Curriculum Book

and

Assessment and Evaluation Scheme

based on

Outcome Based Education (OBE)

and

Choice-Based Credit System (CBCS)

in

Master of Technology in Biotechnology

M. Tech. (Biotechnology)

2 Year Degree Program

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

AKS University

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Curriculum & Syllabus of M. Tech. (Biotechnology) Program

(Revised as of 2023)

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AKS University

Faculty of Life Sciences and Technology

Department of Biotechnology

Curriculum of M. Tech. (Biotechnology) Program

(Revised as on 2023)

Foreword

I am delighted to see that the Biotechnology Department's redesigned curriculum for the M. Tech. (Biotechnology) The program 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. Tech. (Biotechnology) program for implementation in the upcoming session.

Er. Anant Soni
Pro Chancellor & Chairman
AKS University, Satna

01 August 2023

AKS University, *Faculty of Life Sciences and Technology*

Department of Biotechnology

Curriculum of M.Tech. (Biotechnology) Program

(Revised as on 2023)

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 endeavor 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 M. 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 M. 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 M. 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 M. Tech. The Biotechnology Program 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 M. 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 Basic Science Courses: 12 credits, Engineering Science Courses: 18 credits, Program core Courses: 13 credits and Professional Electives 13 credits and most prominently 30 credits of Research Project Work, and hands-on experience to complement theoretical learning. 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.

OVERVIEW OF THE DEPARTMENT

The Department of Biotechnology was established in 2006 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 society.

VISION

The vision of the department is to dedicate research to Human and Environmental welfare. To become a center 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. We aim 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

PO1: Carryout independent research/investigation and development work to solve practical problems

PO2: Write and present a substantial technical report/document

PO3: Design modern Biotechnological methods for bioprocess plant and allied processes.

PO4: Apply research based knowledge and biotechnological methods to investigate complex biological problems

PO5: Identify measures for energy, environment, health, safety and society following ethical principles.

PO6: Pursue life-long learning to enhance knowledge and skills for professional advancement

Program Educational Objectives for M. Tech. Program

PEO-1: To exhibit ability to pursue careers in the bioengineering applied industry, food process engineering, and in bioengineering research where biological system is increasingly employed.

PEO-2: To achieve domain knowledge and technical expertise for successful career in academics, research and industry.

PEO-3: Innovative ability to find routes of solution of existing scientific problems of the domain through identification of research gaps.

PEO-4: To develop a socially responsible professional with scientific ethics.

PEO-5: To develop research approaches to meet the scientific gaps on biotechnology and allied interdisciplinary or multidisciplinary fields.

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

PSO1: Translate bioprocess engineering principles for manufacturing bioproducts. Acquire learners with biotechnology capabilities and deliver solutions through industry-academia collaboration.

PSO2: Encourage learners to be great entrepreneurs and excellent researchers, inventing innovative items for societal needs while adhering to appropriate ethical legislation.

PSO3: Capacity to work individually on research and development projects to address real-world issues

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 PG Degree Course in Biotechnology, the total number of credits proposed for the Two-year M. Tech. (Biotechnology) is kept as 92.

C. Structure of PG Program in Biotechnology:

The structure of the PG 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	12
3.	Engineering Science Courses	18
4.	Program Core Courses (Branch specific)	13
5.	Professional Elective Courses (Branch specific)	12
6.	Open Elective Courses (from Humanities, Technical Emerging or other Subjects)	-
7.	Project work, Seminars and Internships in Industry or elsewhere, or research courses	30
	TOTAL	85

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 (Project/Summer Internship/Seminar)

- **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.

