, 1.9	**1SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2 98BT605** Outline the next-generation sequencing techniques	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	**LI 1** **LI2**	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9	**2SL-1,2,3,4**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3 98BT605**. Apply analytical approach to identify protein structures	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO2.7 SO3.8 SO3.9	**LI 1** **LI 2**	3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8, 3.9	**3SL-1,2,3**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4 98BT605**. Analyse vaccine designing and protein-ligand interactions for drug discovery	SO4.1 SO4.2 SO4.3 SO4.4 SO 4.5 SO4,6 SO4.7 SO4.8 SO4.9	**LI 1** **LI 2**	4.1,4.2,4.3,4.4, 4.5, 4.6, 4.7, 4.8,4.9	**4SL-1,2,3**

PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO5 98BT605.5** Compare various databases and software used in proteomics	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	**LI 1** **LI 2**	5.1,5.2,5.3,5.4,5.5, 5.6, 5.7, 5.8, 5.9	**5SL-1,2,3,4,5**

Program Name	**B. Tech. Biotech Semester-**	
Semester	**VI[th]**	
Course Code:	**98BT606-A**	
Course title:	**Food Biotechnology**	**Curriculum Developer**: Mrs. Maahi choure
Pre-requisite:	A foundational knowledge of molecular biology, microbiology, and biochemistry is necessary to understand and apply biotechnological techniques in food science.	
Rationale:	Food biotechnology is essential for enhancing food quality, safety, and nutritional value, while also increasing agricultural productivity and sustainability to meet the demands of a growing global population.	
Course Outcomes (COs):	**98BT656 CO1. Explain fundamental principles of food science and chemistry** **98BT656CO2. Outline beneficial and harmful effects of microorganisms.** **98BT656CO3. Identify microbes for development of functional food** **98BT656CO4. Examine methods that increase shelf life and food quality** **98BT656CO5. Compare the microbes on the basis of their morphological characteristics**	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program elective (PE)	**98BT606-A**	**Food Biotechnology**	3	2	1	1	7	4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	**Scheme of Assessment (Marks)**						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment	Class Test 2 (2 best out	Seminar one	Class Attendance	Total Marks (CA+CT+SA+AT)		

			5 number 3 marks each (CA)	of 3) 10 marks each (CT)	(SA)	(AT)			
Program elective (PE)	**98BT606-A**	**Food Biotechnology**	16	19	5	5	5	50	50

Scheme of Assessment: practical

Board of Study	Course Code	Course Title	**Scheme of Assessment (Marks)**						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
Program elective (PE)	**98BT656-A**	**Food Biotechnology**	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction, including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours**				
	Item	Cl	LI	SW	SL	Total
	Approx. Hrs	09	04	01	02	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
98BT656 CO1. Explain the fundamental principles of food science and chemistry	SO1.1 Factors Affecting Microbial Growth	LI1.1 Observe effects of temperature, pH, and moisture on microbial growth in food samples.	CI1.1 Introduction to factors affecting microbial growth in food.	SL1.1 Research on intrinsic and extrinsic factors influencing microbial growth in food.
	SO1.2 Microbial Spoilage of Milk	LI1.2 Identify microorganisms involved in spoilage of milk through culture techniques.	CI1.2 Study microbial spoilage mechanisms in milk.	SL1.2 Read articles on microbial spoilage of milk and its prevention.
	SO1.3 Microbial Spoilage of Meat		CI1.3 Analyze microbial spoilage processes in meat.	
	SO1.4 Microbial Spoilage of Plant		CI1.4 Understand microbial spoilage in plant products.	

	Products			
	SO1.5 Methods to Prevent Microbial Spoilage		CI1.5 Discuss methods to prevent microbial spoilage in food.	
	SO1.6 Comparison of Spoilage in Different Foods		CI1.6 Compare microbial spoilage across different food types.	
	SO1.7 Review of Key Concepts		CI1.7 Recap on key factors and methods for preventing spoilage.	
	SO1.8 Case Studies on Spoilage		CI1.8 Analyze real-world cases of food spoilage.	
	SO1.9 Advances in Spoilage Prevention		CI1.9 Study recent advancements in food preservation.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Design mini-project research a specific microbial spoilage problem in a food product of choice and present findings, including the microorganism involved, spoilage mechanisms, and prevention strategies.
	SW1.2 Mini Project	Group Assignment – microbial spoilage
	SW1.3 Other Activities (Specify)	Evaluate students based on their technique, accuracy, and lab equipment skills.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	**09**	4	1	2	16

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
98Bt606CO2. Outline the beneficial and harmful effects of microorganisms.	SO2.1 Bacterial Agents of Foodborne Illness	LI2.1 Isolate and identify bacterial pathogens from food samples.	CI2.1 Overview of bacterial pathogens causing foodborne illnesses.	SL2.1 Study the characteristics of major bacterial foodborne pathogens.
	SO2.2 Clostridium and Listeria	LI2.2 Perform tests to detect Clostridium and Listeria in food samples.	CI2.2 Detailed study of Clostridium and Listeria-related foodborne illnesses.	SL2.2 Read about outbreaks and case studies involving Clostridium and Listeria.
	SO2.3 Salmonella and Shigella		CI2.3 Explore Salmonella and Shigella in foodborne illness cases.	
	SO2.4 Staphylococcus and Vibrio		CI2.4 Study the effects of Staphylococcus and Vibrio on food safety.	
	SO2.5 Yersinia and Non-Bacterial Agents		CI2.5 Investigate Yersinia and non-bacterial agents affecting foodborne illnesses.	
	SO2.6 Toxigenic Algae and Fungi		CI2.6 Study the role of toxigenic algae and fungi in foodborne illnesses.	
	SO2.7 Foodborne Viruses		CI2.7 Explore the impact of foodborne viruses on health and safety.	

	SO2.8 Review of Foodborne Pathogens		CI2.8 Summarize key concepts related to foodborne pathogens.	
	SO2.9 Case Studies on Foodborne Illnesses		CI2.9 Discuss real-world cases of foodborne illnesses.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Write about the Staphylococcus: Characteristics, toxins (enterotoxins), diseases (staphylococcal food poisoning), sources, and prevention.
	SW2.2 Mini Project	Prepare a case studies on food borne pathogen
	SW2.3 Other Activities (Specify)	Find out some you tube videos based on the pathogens, clinical manifestations,.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	**09**	4	**1**	2	16

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
98BT606CO3. Identify microbes for development of functional food	SO3.1 Fermented Milk Products	LI3.1 Prepare and analyze fermented milk samples.	CI3.1 Study the fermentation processes in milk products.	SL3.1 Learn about the health benefits and production methods of fermented milk.
	SO3.2 Cheese	LI3.2 Produce	CI3.2 Explore the	SL3.2 Research the

	and Sauerkraut	cheese and sauerkraut and test for microbial activity.	production processes of cheese and sauerkraut.	microbial cultures used in cheese and sauerkraut production.
	SO3.3 Fermented Meat Products		CI3.3 Analyze the role of fermentation in meat preservation.	
	SO3.4 Beer and Vinegar Production		CI3.4 Understand the microbial processes involved in beer and vinegar production.	
	SO3.5 Mold Fermentation		CI3.5 Study the role of molds in fermentation processes.	
	SO3.6 Benefits of Fermented Foods		CI3.6 Discuss the nutritional and health benefits of fermented foods.	
	SO3.7 Microbial Cultures in Fermentation		CI3.7 Examine the role of specific microbial cultures in fermentation.	
	SO3.8 Review of Fermentation Processes		CI3.8 Summarize the key concepts of fermentation in food production.	
	SO3.9 Case Studies on Fermented Foods		CI3.9 Discuss real-world applications of fermentation in food industry.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Remember fermentation
	SW3.2 Mini Project	To do the case studies on fermented foods
	SW3.3 Other Activities (Specify)	Explore online tutorials and resources on meat processing.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	**09**	4	1	2	16

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
98BT606CO4. Examine methods that increase shelf life and food quality	SO4.1 Direct Microscopic Examination	LI4.1 Perform direct microscopic examination of food samples.	CI4.1 Introduction to direct microscopic techniques for food examination.	SL4.1 Review methods for direct microscopic examination in food microbiology.
	SO4.2 Culture Techniques	LI4.2 Apply various culture techniques to isolate microorganisms from food.	CI4.2 Study the principles of culture techniques in food microbiology.	SL4.2 Learn about different culture media and their applications.
	SO4.3 MPN Count		CI4.3 Understand	

			the MPN method for microbial quantification.	
	SO4.4 Dye Reduction Assay		CI4.4 Discuss the use of dye reduction assays in evaluating microbial growth.	
	SO4.5 Immunological Methods		CI4.5 Explore immunological techniques for foodborne pathogen detection.	
	SO4.6 Advanced Techniques		CI4.6 Introduction to advanced microbiological techniques for food testing.	
	SO4.7 Review of Examination Methods		CI4.7 Summarize key methods for microbiological examination of foods.	
	SO4.8 Case Studies in Microbiological Testing		CI4.8 Discuss real-world applications and challenges in microbiological testing.	
	SO4.9 Innovations in Microbiological Techniques		CI4.9 Study recent advancements in microbiological techniques for food analysis.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Various culture techniques
	SW4.2 Mini Project	To list out the various microbial examination
	SW4.3 Other	Understand dye reduction assay

	Activities (Specify)	

Item	Cl	L I	SW	SL	Total
Approx. Hrs	**09**	4	1	2	16

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO5. Compare the microbes on the basis of their morphological characteristics	SO5.1 Physical Preservation Methods	LI5.1 Test the effectiveness of physical preservation methods (e.g., heat, freezing).	CI5.1 Overview of physical methods for food preservation.	SL5.1 Research different physical preservation techniques and their impacts.
	SO5.2 Chemical Preservation Methods	LI5.2 Apply chemical preservatives to food samples and assess their effectiveness.	CI5.2 Study chemical preservation methods and their safety implications.	SL5.2 Learn about the use and regulations of chemical preservatives in food.
	SO5.3 Biological Preservation Methods		CI5.3 Discuss biological preservation methods and their mechanisms.	
	SO5.4 Quality Control in Preservation		CI5.4 Introduction to quality control and	

			microbiological criteria for food preservation.	
	SO5.5 Cleaning and Disinfection Practices		CI5.5 Discuss the importance of cleaning and disinfection in food safety.	
	SO5.6 Good Manufacturing Practices (GMP)		CI5.6 Study the principles and applications of GMP in food production.	
	SO5.7 Hazard Analysis and Critical Control Points (HACCP)		CI5.7 Introduction to HACCP and its role in food safety.	
	SO5.8 Record Keeping in Food Safety		CI5.8 Discuss the importance of record keeping in food safety management.	
	SO5.9 Review and Innovations in Preservation		CI5.9 Summarize key preservation methods and discuss innovations.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	illustrate the role of quality control for Industrial Bioproducts
	SW5.2 Mini Project	Prepare a list of innovations of preservation
	SW5.3 Other Activities (Specify)	Rewrite the HACCP rule

Course duration (in hours) to attain Course Outcomes:
Course Title: **Food Biotechnology** **Course Code: 98BT606**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
98BT606CO1. Explain fundamental principles of food science and chemistry	9	4	2	1	16
98BT606CO2. Outline beneficial and harmful effects of microorganisms.	9	4	2	1	16
98BT606CO3. Identify microbes for development of functional food	9	4	2	1	16
98BT606CO4. Examine methods that increase shelf life and food quality	9	4	2	1	16
98BT606CO5. Compare the microbes on the basis of their morphological characteristics	9	4	2	1	16
Total Hours	45	20	10	5	80

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: **Food Biotechnology** **Course Code:** 98BT606

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
98BT606-ACO1. Explain fundamental principles of food science and chemistry	02	03	04	1	10
98BT606-ACO2. Outline beneficial and harmful effects of microorganisms.	02	05	02	1	10
98BT606-ACO3. Identify microbes for development of functional food	04	04	01	1	10
98BT606-ACO4. Examine methods that increase shelf life and food quality	03	04	02	1	10
98BT606-ACO5. Compare the microbes on the basis of their morphological characteristics	04	03	02	1	11
Total Marks	15	19	11	05	51

Legend**: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

Books:

S.No.	Title/Author/Publisher details
1	Prescott, Harley and Klein, ' Microbiology', MC Graw Hill, International Edition.
2	Willian C. Fraizier and Dennis C. Westhoff, 'Food Microbiology', Tata McGraw Hill Publishing Company , New Delhi.
3	Willian C. Fraizier and Dennis C. Westhoff, 'Food Microbiology', Tata McGraw Hill Publishing Company , New Delhi.

Online Resources:

Suggested instructions/Implementation strategies:

Improved lecture

Tutorial
Case method
Group Discussion
Role play
Visit to Research lab (BSL-1)
Demonstration
ICT Based teaching Learning
Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: 6th Sem

Course Title: Food Biotechnology

Course Code: 98BT606-A

CO/PO/PSO Mapping															
Course Outcome (Cos)	**Program Outcomes (POs)**											**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1. Explain fundamental principles of food science and chemistry	-	1	-	1	1	2	1	-	3	1	3	1	-	1	-
CO2. Outline beneficial and harmful effects of microorganisms.	-	1	-	-	-	-	3	-	3	2	3	3	-	1	-
CO3. Identify microbes	-	2	1	1	-	-	3	-	3	1	3	3	-	2	1

for development of functional food															
CO4. Examine methods that increase shelf life and food quality	**1**	**1**	**1**	**-**	**2**	**2**	**2**	**3**	**-**	**1**	**3**	**3**	**1**	**1**	**1**
CO5. Compare the microbes on the basis of their morphological characteristics	**1**	**1**	**2**	**-**	**-**	**2**	**3**	**3**	**-**	**2**	**3**	**3**	**1**	**1**	**2**

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	**COs**	**SOs No.**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
PO 2,4,5,6,7,9,10,11,12 PSO 2	**CO1. Explain fundamental principles of food science and chemistry**	SO1.1 SO1.2 SO1.3 SO1.4,SO1.5, SO1.6 SO1.7, SO1.8, SO1.9	**IL 1** **IL 2**	1.1,1.2,1.3,1.4 ,1.5,1.6, 1.7, 1.8, 1.9	**1SL-1,2**
PO 2,7,9,10,11,12 PSO 2,	**CO2. Outline beneficial and harmful effects of microorganisms.**	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5,SO2.6 SO2.7 SO2.8	**IL 1** **IL 2**	2.1, 2.2, 2.3, 2.4,2.5,2.6,2.7, 2.8, 2.9	**2SL-1,2**

		So2.9			
PO 2,3,4, 7,9,10,11,12 PSO 2, 3	**CO3. Identify microbes for development of functional food**	SO3.1 SO3.2 SO3.3 SO3.4 ,3.5,SO3 .6 SO3.7 SO3.8 SO3.9	**IL 1** **IL 2**	3.1,3.2,3.3,3.4.3.5,3.6,3.7, 3.8 ,3.9	**3SL-1,2**
PO 1,2,3,5,6 7,8,10,11,12 PSO 1,2, 3	**CO4. Examine methods that increase shelf life and food quality**	SO4.1 SO4.2 SO4.3 SO4.4 ,SO4.5,S O4.6 SO4.7 SO4.8 SO4.9	**IL 1** **IL 2**	4.1,4.2,4.3,4.4,4.5,4.6, 4.7, 4.8, 4.9	**4SL-1,2**
PO 1,2,3,4,5,6 7,9,10,11,12 PSO 1,2, 3	**CO5. Compare the microbes on the basis of their morphological characteristics**	SO5.1 SO5.2 SO5.3 SO5.4 ,SO5.5,S O5.6 SO5.7 SO5.8 SO5.9	**IL 1** **IL 2**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8, 5.9	**5SL-1,2**

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	VI	
Course Code:	98BT606-B	
Course title:	Vaccine Technology	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of immunology and vaccines	
Rationale:	Vaccines are one of the most important discoveries in the history of Medicine. These biological preparations have been highly successful in preventing infectious diseases, significantly reducing the incidence of childhood diseases and mortality. Importance of Designing New Vaccine - Vaccine "teach" your body to defend itself from pathogens like viruses and bacteria. There are numerous viruses and bacteria discovered which can be potential disease-causing agents to Humans. To tackle these potential threats effective vaccines are required. This course will help students to explore new horizons of innovations in Vaccine designing domain.	
Course Outcomes (COs):	**CO1-98BT606-B.1.** Explain fundamental principles of vaccine science and its role in biotechnology **CO2-98BT606-B.2.** Outline the effects of Vaccine over immunity **CO3-98BT606-B.3.** Identify novel strategies for vaccine design and preservation **CO4-98BT606-B.4.** Examine methods to test the concentration of vaccine **CO5-98BT606-B.5.** Predict, Design and Compare different vaccines the basis of its production	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L: T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Elective (PE)	98BT606-B	Vaccine Technology	3	2	1	3	9	4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number	Class Test 2 (2 best out of 3)	Seminar one	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		

			3 marks each (CA)	10 marks each (CT)	(SA)					
PE	98BT606-B	Vaccine Technology	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	**Scheme of Assessment (Marks)**						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PE	98BT656-B	Vaccine Technology	35	5	5	5	50	50	50

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	0 6	01	05	21

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-98BT606-B.1. Explain fundamental principles of vaccine science and its role in biotechnology	**SO1.1** Explain the concept of Vaccines	**LI1.1** Draw the steps followed in prokaryotic /eukaryotic glycolysis pathways	**Unit-1** **CI1.1** Introduction to Vaccines	**SL1.1** Find out some conventional examples of Indian vaccines
	SO1.2 Define Basic terminology, scope and application for Vaccines	**LI1.2** Draw the steps followed in prokaryotic /eukaryotic TCA pathway	**CI1.2** Terminologies associated with Vaccines	**SL1.2** Explore conventional papers on Vaccines
	SO1.3 Elaborate the Historical Aspects of Vaccines	**LI1.3** To understand the production and consumption of ATPs involve in glycolysis and TCA cycle	**CI1.3** Historical Aspects of Vaccine	**SL1.3** Write down few points on applications of Vaccine deign

	SO1.4 Observe the Applications associated with vaccines		**CI1.4** Importance and Applications: Vaccines	**SL1.4** Write down few points on Applications of Vaccines
	SO1.5 Describe types of VAccines		**CI1.5** Vaccines and its types	**SL1.5** Collect information on career in “Vaccinomics”
	SO1.6 Discuss Role of Vaccines in today’s medical world		**CI1.6** Role of Vaccines in today’s medical world	
	SO1.7 Illustrate the Improvisations in Vaccines development		**CI1.7** Improvisations in Vaccines development	
	SO1.8 Discuss the Indian scenario with respect to Vaccines		**CI1.8** Vaccines – Indian Scenario	
	SO1.9 Revision and assessment		**CI1.9** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail about “Significance of Indian Vaccines”
	SW1.2 Mini Project	Elaborate the role of Innate Immunity
	SW1.3 Other Activities (Specify)	Draw a flowchart of Adaptive immunity

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	0 4	01	05	19

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-98BT606-B.2. Outline the effects of Vaccine over immunity	**SO2.1** Explain concept of Bacterial and Viral vaccines	**LI2.1** Demonstrate the working of Cell Disruption technique	**Unit-2** **CI2.1** Overview of bacterial and viral vaccines and their importance to public health	**SL2.1** Find out more conventional cell disruption techniques
	SO2.2 Illustrate the mechanism behind Diphtheria based Vaccines	**LI2.2** To perform the experiment of production of microbial biomass	**CI2.2** Epidemiology and pathophysiology of vaccine preventable diseases with special emphasis on Diphtheria	**SL2.2** Read the latest research in bioseparations methods
	SO2.3 Illustrate the mechanism behind Titanus based Vaccines		**CI2.3** Epidemiology and pathophysiology of vaccine preventable diseases with special emphasis on Titanus	**SL2.3** Write down few points on biological product's properties
	SO2.4		**CI2.4** Epidemiology and pathophysiology of	**SL2.4**

	Illustrate the mechanism behind Pertussis based Vaccines		vaccine preventable diseases with special emphasis on Pertussis	Find out the different kinds of filter aids and their role
	SO2.5 Explain the role of QC in Vaccine design		**CI2.5** Consistency approach for vaccine quality improvement	
	SO2.6 Discuss Role Antigens in Vaccine development		**CI2.6** Antigens used for immunizations of Equines and storage of antigens	
	SO2.7 Illustrate the Improvisations in Vaccines development by Adjuvants		**CI2.7** Adjuvants used in immunization of Equines. Storage of adjuvants	
	SO2.8 Discuss dose preparation mechanisms		**CI2.8** Dose preparation for immunization of equines and immunization of equines for production of antisera	
	SO2.9 Revision and assessment		**CI2.9** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe the role of Macrophages and Autophagy
	SW2.2 Mini Project	Make a project on Indian Vaccines
	SW2.3 Other Activities (Specify)	Make Power point presentation on Immunoinformatic

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	0 4	01	03	17

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO3-98BT606-B.3. Identify novel strategies for vaccine design and preservation	**SO3.1** Define the Regulation of Enzymatic Activity, Models of Feedback inhibition	**LI3.1** To perform the Centrifugation process as Unit Operation	**Unit-3** **CI3.1** Manufacturing bleeding of equines for production therapeutic antisera, collection and separation of plasma	**SL3.1** Find out the process of Enzyme inhibition in human metabolism
	SO3.2 Derive the mechanism for Reinfusion of RBC's in equines	**Li3.2** To prepare the RBC plate for CFU	**CI3.2** Reinfusion of RBC's in equines	**SL3.2** Read the process of how Michalis Menten equation was derived
	SO3.3 Analyze the Processing of plasma for the production of therapeutic antisera		**CI3.3** Processing of plasma for the production of therapeutic antisera	**SL3.3** Write down the steps followed in Lac operon model
	SO3.4 Distinguish among the working mechanism of different Antiserum		**CI3.4** Antiserum Filtration: Important in Vaccine Development	