F. Evaluation Scheme (Suggestive only):

G. Mapping of Marks to Grades

Each course (Theory/Practical) is to be assigned 100 marks, irrespective of the number of credits, and the mapping of marks to grades may be done as per the following table:

Range of Marks	**Assigned Grade**
91-100	AA/A^{+}
81-90	AB/A
71-80	BB/B^{+}
61-70	BC/B
51-60	CC/C^{+}
46-50	CD/C
40-45	DD/D
< 40	FF/F (Fail due to less marks)
-	F^{R} (Fail due to shortage of attendance and therefore, to repeat the course)

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Department of Biotechnology

Scheme and Syllabus

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

Semester I

Sl. No.	Code	Category	Subject	L	T	P	C
1	55MBT101	ESC	Bioanalytical techniques	3	1	0	4
2	55MBT102	ESC	Bioreactor Engineering	3	1	0	4
3	55MBT103	PCC	Genetic engineering	3	1	0	4
4	55MBT104	BSC	Biomolecules	3	0	0	3
5	55MBT105	BSC	Immunology and Vaccine Technology	3	0	0	3
6	55MBT151	ESC	Bioanalytical techniques Lab	0	0	2	1
7	55MBT152	ESC	Bioreactor Engineering Lab	0	0	2	1
8	55MBT153	PCC	Genetic engineering Lab	0	0	2	1
9	55MBT154	BSC	Biomolecules Lab	0	0	2	1
10	55MBT155	BSC	Immunology and Vaccine Technology Lab	0	0	2	1
			TOTAL	**15**	**3**	**10**	**23**

Semester II

Sl. No.	Code	Category	Subject	L	T	P	C
1	55MBT201	ESC	Industrial Enzymes and Its Application	3	0	0	3
2	55MBT202	ESC	Entrepreneurship and Bioethics	3	0	0	3
3	55MBT203	PCC	Bioprocess Equipment Design	3	0	0	3
4	55MBT204	BSC	Research Methodology and Statistical Analysis	3	0	0	3
5	55MBT205	PE	Elective 1 (Group A/B)	3	0	0	3
6	55MBT206	PE	Elective 2 (Group A/B)	3	0	0	3
7	55MBT251	ESC	Industrial Enzymes and Its Application Lab	0	0	2	1
8	55MBT252	ESC	Entrepreneurship and Bioethics lab	0	0	2	1
9	55MBT253	PCC	Bioprocess Equipment Design Lab	0	0	2	1
10	55MBT254	BSC	Research Methodology and Statistical Analysis Lab	0	0	2	1
11	55MBT255 /256	PE	Elective Lab (Group A/B)	0	0	4	2
			TOTAL	**15**	**0**	**12**	**24**

LIST OF ELECTIVE SUBJECTS -Semester II

Group	Name of Specialization	Elective no.	Name of subjects
A	Industrial Biotechnology	1	Bioinformatics and Molecular Modeling
		2	Tissue Culture and Stem Cell Engineering
B	Food Biotechnology	1	Food Process Engineering
		2	Dairy Technology

Semester III							
Sl. No.	**Code**	**category**	**Subject**	**L**	**T**	**P**	**C**
1	55MBT301	PE	Elective 3 (Group A/B)	4	0	0	4
2	55MBT302	PCC	Waste Management	4	0	0	4
3	55MBT351		Project Work (Synopsis Submission and Presentation)	0	0	20	10
			TOTAL	**8**	**0**	**20**	**18**

Annexure-II

LIST OF ELECTIVE SUBJECTS- Semester III

Group	Name of Specialization	Elective no.	Name of subjects
A	Industrial Biotechnology	3	Quality control management in biotechnology
B	Food Biotechnology	3	Quality Control and Management in Food Technology and Industry

Semester IV						
Sl. No.	**Code**	**Subject**	**L**	**T**	**P**	**C**
1	55MBT451	Project Work (Viva voce and Presentation)	0	0	0	18
2	55MBT452	Conference paper presentation /Paper publication	0	0	0	2
		TOTAL	**0**	**0**	**0**	**20**