	Filtration techniques			
	SO3.5 Explain the role of Testing of venoms (in vivo & in vitro)		**CI3.5** Testing of venoms (in vivo & in vitro)	
	SO3.6 Discuss Testing of toxoid (in vivo & in vitro)		**CI3.6** Testing of toxoid (in vivo & in vitro)	
	SO3.7 Illustrate the Abnormal Toxicity testing mechanism		**CI3.7** Abnormal Toxicity testing: Important factor in vaccine development	
	SO3.8 Illustrate the Abnormal Sterility testing mechanism		**CI3.8** Sterility testing: Important factor in vaccine development	
	SO3.9 Revision and assessment		**CI3.9** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe the role of Adjuvants in Vaccines
	SW3.2 Mini Project	Make a project on RBC Infusion Protocol: Vaccine Development
	SW3.3 Other Activities (Specify)	Make Power point Different Testings used in Vaccine Development

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	04	18

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-98BT606-B.4. Examine methods to test the concentration of vaccine	**SO4.1** Distinguish among different nodes and branches in MFA	**LI4.1** To perform the Column Chromatography & Filtration process as Unit Operation for extraction of different compounds	**Unit-4** **CI4.1** Production of Proteus agglutinating suspension for Weil Felix Test	**SL4.1** Find out the types of classifications of nodes in MFA
	SO4.2 Distinguish among different theories of MFA	**LI4.2** to perform Weil Felix test	**CI4.2** Production of Vibrio cholera antisera	**SL4.2** Write down some more examples of Tissue dynamics
	SO4.3 Analyze the Preparation of absorbing suspension of V. Cholera		**CI4.3** Preparation of absorbing suspension of V. Cholera	**SL4.3** List down the role of MFA in metabolism
	SO4.4 Discuss the Filtration, preservation, labelling and storage of		**CI4.4** Filtration, preservation, labelling and storage of antisera	**SL4.4** List down the steps involve in Lysine biosynthesis

	antisera			
	SO4.5 Interpret the mechanism for Immunization of rabbits		**CI4.5** Immunization of rabbits	
	SO4.6 Discuss Typhoid Antigen preparation		**CI4.6** Typhoid Antigen preparation	
	SO4.7 Illustrate the Production of *Salmonella* antisera		**CI4.7** Production of *Salmonella* antisera	
	SO4.8 Illustrate the Preparation of absorbing suspension of *Salmonella*		**CI4.8** Preparation of absorbing suspension of *Salmonella*	
	SO4.9 Revision and assessment		**CI4.9** Revision and assessment	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	9	02	01	05	17

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Determine the working mechanism and applications of Tissue Dynamics
	SW4.2 Mini Project	Derive the Qualitative and Quantitative data optimization and retrieval through MFA in isotopic labelling
	SW4.3 Other Activities (Specify)	Make a presentation on Lysine biosynthesis and its importance in metabolism

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory**	**Class room Instruction (CI)**	**Self-Learning (SL)**

		Instruction (LI)		
CO5-98BT606-B.5. Predict, Design and Compare different vaccines the basis of its production	**SO5.1** Elucidate the protocol for testing of Vaccines	**LI5.1** To determine the AA sequences comparison on the basis of peptide mapping using ProteoMapper (Server/tool)	**Unit-5** **CI5.1** Maintenance and use of national reference standards for testing of vaccines	**SL5.1** Explore amino acid metabolism in eukaryotes
	SO5.2 Interpret the role of animals in the quality control testing of vaccines		**CI5.2** Role of animals in the quality control testing of vaccines	**SL5.2** Write down the enzymes associated in glycolysis
	SO5.3 Describe the maintenance and handling of small laboratory animals during quality control testing		**CI5.3** Maintenance and handling of small laboratory animals during quality control testing	**SL5.3** List down various kinds of amino acids and their structures
	SO5.4 Describe the Ethical Aspects and Issues in vaccine Design and Development		**CI5.4** Ethical Aspects and Issues in vaccine Design and Development	**SL5.4** List down the applications of CRISPR
	SO5.5 Describe Active viable air sampling of classified areas		**CI5.5** Active viable air sampling of classified areas by HI-AIR PETRITM AIR SAMPLING SYSTEM	**SL5.5** List down the various bioinformatics-based server/tool that assist in study of metabolism
	SO5.6 Explain the different types of reporting methods		**CI5.6** Preparation of results, documentation, reporting and maintenance of records	
	SO5.7 Discuss Quality control tests of antisera: Potency		**CI5.7** Quality control tests of antisera: Potency test.	

	test.			
	SO5.8 Illustrate the Production of *COVID-19 Vaccine*		**CI5.8** Production of *COVID-19 Vaccine*	
	SO5.9 Illustrate the Preparation COVID-19 Vaccines – Indian Scenario. Discuss Immunoinformatics and Epitope Design		**CI5.9** COVID-19 Vaccines – Indian Scenario Immunoinformatics and Epitope Design: Dry Lab method in Vaccine designing	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general mechanism behind Preparation of COVID-19 Vaccines
	SW5.2 Mini Project	Describe the applications of Vaccines
	SW5.3 Other Activities (Specify)	Prepare one article on the "Immunological Response of COVID-19 Vaccines"

Course duration (in hours) to attain Course Outcomes:

Course Title: Vaccine Technology **Course Code:** 98BT606-B

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98BT606-B.1. Explain fundamental principles of vaccine science and its role in biotechnology	9	6	5	1	21
CO2-98BT606-B.2. Outline the effects of Vaccine over immunity	9	4	5	1	19
CO3-98BT606-B.3. Identify novel strategies for vaccine design and preservation	9	4	3	1	17
CO4-98BT606-B.4. Examine methods to test the concentration of vaccine	9	4	4	1	18
CO5-98BT606-B.5. Predict, Design and Compare different vaccines the basis of its	9	2	5	1	19

production					
Total Hours	45	20	22	05	94

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Vaccine Technology **Course Code:** 98BT606-B

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-98BT606-B.1. Explain fundamental principles of vaccine science and its role in biotechnology	2	1	1	1	5
CO2-98BT606-B.2. Outline the effects of Vaccine over immunity	2	4	5	1	12
CO3-98BT606-B.3. Identify novel strategies for vaccine design and preservation	3	5	5	1	14
CO4-98BT606-B.4. Examine methods to test the concentration of vaccine	2	3	5	1	11
CO5-98BT606-B.5. Predict, Design and Compare different vaccines the basis of its production	5	4	1	0	10
Total Marks	**14**	**17**	**17**	**04**	**52**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

Books:

S.No.	Title/Author/Publisher details
1	Vaccines. 6th Edition, Stanley Plotkin Walter Orenstein Paul Offit.
2	New Generation Vaccines. Fourth Edition, Myrone M. Levine, Myron M. Levine, Gordon Dougan , Michael F. Good , Margaret A. Liu , Gary J. Nabel , James P. Nataro, Rino Rappuoli.
3	J.C. Janson And L. Ryden, (Ed.) – Protein Purification – Principles, High Resolution Methods And Applications, VCH Pub. 1989.
4	Fundamentals of Biochemistry. Author, JL Jain et al. Edition, reprint. Publisher, S. Chand Publishing, 2004.
5	Kuby Immunology. Thomas J. Kindt, Richard A. Goldsby, Barbara A. Osborne, Janis Kuby

6	"Biotechnology – Questioning The Reasons" – 2nd Edition, Arpit Srivastava, (2024), Book Rivers Publication - India

Online Resources:

Suggested instructions/Implementation strategies:

Improved lecture
Tutorial
Case method
Group Discussion
Role play
Visit to Waste water/Effluent Treatment plant and downstream pharmaceutical plants
Demonstration
ICT Based teaching Learning
Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: VI Semester

Course Title: Vaccine Technology

Course Code: 98BT606-B

CO/PO Mapping		
Course Outcome	**Program Outcomes (POs)**	**Program Specific Outcomes (PSOs)**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-98BT606-B.1. Explain fundamental principles of vaccine science and its role in biotechnology	-	1	-	1	2	2	3	-	3	2	2	3	1	2	1
CO2-98BT606-B.2. Outline the effects of Vaccine over immunity	-	1	-	-	1	-	3	1	2	2	3	3	2	-	2
CO3-98BT606-B.3. Identify novel strategies for vaccine design and preservation	-	1	1	1	-	-	1	-	2	1	1	2	3	2	-
CO4-98BT606-B.4. Examine methods to test the concentration of vaccine	-	-	1	-	2	2	3	3	-	1	3	3	2	1	3
CO5-98BT606-B.5. Predict, Design and Compare different vaccines the basis of its production	1	-	1	2	-	2	3	3	1	2	2	2	1	1	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs	COs	SOs No.	Laboratory	Classroom	Self-Learning (SL)

No.			Instruction (LI)	Instruction (CI)	
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-98BT606-B.1.** Explain fundamental principles of vaccine science and its role in biotechnology	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8	**LI 1** **LI 2** **LI 3**	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8	**1SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-98BT606-B.2.** Outline the effects of Vaccine over immunity	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8	**LI 1** **LI 2**	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8	**2SL-1,2,3,4**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3-98BT606-B.3.** Identify novel strategies for vaccine design and preservation	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8	**LI 1**	3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8	**3SL-1,2,3**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-98BT606-B.4.** Examine methods to test the concentration of vaccine	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO1.7 SO1.8	**LI 1**	4.1,4.2,4.3,4.4, 4.5, 4.6, 4.7, 4.8	**4SL-1,2,3,4**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO5-98BT606-B.5.** Predict, Design and Compare different vaccines the basis of its production	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9 SO5.10	**LI 1** **LI 2**	5.1,5.2,5.3,5.4,5.5, 5.6, 5.7, 5.8, 5.8, 5.9, 5.10	**5SL-1,2,3,4,5**

Program Name	**B. Tech. Biotech Semester-**	
Semester	**VIth**	
Course Code:	98BT606-C	
Course title:	**Bio-programming and Soft Computing Techniques**	**Curriculum Developer**: Mr. Piyush Kant Rai, Teaching associate
Pre-requisite:	Students must have knowledge of Bio-programming and Soft Computing Techniques.	
Rationale:	The paper on Bio-programming and Soft Computing Techniques in B. Tech. Biotech Semester-VIth program explores the Bio-programming and soft computing techniques integrate principles from biology and computer science to develop innovative solutions for complex problems. By mimicking biological processes such as evolution, neural networks, and genetic algorithms, these techniques offer efficient ways to model, analyze, and optimize systems in various fields such as healthcare, bioinformatics, and robotics. They enable advancements in personalized medicine, biomolecular engineering, and adaptive systems, contributing to interdisciplinary research and technological innovation.	
Course Outcomes (COs):	**CO1 98BT606-C. Understand about the biocomputing methods, principles and practices.** **CO2 98BT606-C. Outline the advanced genomics, transcriptomics and proteomics methods** **CO3 98BT606-C. Apply web-based methods and tools for simulation of biological problems** **CO4 98BT606-C. Analyse vaccine designing and protein-ligand interactions for drug discovery** **CO5 98BT606-C. Compare various databases and softwares used in Bio-computing**	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=3:0:1)
			CI	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Elective (PE)	98BT606-C	**Bio-programming and Soft Computing Techniques**	3	2	1	1	7	4

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks
				Class		Class	Total Marks		

			Class/ Home Assignment 5 number 3 marks each (CA)	Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Attendance (AT)	(CA+CT+SA+AT)		(PRA+ ESA)
Program Elective (PE)	**98BT606-C**	**Bio-programming and Soft Computing Techniques**	15	20	5	5	5	50	50

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		

			(CA)						
Program Elective (PE)	**98BT656-C**	**Bio-programming and Soft Computing Techniques**	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	9	04	01	03	17

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
98BT606-CCO1. Understand about the biocomputing methods,	SO1.1: Install and configure R programming software	LI1.1: Installation of R program via R Project installer	CI1.1: Introduction to R programming: Overview of the R language and its features	SL1.1: Explore the R Project website for additional resources and help

principles and practices.	SO1.2: Understand the concept of R projects and basic programming concepts	LI1.2: Create a new R project and execute basic scripts	CI1.2: Defining R projects, obtaining R, and generating R code using scripts and editors	SL1.2: Research the significance of R scripts and the available text editors for R programming
	SO1.3: Learn about the graphical user interfaces (GUIs) in R		CI1.3: Features of R GUIs: Vectors, matrices, and data frames	SL1.3: Explore how GUIs enhance ease of use in R programming
	SO1.4: Explore the datasets included in R packages		CI1.4: Overview of datasets included in R packages and their utility	
	SO1.5: Learn how to manipulate objects and perform mathematical operations in R		CI1.5: Manipulating objects, graphics basics, and mathematical operations in R	
	SO1.6: Understand matrix computation and regular sequences in R		CI1.6: Matrix computation and regular sequences in R programming	
	SO1.7: Apply strings and pattern matching in R		CI1.7: Strings and pattern matching: Techniques and applications	
	SO1.8: Conduct hypothesis testing using t-tests in R		CI1.8: Hypothesis testing and data handling in R	
	SO1.9: Learn the basics of ANOVA		CI1.9: Introduction to ANOVA:	

	in R		Basics and application in R programming	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Write about the R packages
	SW1.2 Mini Project	Learn different types of libraries in R
	SW1.3 Other Activities (Specify)	What is annova do a thorough searching

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
98BT606-C CO2. Outline the advanced genomics, transcriptomics and proteomics	SO2.1: Introduction to MATLAB basics	LI2.1: Introduction to MATLAB	CI2.1: Overview of MATLAB: Features and functionality	SL2.1: Explore MATLAB's history and significance
	SO2.2: Learn to use MATLAB as a calculator	LI2.2: Perform calculations using MATLAB tools	CI2.2: Using MATLAB as a calculator: Basic operations and examples	SL2.2: Research advanced uses of MATLAB as a computational tool

Item	Cl	LI	SW	SL	Total
Approx. Hrs	**09**	4	1	3	17

methods	SO2.3: Understand standard MATLAB windows		CI2.3: Introduction to standard MATLAB windows and their functionalities	SL2.3: Review the steps to access and call MATLAB tools
	SO2.4: Perform operations with variables in MATLAB		CI2.4: Operations with variables: Basic concepts and usage in MATLAB	
	SO2.5: Understand operations with arrays in MATLAB		CI2.5: Working with arrays: Operations and applications	
	SO2.6: Learn how to write script files in MATLAB		CI2.6: Writing script files: Syntax, structure, and debugging	
	SO2.7: Learn to write functions and create simple graphics		CI2.7: Writing functions and generating graphics in MATLAB	
	SO2.8: Explore data types and file input-output in MATLAB		CI2.8: Data types and file handling: Basics and practical applications in MATLAB	
	SO2.9: Understand communication with external devices via MATLAB		CI2.9: Communication with external devices: Examples and applications	

Suggested Sessional	**SW2.1** Assignments	Write about the basics of MATLAB

Work (SW): *anyone*	**SW2.2** Mini Project	List a various operations and array used in MATLAB
	SW2.3 Other Activities (Specify)	Find out some you tube videos based on how to getting started with MATLAB

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
98BT606-C CO3. Apply web-based methods and tools for simulation of biological problems	SO3.1: Learn to write the first Python program using PyCharm	LI3.1: Write the first Python program using PyCharm	CI3.1: Introduction to Python: Basics and features	SL3.1: Review the basic principles of Python programming
	SO3.2: Understand the features of Python	LI3.2: Learn the data input and output operations in Python	CI3.2: Features of Python and its applications	SL3.2: Understand how Python processes and executes code
	SO3.3: Explore data types, variables, and		CI3.3: Data types, variables, operators:	SL3.3: Explore the features of

Item	Cl	LI	SW	SL	Total
Approx. Hrs	**09**	4	**1**	3	17

	operators in Python		Basics and examples	PyCharm as a Python IDE
	SO3.4: Study expressions and their usage in Python - Part 1		CI3.4: Data types, variables, operators, and expressions: Introduction	
	SO3.5: Study expressions and their usage in Python - Part 2		CI3.5: Data types, variables, operators, and expressions: Advanced concepts	
	SO3.6: Understand functions and data structures in Python		CI3.6: Functions and data structures: Basics and examples	
	SO3.7: Learn input and output operations in Python		CI3.7: Input and output operations: Syntax and applications	
	SO3.8: Introduction to object-oriented programming in Python (CSS and Zope) - Part 1		CI3.8: Object-oriented programming (CSS and Zope): Overview	
	SO3.9: Introduction to object-oriented programming in Python (CSS and Zope) - Part 2		CI3.9: Object-oriented programming (CSS and Zope): Advanced concepts	

Suggested Sessional Work	**SW3.1** Assignments	Write about the Objected oriented CSS

(SW): *anyone*	**SW3.2** Mini Project	
	SW3.3 Other Activities (Specify)	Employ the python programming skill to make a DNA base counter

Item	Cl	LI	SW	SL	Total
Approx. Hrs	**09**	4	1	1	15

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
98BT606-C CO4. Analyse vaccine designing and protein-ligand interactions for drug discovery	SO4.1: Learn the fundamentals of soft computing techniques	LI4.1: Create the first algorithm for biological sequences	CI4.1: Introduction to soft computing techniques and algorithms	SL4.1: Study the basics of soft computing and its real-world applications
	SO4.2: Understand the concept of soft computing in bioinformatics	LI4.2: Search for the gene-gene network in the KEGG database	CI4.2: Overview of soft computing applications in bioinformatics	
	SO4.3: Explore the application of Hidden Markov Models (HMMs) in bioinformatics		CI4.3: Hidden Markov Models: Applications in bioinformatics	
	SO4.4: Understand Artificial Neural Networks (ANN) basics - Part 1		CI4.4: Artificial Neural Networks (ANN): Introduction	
	SO4.5: Study the types of Artificial Neural Networks		CI4.5: Types of ANN: Applications and examples	

	SO4.6: Learn identification techniques and lead optimization - Part 1		CI4.6: Identification techniques: Lead optimization basics	
	SO4.7: Learn identification techniques and lead optimization - Part 2		CI4.7: Lead optimization: Advanced strategies and examples	
	SO4.8: Study the basic concepts and applications of Genetic Algorithms - Part 1		CI4.8: Genetic Algorithms: Basic concepts and workflow	
	SO4.9: Study the basic concepts and applications of Genetic Algorithms - Part 2		CI4.9: Genetic Algorithms: Applications in bioinformatics	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	prepare a flow chart of classical case of ANN
	SW4.2 Mini Project	
	SW4.3 Other Activities (Specify)	Relate The genetic algorithm with ANN

item	Cl	LI	SW	SL	Total
Approx. Hrs	**09**	4	1	2	16

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
98BT606-C CO5. Compare various databases and software's used in Bio-computing	SO5.1: Learn the basics of VB programming	LI5.1: Create an HTML file using VB	CI5.1: Introduction to VB programming: Features and applications	SL5.1: Revise the fundamentals of VB programming
	SO5.2: Understand client/server technology and its introduction	LI5.2: Create the first program using Visual Basic	CI5.2: Overview of client/server technology in VB	SL5.2: Explore the importance of client/server technology in programming
	SO5.3: Explore data types and strings in VB		CI5.3: Data types and strings: Concepts and examples	
	SO5.4: Study variants, constants, and data arrays in VB		CI5.4: Variants, constants, and data arrays: Basics and applications	

	SO5.5: Learn looping and interactive statements in VB		CI5.5: Looping and interactive statements: Examples and best practices	
	SO5.6: Understand controls and procedures in VB		CI5.6: Controls and procedures: Introduction and functionality	
	SO5.7: Introduction to data connectivity in VB - Part 1		CI5.7: Introduction to data connectivity: Overview and basics	
	SO5.8: Introduction to data connectivity in VB - Part 2		CI5.8: Data connectivity in VB: Advanced concepts and examples	
	SO5.9: Explore different database connectivity options in VB		CI5.9: Different database connectivity techniques: Practical overview	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	illustrate the theories of DATA types
	SW5.2 Mini Project	
	SW5.3 Other Activities (Specify)	Rewrite the Scope and limitations of VB

Course duration (in hours) to attain Course Outcomes:

Course Title: Bio-programming and Soft Computing Techniques **Course Code: 98BT606-C**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
98BT606-C CO1. Understand about the biocomputing methods, principles and practices.	9	4	3	1	17
98BT606-C CO2. Outline the advanced genomics, transcriptomics and proteomics methods	9	4	3	1	17
98BT606-C CO3. Apply web-based methods and tools for simulation of biological problems	9	4	3	1	17
98BT606-C CO4. Analyse vaccine designing and protein-ligand interactions for drug discovery	9	4	1	1	15
98BT606-C CO5. Compare various databases and software's used in Bio-	9	4	2	1	13

computing					
Total Hours	45	20	12	5	79

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Bio-programming and Soft Computing Techniques **Course Code:**

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
98BT606-C CO1. Understand about the biocomputing methods, principles and practices.	03	02	04	1	10
98BT606-C CO2. Outline the advanced genomics, transcriptomics and proteomics methods	03	04	02	1	10
98BT606-C CO3. Apply web-based methods and tools for simulation of biological problems	03	04	02	1	10
98BT606-C CO4. Analyse vaccine designing and protein-ligand interactions for drug discovery	03	03	03	1	10
98BT606-C CO5. Compare various databases and software's used in Bio-computing	03	02	04	1	10
Total Marks	15	15	15	05	50

Legend: **A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

Books:

S.No.	Title/Author/Publisher details
1	Nathan Yan The Art of R Programming No Starch Press,US; 7 edition 2016
2	Rudra Prathap –Getting started with MATLAB oxford 2019
3	**Soft Computing: Fundamentals and Applications Alpha Science International Ltd** 2015

Online Resources:

Suggested instructions/Implementation strategies:

Improved lecture
Tutorial
Case method
Group Discussion
Role play
Visit to bioinformatics lab
Demonstration
ICT Based teaching Learning
Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: 6th Sem

Course Title: Bio-programming and Soft Computing Techniques

Course Code: 98BT606-C

CO/PO/PSO Mapping															
Course Outcome (Cos)	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
98BT606-C CO1. Understand about the biocomputing methods,	-	1	-	1	2	2	3	-	3	3	3	3	-	1	-

principles and practices.															
98BT606-C CO2. Outline the advanced genomics, transcriptomics and proteomics methods	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**-**	**3**	**2**	**3**	**3**	**-**	**-**	**-**
98BT606-C CO3. Apply web-based methods and tools for simulation of biological problems	**-**	**-**	**1**	**1**	**-**	**-**	**3**	**-**	**3**	**1**	**-**	**-**	**-**	**-**	**1**
98BT606-C CO4. Analyse vaccine designing and protein-ligand interactions for drug discovery	**1**	**-**	**1**	**-**	**2**	**-**	**3**	**3**	**-**	**1**	**-**	**1**	**1**	**-**	**1**
98BT606-C CO5. Compare various databases and	**1**	**1**	**1**	**-**	**-**	**2**	**3**	**3**	**1**	**2**	**3**	**3**	**1**	**1**	**1**

software's used in Bio-computing															

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	**COs**	**SOs No.**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
PO 2,4,5,6 7,9,10,11,12 PSO 2	**98BT606-C CO1. Understand about the biocomputing methods, principles and practices.**	SO1.1 SO1.2 SO1.3 SO1.4,SO1.5, SO1.6, SO1.7, SO1.8,SO1.9 SP1.10	**IL 1** **IL 2**	1.1,1.2,1.3,1.4 ,1.5,1.6, 1.7, 1.8, 1.9	**1SL-1,2,3**
PO 7,9,10,11,12	**98BT606-C CO2. Outline the advanced genomics, transcriptomics and proteomics methods**	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5,SO2.6SO2.7 SO2.8 SO2.9	**IL 1** **IL 2**	2.1, 2.2, 2.3, 2.4,2.5,2.6, 2.7, 2.8, 2.9	**2SL-1,2,3**
PO 3,4,5, 7,9,10	**98BT606-C CO3. Apply web-based methods and tools for simulation of biological problems**	SO3.1 SO3.2 SO3.3 SO3.4 ,3.5,SO3.6,SO3.7, SO3.8 SO3.9	**IL 1** **IL 2**	3.1,3.2,3.3,3.4.3.5,3.6,3.7, 3.8, 3.9	**3SL-1,2,3**

PSO 3					
PO 1,3,5, 7,8,10,12 PSO 1,3	**98BT606-C CO4. Analyse vaccine designing and protein-ligand interactions for drug discovery**	SO4.1 SO4.2 SO4.3 SO4.4 ,SO4.5,SO4.6,SO4.7 SO4.8 SO4.9	**IL 1** **IL 2**	4.1,4.2,4.3,4.4,4.5,4.6,4.7, 4.8, 4.9	**4SL-1**
PO 1, 2,3,6 7,8,10,11,12 PSO 1,2, 3	**98BT606-C CO5. Compare various databases and software's used in Bio-computing**	SO5.1 SO5.2 SO5.3 SO5.4 ,SO5.5,SO5.6,SO5.7 SO5.8 SO5.9	**IL 1** **IL 2**	5.1,5.2,5.3,5.4,5.5,5.6,5.7, 5.8, 5.9	**5SL-1,2**

Program name	Bachelor of Technology (B. Tech.)- Biotechnology	
Semester	VIIth	
Course Code:	98BT701	
Course title:	Stem Cell & Tissue Engineering	**Curriculum Developer**: Dr. Monika Soni, Assistant Professor
Pre-requisite:	Students should have basic knowledge of stem cell & tissue engineering	
Rationale:	The subject aims to provide an overview of stem cells & tissue engineering, and describe the current progress with stem cell research in tissue engineering, and the potential implications on medical treatment.	
Course Outcomes (COs):	**CO1-98BT701.1**: To explain about fundamentals of tissue engineering and define the role in stem cell research. **CO2-98BT701.2**: To study about the biomaterials for tissue engineering. **CO3-98BT701.3**: To understand the biological study of different cell types. **CO4-98BT701.4**: To understand the principle and practice of gene therapy. **CO5-98BT701.5**: To study about the development of artificial tissues by tissue engineering.	

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=3:0:1)
			CI	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
Program Common(PC)	98BT701	Stem Cell & Tissue Engineering	3	2	1	2	8	3+1=4

Scheme of Studies:

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA+CAT+AT)		
PE	98BT701	Stem Cell & Tissue Engineering	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
PE	98BT751	Stem Cell & Tissue Engineering-lab	15	20	10	5	50	50	100

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Item	CI	LI	SW	SL	Total
Approx. Hours	9	4	1	5	19

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO1-98BT701.1: To explain about fundamentals of tissue engineering and define the role in stem cell research.			**Unit-1**	
	SO1.1 Explain in detail about introduction to tissue engineering.		**CI1.1** Brief details of introduction to tissue engineering.	**SL1.1** Search vario reference books and oth study material to start t learning about stem cell tissue engineering.
	SO1.2 Explain in detail to sources of cells for tissue engineering.		**CI1.2** Describe the sources of cells for tissue engineering.	
	SO1.3 Describe & define the culture methods in tissue engineering.		**CI1.3** Study the culture methods in tissue engineering.	**SL1.2** Learn about the c therapies in stem cell & tiss engineering.
	SO1.4 Explain in detail to the maturation of tissue constructs.	**LI1.1** To understand the basics of tissue engineering and practice cell culture techniques for tissue construct formation.	**CI1.4** Study the maturation of tissue constructs.	**SL1.3** Learn about the tiss construction & creation.
	SO1.5 Explain in detail to the musculoskeletal tissue engineering.		**CI1.5** Study the musculoskeletal tissue engineering.	
	SO1.6 Describe the modifications of tissue rings.		**CI1.6** Understand the modifications of tissue rings.	
	SO1.7 Explain in detail to the receptor-ligand interactions in tissue engineering.	**LI1.2** To investigate receptor-ligand interactions using a biochemical assay.	**CI1.7** Understand the receptor-ligand interactions in tissue engineering.	**SL1.4** Learn about differe receptors & their ligar interaction in tiss engineering.
	SO1.8 Describe the receptor engineering in tissue engineering.		**CI1.8** Study the receptor engineering in tissue engineering.	

	SO1.9 Describe the cosmetics measures in tissue engineering. Explain in detail to the future directions in tissue engineering. Describe the regulatory considerations in tissue engineering. Explain in detail to the organ modules in tissue engineering.		**CI1.9** Study the cosmetics measures in tissue engineering. Study the future directions in tissue engineering. Study the organ modules in tissue engineering. Study the regulatory considerations in tissue engineering.	**SL1.5** Learn about advanc topics in tissue engineering.

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignment	Describe in detail to tissue creation & construction.
	SW1.2 Mini Project	Describe the receptors & their ligand interaction in tissue engineering.
	SW1.3 Other Activities (Specify)	Explain the cell therapies in stem cell & tissue engineering.

Item	CI	LI	SW	SL	Total
Approx. Hours	9	4	1	5	19

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO2-98BT701.2: To study about the biomaterials for tissue engineering.			**Unit-2**	
	SO2.1 Explain in detail introduction to tissue engineering related to biomaterials and bioreactors.		**CI2.1** Brief details of introduction to tissue engineering related to biomaterials and bioreactors.	**SL2.1** Search vario reference books and oth study material to start t learning about biomaterials.
	SO2.2 Explain in detail the biomaterials in tissue engineering.		**CI2.2** Study the biomaterials in tissue engineering.	

	SO2.3 Describe & define the polymeric scaffolds and cell seeding.	**LI2.1** To fabricate degradable polymeric scaffolds and seed cells onto the fabricated scaffolds.	**CI2.3** Study the polymeric scaffolds and cell seeding.	**SL2.2** Understanding degradable polymer scaffolds in tissue engineerin
	SO2.4 Explain in detail to cell sources in tissue engineering.		**CI2.4** Brief details to cell sources in tissue engineering.	**SL2.3** Explore the role acellular bio-matrices in tissu engineering.
	SO2.5 Explain in detail to the stem cells in tissue engineering.		**CI2.5** Study the stem cells in tissue engineering.	**SL2.4** Explore the role of ste cells as cell sources in tissu engineering.
	SO2.6 Explain in detail to bioreactors in tissue engineering.		**CI2.6** Brief details to bioreactors in tissue engineering.	
	SO2.7 Describe the nail naughton's bioreactor.	**LI2.2** To operate Nail Naughton's bioreactor and culture cells within the bioreactor under controlled conditions.	**CI2.7** Brief details to nail naughton's bioreactor.	
	SO2.8 Describe the pulsatile bioreactors.		**CI2.8** Brief details to pulsatile bioreactors.	
	SO2.9 Describe the scaffold fabrication techniques. Explain in detail on emerging trends and future directions. Explain in detail the tissue engineering applications. Describe the regulatory considerations		**CI2.9** Study the scaffold fabrication techniques. Study the regulatory considerations. Understand the tissue engineering applications. Discussion on emerging trends and future directions.	**SL2.5** Learn about natural ar synthetic biological-derive polymers used in tissu engineering.

Suggested Sessional	**SW1.1** Assignment	Describe in detail about biomaterials used in tissue engineering.

Work (SW): *anyone*	**SW1.2** Mini Project	Describe the biological derived polymers & their function & mechanism.
	SW1.3 Other Activities (Specify)	Explain the parts of bioreactors.

Item	CI	LI	SW	SL	Total
Approx. Hours	9	4	1	2	16

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO3-98BT701.3: To understand the biological study of different cell types.			**Unit-3**	
	SO3.1 Explain in details to cell lines and cell culture.		**CI3.1** Brief details of cell lines and cell culture.	**SL3.1** Search vario reference books and oth study material to start th learning about cell lines.
	SO3.2 Explain in details to establishment of cell lines.		**CI3.2** Brief details to establishment of cell lines.	**SL3.2** Understand the proce of establishing cell lines an its importance in research an medicine.
	SO3.3 Explain in detail to endothelial cells.	**LI3.1** To learn the techniques for establishing primary cell cultures from different cell types.	**CI3.3** Study the endothelial cells.	
	SO3.4 Explain in detail to fibroblast cells.	**LI3.1** To identify and characterize different cell types in primary cell cultures.	**CI3.4** Study the fibroblast cells.	
	SO3.5 Explain in detail to epithelial cells.		**CI3.5** Study the epithelial cells.	
	SO3.6 Explain in detail to myoblast cells.		**CI3.6** Study the myoblast cells.	
	SO3.7 Explain in detail to chromaffin cells.		**CI3.7** Study the chromaffin cells.	

	SO3.8 Explain in detail to smooth muscle cells.		**CI3.8** Study the smooth muscle cells.	
	SO3.9 Explain in detail to plasma cells. Explain in detail the applications of cell lines. Explain in detail the pros & cons to cell lines. Discussion on findings of specific cell types.		**CI3.9** Study the plasma cells. Study the applications of cell lines. Study the pros & cons to cell lines. Study the findings of specific cell types.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignment	Describe in details to cell lines.
	SW3.2 Mini Project	Explain in details of different cell types & its function, and application.
	SW3.3 Other Activities (Specify)	Prepare one review article on cell lines.

Item	CI	LI	SW	SL	Total
Approx. Hours	9	4	1	5	19

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO4-98BT701.4: To understand the principle and practice of gene therapy.			**Unit-4**	
	SO4.1 Describe and define the gene therapy.		**CI4.1** Brief details to introduction to gene therapy.	**SL4.1** Search vario reference books and oth study material to start tl learning about transgen animals.
	SO4.2 Explain in detail to requirements of gene therapy.		**CI4.2** Study the requirements of gene therapy.	**SL4.2** Understand tl essential components ar considerations for successf gene therapy interventions.
	SO4.3 Describe the genetic		**CI4.3** Study the genetic defects.	**SL4.3** Study the genet

	defects.			diseases on the basis molecular level and the implications for gene therapy
	SO4.4 Explain in detail to targeted cells for gene therapy.	**LI4.1** To understand gene delivery methods and evaluate transduction efficiency in target cells.	**CI4.4** Study the targeted cells for gene therapy.	
	SO4.5 Explain in detail to process of gene therapy.	**LI4.2** To investigate target cell specificity and regulate gene expression in vitro.	**CI4.5** Study the process of gene therapy.	
	SO4.6 Describe in detail to the factors responsible for effective gene therapy.		**CI4.6** Brief in details the factors responsible for effective gene therapy.	
	SO4.7 Describe the recent developments in gene therapy research.		**CI4.7** Study the recent developments in gene therapy research.	**SL4.4** Stay updated on th latest advancements an breakthroughs in the field gene therapy.
	SO4.8 Explain in detail ethical considerations of gene therapy.		**CI4.8** Study the ethical considerations of gene therapy.	**SL4.5** Explore the ethic implications surrounding th development and applicati of gene therapy.
	SO4.9 Explain in detail the applications of gene therapy. gene therapy. concepts and their implications for healthcare and society.		**CI4.9** Study the applications of gene therapy. the gene therapy concepts and their implications for healthcare and society.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe the genetic defects.
	SW4.2 Mini Project	Describe in the detail of gene therapy and its application.
	SW4.3 Other Activities (Specify)	Study one research article on gene therapy.

Item	CI	LI	SW	SL	Total
Approx. Hours	9	4	1	1	15

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO5-98BT701.5: To study about the development of artificial tissues by tissue engineering.			**Unit-5**	
	SO5.1 Describe in details to tissue engineering and artificial tissues.		**CI5.1** Brief details of introduction to tissue engineering and artificial tissues.	**SL5.1** Search vario reference books and oth study material to start t learning about tiss engineering & transplantati biology.
	SO5.2 Explain in detail the basic concepts in transplantation biology.		**CI5.2** Study the basic concepts in transplantation biology.	
	SO5.3 Explain in detail the tissue typing.		**CI5.3** Brief in details the tissue typing.	
	SO5.4 Explain in detail the techniques of tissue typing.	**LI5.1** To familiarize students with the techniques used in tissue typing for transplantation.	**CI5.4** Brief in details the techniques of tissue typing.	
	SO5.5 Explain in detail the minor histocompatibility antigens.		**CI5.5** Study the minor histocompatibility antigens.	
	SO5.6 Explain in detail the immunosuppression in transplantation.	**LI5.2** To investigate the effects of immunosuppressive drugs on immune cell function.	**CI5.6** Study the immunosuppression in transplantation.	
	SO5.7 Explain in detail to types of immunosuppression.		**CI5.7** Study the types of immunosuppression.	

	SO5.8 Describe in detail the side effects of immunosuppression.		**CI5.8** Study the side effects of immunosuppression.	
	SO5.9 Describe in detail the alternative approaches to immunosuppression. clinical applications of tissue engineering.		**CI5.9** Study the alternative approaches to immunosuppression. clinical applications of tissue engineering.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain in detail about transplantation biology.
	SW5.2 Mini Project	Describe in the detail of tissue typing & its techniques.
	SW5.3 Other Activities (Specify)	Study review articles on the minor histocompatibility antigens.

Course duration (in hours) to attain Course Outcomes:

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98BT701.1: To explain about fundamentals of tissue engineering and define the role in stem cell research.	9	4	5	1	19
CO2-98BT701.2: To study about the biomaterials for tissue engineering.	9	4	5	1	19
CO3-98BT701.3: To understand the biological study of different cell types.	9	4	2	1	16
CO4-98BT701.4: To understand the principle and practice of gene therapy.	9	4	5	1	19
CO5-98BT701.5: To study about the development of artificial tissues by tissue engineering.	9	4	1	1	15
Total Hours	45	20	18	05	88

Course Title: Stem cell & tissue engineering **Course Code:** 98BT701

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcomes:

Course Title: Stem cell & tissue engineering **Course Code:** 98701

***Legend*: R,** Remember; **U,** Understand; **A,** Apply; **A,** Analyze

Course Outcomes	**Marks Distribution**				**Total Marks**
	R	**U**	**A**	**A**	
CO1-98BT701.1: To explain about fundamentals of tissue engineering and define the role in stem cell research.	2	2	3	2	9
CO2-98BT701.2: To study about the biomaterials for tissue engineering.	2	3	3	3	11
CO3-98BT701.3: To understand the biological study of different cell types.	2	3	3	2	10
CO4-98BT701.4: To understand the principle and practice of gene therapy.	2	3	3	2	10
CO5-98BT701.5: To study about the development of artificial tissues by tissue engineering.	2	2	3	3	10
Total Marks	**10**	**13**	**15**	**12**	**50**

Suggested learning Resources:

(a) Books:

S.No.	**Title/Author/Publisher details**
1.	Robert Lanza, Robert Langer, Joseph P. Vacanti, and Antonios G. Mikos., Principles of Tissue Engineering. Academic Press.
2.	Jonathan Slack., Stem Cells: A Very Short Introduction. New York Oxford University Press, 2016.
3.	Robert Lanza, Anthony Atala, and Helen M. Blau., Essentials of Stem Cell Biology. Academic Press, 2014
4.	Eapen Cherian, G Nandhini, Anil Kurian., Stem Cells. Jaypee Brothers Medical Publishers (P) Ltd. 2011.

(b) Online Resources:
Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to stem cell biology lab
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: VII[th] Semester

Course Title: Stem cell & tissue engineering

Course Code: 98BT701

CO/PO/PSO Mapping															
Course Outcome (Cos)	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO 4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO1 0**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-98BT701.1: To explain about fundamentals of tissue engineering and define the role in stem cell research.	-	1	-	1	2	2	2	-	3	1	3	-	2	2	1
CO2-98BT701.2: To study about the biomaterials for tissue engineering.	-	1	-	-	-	-	3	-	3	2	3	2	1	1	2
CO3-98BT701.3: To understand the biological study of different cell types.	1	1	1	1	-	-	2	-	3	1	2	3	1	1	1
CO4-98BT701.4: To understand the principle and practice of gene therapy.	1	-	1	-	2	2	3	3	-	1	3	2	1	1	3
CO5-98BT701.5: To study about the development of artificial tissues by tissue engineering.	1	-	1	-	-	2	2	3	-	2	2	3	1	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO1-98BT701.1:** To explain about fundamentals of tissue engineering and define the role in stem cell research.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	LI 1 LI 2	1.1,1.2,1.3,1.4,1.5 1.6,1.7,1.8,1.9	1SL-1,2,3,4,5
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO2-98BT701.2**: To study about the biomaterials for tissue engineering.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	LI 1 LI 2	2.1, 2.2, 2.3, 2.4, 2.5,2.6,2.7,2.8,2.9,	2SL-1,2,3,4,5
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO3-98BT701.3**: To understand the biological study of different cell types.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	LI 1 LI 2	3.1,3.2,3.3,3.4,3.5, 3.6,3.7,3.8,3.9	3SL-1,2
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO4-98BT701.4**: To understand the principle and practice of gene therapy.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	LI 1 LI 2	4.1,4.2,4.3,4.4,4.5, 4.6,4.7,4.8,4.9	4SL-1,2,3,4,5
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO5-98BT701.5**: To study about the development of artificial tissues by tissue engineering.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	LI1 LI2	5.1,5.2,5.3,5.4,5.5, 5.6,5.7,5.8,5.9	5SL-1

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	VII	
Course Code:	98BT702	
Course title:	Bioprocess Engineering and Unit Operation	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of fermentation and biochemical engineering	
Rationale:	Bioprocess engineering is a conglomerate of mathematics, biology and industrial design, and consists of various spectrums like the design and study of bioreactors (operational mode, instrumentation, and physical layout) to the creation of kinetic models. Biochemical engineers find employment opportunities in various industries. They provide their services in the food sector, nuclear sector, healthcare industry, pharmaceuticals, chemical manufacturing companies, research laboratories and other areas. This course provides us about the knowledge about the living organisms such as plants, animals, bacteria and fungi but the bioprocess engineering helps in development of the essential skills required to utilize the living organisms for the betterment of the human beings and the nature itself.	
Course Outcomes (COs):	**CO1-98BT702.1. Recall the basic fundamentals of bioprocess engineering** **CO2-98BT702.2. Explain the production process of industrial fermented products** **CO3-98BT702.3. Apply unit operations to isolate biological products** **CO4-98BT702.4. Analyse the purity of products isolated through unit operations** **CO5-98BT702.5. Evaluate & Design numerical values for development of biomass and product formation by downstream processing**	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=2:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Common (PC)	98BT702	Bioprocess Engineering and Unit Operation	2	2	1	3	8	3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of	Couse	Course Title		Scheme of Assessment (Marks)		
			Progressive Assessment (PRA)		End Semester Assessment	Total Marks

Study	Code		Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)	(ESA)	(PRA+ ESA)
PC	98BT702	Bioprocess Engineering and Unit Operation	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		

PC	98BT752	Bioprocess Engineering and Unit Operation	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	03	14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1-98BT505.1 Illustrate the basic mechanism of Bioprocess engineering	**SO1.1** Explain concept of Bioprocess engineering	**LI1.1** To Demonstrate the working of a Bench Top bioreactor with all its parts	**Unit-1** **Introduction and Overview CI1.1** A historical overview of industrial fermentation process - traditional and modern biotechnology	**SL1.1** Find out some examples of bioprocess technique used in ancient India
	SO1.2 Determine the basic and advanced terminology, scope and application	**LI1.2** To perform the isolation of microorganisms from different kinds of samples	**CI1.2** Brief survey of organisms, processes, products relating to modern biotechnology	**SL1.2** Search various reference books and study material to start the learning of microorganisms
	SO1.3 Elaborate the scientific applications of Bioseparation		**CI1.3** Process flow sheeting – block diagrams, pictorial representation	**SL1.3** Draw a flow chart showing upstream and fermentation processing
	SO1.4		**CI1.4**	

	Define the Fundamental		Fundamental mechanism of Fermentation	
	SO1.5 mechanism of Fermentation		**CI1.5** mechanism of Fermentation	
	SO1.6 Revision and assessment		**CI1.6** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail "Applications of Microorganisms in various Sectors"
	SW1.2 Mini Project	Draw various types of Fermenters with specifications and parts
	SW1.3 Other Activities (Specify)	Make a power point presentation on "Role of Fermentations in Ancient India"

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	06	01	03	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-98BT752.2. Explain the production process of industrial fermented products	**SO2.1** Explain the production mechanism of multiple weak organic acids	**LI2.1** To perform the experiment on the microbial production of Acetic Acid	**CI2.1** Production of some commercially important organic acids (e.g. citric acid, lactic acid, acetic acid	**SL2.1** Find out more conventional cell disruption techniques
	SO2.2 Explain the production mechanism of Amino acids	**LI2.2** To perform the experiment of microbial production of Amino acids	**CI2.2** Microbial production of amino acids (Glutamic acid, Phenyalanine, Aspartic acid)	**SL2.2** Read the latest research in bioseparations methods
	SO2.3	**LI2.3**	**CI2.3**	**SL2.3**

	Explain the production mechanism of ABE fermentation	To perform the cell disruption technique using physical, chemical and biological methods	ABE Fermentation (Acetone, Butanol and Ethanol)	Write down few points on biological product's properties
	SO2.4: Study the commercial importance of these compounds		**CI2.4**: Commercial Importance of Organic Acids, Amino Acids, and Alcohols	
	SO2.5: Learn about the fermentation conditions for these products		**CI2.5:** Fermentation Conditions for Bioproducts	
	SO2.6: Explore the role of microorganisms in these processes		**CI2.6:** Microorganisms in Production Processes	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe Biosynthetic pathway for Acetone, Butanol and Ethanol derived fermentation
	SW2.2 Mini Project	Make a project on different kinds of Amino acids, their structure and functions
	SW2.3 Other Activities (Specify)	Make Power point presentation on Distillation as Unit operations

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	06	01	03	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-98BT505.3 Apply unit operations to isolate biological products using bioprocessing	**SO3.1** Elucidate the application of various kinds of separation process	**LI3.1** To perform the microbial production of Secondary metabolites using shake flask fermentation method	**Unit-3** **CI3.1** Study of production processes for various classes of secondary	**SL3.1** Find out the process of Aqueous two-phase extraction, instrument setup

			metabolites	
	SO3.2 Derive the mathematical expression for centrifugal sedimentation	**LI3.2** To observe the growth of microbial biomass and calculate its kinetics using graph	**CI3.2** Production processes for Beta-lactams (penicillin, cephalosporin etc.),	**SL3.2** Read the process of protein precipitation and its application in healthcare
	SO3.3 Analyze the partition coefficient associated with phase extraction	**LI3.3** To determine the production of weak organic acids through fermentation	**CI3.3** Production processes for aminoglycosides (streptomycin etc.,) macrolides (erythromycin	**SL3.3** Find out the process of Ultracentrifugation and its application
	SO3.4 Distinguish among the working mechanism of Precipitation of proteins by different methods sedimentation		**CI3.4** Microbial production of vitamins and Steroids	
	SO3.5 Examine the role of microorganisms in secondary metabolite production		**CI3.5:** Microorganisms in Secondary Metabolite Production	
	SO3.6: Discuss the commercial significance of secondary metabolites		**CI3.6:** Commercial Significance of Secondary Metabolites	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Derive the equations for Centrifugation using sedimentation, terminal velocity and gravity
	SW3.2 Mini Project	Describe the role of Ultracentrifuge in industries
	SW3.3 Other Activities (Specify)	Prepare one Power point presentation on “Different types of Centrifuge and their applications”

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-98BT505.4 Analyse the purity of products isolated through unit operations	**SO4.1** Elucidate the application of various kinds of separation process	**LI4.1** To perform the production of Antibiotics using fungi in a Shake Flask reactor.	**Unit-4 Role of RDT in Bioprocessing** **CI4.1** Production of recombinant proteins having therapeutic and diagnostic applications	**SL4.1** List down the different kinds of vaccine produced through RDT process in India
	SO4.2 Derive the mathematical expression for centrifugal sedimentation		**CI4.2** Production of vaccines (Recombinant)	**SL4.2** Read the process of MoAb production and its application in healthcare
	SO4.3 Analyze the partition coefficient associated with phase extraction		**CI4.3** Production of monoclonal antibodies (MoAb), types and mechanism	**SL4.3** Find out the size of genome of various important microorganisms
	SO4.4 Distinguish among the working mechanism of Precipitation of proteins by different methods sedimentation		**CI4.4** Products of plant and animal cell culture which can be produced through Bioprocess	
	SO4.5		**CI4.5**	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	02	01	03	12

	Interpretate and analyze various host vector system for recombinant cell cultivation		Different host vector system for recombinant cell cultivation strategies and advantages	
	SO4.6 Interpretate and analyze E. coli, yeast, Pichia pastoris / Saccharomyces cereviseae		**CI4.6** Recombinant cell cultivation strategies using E. coli, yeast, Pichia pastoris / Saccharomyces cereviseae	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	6	02	01	05	14

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Determine the working mechanism and applications of different kind of Vectors used in RDT
	SW4.2 Mini Project	Derive the Plant and Animal Cell Culture based metabolites having therapeutic applications
	SW4.3 Other Activities (Specify)	Make a Power point presentation for description of "Role of Host-vector system" in RDT for Bioprocessing

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-98BT752.5. Evaluate & Design numerical values for	**SO5.1** Elucidate the application & working mechanism of	**LI5.1** To perform the Column	**Unit-5 Chromatography and Electrophoresis** **CI5.1**	**SL5.1** Find out the industrial applications of

development of biomass and product formation by downstream processing	Chromatography	Chromatography process as Unit Operation for extraction of different compounds	Introduction, Principle and Working fundamentals of Chromatography	Chromatography
	SO5.2 Distinguish among Ion-exchange, size exclusion, hydrophobic interactions		**CI5.2** Types of Chromatography (Gel filtration, Reversed-phase, Hydrophobic interaction, Ion exchange; IEC)	**SL5.2** List down various kinds of Chromatographic columns used in analysis
	SO5.3 Analyze the working of Bioaffinity chromatography		**CI5.3** IMAC and bio-affinity chromatography	**SL5.3** List down various kinds of Solvents used in Chromatographic technique
	SO5.4 Distinguish among the working mechanism of Pseudo affinity Chromatographic techniques		**CI5.4** Design and selection of chromatographic matrices modes of operation	**SL5.4** List down the various kinds of Detectors associated with chromatography
	SO5.5 Describe and draw Amnio acid's structure and functions		**CI5.5** Introduction, Principle and Working fundamentals of Electrophoresis; Electrophoretic Mobility and equations	**SL5.5** Find out the role of different tracking dyes used in Electrophoresis
	SO5.6 Explain the process of Protein sequencing		**CI5.6** Agarose Gel Electrophoresis, Working mechanisms. Capillary Gel Electrophoresiws and application of Gel Electrophoresis	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain the working and Application of Ion Exchange Chromatography
	SW5.2 Mini Project	Describe the working mechanism and role of Agarose in Gel Electrophoresis
	SW5.3 Other Activities (Specify)	Prepare one article on the "Types of Bioinstrumentation and their applications in Bioprcess Engineeirng"

Course duration (in hours) to attain Course Outcomes:

Course Title: Bioprocess Engineering and Unit Operations **Course Code:** 98BT702

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98BT702.1. Recall the basic fundamentals of bioprocess engineering	6	4	3	1	14
CO2-98BT702.2. Explain the production process of industrial fermented products	6	6	3	1	16
CO3-98BT702.3. Apply unit operations to isolate biological products	6	6	3	1	16
CO4-98BT702.4. Analyse the purity of products isolated through unit operations	6	2	3	1	12
CO5-98BT702.5. Evaluate & Design numerical values for development of biomass and product formation by downstream processing	6	2	5	1	14
Total Hours	30	20	17	05	72

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Bioprocess Engineering and Unit Operations **Course Code:** 98BT702

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	

CO1-98BT702.1. Recall the basic fundamentals of bioprocess engineering	2	1	1	1	5
CO2-98BT702.2. Explain the production process of industrial fermented products	2	4	5	1	12
CO3-98BT702.3. Apply unit operations to isolate biological products	3	5	5	1	14
CO4-98BT702.4. Analyse the purity of products isolated through unit operations	2	3	5	1	11
CO5-98BT702.5. Evaluate & Design numerical values for development of biomass and product formation by downstream processing	2	4	1	1	10
Total Marks	**11**	**17**	**17**	**05**	**50**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

(b)

S.No.	Title/Author/Publisher details
1	Pauline M. Doran, "Bioprocess engineering principles" : Acedemic press
2	James E. Bailey & David F. Ollis- Biochemical engineering fundamentals
3	J.C. Janson And L. Ryden, (Ed.) – Protein Purification – Principles, High Resolution Methods and Applications, VCH Pub. 1989.
4	Peter F. Stanbury, Allan Whitekar "Principles fo fermentation technology"
5	Bioseparations: Principles and Techniques; Sivasankar, B; PHI Publications, 2009

(c) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Beverage producing plants & Distillery/Fermenter units
7. Demonstration
8. ICT Based teaching Learning

9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: VII Semester

Course Title: Bioprocess Engineering and Unit Operations

Course Code: 98BT702

CO/PO Mapping	

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
COs	PO1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-98BT702.1. Recall the basic fundamentals of bioprocess engineering	-	1	-	1	2	2	1	-	3	1	3	1	1	2	1
CO2-98BT702.2. Explain the production process of industrial fermented products	-	1	-	-	-	-	3	-	3	2	3	3	3	-	2
CO3-98BT702.3. Apply unit operations to isolate biological products	-	2	1	1	-	-	3	-	3	1	3	3	1	1	1
CO4-98BT702.4. Analyse the purity of products isolated through unit operations	1	-	1	-	2	2	2	3	-	1	3	3	2	2	3
CO5-98BT702.5. Evaluate & Design numerical values for development of biomass and product formation by downstream processing	1	-	2	-	-	2	3	3	-	2	3	3	1	1	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory	Classroom	Self-Learning (SL)

			Instruction (LI)	Instruction (CI)	
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-98BT702.1.** Recall the basic fundamentals of bioprocess engineering	SO1.1 SO1.2 SO1.3 SO1.4 So1.5 SO1.6	**LI 1** **LI 2**	1.1,1.2,1.3,1.4, 1.5, 1.6	**1SL-1,2,3**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-98BT702.2.** Explain the production process of industrial fermented products	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6	**LI 1** **LI 2** **LI 3**	2.1, 2.2, 2.3, 2.4, 2.5, 2.6	**2SL-1,2,3**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3-98BT702.3.** Apply unit operations to isolate biological products	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6	**LI 1** **LI 2** **LI 3**	3.1,3.2,3.3,3.4, 3.5, 3.6	**3SL-1,2,3**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-98BT702.4.** Analyse the purity of products isolated through unit operations	SO4.1 SO4.2 SO4.3 SO4.4 SO5.5 SO5.6	**LI 1**	4.1,4.2,4.3,4.4, 4.5, 4.6	**4SL-1,2,3**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO5-98BT702.5.** Evaluate & Design numerical values for development of biomass and product formation by downstream processing	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6	**LI 1**	5.1,5.2,5.3,5.4,5.5, 5.6	**5SL-1,2,3,4,5**

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	VII	
Course Code:	**98BT703**	
Course title:	Proteomics & Protein Engineering	**Curriculum Developer**: Sonal Gupta, Assistant Professor
Pre-requisite:	Students should have basic knowledge of biochemistry and bioanalytical techniques.	
Rationale:	Proteomics is the large-scale study of the structure and function of proteins in complex biological sample. Such an approach has the potential value to understand the complex nature of the organism. Current proteomic tools allow large-scale, high-throughput analyses for the detection, identification, and functional investigation of proteome. Protein engineering is the process by which a researcher modifies a protein sequence through substitution, insertion, or deletion of nucleotides in the encoding gene, with the goal of obtaining a modified protein that is more suitable for a particular application or purpose than the unmodified protein.	

Course Outcomes (COs):	**CO1 98BT703.** Explain the classification and construction of proteins **CO2 98BT703.** Analyse and compare the amino acid sequences and structures of proteins and relate this information to function **CO3 98BT703**. Modify a protein purification scheme to a specific application. **CO4 98BT703**. Understand the different systems of recombinant protein expression with advantages and disadvantages of each one. **CO5 98BT703**. Comprehend the difficulties in working with proteomics compare to genomics. **CO6 98BT703**. Gain thinking and analysis skills in protein biochemistry, Protein 3-D Structure and Protein folding.

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=2:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program elective (PC)	**98BT703**	Proteomics & Protein Engineering	2	2	1	3	8	3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	**Scheme of Assessment (Marks)**							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		
PE	**98BT753**	Proteomics & Protein Engineering	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PE	**98BT753**	Proteomics & Protein Engineering	35	5	5	5	50	50	50

Course-Curriculum:

<table>
<tr>
<td>This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.</td>
<td>
Approximate Hours
<table>
<tr><td>Item</td><td>Cl</td><td>LI</td><td>SW</td><td>SL</td><td>Total</td></tr>
<tr><td>Approx. Hrs</td><td>10</td><td>04</td><td>01</td><td>04</td><td>19</td></tr>
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Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-98BT703.1 Architecture of Proteins	**SO1.1** Introduction of amino acids	**LI1.1** Basic instruments used for the study of proteomics.	**Unit-1** **Introduction and Overview CI1.1** Basic structure, classification and properties of amino acids.	**SL1.1** Classification of amino acids and proteins
	SO1.2 Basic classification of proteins	**LI1.2** To Demonstrate various qualitative and quantitative analysis used for proteins.	**CI1.2** Classify protein on various basis and their biological significance.	**SL1.2** Explore mechanism of protein folding
	SO1.3 Explain the structural organization of proteins		**CI1.3** Overview on various levels (primary, secondary, tertiary and quaternary) levels of the protein structure.	**SL1.3** Write a note on protein structural organization
	SO1.4 Define the kinetics and thermodynamics of protein folding.		**CI1.4** Mechanism of protein folding. Kinetics and thermodynamic behind the protein folding process.	**SL1.4** Write down an overview on proteomics
	SO1.5 Describe the stability of proteins		**CI1.5** Explain the various factors affect the stability of proteins	
	SO1.6 Identification and quantification of amino acids and proteins and Explain In-silico protein		**CI1.6** Describe the various methods to analyse amino acids and protein qualitatively and	

	modelling		quantitatively and various computational methods to study protein 3D structure.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe the structural organization of protein in detail.
	SW1.2 Mini Project	Explain protein folding and its biological significance.
	SW1.3 Other Activities (Specify)	Elaborate in silico methods of protein modelling

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	04	01	04	19

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-98BT703.2. Control of Protein Function	**SO2.1** Explain various mechanism of protein regulation	**LI2.1** Demonstrate the denaturation of protein by using temperature	**CI2.1** Describe protein interaction domains	**SL2.1** Find out various mechanism to regulate protein functions.
	SO2.2 Describe the regulation of protein function by its location	**LI2.2** To perform the cell transformation experiment	**CI2.2** How proteins regulate their functions by intracellular location.	**SL2.2** Read the latest research articles on regulatory mechanisms of protein functions.
	SO2.3 Regulation of proteins by conformational change: Allostery		**CI2.3** Allostery: Effector ligand and Cooperativity	**SL2.3** Write down a note on protein kinase and its significance in cell signaling

	SO2.4 Protein switches based on nucleotide hydrolysis		**CI2.4** G-protein: Types and mechanism of action	**SL2.4** An overview on protein trafficking
	SO2.5 Explain the motor protein switches		**CI2.5** Describe various switches to regulate motor proteins.	
	SO2.6 Explain protein synthesis And Various mechanisms of protein degradation to control its activity, Protein kinase and their role in regulation of various biological activities like cell signaling, cell cycle, two components signaling system, mechanisms of protein trafficking		**CI2.6** Various steps of protei9n synthesis: Transcription and Translation and Various mechanisms of protein degradation to control its activity, Protein kinase and their role in regulation of various biological activities like cell signaling, cell cycle, two components signaling system, mechanisms of protein trafficking	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Make a diagrammatic presentation on two components signaling
	SW2.2 Mini Project	Make a project on role of protein kinase in cell signaling
	SW2.3 Other Activities (Specify)	Make Power point presentation on protein synthesis

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	4	01	03	18

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-98BT703.3 Protein-Protein Interactions	**SO3.1** Describe protein-protein interactions	**LI3.1:** To use string database for the given protein	**Unit-3** **CI3.1** Study the protein-protein interactions	**SL3.1** Study the protein-protein interaction and its significance
	SO3.2 Elaborate Topoisomerase based gene cloning	**LI3.2:** To use ensemble genome browser for gene ontology	**CI3.2** Describe single step gene cloning method: TOPO Cloning (Topoisomerase based gene cloning).	**SL3.2** Read the various advanced methods of single step gene cloning.
	SO3.3 Explain Univector plasmid fusion system		**CI3.3** Elaborate single step gene cloning methos: UPS (Univector plasmid fusion system).	**SL3.3** Explain the various methods to find out protein-protein interactions
	SO3.4 Study two hybrid analysis in yeast, bacteria and virus		**CI3.4** How to study protein-protein interaction by two hybrid analysis.	
	SO3.5 Explain the Phage display method		**CI3.5** Describe phage display method to study protein-protein interactions.	
	SO3.6 Elaborate protein fragment complementation assay		**CI3.6** Protein fragment complementation assay to explain protein- protein interaction.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Make a chart of various methods to study protein-protein interactions.
	SW3.2 Mini Project	Describe the Univector plasmid fusion system in detail.
	SW3.3 Other Activities (Specify)	Prepare one Power point presentation on "phage display method".

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	04	01	04	19

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-98BT703.4 Protein Engineering & Protein Design	**SO4.1** Bioengineering of macromolecules	**LI4.1** Make a chart of various steps involved in protein engineering	**Unit-4 Protein Engineering & Protein Design** **CI4.1** Explain biomolecular engineering as a multidisciplinary science	**SL4.1** Find out the industrial significance of protein engineering
	SO4.2 Describe the methods used to alter the primary structure of proteins	**LI4.2** to use the homology modelling using modeller	**CI4.2** Study the detailed mechanism of site directed mutagenesis and its role in protein alteration	**SL4.2** List down various steps of protein designing and engineering.
	SO4.3 Principle of protein designing		**CI4.3** Describe the principle behind protein design and modelling	**SL4.3** An overview on various methods used to characterize a protein
	SO4.4 Elaborate various steps of protein engineering		**CI4.4** Elaborate the multistep process of protein engineering to create	**SL4.4** Describe site directed mutagenesis

			protein with desired needs	
	SO4.5 Various methods of protein characterization: Amino acid sequencing		**CI4.5** Explain various methods of amino acid sequencing	
	SO4.6 Various methods of protein characterization: Mass peptide fingerprinting and Mass intact protein. Define glycan analysis		**CI4.6** Elaborate Mass peptide fingerprinting and Mass intact protein techniques of protein identification. glycan analysis of proteins in detail	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Make a flow chart of various steps of protein engineering
	SW4.2 Mini Project	Write an overview on Mass peptide fingerprinting.
	SW4.3 Other Activities (Specify)	Prepare a PowerPoint presentation on site directed mutagenesis

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	04	01	04	19

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-98BT703.5 Techniques used in Protein engineering	**SO5.1** Physical methods of determining the three-dimensional structure of proteins by various optical spectroscopic techniques: i) X-ray	**LI5.1** To perform SDS PAGE to separate given mixture of proteins.	**Unit-5** Techniques used in Protein engineering **CI5.1** How to elaborate protein structure by X-ray crystallography.	**SL5.1** Find out the principles of various spectroscopic methods used in proteomics.

	crystallography			
	SO5.2 ii) Nuclear magnetic resonance spectroscopy,	**LI5.2** To perform the spectroscopy method of protein detection	**CI5.2** Describe NMR: Principle, instrumentation and mechanism.	**SL5.2** Write down various steps of 2D PAGE.
	SO5.3 iii) Neutron diffraction		**CI5.3** Describe Neutron diffraction: principles, instrumentation and mechanism.	**SL5.3** Explain principle of cryo electron microscopy and its sample preparation.
	SO5.4 iv) Vibrational spectroscopy, (Raman spectroscopy)		**CI5.4** Explain principle, instrumentation and mechanism of Raman spectroscopy.	**SL5.4** Explain mechanism of X-ray crystallography
	SO5.5 v) Circular dichroism		**CI5.5** Explain Circular dichroism in detail.	
	SO5.6 Describe 2D PAGE, Cryo electron microscopy		**CI5.6** Describe 2D PAGE: Sensitivity, resolution and representation 2D PAGE. Cryo electron microscopy	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general mechanism of NMR (Nuclear Magnetic Resonance)
	SW5.2 Mini Project	Describe the circular dichroism and its role in protein study
	SW5.3 Other Activities (Specify)	Prepare one article on the “Raman Spectroscopy”

Course duration (in hours) to attain Course Outcomes:

Course Title: Proteomics and Protein Engineering **Course Code:** 98BT703

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO198BT703. Explain the classification and construction of proteins	10	2	4	1	17
CO2 98BT703. Analyse and compare the amino acid sequences and structures of proteins and relate this information to function	10	2	4	1	17
CO3 98BT703. Modify a protein purification scheme to a specific application.	10	2	3	1	16
CO4 98BT703. Understand the different systems of recombinant protein expression with advantages and disadvantages of each one.	10	2	4	1	17
CO5 98BT703. Comprehend the difficulties in working with proteomics compare to genomics.	10	2	4	1	17
Total Hours	50	20	19	05	84

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Proteomics and Protein Engineering **Course Code:** 98BT703

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1 98BT703. Explain the classification and construction of proteins	2	1	1	1	5
CO2 98BT703. Analyse and compare the amino acid sequences and structures of proteins and relate this information to function	2	4	5	1	12

CO3 98BT703. Modify a protein purification scheme to a specific application.	3	5	5	1	14
CO4 98BT703. Understand the different systems of recombinant protein expression with advantages and disadvantages of each one.	2	3	5	1	11
CO5 98BT703. Comprehend the difficulties in working with proteomics compare to genomics.	5	4	1	0	10
Total Marks	**14**	**17**	**17**	**04**	**52**

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

(b)

S.No.	Title/Author/Publisher details
1	TE Creighton. Protein Function A Practical Approach, 2005. W.H. Freeman & Company. New Edition.
2	Thomas E Creighton , Creighton. Proteins: Structures and Molecular Properties, W.H. Freeman & Company. New Edition
3	N J Darby, T E Creighton. Protein Structure (In Focus), W.H. Freeman & Company. New Edition.
4	TE Creighton. Protein Function A Practical Approach, 2005. W.H. Freeman & Company. New Edition.
5	Thomas E Creighton , Creighton. Proteins: Structures and Molecular Properties, W.H. Freeman & Company. New Edition

(c) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Waste water/Effluent Treatment plant and downstream pharmaceutical plants
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: V Semester

Course Title: Bioseparations

Course Code: 98BT703

CO/PO Mapping															
Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1 98BT703. Explain	-	-	-	1	2	2	1	-	3	1	3	1	-	-	-

the classification and construction of proteins															
CO2 98BT703. Analyse and compare the amino acid sequences and structures of proteins and relate this information to function	-	1	-	-	1	-	3	-	3	2	3	3	-	1	-
CO3 98BT703. Modify a protein purification scheme to a specific application.	-	2	1	1	-	-	3	-	3	1	2	3	-	2	1
CO4 98BT703. Understand the different systems of recombinant protein expression with advantages and disadvantages of each one.	1	1	1	-	2	2	2	3	-	1	2	3	1	1	1
CO5 98BT703. Comprehend the difficulties in working with proteomics compare to genomics.	1	-	2	1	-	2	3	3	-	2	2	3	1	-	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	**COs**	**SOs No.**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
PO 1,2,3,4,5,6	**CO1 98BT703**. Explain the	SO1.1 SO1.2	**LI 1**	1.1,1.2,1.3,1.4,1.5,	**1SL-1,2,3,4,**

7,8,9,10,11,12 PSO 1,2, 3	classification and construction of proteins	SO1.3 SO1.4 SO1.5 SO1.6	**LI 2**	1.6	
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2 98BT703**. Analyse and compare the amino acid sequences and structures of proteins and relate this information to function	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6	**LI 1** **LI 2**	2.1, 2.2, 2.3, 2.4, 2.5, 2.6	**2SL-1,2,3,4**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3 98BT703.** Modify a protein purification scheme to a specific application.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6	**LI 1** **LI 2**	3.1,3.2,3.3,3.4,3.5, 3.6	**3SL-1,2,3**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4 98BT703**. Understand the different systems of recombinant protein expression with advantages and disadvantages of each one.	SO4.1 SO4.2 SO4.3 SO4.4 SO2.5 SO2.6	**LI 1** **LI 2**	4.1,4.2,4.3,4.4, 4.5, 4.6	**4SL-1,2,3,4**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO5 98BT703**. Comprehend the difficulties in working with proteomics compare to genomics.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6	**LI 1** **LI 2**	5.1,5.2,5.3,5.4,5.5, 5.6	**5SL-1,2,3,4,**

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	V	
Course Code:	**98BT704-A**	
Course title:	Biofuels and Bioenergy	**Curriculum Developer**: Kamlesh Kumar Soni
Pre-requisite:	Student should have basic knowledge of life sciences and Biotechnology	
Rationale:	The paper on Biofuels and Bioenergy in B. Tech. Biotech Semester-VII program, Biofuels is a rather young discipline, which came up in the nineties. Nevertheless, Biofuels has gained so much importance within the last years that universities at all rankings have introduced or are going to introduce Biofuels and Bioenergy teaching programs. Predictions say that Biofuels and Bioenergy will change our lives and society more than computer technology and electricity have done together. The course will provide an overview over Biofuels and Bioenergy. Biofuels and Bioenergy is a highly interdisciplinary science, which will be reflected in the course by making reference to chemistry, physics, biology, pharmacy, and engineering. Applications of biosensors, as they are already in use today or as they are planned for the future, will be discussed	
Course Outcomes (COs):	**98BT704-A.1.** Understand the different generations of biofuels and discuss the steps involve in their production. **98BT704-A.2.** Compare different energy based, starch-based crops for the production of biofuel **98BT704-A.3.** Explain the role of bioleaching in metallurgy **98BT704-A.4.** Identify the types of resources and their application in day-to-day life **98BT704-A.5.** Develop the prototype of the Microbial Fuel Cell and demonstrate its working principle	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=2:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Common (PC)	98BT704-**A**	Biofuels and Bioenergy	2	2	1	3	8	3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

				Scheme of Assessment (Marks)

Board of Study	Couse Code	Course Title	Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity (CAT)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+ AT)		
PC	98BT704 **-A**	Biofuels and Bioenergy	**15**	**20**	**5**	**5**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	**Scheme of Assessment (Marks)**						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+
			Class/Home Assignment 5 number	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		

			7 marks each (CA)						ESA)
PC	98BT754-**A**	Biofuels and Bioenergy	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	02	13

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-98BT704-A Understand the different generations of biofuels and discuss the steps involve in their production.	SO1.1: Understand the production mechanisms of bioethanol by microbes	LI1.1: To demonstrate the fermentation process for bioethanol production.	CI1.1: Production Mechanisms of Bioethanol	SL1.1: Study the microbial pathways involved in bioethanol production
	SO1.2: Learn about the production mechanisms of methane and hydrogen as	LI1.2: To set up a bioreactor for	CI1.2: Production Mechanisms of Methane and Hydrogen	SL1.2: Research on the microbial processes involved in methane and

	second-generation biofuels	methane and hydrogen production.		hydrogen production
	SO1.3: Study the factors affecting biogas yields		CI1.3: Factors Affecting Biogas Yields	
	SO1.4: Understand the production mechanisms of biobutanol		CI1.4: Production Mechanisms of Biobutanol	
	SO1.5: Learn about biodiesel production from algae		CI1.5: Biodiesel Production from Algae	
	SO1.6: Explore the differences between first, second, and third-generation biofuels		CI1.6: Comparison of Biofuel Generations	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Write the difference in the aerobic respiration and anaerobic respiration
	SW1.2 Mini Project	Case study: algae being utilize for the production of biodiesel
	SW1.3 Other Activities (Specify)	Find the interesting videos explaining the pathways involve in ethanol production from yeast

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-98BT704-A.2: Compare different energy based, starch-based crops for	SO2.1: Understand the degradation of lignocellulose by	LI2.1: To isolate and characterize microorganisms	CI2.1: Degradation of Lignocellulose by Microorganisms	SL2.1: Study the microbial pathways for lignocellulose degradation

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	02	13

the production of biofuel	microorganisms	involved in lignocellulose degradation.		
	SO2.2: Learn about the degradation of sugar and starch crops by microorganisms	LI2.2: To set up an experiment to study the microbial degradation of sugar and starch crops.	CI2.2: Degradation of Sugar and Starch Crops by Microorganisms	SL2.2: Research on the biochemical pathways involved in sugar and starch degradation
	SO2.3: Study the degradation of oilseed crops by microorganisms		CI2.3: Degradation of Oilseed Crops by Microorganisms	
	SO2.4: Understand the degradation of hydrocarbon-producing crops by microorganisms		CI2.4: Degradation of Hydrocarbon-Producing Crops by Microorganisms	
	SO2.5: Explore the microbial pathways involved in the degradation of various energy crops		CI2.5: Microbial Pathways for Energy Crop Degradation	
	SO2.6: Learn about the commercial significance of microbial degradation of energy crops		CI2.6: Commercial Significance of Microbial Degradation	

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	List the oil seed crops and their processing for the fuel production
	SW1.2 Mini Project	Hydrocarbon: is it a better energy than others? How?

	SW1.3 Other Activities (Specify)	Read into details about the recombinant microbe to enhance the degradation of lignocellulosic crop: a case study

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	02	13

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO3-98BT704-A.3: Explain the role of bioleaching in metallurgy	SO3.1: Understand the principles of microbial metal leaching	LI3.1: To demonstrate the basic principles of microbial metal leaching.	CI3.1: Principles of Microbial Metal Leaching	SL3.1: Study the theoretical background of microbial metal leaching
	SO3.2: Learn about leaching mechanisms and models	LI3.2: To analyze different models of leaching mechanisms.	CI3.2: Leaching Mechanisms and Models	SL3.2: Research on the various models of leaching mechanisms
	SO3.3: Study the factors influencing bioleaching		CI3.3: Factors Influencing Bioleaching	

	SO3.4: Understand bacterial attachment on mineral surfaces		CI3.4: Bacterial Attachment on Mineral Surfaces	
	SO3.5: Learn about microbial diversity in bioleaching environments		CI3.5: Microbial Diversity in Bioleaching Environments	
	SO3.6: Understand the principles of microbial metal leaching		CI3.6: Principles of Microbial Metal Leaching	

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Bacterial attachment for the bioleaching
	SW1.2 Mini Project	A short report on the application of bioleaching at commercial scale
	SW1.3 Other Activities (Specify)	NA

Item	Cl	LI	SW	SL	Total
Approx. Hrs	0 6	4	01	02	13

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-98BT704-A.4: Identify the types of resources and their application in day-to-day life	O4.1: Understand the classification of resources	LI4.1: To categorize and classify various resources in a lab setting.	CI4.1: Classification of Resources	SL4.1: Study the different types of resources and their classification
	SO4.2: Learn about renewable and non-renewable resources	LI4.2: To analyze the properties and uses of renewable and non-renewable	CI4.2: Renewable and Non-Renewable Resources	SL4.2: Research on the characteristics of renewable and non-renewable resources

		resources.		
	SO4.3: Study the use and overexploitation of resources		CI4.3: Use and Overexploitation of Resources	
	SO4.4: Understand the classification and sources of energy		CI4.4: Classification and Sources of Energy	
	SO4.5: Learn about the problems relating to the demand and supply of energy		CI4.5: Problems Relating to Demand and Supply of Energy	
	SO4.6: Explore the energy sources like coal and petroleum		CI4.6: Energy Sources: Coal and Petroleum	

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	How overexploitation can affect the future; Make detail report on it
	SW1.2 Mini Project	A short report on the fossil fuels and their availability
	SW1.3 Other Activities (Specify)	Find the recent discovery of green technology

Item	Cl	LI	SW	SL	Total
Approx. Hrs	0 6	4	01	02	13

Course outcome (COs)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO5-98BT704-A.5: Develop the prototype of the Microbial Fuel Cell and	SO5.1: Understand the types and working principles of microbial fuel cells	LI5.1: To construct and evaluate a	CI5.1: Types and Working Principles of	SL5.1: Study the different types of microbial fuel cells

demonstrate its working principle		microbial fuel cell.	Microbial Fuel Cells	and their principles
	SO5.2: Learn about the applications of microbial fuel cells	LI5.2: To demonstrate the applications of microbial fuel cells in a lab setting.	CI5.2: Applications of Microbial Fuel Cells	SL5.2: Research on the various applications of microbial fuel cells
	SO5.3: Study the theory and applications of biofilms		CI5.3: Theory and Applications of Biofilms	
	SO5.4: Understand the theory and applications of biosensors		CI5.4: Theory and Applications of Biosensors	
	SO5.5: Learn about environmental nanobiotechnology applications		CI5.5: Environmental Nanobiotechnology Applications	
	SO5.6: Understand the significance of nanobiotechnology in waste management		CI5.6: Nanobiotechnology in Waste Management	

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	What is nanocarbon and its application
	SW1.2 Mini Project	How Biosensors are playing important role in biotechnology, write an article for the same
	SW1.3 Other Activities (Specify)	Find out some you tube videos explaining Nano-aerosols for waste water treatments

Course duration (in hours) to attain Course Outcomes **(Course Title:** Biofuels & Bioenergy) (**Course Code: 98BT704-A)**					
Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-98BT704-A.1: Understand the different generations of biofuels and discuss the steps involve in their production	6	4	2	1	13
CO2-98BT704-A.2: Compare different energy based, starch-based crops for the production of biofuel	6	4	2	1	13
CO3-98BT704-A.3: Explain the role of bioleaching in metallurgy	6	4	2	1	13
CO4-98BT704-A.4: Identify the types of resources and their application in day-to-day life	6	4	2	1	13
CO5-98BT704-A.5. Examine and demonstrate the mechanism of product purification	6	4	2	1	13
Total Hours	30	20	10	05	65

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome: **(Course Title:** Biofuels & Bioenergy) (**Course Code: 98BT704-A)**					
Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	

CO1-98BT704-A.1: Understand the different generations of biofuels and discuss the steps involve in their production	2	1	1	1	5
CO2-98BT704-A.2: Compare different energy based, starch-based crops for the production of biofuel	2	4	5	1	12
CO3-98BT704-A.3: Explain the role of bioleaching in metallurgy	3	5	5	1	14
CO4-98BT704-A.4: Identify the types of resources and their application in day-to-day life	2	3	5	1	11
CO5-98BT704-A.5. Examine and demonstrate the mechanism of product purification	5	4	1	0	10
Total Marks	**14**	**17**	**17**	**04**	**52**
Legend: **A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create					

Suggested learning Resources:

(a) Books:

S.no.	Title	Author	Publisher	Edition & Year
1	Biofuels and Bioenergy	John Love, John A. Bryant John	Wiley & Sons	1 & 2017
2	Biofuels and Bioenergy: Processes and Technologies	Sunggyu Lee, Y.T. Shah	CRC Press	1 & 2012
3	Bioenergy and Biofuels	Ozcan Konur	CRC Press	1 & 2018
4	Bioenergy: Biomass to Biofuels	Anju Dahiya	Academic Press	1 & 2014
5	Biofuels and Bioenergy	Robbie Larkin	Syrawood Publishing House	1 & 2016

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Waste water/Effluent Treatment plant and downstream pharmaceutical plants
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

CO/PO Mapping		
Course Outcome	**Program Outcomes (POs)**	**Program Specific Outcomes (PSOs)**

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO1	PSO2	PSO3
CO1-98BT704-A.1: Understand the different generations of biofuels and discuss the steps involve in their production	**1**	**1**	**1**	**-**	**2**	**2**	**2**	**-**	**1**	**2**	**2**	**2**	**2**	**3**	**2**
CO2-98BT704-A.2: Compare different energy based, starch-based crops for the production of biofuel	**-**	**-**	**-**	**2**	**-**	**-**	**2**	**-**	**2**	**2**	**3**	**1**	**2**	**2**	**2**
CO3-98BT704-A.3: Explain the role of bioleaching in metallurgy	**-**	**2**	**1**	**-**	**1**	**-**	**2**	**-**	**2**	**1**	**1**	**2**	**2**	**1**	**1**
CO4-98BT704-A.4: Identify the types of resources and their application in day-to-day life	**-**	**1**	**-**	**1**	**2**	**2**	**2**	**3**	**-**	**1**	**-**	**-**	**1**	**2**	**3**
CO5-98BT704-A.5. Examine and demonstrate the mechanism of product purification	**-**	**-**	**1**	**1**	**-**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**1**	**-**	**2**
Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3															

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-98BT704-A.1:** Explain fundamentals of Plant Biotechnology	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6	**LI 1** **LI2**	1.1,1.2,1.3,1.4, 1.5, 1.6	**1SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-98BT704-A.2:** Define the role of tissue culture media and its constituents in micropropagation of ex-plants	SO2.1 SO2.2 SO2.3 SO2.4 SO25 SO2.6	**LI 1** **LI2**	2.1, 2.2,2.3,2.4, 2.5, 2.6	**2SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3-98BT704-A.3:** Understand the working mechanism of callus culture	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6	**LI 1** **LI2**	3.1,3.23.3,3.4, 3.5, 3.6	**3SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-98BT704-A.4:** Interpretate the mechanism of plant-based vector and plasmids	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6	**LI 1** **LI2**	4.1,4.2,4.3,4.4, 4.5, 4.6	**4SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO5-98BT704-A.5.** Examine and demonstrate the mechanism of product purification	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6	**LI 1** **LI2**	5.1,5.2,5.3,5.4, 5.5, 5.6	**5SL-1,2**

Program Name	**Bachelor of Technology (B.Tech.)- Biotechnology**	
Semester	VII	
Course Code:	98BT704-B	
Course title:	Bioremediation	**Curriculum Developer**: Dr. Ashwini A. Waoo, Professor
Pre-requisite:	Student should have basic knowledge of environmental factors and pollution	
Rationale:	Bioremediation, integral to a BTech Biotechnology curriculum, offers a crucial understanding of eco-friendly solutions to environmental pollution. Its inclusion cultivates interdisciplinary skills, aligning students with sustainable practices and equipping them with applied biotechnological expertise for addressing real-world environmental challenges effectively.	
Course Outcomes (COs):	**CO1-98BT704-B.1**: Identify the different types of bioremediation techniques, mechanism and microbes for bioremediation **CO2-98BT704-B.2**: Differentiate criteria of types of bioremediations and its detail process. **CO3-98BT704-B.3**: Evaluate the roles Bio sorption & Bioleaching and phytoremediation. **CO4-98BT704-B.4**: Use of Bioremediation of phenols, cyanides, dyes, understand biodegradation through pathway engineering. **CO5-98BT704-B.5**: Case study and demonstration of bioremediation plan for industrial waste.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=2:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Elective (PE)	98BT704-B	Bioremediation	2	2	1	5	10	3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
PE	98BT704-B	Bioremediation	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PE	**98BT754-B**	Bioremediation-lab	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

Approximate Hours

Item	CI	LI	SW	SL	Total
Approx. Hrs	10	00	01	05	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-98BT704-B.1: Identify the different types of	**SO1.1** Understand scope, types and need of bioremediation	**LI1.1:** To demonstrate the process of	**Unit-1**	**SL1.1** Study of biotic and abiotic factors of

bioremediation techniques, mechanism and microbes for bioremediation		bioremediation using microbial cultures.	**CI1.1** Types of Bioremediations	environment
	SO1.2 Understand factors affecting bioremediation	**LI1.2:** To evaluate the factors affecting bioremediation efficiency in controlled environments.	**CI1.2** Factors affecting Bioremediation.	**SL1.2** Factors affecting growth of microbes
	SO1.3 Illustration of and mechanism of bioremediation		**CI1.3** Bioremediation Mechanisms,	**SL1.3** Mechanism of Bioremediation in algae, fungi, bacteria
	SO1.4 Evaluate limitations of bioremediation		**CI1.4** Limitations of Bioremediations	
	SO1.5 Analyze microbial diversity for use in bioremediation experiment.		**CI1.5** Microbes for Bioremediation	**SL1.4** List out microorganisms used for bioremediation
	SO1.6 Study characteristics of microbes for bioremediation. adptations for bioremediation		**CI1.6** Essential Characteristics of Microbes for Bioremediation. adptations for bioremediation	**SL1.5** List out adaptations for bioremediation

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Enlist types of Bioremediation techniques.
	SW1.2 Mini Project	Prepare list of microorganisms and respective pollutants used for bioremediation
	SW1.3 Other Activities (Specify)	Prepare chart on mechanism of bioremediation.

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-98BT704-B.2: Differentiate criteria of types of bioremediations and its detail process.	**SO2.1** Explore types of bioremediation technique	LI 1 Isolation of pollutant degrading bacteria from various contaminated sits	**Unit-II** **CI2.1** Insitu & Exsitu bioremediation techniques	**SL2.1** Search various techniques of bioremediation
	SO2.2 Describe the Land farming technique	LI 2 Strain improvement for bioremediation	**CI2.2** Application, specific advantages and disadvantages of bioremediation technologies - land farming	**SL2.2** Write a note on land farming
	SO2.3 Study advantages, disadvantages and applications of Biopiles		**CI2.3** prepared beds, biopiles	**SL2.3** Learn about contents prepared bed and biopiles
	SO2.4 Explain Study		**CI2.4** composting	**SL2.3** Searching

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	04	01	05	19

	advantages, disadvantages and applications of composting			online about ongoing composting plants
	SO2.5 Assessing advantages, disadvantages and applications of Bioventing		**CI2.5** Bioventing	
	SO2.6 Explaining the steps of Biosparging		**CI2.6** Biosparging	**SL2.5** Prepare design of biosparging implementation plan
	SO2.7 Explaining the stages of execution of constructed wet land		**CI2.7** constructed wet lands,	
	SO2.8 explain about Bioreactor used in bioremediation	LI 1 Demonstration of bioreactor for bioremediation	**CI2.8** use of bioreactors for bioremediation.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe principles of types of bioremediation techniques
	SW2.2 Mini Project	Prepare complete draft on mechanism, advantages and disadvantages of each type
	SW2.3 Other Activities (Specify)	Prepare a bioremediation plan using bioreactor for industry waste.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	04	01	04	19

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-98BT704-B.3: Evaluate the roles Bio sorption & Bioleaching and phytoremediation.	**SO3.1** Explain the role of Bioleaching in bioremediation	**LI3.1** To perform the phytostablization	**Unit-III** **CI3.1** Microorganisms involved in Bioleaching of ores	**SL3.1** Read about Bioleaching and applications
	SO3.2 Assessing efficiency of Mechanism		**CI3.2** mechanisms of bioleaching	**SL3.2** Collection of research data on bioleaching
	SO3.3 Understand metal recovery in mines		**CI3.3** metal recovery.	**SL3.3** Illustration about different techniques of metal recovery
	SO3.4 Study microbial transformation		**CI3.4** Microbial transformation	
	SO3.5 Describe phytoremediation	**LI3.2** Demonstration of phytoremediation of waste water	**CI3.5** Phytoremediation, mechanisms	
	SO3.6 Assessing the role of phytoextraction, phytostabilization, phytovolatilaztion, rhizodegradation, rhizofiltration, Phytoremediation of contaminated sites		**CI3.6** phytoextraction, phytostabilization, phytovolatilaztion, rhizodegradation, rhizofiltration, Phytoremediation of contaminated sites	**SL3.4** Write a note on Phytoextraction

Suggested Sessional Work	**SW3.1** Assignments	Describe principles of biosorption, bioleaching and phytoremediation

(SW): *anyone*	**SW3.2** Mini Project	Prepare complete draft on mechanism, advantages and disadvantages of each type of phytoremediation
	SW3.3 Other Activities (Specify)	Prepare a phytoremediation plan for industry waste.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	04	01	05	19

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO4-98BT704-B.4: Use of Bioremediation of phenols, cyanides, dyes, understand biodegradation through pathway engineering.	**SO4.1** Understand process of bioremediation of phenols dyes and cynaides	Li4.1To demonstrate the process of bioremediation using microbial cultures.	**Unit-IV** **CI4.1** Bioremediation of phenols	**SL4.1** Learn about phenol health hazards
	SO4.2 Assessing the bioremediation of cyanides		**CI4.2** cyanides,	**SL4.2** Discuss health hazards and sources of Cyanide pollution
	SO4.3 Illustration of Dye bioremediation	1. LI 4.2 Isolation of dye degrading bacteria and dye degradation.	**CI4.3** dyes;	**SL4.3** Learn about various types of dyes in textile industry
	SO4.4 Illustrate mechanism and applications of Rhizoremediation		**CI4.4** Rhizoremediation: a beneficial plant-microbe interaction;	**SL4.4** Case studies related to rhizoremediation
	SO4.5 Understand Enhanced biodegradation through		**CI4.5** Molecular techniques in bioremediation	

	pathway engineering			
	SO4.6 Learn pathway engineering strategies.		**CI4.6** Enhanced biodegradation through pathway engineering;	**SL4.5** Evaluate the need of GMOs for bioremediation

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe health effects of cyanides, dyes and phenols and their need for remediation.
	SW4.2 Mini Project	Describe the rhizoremediation detail and its applications
	SW4.3 Other Activities (Specify)	Prepare list of experiments done for pathway engineering for bioremediation

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	04	01	05	19

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO5-98BT704-B.5: Case study and demonstration of bioremediation plan for industrial waste.	**SO5.1** Illustrate technique of Bioremediation of industrial wastes.	**LI5.1:** To demonstrate the process of bioremediation using microbial cultures.	**Unit-V** **CI5.1** Bioremediation of industrial wastes.	**SL5.1** learn about basic concept of Bioremediation of industrial wastes.
	SO5.2 Illustrate the use of bioindicators,	**LI5.2:** To evaluate the factors affecting bioremediation efficiency in	**CI5.2** Bioindicators	**SL5.2** Review different bioindicators

		controlled environments.		
	SO5.3 Apply the biomarkers for bioremediation		**CI5.3** Biomarkers	**SL5.3** learn how biomarkers help in bioremediation
	SO5.4 Understand the mechanism and types of biosensors		**CI5.4** Biosensors in waste treatment.	**SL5.4** Learn about types of biosensors and give examples
	SO5.5 Understand the process of Bioconversion of agricultural, Sewage		**CI5.5** Bioconversion of agricultural	
	SO5.6 Describe sewage sludge treatment, waste bioremediation, conversion of sugar waste to fertilizers		**CI5.6** Sewage sludge, waste bioremediation., conversion of sugar waste to fertilizers	**SL5.5** Learn about sugar mill waste products

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Describe short term plan for bioremediation of industry.
	SW5.2 Mini Project	Describe the applications of bioremediation.
	SW5.3 Other Activities (Specify)	Prepare a detail document on biosensors available commercially.

Course duration (in hours) to attain Course Outcomes:

Course Title: Bioremediation **Course Code:** 98BT704-B

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98BT704-B.1: Identify the different types of bioremediation techniques, mechanism and microbes for bioremediation	10	4	5	1	20

CO2-98BT704-B.2: Differentiate criteria of types of bioremediations and its detail process.	10	4	5	1	20
CO3-98BT704-B.3: Evaluate the roles Bio sorption & Bioleaching and phytoremediation.	10	4	4	1	19
CO4-98BT704-B.4: Use of Bioremediation of phenols, cyanides, dyes, understand biodegradation through pathway engineering.	10	4	5	1	20
CO5-98BT704-B.5: Case study and demonstration of bioremediation plan for industrial waste.	10	4	5	1	20
Total Hours	50	20	24	05	99

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Bioremediation **Course Code:** 98BT704-B

***Legend*: A,** Apply; **An,** Analyze; **E,** Evaluate;

Course Outcomes	**A**	**An**	**E**	**Total Marks**
CO1-98BT704-B.1: Identify the different types of bioremediation techniques, mechanism and microbes for bioremediation	02	02	01	05
CO2-98BT704-B.2: Differentiate criteria of types of bioremediations and its detail process.	03	05	02	10
CO3-98BT704-B.3: Evaluate the roles Bio sorption & Bioleaching and phytoremediation.	05	05	05	15
CO4-98BT704-B.4: Use of Bioremediation of phenols, cyanides, dyes, understand biodegradation through pathway engineering.	04	03	03	10
CO5-98BT704-B.5: Case study and demonstration of bioremediation plan for industrial waste.	05	04	01	10
Total Marks	19	19	12	50

Suggested learning Resources:

(a) Books:

(b)

S. No.	Title	Author	Publisher	Edition & Year
1	Microbial Biodegradation and Bioremediation,	Surajit Das,	Elsevier,	2017
2	Bioremediation Technology: Recent Advances,	M. H. Fulekar,	Springer Science & Business Media	2012
3	Biodegradation and Bioremediation, , ,	Martin Alexander	Academic Press	1994,
4	Bioremediation: Principles and Applications	Ronald L. Crawford, Don L. Crawford	Cambridge University Press	2005
5	Applied Bioremediation and Phytoremediation, ,	Ajay Singh, Owen P. Ward	Springer Berlin Heidelberg,	2011

(c) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial

3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: VII

Course Title: Bioremediation

Course Code: 98BT704-B

CO/PO Mapping															
Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
COs	**PO1**	**PO2**	**PO3**	**PO 4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-98BT704-B.1: Identify the different	-	-	1	2	2	2	2	-	1	2	2	3	3	-	-

types of bioremediation techniques, mechanism and microbes for bioremediation															
CO2-98BT704-B.2: Differentiate criteria of types of bioremediations and its detail process.	-	-	-	-	-	-	-	-	**2**	**2**	**3**	**3**	**2**	-	**1**
CO3-98BT704-B.3: Evaluate the roles Bio sorption & Bioleaching and phytoremediation.	-	**1**	**1**	**1**	-	**2**	**2**	-	**3**	**3**	**3**	**2**	**2**	**2**	**1**
CO4-98BT704-B.4: Use of Bioremediation of phenols, cyanides, dyes, understand biodegradation through pathway engineering.	-	**1**	**1**	**2**	**2**	**2**	**2**	**3**	-	**1**	**2**	**2**	**2**	**2**	**2**
CO5-98BT704-B.5: Case study and demonstration of bioremediation plan for industrial waste.	**1**	**1**	**1**	-	-	**3**	**3**	**3**	**1**	**2**	**3**	**2**	**2**	**2**	**1**

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	**COs**	**SOs No.**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2,3	**CO1-98BT704-B.1:** Identify the different types of bioremediation techniques, mechanism and microbes for bioremediation	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6	Li 1, LI 2	1.1,1.2,1.3,1.4,1.5, 1.6	1SL-1,2,3,4,5
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2,3	**CO2-98BT704-B.2:** Differentiate criteria of types of bioremediations and its detail process.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6	Li 1, LI 2	2.1, 2.2, 2.3, 2.4, 2.5, 2.6	2SL-1,2,3,4,5
PO 1,2,3,4,5,6,7,8,9,10,11,12	**CO3-98BT704-B.3:** Evaluate the roles Bio sorption & Bioleaching	SO3.1 SO3.2 SO3.3 SO3.4	Li 1, LI 2	3.1,3.2,3.3,3.4,3.5, 3.6	3SL-1,2,3,4

PSO 1,2,3	and phytoremediation.	SO3.5 SO3.6			
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2,3	**CO4-98BT704-B.4:** Use of Bioremediation of phenols, cyanides, dyes, understand biodegradation through pathway engineering.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6	Li 1, LI 2	4.1,4.2,4.3,4.4, 4.5, 4.6	4SL-1,2,3,4,5
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2,3	**CO5-98BT704-B.5:** Case study and demonstration of bioremediation plan for industrial waste.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6	Li 1, LI 2	5.1,5.2,5.3,5.4,5.5, 5.6	5SL-1,2,3,4,5

Program Name	**B. Tech. Biotech Semester-**	
Semester	**VIIth**	
Course Code:	**98BT704-C**	
Course title:	**Metagenomics**	**Curriculum Developer**: Mr. Piyush Kant Rai, Assistant professor
Pre-requisite:	Proficiency in bioinformatics and molecular biology techniques.	
Rationale:	Equipping students with skills to analyze and manage metagenomic data, interpret phylogenetic trees, utilize protein databases, and contribute to scientific knowledge sharing and collaboration.	
Course Outcomes (COs):	**98BT704-C-CO1. Conduct appropriate quality control and decontamination of metagenomic data** **98BT704-C-CO2. Discuss and interpret phylogenetic tree construction models** **98BT704-C-CO3. Utilize protein databases and tools for analysis of annotated structures and functions** **98BT704-C-CO4. Apply relevant tools in the analysis of metagenomic data** **98BT704-C-CO5. Submit metagenomic data to online repositories for sharing and future analysis**	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C) (L:T:P=2:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program elective (PE)	98BT704-C	Metagenomics	2	2	1	1	6	3

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of	Couse	Course Title	Scheme of Assessment (Marks)		
				End Semester Assessmen	Total Marks

Study	Code		Progressive Assessment (PRA)					t (ESA)	(PRA+ ESA)
			Class/ Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
Program elective (PE)	**98BT704-C**	**Metagenomics**	16	19	5	5	5	50	50

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	**Scheme of Assessment (Marks)**						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
Program	**98BT754-**	**Metagenomics**	35	5	5	5	50	50	50

elective (PE)	C								

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction, including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	04	01	03	14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
98BT704-C-CO1. Conduct appropriate quality control and decontamination of metagenomic data	**SO5.1** Metagenomic Analysis of Soil Microbial Communities	**LI1.1** Introduction to Experimental Setup of DNA Isolation	**CI1.1** Metagenomic Analysis of Soil Microbial Communities	**SL1.1** Independent research on soil microbial community
	SO5.2 Metagenomic Analysis of Marine Microbial Communities	**LI1.2** to isolate the genomic DNA from environmental sample	**CI1.2** Metagenomic Analysis of Marine Microbial Communities	**SL1.2** Self-paced learning to understand the workflow and differences between these sequencing approaches.
	SO5.3 Metagenome of the Microbial Community in Acid Mine Drainage		**CI1.3** Metagenome of the Microbial Community in Acid Mine Drainage	**SL1.3** Revise Microbial Community in Acid Mine Drainage
	SO5.4 Understand		**CI1.4** Metagenomic Analysis of Bacteriophages	

	Metagenomic Analysis of Bacteriophages			
	SO5.5 Metagenomics and Its Applications to the Study of the Human Microbiome		**CI1.5** Metagenomics and Its Applications to the Study of the Human Microbiome	
	SO5.6 Archaeal Metagenomics: Bioprospecting Novel Genes and Exploring New Concepts		**CI1.6** Archaeal Metagenomics: Bioprospecting Novel Genes and Exploring New Concepts	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Design a mini-project comparing different metagenomics approaches
	SW1.2 Mini Project	Group Assignment - Genome Sequencing Project
	SW1.3 Other Activities (Specify)	Evaluate students based on their technique, accuracy, and data interpretation skills.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	**06**	4	1	3	14

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**

98BT704-C-CO2. Discuss and interpret phylogenetic tree construction models	**SO2.1** Overview of Phylogenetic Tree Construction	**LI2.1** To learn Basics of analysis platforms	**CI2.1** Phylogenetic Tree Construction	**SL2.1** Practice phylogenetic tree reconstruction method
	SO2.2 What are Web-based Servers and Software	**LI2.2** To search and explore various genomes using metagenome analysis	**CI2.2** Construction of a Metagenomic Library	**SL2.2** Explore Phylip
	SO2.3 Analysis of Metagenomic Libraries		**CI2.3** Analysis of Metagenomic Libraries	**SL2.3** Remember steps of metagenome analysis
	SO2.4 Sequence-based Metagenomics Analysis		**CI2.4** Sequence-based Metagenomics Analysis	
	SO2.5 Function-based Metagenomics Analysis.		**CI2.5** Function-based Metagenomics Analysis	
	SO2.6 Phylogenetic Analysis and Comparative Genomics		**CI2.6** Phylogenetic Analysis and Comparative Genomics	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Write about the comparative genomics
	SW2.2 Mini Project	Write about web-based tools.
	SW2.3 Other Activities (Specify)	Find out some you tube videos based on how to do genome analysis.

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory**	**Classroom**	**Self-Learning (SL)**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	**06**	4	**1**	3	14

		Instruction (LI)	**Instruction (CI)**	
98BT704-C-CO3. Utilize protein databases and tools for analysis of annotated structures and functions	**SO3.1** Protein Separations Before Digestion	**LI3.1** Apply ADMET properties to any lead compound	**CI3.1** Protein Separations Before Digestion	**SL3.1**Remember HPLC process
	SO3.2 High-Performance Liquid Chromatography (HPLC)	LI3.2 to perform the HPLC for the given sample	**CI3.2** High - Performance Liquid Chromatography (HPLC)	**SL3.2**Understand the role of protein-protein interactions using SDS
	SO3.3 Protein Separations After Digestion		**CI3.3** Protein Separations After Digestion	**SL3.3** Write Develop an experimental design for protein separation
	SO3.4 MALDI-TOF-MS: The TOF Mass Analyzer		**CI3.4** MALDI-TOF-MS: The TOF Mass Analyzer	
	SO3.5 Problems with 2D-SDS-PAGE		**CI3.5** Problems with 2D-SDS-PAGE	
	SO3.6 Pros and Cons of MALDI		**CI3.6** Pros and Cons of MALDI.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Remember MALDI TOF
	SW3.2 Mini Project	
	SW3.3 Other Activities (Specify)	Explore online tutorials and resources on SDS PAGE.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	**06**	4	1	1	12

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
98BT704-C-CO4. Apply relevant tools in the analysis of metagenomic data	**SO4.1** Answer Introduction to Environmental Metagenomics	**LI4.1** Safety instructions and laboratory protocols for handling Raw data of metagenome	**CI4.1** Introduction to Environmental Metagenomics	**SL4.1** learn Interpretation of Metagenomics
	SO4.2 Pure Culture and Consortium in Environmental Metagenomics	**LI4.2** To prepare the recombinant DNA using E.coli	**CI4.2** Pure Culture and Consortium in Environmental Metagenomics	
	SO4.3 Cultivable and Non-Cultivable Microbial Analysis		**CI4.3** Cultivable and Non-Cultivable Microbial Analysis	
	SO4.4 Recombinant DNA Technology and DNA Cloning		**CI4.4** Recombinant DNA Technology and DNA Cloning	

	SO4.5 Molecular Fingerprinting Techniques		**CI4.5** Molecular Fingerprinting Techniques	
	SO4.6 Stable Isotope Probing (SIP) and Suppressive Subtractive Hybridization		**CI4.6** Stable Isotope Probing (SIP) and Suppressive Subtractive Hybridization	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	**06**	4	1	3	14

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Stable Isotope Probing (SIP) and Suppressive Subtractive Hybridization.
	SW4.2 Mini Project	
	SW4.3 Other Activities (Specify)	Relate the Molecular finger printing

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
98BT704-C-CO5. Submit metagenomic data to online repositories for sharing and future analysis	**SO5.1** What is Application of Metagenomics to Bioremediation	**LI5.1** How to do the DNA sequencing of uncultured microbes	**CI5.1** Application of Metagenomics to Bioremediation.	**SL5.1** Revise Application of Metagenomics to Bioremediation
	SO5.2 Able to apply Applications of Metagenomics for Industrial Bioproducts.	**LI5.2** to understand the Raw data came from NGS	**CI5.2** Applications of Metagenomics for Industrial Bioproducts.	**SL5.2** Recall Metagenomic Enzyme Discovery.
	SO5.3 Escherichia coli Host Engineering for Efficient		**CI5.3** Escherichia coli Host Engineering for	**SL5.3** Remember Next-

	Metagenomic Enzyme Discovery		Efficient Metagenomic Enzyme Discovery	Generation Sequencing Approaches to Metagenomics
	SO5.4 Next-Generation Sequencing Approaches to Metagenomics		**CI5.4** Next-Generation Sequencing Approaches to Metagenomics	
	SO5.5 Stable Isotope Probing: Uses in Metagenomics		**CI5.5** Stable Isotope Probing: Uses in Metagenomics	
	SO5.6 DNA Sequencing of Uncultured Microbes from Single Cells		**CI5.6** DNA Sequencing of Uncultured Microbes from Single Cells	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	illustrate the Applications of Metagenomics for Industrial Bioproducts
	SW5.2 Mini Project	Make a flow chart of approaches to metagenomics
	SW5.3 Other Activities (Specify)	Rewrite the Next-Generation Sequencing Approaches to Metagenomics

Course duration (in hours) to attain Course Outcomes:

Course Title: Metagenomics **Course Code: 98BT704-C**

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
98BT704-C-CO1. Conduct appropriate quality control and decontamination of metagenomic data	6	4	3	1	14
98BT704-C-CO2. Discuss and interpret phylogenetic tree construction models	6	4	3	1	14

98BT704-C-CO3. Utilize protein databases and tools for analysis of annotated structures and functions	6	4	3	1	14
98BT704-C-CO4. Apply relevant tools in the analysis of metagenomic data	6	4	1	1	12
98BT704-C-CO5. Submit metagenomic data to online repositories for sharing and future analysis	6	4	3	1	14
Total Hours	30	20	13	5	68

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: **Metagenomics** **Course Code: 98BT704-C**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
98BT704-C-CO1. Conduct appropriate quality control and decontamination of metagenomic data	02	03	04	1	10
98BT704-C-CO2. Discuss and interpret phylogenetic tree construction models	02	05	02	1	10
98BT704-C-CO3. Utilize protein databases and tools for analysis of annotated structures and functions	04	04	01	1	10
98BT704-C-CO4. Apply relevant tools in the analysis of metagenomic data	03	04	02	1	10
98BT704-C-CO5. Submit metagenomic data to online repositories for sharing and future analysis	04	03	02	1	11
Total Marks	15	19	11	05	51

Legend**: A,** Apply; **An,** Analyze; **E,** Evaluate; **C,** Create

Suggested learning Resources:

(a) Books:

(b)

S.No.	Title/Author/Publisher details
1	Genes IX by Benjamin Lewin, Johns and Bartlett Publisher, 2016
2	Metagenomics: Methods and Protocols, Wolfgang R. Streit, Rolf Daniel, Springer New York, 2016
3	Metagenomics: Perspectives, Methods, and Applications, Muniyandi Nagarajan, ACADEMIC PRESS, 2017

(c) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Research lab (BSL-1)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology

Semester: 7^{th} Sem

Course Title: Metagenomics

Course Code: 98BT704-C

CO/PO/PSO Mapping															
Course Outcome (Cos)	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
98BT704-C-CO1. Conduct appropriate quality control and decontamination of metagenomic data	-	1	-	1	1	2	1	-	3	1	3	1	-	1	-
98BT704-C-CO2. Discuss and interpret phylogenetic tree construction models	-	1	-	-	-	-	3	-	3	2	3	3	-	1	-
98BT704-C-CO3. Utilize protein databases and tools for analysis of annotated structures and functions	-	2	1	1	-	-	3	-	3	1	3	3	-	2	1
98BT704-C-CO4. Apply relevant tools in the analysis of metagenomic data	1	1	1	-	2	2	2	3	-	1	3	3	1	1	1
98BT704-C-CO5. Submit metagenomic data to online repositories for sharing and future analysis	1	1	2	-	-	2	3	3	-	2	3	3	1	1	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 2,4,5,6,7,9,10,11,12 PSO 2	**98BT704-C-CO1. Understand about the fundamentals of genomics and proteomics**	SO1.1 SO1.2 SO1.3 SO1.4,SO1.5, SO1.6	**IL 1** **IL 2**	1.1,1.2,1.3,1.4 ,1.5,1.6	**1SL-1,2,3**
PO 2,7,9,10,11,12 PSO 2,	**98BT704-C-CO2. Outline the next-generation sequencing techniques**	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5,SO2.6	**IL 1** **IL 2**	2.1, 2.2, 2.3, 2.4,2.5,2.6	**2SL-1,2,3**
PO 2,3,4, 7,9,10,11,12 PSO 2, 3	**98BT704-C-CO3. Apply analytical approach to identify protein structures**	SO3.1 SO3.2 SO3.3 SO3.4 ,3.5,SO3.6	**IL 1** **IL 2**	3.1,3.2,3.3,3.4.3.5,3.6	**3SL-1,2,3**
PO 1,2,3,5,6 7,8,10,11,12 PSO 1,2, 3	**98BT704-C-CO4. Analyse vaccine designing and protein-ligand interactions for drug discovery**	SO4.1 SO4.2 SO4.3 SO4.4 ,SO4.5,SO4.6	**IL 1** **IL 2**	4.1,4.2,4.3,4.4,4.5,4.6	**4SL-1**
PO 1,2,3,4,5,6 7,9,10,11,12 PSO 1,2, 3	**98BT704-C-CO5. Compare various databases and software used in proteomics**	SO5.1 SO5.2 SO5.3 SO5.4 ,SO5.5,SO5.6	**IL 1** **IL 2**	5.1,5.2,5.3,5.4,5.5,5.6	**5SL-1,2,3**

Program Name	B.Tech. in Biotechnology	
Semester	VII	
CourseCode:	98BT705	
Coursetitle:	Research Methodology	**Curriculum Developer**: Dr. Deepak Mishra, Professor
Pre-requisite:	Student should have basic and advanced knowledge of Biotechnology and practical as well as research skills.	
Rationale:	The paper on Research Methodology in an BTech Biotechnology program explores the critical role of specialized research and scientific tools in analyzing Biotechnological research. It delves into the use of precise instruments for monitoring and analyzing data and literature, development of research skills and scientific aptitudes. This study enables students to understand how systematic research process helps us for doing any research in a systematic manner along with data publication. It also explore the publication ethics and plagiarism knowledge.	
Course Outcomes (COs):	**CO1-98BT705.1:** Students are being knowledgeable with essentials of research methodology through various tools available. **CO2-98BT705.2:** Development of critical thinking skills for evaluating scientific literature and identifying research problems. **CO3-98BT705.3:** Proficiency in communicating research findings through various written forms. **CO4-98BT705.4:** Recognize various issues related to research ethics, data processing and integrity, research commercialization. **CO5-98BT705.5:** Proficiency in report writing, plagiarism rectification, making deliberations and presentation.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme ofstudies (Hours/Week)					Total Credits(C) (L:T:P=2:0:0)
			CI	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
Program Common(PC)	98BT705	Research Methodology	2	-	1	5	8	2

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);

SW: Sessional Work (includes assignment, seminar, mini project etc.);

SL: Self Learning;

C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to achieve course outcome.

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each	Class Test 2 (2 best out of 3)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		

			(CA)	10 marks each (CT)					
PC	**98BT705**	Research Methodology	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours**

Item	Cl	LI	SW	SL	Total
Approx.Hrs	06	00	01	05	12

Course outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Class room Instruction(CI)**	**Self-Learning(SL)**
CO1-98BT705.1: Students are being knowledge-able with essentials of research methodology through various tools available	**SO1.1** Define and Describe concept of scientific writing and research, its types		**Unit-1** **CI1.1** Scientific Writing & Research- meaning, types,	**SL1.1** Search various reference books and study material to start the learning of research and scientific writing
	SO1.2 Describe about objectives and approaches of research		**CI1.2** objectives, and approaches	**SL1.2** Differentiation of research problems based on objective

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	00	01	05	12

	SO1.3 Explain about methods and sources of literature		**CI1.3** Literature collection: Different sources,	**SL1.3** Searching and literature on different online resources.
	SO1.4 Describe about biological online database		**CI1.4** Biological online databases,	
	SO1.5 Study of sampling techniques		**CI1.5** Determining sample design,	**SL1.4** Use of sampling methods for collection of scientific data related to different research problems
	SO1.6 Study of data collection methods, hypothesis testing		**CI1.6** collecting data, hypothesis testing	**SL1.5** Setting up the Hypothesis and their application in research

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Describe in detail research and its types
	SW1.2 Mini Project	Collection of data and literature related to any biotechnological research problem
	SW1.3 Other Activities (Specify)	Searching of online database available on internet and their application in research

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-98BT705.2: Development of critical thinking skills for evaluating scientific literature and identifying research problems	**SO2.1**Explore the concept and techniques of writing reviews		**Unit-II** **CI2.1** Writing review articles,	**SL2.1** Search various contents for writing a review article
	SO2.2 Describe the contents of research article		**CI2.2** Writing Journal articles, bibliography	**SL2.2** designing of a research article

	SO2.3 Reflecting about the concept and contents of books and monograph		**CI2.3** books, and monographs-	**SL2.3** Learn about contents of an ideal book
	SO2.4 Explain about contents of an ideal thesis		**CI2.4**Structure of thesis;	**SL2.3** Searching and literature on different online resources.
	SO2.5 Assessing the role of manuscript and proof correction in research		**CI2.5**Manuscript and proof correction,	
	SO2.6 Explaining the steps of research process, execution of research, types of research designs.		**CI2.6**Research Process: selection of problems, execution of research, types of research designs.	**SL2.5** Use of research process to solve different research problems

Suggested Sessional Work (SW):*anyone*	**SW2.1** Assignments	Describe in detail about different stages of execution of research by using research process.
	SW2.2 Mini Project	Designing of a research thesis.
	SW2.3 Other Activities (Specify)	Take a research problem a select a specific research design for solving it.

Course Outcome (CO)	Session Outcomes(SOs)		Laboratory Instruction (LI)	Class room Instruction (CI)		Self-Learning(SL)	
CO3-98BT705.3: Proficiency in communicating research findings through various written forms.	**SO3.1**	Explain the role of different types of data in research.		**CI3.1**	Data Collection: Secondary Data, Primary Data	**SL3.1**	Read about various types of data and their applications in research
	SO3.2	Assessing different methods used in data collection		**CI3.2**	Methods of collection	**SL3.2**	Collection of research data using different tools
	SO3.3	Explaining concept and types of scales		**CI3.3**	Scaling Techniques Concepts and types,	**SL3.3**	Illustration about different scaling techniques
	SO3.4	Assessing different		**CI3.4**	Rating scales and		

Item	Cl	LI	SW	SL	Total
Approx.Hrs	06	00	01	05	12

	scaling methods used in research		Ranking scales, Scale Construction techniques	
	SO3.5 Describe about multi-dimensional scaling		**CI3.5** Multi-Dimensional Scaling.	**SL3.4** Collection of different research journals
	SO3.6 Assessing the role of research journals in research and their standards, concept of impact factor and citation index		**CI3.6** Journals: Standard of research Journals, Impact factor, citation index	**SL3.5** Assess role of impact factor and citation index in research

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail different categories of data and its collection methods.
	SW3.2 Mini Project	Describe the role of scaling methods in research and their application for data validation
	SW3.3 Other Activities (Specify)	Prepare a list of research journal and checking their standard parameters.

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO4-98BT705.4: Recognize various issues related to research ethics, data processing and integrity,	**SO4.1** Exploring the concept of data processing		**CI4.1** Data processing	**SL4.1** Learn about data processing approaches and its implementation.

research commercialization				
	SO4.2 Explaining the analytical/ statistical methods involved in research		**CI4.2** Qualitative and Quantitative analytical / statistical methods involved in research.	**SL4.2** Learn about analytical and scientific methods of research.
	SO4.3 Assessing the sources of ethical issues in science and biotechnology		**CI4.3** Research Ethics- The source of ethical issues in science and biotechnology	**SL4.3** Discuss ethical concern of research in science and biotechnology
	SO4.4 Explaining the concept of objectivity and integrity		**CI4.4** research and reporting objectivity and integrity,	**SL4.4** Learn about various types of reports
	SO4.5 Explaining the plagiarism and related issues		**CI4.5** the problem of plagiarism and related issues	**SL4.5** SL4.4 Case studies related to plagiarism
	SO4.6 Evaluate impact of international norms and standards.		**CI4.6** international norms and standards, the impact of scientific temper and virtues ethical issues and environmental impact and commercializing research.	

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	00	01	05	12

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain about Qualitative and Quantitative analytical / statistical methods involved in research.
	SW4.2 Mini Project	Describe the various ethical issues related to biotechnological research.
	SW4.3 Other Activities (Specify)	Prepare one article on commercialization of research

Item	Cl	LI	SW	SL	Total
Approx.Hrs	6	00	01	05	12

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO5-98BT705.5: Proficiency in report writing, plagiarism rectification, making deliberations and presentation	**SO5.1** Define the concept and types and components of scientific reports		**CI5.1** Structure, Types and components of scientific reports	**SL5.1** learn about basic concept & requirement of research report
	SO5.2 Able to execute steps layout and structure of research.		**CI5.2** Steps, Layout and structure; Illustrations and tables	**SL5.2**Review different layouts of report
	SO5.3 Apply the role of Bibliography, referencing and footnotes		**CI5.3** Bibliography, referencing and footnotes	**SL5.3**learn how prepare a report
	SO5.4 Evaluate the concept of plagiarism in research		**CI5.4** Reproduction of published material Plagiarism,	**SL5.4** Learn about plagiarism checking

	SO5.5 Evaluate the citation and bibliography, reproducibility and accountability		**CI5.5** Citation and acknowledgement, Reproducibility and accountability	
	SO5.6 Describe about Seminars; Symposia; Workshops, Conferences and Elaborate the role of deliberations in research methods of presentation preparation, visual aids in effective communication		**CI5.6** General idea about: Seminars; Symposia; Workshops, Conferences Making deliberations (Oral presentation) Planning - Preparation and Making presentation, visual aids in effective communication	**SL5.5** Learn about role of deliberation.

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general characteristics and components of research report
	SW5.2 Mini Project	Describe the role of deliberation in research
	SW5.3 Other Activities (Specify)	Prepare a detail document on Use of visual aids- Importance of effective communication

Course duration (in hours)to attain Course Outcomes:

Course Title: Research Methodology **Course Code:**98BT705

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98BT705.1: Students are being knowledgeable with essentials of research	6	0	5	1	12

methodology through various tools available.					
CO2-98BT705.2: Development of critical thinking skills for evaluating scientific literature and identifying research problems.	6	0	5	1	12
CO3-98BT705.3: Proficiency in communicating research findings through various written forms.	6	0	5	1	12
CO4-98BT705.4: Recognize various issues related to research ethics, data processing and integrity, research commercialization.	6	0	5	1	12
CO5-98BT705.5: Proficiency in report writing, plagiarism rectification, making deliberations and presentation.	6	0	5	1	12
Total Hours	30	00	25	05	60

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome:

Course Title: Research Methodology **Course Code:**98BT705

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-98BT705.1: Students are being knowledgeable with essentials of research methodology through various tools available.	2	1	1	1	5
CO2-98BT705.2: Development of critical thinking skills for evaluating scientific literature and identifying research problems.	2	4	2	2	10
CO3-98BT705.3: Proficiency in communicating research findings through various written forms.	2	3	3	2	10
CO4-98BT705.4: Recognize various issues related to research ethics, data processing and integrity, research commercialization.	3	5	5	2	15
CO5-98BT705.5: Proficiency in report writing, plagiarism rectification, making deliberations and presentation.	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

***Legend*:A,** Apply;**An,** Analyze;**E,** Evaluate;**C,** Create

Suggested learning Resources:

(a) Books:

(b)

S.No.	Title/Author/Publisher details
1	Beier, F.K., Crespi, R.S. and Straus, T. Biotechnology and Patent protection-Oxford and IBH Publishing Co. New Delhi.
2	Singh K, Intellectual Property rights on Biotechnology, BCIL, New Delhi
3	Writing the doctoral dissertation. Barrons Educational series, 2nd edition, Davis, G.B. and C.A. Parker, 1997. pp 160.
4	Authoring a PhD, thesis: how to plan, draft, write and finish a doctoral dissertation, Duncary, P. 2003.
5	Beier, F.K., Crespi, R.S. and Straus, T. Biotechnology and Patent protection-Oxford and IBH Publishing Co. New Delhi.

(c) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B.Tech. Microbiology
Semester: VII Semester
Course Title: Research Methodology
Course Code: 98BT705

Course Outcome (Cos)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	**PO2**	**PO 3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-98BT705.1: Students are being knowledgeable with essentials of research methodology through various tools available.	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3
CO2-98BT705.2: Development of critical thinking skills for evaluating scientific literature and identifying research problems.	2	2	3	2	3	2	2	3	2	2	3	2	2	3	3
CO3-98BT705.3: Proficiency in communicating research findings through various written forms.	2	2	3	2	3	2	2	3	2	2	3	2	2	3	3
CO4-98BT705.4: Recognize various issues related to research ethics, data processing and integrity, research commercialization	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3

.															
CO5-98BT705.5: Proficiency in report writing, plagiarism rectification, making deliberations and presentation.	3	3	3	3	2	3	3	3	3	3	3	3	3	3	2

Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3

Course Curriculum:

POs & PSOs No.	**COs**	**SOs No.**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
PO 1,2,3,4,5 PSO 1,2,3	**CO1-98BT705.1:** Students are being knowledgeable with essentials of research methodology through various tools available.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6		1.1,1.2,1.3,1.4,1.5, 1.6	1SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO2-98BT705.2:** Development of critical thinking skills for evaluating scientific literature and identifying research problems.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6		2.1, 2.2, 2.3, 2.4, 2.5, 2.6	2SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO3-98BT705.3:** Proficiency in communicating research findings through various written forms.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6		3.1,3.2,3.3,3.4,3.5, 3.6	3SL-1,2,3,4,5
PO 1,2,3,4,5	**CO4-98BT705.4:** Recognize various issues related to research ethics, data processing	SO4.1 SO4.2 SO4.3 SO4.4		4.1,4.2,4.3,4.4, 4.5, 4.6	4SL-1,2,3,4,5

PSO 1,2,3	and integrity, research commercialization.	SO4.5 SO4.6			
PO 1,2,3,4,5 PSO 1,2,3	**CO5-98BT705.5:** Proficiency in report writing, plagiarism rectification, making deliberations and presentation.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6		5.1,5.2,5.3,5.4,5.5, 5.6	5SL-1,2,3,4,5

TABLE OF CONTENT

PART 1: MUST-KNOW ISSUES

1. Enrolment and Pre-requisites

Your research project begins in your last semester. The project is considered as a credit course which must be completed within the same semester to qualify for graduation/post graduation. Other important courses such as Biostatistics, Scientific Writing Workshop and Research Methodology should be taken prior to the start of your thesis project.

2. Goals and Objectives

The aim of the research project is to provide students with practice on how to undertake an original research in the major fields of biotechnology. The results will be presented to examiners set up by the University. By the end of the research project students will have gained experience in conducting an independent research and should be capable in it.

3. Duration and workload

The research project comprises a credit module equivalent to 45 days-six months working months. Students are expected to devote regular time in preparing the research proposal, commencing the research project, writing the thesis and presenting it before an Evaluation Committee.

4. Scope

Projects should be original laboratory, field-based or survey research on a topic proposed a internal adviser at University or any outside relevant organization/research lab or industry. You could also conduct their thesis project outside the University given that your proposal is approved with adequate supervision by external supervisor.

5. Choice of projects

Department of Biotechnology and its faculty members will offer a list of possible projects for students' consideration. The proposed projects are closely related to the supervisor's expertise and considered feasible given the current conditions of the University laboratory system or alternatives elsewhere. Students can select the project they are most interested in and discuss with the faculty member proposing the project. Competition may exist when more than one student are interested in the same project. The supervisor has the right to select the most suitable student but criteria for selection should be publicized.

It is possible for students to propose and arrange these projects themselves, but the topic and scientific content must be endorsed by an Advisor of the Department of the University. For project that will be conducted outside the University and supervised by non-University employer, students are requested to provide evidence for such an arrangement by completing Form BT01 along with a CV of your supervisor.

6. Assessment

The thesis will be evaluated by an anonymous examiner assigned by the University. Students are allowed to present his/her thesis only if the examiner approved the same.

8. Progress report

About four weeks after the start of your research you are required to submit a progress report to the Department using Form BT02. This progress report must be certified by the supervisor. Change of the initial research title and/or objectives, if well justified, are possible and should be officially approved by the Department.

9. Thesis submission and revision

- The date for submission of completed theses is set by the Department (i.e. 45 days to six months depending on the course scheme and commencement of the research) and will be confirmed before the beginning of the semester.
- Two copies of thesis (soft-bounded) should be submitted to the Department two weeks before the date set for thesis defence.
- After a successful defence, the student revises his/her thesis according to the comments and amendments required by the Examiner. The adviser should make sure that all corrections are followed by the student by approving the revised thesis using Form BT03.
- The revised thesis is finally checked and approved by the Department.
- Students are required to submit two copies of thesis (no binding is required) and a and the electronic versions of the thesis (in both .doc and /pdf formats) and the presentation in PowerPoint. The Pen Drive should be labelled with student name, ID and year of graduation/post graduation.

PART 2: THESIS CONTENT

From 2022 onwards students are required to write theses in the form of an extended paper. This new requirement is not only to train students with manuscript preparation, but also to facilitate later publication of good research by the Department. For your thesis the following sections are required in the order shown below. Start each section on a new page.

- Cover page: use the format issued by the Department
- Acknowledgment
- Main body: paper-styled, including
  - *Title, author name(s) and affiliation*
  - *Abstract*
  - *Introduction*
  - *Materials and Methods*
  - *Results*
  - *Discussion*
  - *Conclusion*
  - *References*
- Appendix (if needed only)

ACKNOWLEDGMENT

This section is to recognize the people, and institutions who have helped you in completing your research project. The page is very informal and you can write in any style that you want. It is best to keep this section short. List here those individuals who provided help during the research (e.g., providing funding, language help, writing assistance or proof reading the article, etc.).

ABSTRACT

The abstract is a very brief overview of your entire study. It must come immediately after the title page. The abstract should briefly state the purpose of the research (introduction), how the problem was studied (methods), the important findings (results), and what the findings mean (conclusion). It is important to be descriptive but concise and to say only what are essential, using no more than 200 words. The author should also suggest some keywords that well represent the content of the research.

INTRODUCTION

This section is short (about 2 - 3 pages) and should be comprehensible to an informed lay person and give enough background to enable the reader to place the particular research problem in a context of common knowledge. It is important to state (i) the research problems (ii) a snap-shot literature review on what have been known or not known yet in relation to relevant hypotheses or assumptions suggested by you, (iii) the purposes of your research, (iv) scope and limitation and (v) expected outcomes.

More specifically, all problem elements, including the variables to be studied, should be expressed in an orderly system of relationships. Research questions must be clear, consistent, and measurable. They guide the research design process. Indicate "why" the study is being proposed.

Provide an adequate background (literature review) and clearly state the objectives of the work, avoiding a detailed literature survey or a summary of the results. Try to answer the question: "what potential impact will the results of the study have on the current body of knowledge?

MATERIALS & METHODS

This section should provide an accurate description of all methods and materials used in your study. It should be written in the past tense in the passive voice. Provide sufficient detail to allow the work to be reproduced, with details of supplier and catalogue number when appropriate. Methods already published should be indicated by a reference: only relevant modifications should be described. See Appendix 2 for an example of this section.

Recommended structure of the section:

2.1 Research object and location (information about the object of your research and where it was conducted)

2.2 Experimental design: describe the experimental design, methods adopted or developed to collect data. Relevant instruments and materials should be mentioned along with their description. Do not just simply list all the chemicals, instruments or devices used in the research. If you use standard methods (published and used by many similar studies, for example Kjeldall method to determine crude protein concentration), just mention the name of the methods and cite the reference that describe the method. In case the method should be described but too long, detailed information can be presented in the Appendix.

2.3 Data analysis: describe statistical methods used for data analysis with enough details so that the reliability of your research can be assessed. Data should be analyzed using statistics, either descriptive or inferential or both. Raw data are never included in your thesis unless they are needed to give evidence for specific conclusions which cannot be obtained by looking at an analysis, or summation, of the data.

If your study includes more than one experiment, describe one by one.

RESULTS

Summarize the findings without interpretation. Results should be clear and concise. Only analyzed data should be presented in forms of figures, graphs, tables and/or text descriptions of observations. When presenting statistically summarised data, you should state whether the number is a mean or median and clearly state how the data spread is expressed (± standard deviation, ± standard error of the mean, or inter-quartile range). When claiming a statistically significant result, you must support such a statement with a declaration of the probability (p) value and the test that was used to generate that value. Consult a statistician if you feel you need help in doing your statistical test and seek his advice in presenting your results.

All Figures and Tables should be numbered chronologically as they appear in your thesis. All Figures and Tables must be referred to in the text to facilitate reading. See further guidelines for constructing tables and figures in Part 3.

DISCUSSION

This should explore the significance of the results of the work, not repeat them. Discuss all the significant outcomes of your research; see how they fit with our current understanding of the research areas or what implications it implies for future studies or industrial application. Any limitation or weakness of the research should also be discussed and ended up with recommendations for possible improvement.

CONCLUSION

This section should state the conclusions and recommendations that you have drawn from your work (in relation to the research question or tested hypothesis) and relate the findings of your study to previously published work. Students should avoid to state the key results here instead of conclusions. Recommendations should be relevant to your research findings in order to provide the readers with tips, suggestions or modes of action so that they can follow if interested.

REFERENCES

This must contain complete list of **all** references cited in the text (see Section 5.2 on referencing).

APPENDIX

Any other relevant information that cannot be appropriately accommodated elsewhere can be placed in an Appendix (or Appendices) at the end of the dissertation. Try not to use them unless you absolutely have to. They are considered useful for listing raw data or details of experimental protocols if you feel it is necessary to do so

PART 3: THESIS FORMAT

From 2022 onwards students at the Department of Biotechnology are required to write their theses in the form of an extended paper. The format of your thesis is, therefore, a blended design of a traditional thesis, i.e. with the cover page, followed by Acknowledgment and ended up with an Appendix. The main body of the thesis is, however, a paper which is allowed to be a bit longer than the standard. In order to facilitate professional writing the format of Journal of Innovation in Applied Research (jiar.in). You are advised to strictly follow the instructions below.

THESIS LAYOUT

- The thesis must be word-processed in English (American or British usage is accepted, but not a mixture of these) using TIME NEW ROMAN font 12 point size with 1.5 line spacing. The text should be fully justified and leave 1 space between sentences. Content Font Size = 12; Heading = 14.
- Page set-up: use A4 paper with the left margin of 4.0 cm to allow binding. All the other margins are 2.5 cm.
- Each page of the main body must be numbered, starting with the page that has the title of your research and the abstract. Place the number in the centre of the bottom of the page. No header/footer is allowed.
- <u>Binding will be arranged by the Department</u> once you submit the final version of your thesis.

NUMBER OF PAGES

- Keep your writing short, informative and as concise as possible.
- No page number is required for the Cover page, Acknowledgment, References and Appendix.
- The length of the main body of your thesis should be <u>ideally between 15 and 20</u> <u>pages</u>. When needed the addition of few more pages are allowed, but the total number of pages of the main body should not exceed 25.
- Your supervisor will advise you on the length of each section and the level of details required.

COVER PAGE

- The cover page is designed to highlight your research title while providing important information such as the name of the educational provider, name of student and adviser(s) and year of publication.
- Use the standard format provided by the Department (see Appendix 1).

HEADINGS

The appropriate use of headings is a great assistance to the reader, breaking the text into logical blocks. Divide your thesis into clearly defined and numbered sections. Subsections should be numbered 1.1 (then 1.1.1, 1.1.2, ...), 1.2, etc. Any subsection may be given a brief heading. Each heading should appear on its own separate line. The recommended structure and headings of the main body is as follows:

Title

Author name(s) and affiliation

Abstract

Keywords

1. Introduction
2. Materials & Methods
    - 2.1 Research object and location
    - 2.2 Experimental design
    - 2.3 Data analysis
3. Results
    - 3.1 sub-headline 1
    - 3.2 sub-headline 2
    - 3.n sub-headline n
4. Discussion
5. Conclusio

n References

Constructed molecular sensor to enhance metal detection by bacterial ribosomal switch–ion channel protein interaction

Raul Cuero[a,*], J. Lilly[a], David S. McKay[b]

[a] Prairie View A&M University, CARC, Prairie View, TX 77446, USA
[b] NASA Johnson Space Center, Houston, TX 77058, USA

TITLE PAGE INFORMATION (see the example above)

- The title should be concise and informative as it will be used in information- retrieval systems. Avoid abbreviations and formulae where possible.

- Author names and affiliations: where the family name may be ambiguous (e.g., a double name), please indicate this clearly. Your official affiliation address is "Department of Biotechnology, AKS University, Satna". Indicate all affiliations with a lower-case superscript letter immediately after the author's name and in front of the appropriate address if your adviser/co-worker is from another institution. Provide the e-mail address of the corresponding author, i.e. yours in most cases.

ABSTRACT

- Not more than 200 words and should be as a single paragraph.

- Keywords: immediately after the abstract. Provide a maximum of 6 keywords, using American spelling and avoiding general and plural terms and multiple concepts (avoid, for example, 'and', 'of'). Be sparing with abbreviations: only abbreviations firmly established in the field may be eligible. These keywords will be used for indexing purposes.

A B S T R A C T

Molecular biosensors are useful tools that detect metal ions or other potentially toxic chemicals. However, the efficiency of conventional sensors is limited in mixed metals substrates, which is the common way they are found in nature. The use of biosensors constructed from genetically modified living microbial systems has the potential of providing sensitive detection systems for specific toxic targets. Consequently, our investigation was aimed at assembling different genetic building blocks to produce a focused microbial biosensor with the ability to detect specific metals. This objective was achieved by using a synthetic biology approach. Our genetic building blocks, including a synchronized ribosomal switch–iron ion channel, along with sequences of promoters, metal-binding proteins (Fe, Pb), ribosomal binding sites, yellow fluorescence reporter protein (YFRP), and terminators, were constructed within the same biobrick in *Escherichia coli*. We used an rpoS ribosomal switch containing an aptamer, which responds to the specific metal ligands, in synchronization with an iron ion channel, TonB. This switch significantly stimulates translation, as expressed by higher fluorescence, number of colonies, and concentration of RNA in *E. coli*. The positive results show the effectiveness of using genetically tailored synchronized ribosomal switch–ion channels to construct microbial biosensors to detect specific metals, as tested in iron solutions.

Keywords:
Biosensor
Ribosomal switch
Ion channel

TABLES

- Number tables consecutively in accordance with their appearance in the text.

- Place footnotes to tables below the table body and indicate them with superscript lowercase letters. Avoid vertical rules.

- Be sparing in the use of tables and ensure that the data presented in tables do not duplicate results described elsewhere in the article.

Examples:

Table 1
First central composite design 2^2 coded for the study of the effect of pH, enzyme concentration and glutaraldehyde concentration on the immobilization process of glucosyltransferase onto Celite, for conversion of sucrose into isomaltulose; the statistical analyses were carried out only in the first batch of 2.5 h, at 33 °C and 130 rpm.

Assay	Variables			Conversion of sucrose into isomaltulose (%)		
	pH	Enzyme (U/g of Celite)	Glutaraldehyde (%)	1° batch	2° batch	3° batch
1	−1 (5.6)	−1 (32.6)	−1 (0.10)	7.38	7.38	9.03
2	+1 (7.4)	−1 (32.6)	−1 (0.10)	0.00	0.00	0.00
3	−1 (5.6)	+1 (87.0)	−1 (0.10)	21.92	21.92	23.63
4	+1 (7.4)	+1 (87.0)	−1 (0.10)	1.34	1.34	1.59
5	−1 (5.6)	−1 (32.6)	+1 (0.40)	1.51	0.00	1.59
6	+1 (7.4)	−1 (32.6)	+1 (0.40)	0.00	0.00	0.00
7	−1 (5.6)	+1 (87.0)	+1 (0.40)	12.75	8.73	10.64
8	+1 (7.4)	+1 (87.0)	+1 (0.40)	0.00	1.52	1.15
9	−1.68 (5.0)	0 (59.8)	0 (0.25)	19.81	18.09	20.32
10	+1.68 (8.0)	0 (59.8)	0 (0.25)	0.00	0.00	0.09
11	0 (6.5)	−1.68 (14.1)	0 (0.25)	0.00	0.00	0.00
12	0 (6.5)	+1.68 (105.5)	0 (0.25)	7.23	8.00	7.19
13	0 (6.5)	0 (59.8)	−1.68 (0.00)	16.94	14.12	11.54
14	0 (6.5)	0 (59.8)	+1.68 (0.50)	3.25	2.87	3.77
15	0 (6.5)	0 (59.8)	0 (0.25)	4.31	6.33	4.62
16	0 (6.5)	0 (59.8)	0 (0.25)	6.18	5.96	4.29

FIGURE CAPTION

Ensure that each illustration has a caption. A caption should comprise a brief title and a description of the illustration. Keep text in the illustrations themselves to a minimum but explain all symbols and abbreviations used.

Example:

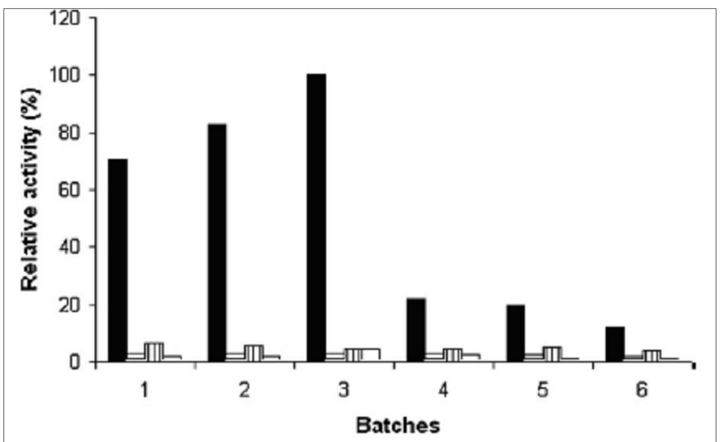

Fig. 5. Relative glucosyltransferase activity of the different low methoxyl pectin microcapsules containing glucosyltransferase after six batches of 30 min each of conversion of sucrose into isomaltulose. (■) Microcapsules with fat; (⊟) microcapsules without fat; (◘) lyophilized microcapsules with fat; and (□) lyophilized microcapsules without fat.

CITATION IN TEXT

Please ensure that every reference cited in the text is also present in the reference list and vice versa. Any references cited in the abstract must be given in full. Unpublished results and personal communications are not recommended in the reference list, but may be mentioned in the text. If these references are included in the reference list they should follow the standard reference style as follows and should include a substitution of the publication date with either 'Unpublished results' or 'Personal communication'. Citation of a reference as 'in press' implies that the item has been accepted for publication.

All citations in the text should refer to:

- *Single author:* the author's name (without initials, unless there is ambiguity) and the year of publication;
- *Two authors:* both authors' names and the year of publication;
- *Three or more authors:* first author's name followed by 'et al.' and the year of publication.

Citations may be made directly (or parenthetically). Groups of references should be listed first alphabetically, then chronologically.

> There are several works in the literature reporting bacterial cell immobilization in isomaltulose production (Kawaguti et al., 2006; Oliva-Neto and Menão, 2009). However, few studies are focused on the immobilization of extracted glucosyltransferase, which converts sucrose into isomaltulose. The immobilization of the enzyme presents some advantages compared to cell immobilization, such as lower risk of microbial contamination of the product, the former prevents the risk of unwanted catalytic activity; whole cells bring along further resistance to mass transfer due to the presence of the cell wall, which drastically reduces reaction rates (Chen, 2007). Thus, this work aimed to immobilize the glucosyltransferase from *Erwinia* sp. D12, in two different supports by adsorption (Celite) and entrapment (low-methoxyl pectin

WEB REFERENCE

As a minimum, the full URL should be given and the date when the reference was last accessed. Any further information, if known (DOI, author names, dates, reference to a source publication, etc.), should also be given. Web references can be listed separately (e.g., after the reference list) under a different heading if desired, or can be included in the reference list. Avoid using websites as reference unless absolutely necessary.

REFERENCE LIST

References should be arranged first alphabetically and then further sorted chronologically if necessary. More than one reference from the same author(s) in the same year must be identified by the letters 'a', 'b', 'c', etc., placed after the year of publication. Journal name must be written in full name.

Examples:

Reference to a journal publication:

Van der Geer, J., Hanraads, J.A.J., Lupton, R.A., 2010. The art of writing a scientific article. Journal of Science Communication 163, 51–59.

Reference to a book:

Strunk Jr., W., White, E.B., 2000. The Elements of Style, fourth ed. Longman, New York.

Reference to a chapter in an edited book:

Mettam, G.R., Adams, L.B., 2009. How to prepare an electronic version of your article, in: Jones, B.S., Smith , R.Z. (Eds.), Introduction to the Electronic Age. E-Publishin.

References

Andrianantoandro, E., Basu, S., Karig, D.K., Weiss, R., 2006. Synthetic biology: new engineering rules for an emerging discipline. Molecular Systems Biology 2 (28), 1–14.

Breaker, R.R., 2010. RNA second messengers and riboswitches: relics from the RNA world. Microbe American Society for Microbiology 5 (1), 13–20.

Cuero, R., Ouellett, T., Yu, J., Mogongwa, N., 2003. Metal ion enhancement of fungal growth, gene expression, and aflatoxin synthesis in *Aspergillus flavus*: RT-PCR characterization. Journal of Applied Microbiology 94 (6), 953–961.

Cuero, R., Ouellett, T., 2005. Metal ions modulate gene expression, and accumulation of the mycotoxins aflatoxin and zearalenone. Journal of Applied Microbiology 98 (3), 598–605.

Failla, M.L., 1977. Zinc Functions and Transport in Microorganisms, 4th ed. Weinberg, New York.

Grundy, F.J., Henkin, T.M., 2006. From ribosome to riboswitch: control of gene expression in bacteria by RNA structural rearrangements. Critical Reviews in Biochemistry and Molecular Biology 41 (6), 329–338.

Hengge-Aronis, R., 2002. Signal transduction and regulation mechanisms involved in control of the sigma (s) RpoS subunit of RNA polymerase. Microbiology and Molecular Biology Review 66 (3), 373–395.

Hille, B., 2001. Ion Channels of Excitable Membranes, 3rd ed. Sinauer, Sunderland.

Ito, M., Xu, H., Gufanti, A.A., Wei, Y., Zvi, L., Clapham, D.E., Krulwich, T.A., 2004. The voltage-gated Na+ channel NavBP has a role in motility, chemotaxis, and pH homeostasis of an alkalinophilic *Bacillus*. Proceedings of the National Academy of Sciences 101 (29), 10566–10571.

Kauffman, S., 2000. Investigations. Oxford University Press, New York.

Lei, Y., Chen, W., Mulchandani, A., 2006. Microbial biosensors. Analytica Chimica Acta 568 (1), 200–210.

Mijakovic, I., 2010. Protein phosphorylation in bacteria. Microbe ASM News 5 (1), 21–25.

Nudler, E., Mironov, A.S., 2004. The riboswitch control of bacterial metabolism. Trends in Biochemical Science 29 (1), 11–17.

APPENDIX

All materials placed in the appendix must be directly relevant to the paper. The material must be cross-referenced to the development of the research in the text of the paper using an explanatory note or a parenthetical reference. Avoid the temptation to use the appendix to bulk up the paper.

LANGUAGE AND GRAMMAR

- Use simple but clear language
- Take time to check your work for misspelled words, typographical error, mislabelled figures, tables or photos.
- If you need help in grammar, seek the help of an editor before submitting your work to your adviser. Your adviser is not expected to correct errors in spelling, punctuation, grammar, and formatting.

ABBREVIATION

Define abbreviations that are not standard in this field in a footnote to be placed on the first page of the article. Such abbreviations that are unavoidable in the abstract must be defined at their first mention there, as well as in the footnote. Ensure consistency of abbreviations throughout the article.

ACKNOWLEDGING THE WORK OF OTHERS

Plagiarism

Plagiarism is copying another person's idea or written work and claiming it as your own. This is an academic offence and you are strictly prohibited from doing this. Make sure that all information, photos, figures and tables are properly acknowledged

Citations

You must always acknowledge your sources of factual information and diagrams you wish to use. This is known as a *citation*.

PART 4: THESIS DEFENCE

PRESENTATION

- Presentation should last up to 15 minutes with another 15 minutes for questions and answers
- Slides should be prepared using Microsoft PowerPoint and presented from a disk.
- Rehearse your presentation and anticipate questions that may be asked by the Evaluation Committee.
- If you are not sure about the pronunciation of certain terminologies, be sure to ask a knowledgeable person before your defence.
- Try not to read from your slides and maintain eye contact with your audience
- Use pointers or laser devices properly
- Ask your supervisor for advice on the content and structure of your presentation.
- Even a successful defense is generally followed by certain minor adjustments in your document, and a some final paperwork amendments. You should take notes during the Q&A session, and contact the Secretary of the Evaluation Committee for a detailed request for thesis improvement.

CONTENT OF PRESENTATION

- The presentation should be a brief introduction of your topic, purpose of your study; description of the methods used and the results.
- It is advisible that your presentation has enough important details in order to avoid misunderstanding or excessive questions. Also, keep it short as time is limited.
- Make sure your answers are relevant to the questions of the Evaluation Committee.

APPENDIX 1: FORMAT OF THESIS COVER PAGE

AKS University, Satna

(5 lines from logo)

TITLE OF THESIS

(3 lines)

A thesis submitted to

The Department of Biotechnology, AKS University In partial fulfillment of the requirements for the degree of

B.Sc. (Hons.) in …………………….

(6 lines)

Student name: Full name of student – ID No.

Supervisor: Title and full name of supervisor(s)

(7 lines)

Month/Year

APPENDIX 2: RELEVANT FORMS

(proposal development, proposal defense, midway progress report, evaluation, etc.)

Content **Page**

Form **BT01**

THESIS REGISTRATION

1. (Student's name) .... (ID) ....
2. (Department) ....
3. (Thesis title) ....

....

....

4. (Objectives) ....

....

....

....

.... 5. (Research content)

....

....

....

....

.... 6.(Research location)

....

....

7. (Duration) (from): .... (to): ....
8. (Supervisor):

   (Full name)......................................

   (Address)..

   ....

   Email: ....

(Supervisor)

(Department)

Form **BT02**

THESIS PROGRESS REPORT

1. Student name: .... Student's ID...................................
2. Supervisor ....
3. Thesis title ....

....

<u>SECTION A</u>: to be completed by student

Thesis processing management

Content	**Status**		**Tentative completion time**
	Complete	On going	
1.	♦	♦	
2.	♦	♦	
3.	♦	♦	
n.	♦	♦	

Presence of obstacles to thesis completion, if any,

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Important note: Date to submit the completed thesis:

Date:....................................

Signature of student

SECTION B: to be completed by the principal Supervisor

Has the student:	Yes	No
(i) Shown relevant knowledge and understanding toward specific project field?	♦	♦
(ii) Shown initiative consistent with the requirements of the research program?	♦	♦
(iii) Made satisfactory progress in the research program?	♦	♦
(iv) Shown the ability to complete the research program by the due date?	♦	♦

If no, please recommend extension for completion or cut some parts of the proposal

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Date:.....................................

Signature of supervisor

Form **BT03**

Evaluation Form

Academic Adviser

Name of Student .... ID: ....

Criteria	Maximum marks	Your mark
Independence in work	10	
Creativity	10	
Level of commitment	20	
Writing skill	20	
Overall quality of thesis *	40	
Total	**100**	

* The maximum mark should not exceed 30 unless the student produced a manuscript for possible publication. A hard copy of the manuscript should be enclosed with this evaluation form.

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Name of Adviser

____

Date Signed

Evaluation Form

Thesis Reviewer

Name of Student____ID: ______________________

Criteria	**Maximum mark**	**Your mark**
Project goal and objectives (clear, achievable)	15	
Quality of Literature Review *(comprehensive, relevant)*	15	
Materials and Methods *(sound methods, appropriate materials and supporting equipment)*	25	
Results and Significant contribution *(please evaluated against the specific objectives of the project)*	30	
Writing skill and format (including compliance do thesis guidelines)	15	
Total	**100**	

Comments and recommendations for improvement/ correction (blank section is not acceptable)

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Name of Examiner (Signature and Date)

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Date Signed

Form **BT05**

Evaluation Form

For examiner of the Scientific Committee

Name of Student .... ID: ....

Criteria	**Maximum mark**	**Your mark**
Introduction *(research problem well stated, clear objectives)*	10	
Good understanding of the research field	10	
Methodology *(sound, appropriate or creative)*	20	
Quality of results *(evaluated against the research objectives)*	20	
Presentation skills *(quality of slides, speaking skills, timing)*	20	
Quality of answers *(relevant to questions, satisfied by the committee members)*	20	
Total	**100**	

Additional comments/suggestions for improvement:

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Name of Examiner

Date Signed