Total Credits: 85

Semester I

Program Name	**Master of Technology (M. Tech)- Biotechnology**	
Semester	I	
Course Code:	**55MBT101**	
Course title:	Bioanalytical techniques	**Curriculum Developer**: Dr. Ashwini A. Waoo, Professor
Pre-requisite:	Student should have basic knowledge of biotechnology instrumentation	
Rationale:	An M.Tech in Bioanalytical Techniques is a strategic choice driven by a profound interest in merging biology with cutting-edge analytical methods. This program offers a focused platform to delve into sophisticated techniques such as chromatography, mass spectrometry, and immunoassays, fostering expertise crucial for deciphering complex biological systems. With a strong emphasis on practical application, it aims to cultivate the skills necessary for innovating diagnostics, contributing to healthcare advancements, and shaping the future of biotechnology. This pursuit symbolizes an endeavor to bridge scientific disciplines, aiming to make tangible contributions at the forefront of bioscience research and technological innovation.	
Course Outcomes (COs):	**CO1-55MBT101.1:** Understanding the basics of microscopes, SEM, TEM and newer techniques in microscopy **CO1-55MBT101.2:** Generation wise, analyze sequencing techniques and their applications **CO1-55MBT101.3:** Acquiring theoretical and practical knowledge in the various spectroscopy techniques **CO1-55MBT101.4:** Studying the various chromatographic techniques. **CO1-55MBT101.5:** Learn the applications of flow cytometer and protein research	

Scheme of Studies:

Board of Study	CourseCode	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 (ESC)	**55MBT101**	Bioanalytical techniques	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 (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 Core (ESC)	**55MBT101**	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 Assignment5 number 7 marks each(CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+ SA+AT)		
ESC	**55MBT151**	**Bioanalytical techniques Lab**	**35**	**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 thecourse's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	05	19

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-55MBT101.1: Understanding the basics of microscopes, SEM, TEM and newer techniques in microscopy	**SO 1.1** Understand working of live cell imaging		**Unit-1** **CI1.1** Live cell imaging,	**SL1.1** Study of history and technique of live cell imaging
	SO 1.2 Illustrate the mechanism of confocal microscopy		**CI1.2** Confocal microscopy and	**SL1.2** Which are parts of confocal microscope?
	SO 1.3 Understand fluorescence microscopy		**CI1.3** sample preparation for fluorescence microscopy -	**SL1.3** Write process of SEM sample preparation
	SO 1.4 Understand need of High content/throughput screening		**CI1.4** High content/throughput screening -	**SL1.4** Write short note on High content/throughput screening
	SO 1.5 Describe basics of SEM	LI 1 Virtual demonstration of SEM	**CI1.5** Basics of SEM &	**SL1.5** Give principle of SEM
	SO 1.6 Illustrate the technique of Specimen preparation for SEM		**CI1.6** Specimen preparation for SEM	
	SO 1.7 LearnTEM Basics of	LI 2 Virtual demonstration of TEM	**CI1.7** Basics of TEM	
	SO 1.8 Knowledge about Specimen preparation for TEM		**CI1.8** and Specimen preparation for TEM	
	SO1.9 Revision and assessment		**CI 1.9** Revision and assessment	

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.

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)
CO1-55MBT101.2: Generation wise, analyze sequencing techniques and their applications	**SO2.1** Illustration of High-Throughput Next generation sequencing (HT-NGS) platforms		**Unit-II** **CI2.1** High-Throughput Next generation sequencing (HT-NGS) platforms-	**SL2.1** Learn High-Throughput Next generation sequencing (HT-NGS) platforms
	SO2.2 Illustration of DNA Sequencing		**CI2.2** First generation sequencing platform: Sanger DNA sequencing-	**SL2.2** Explain Sanger DNA sequencing
	SO2.3 Understand working of Roche 454		**CI2.3** Second generation sequencing platforms: Roche 454	**SL2.3** Learn mechanism and applications of Roche 454
	SO2.4 Acquire knowledge about Illumina Solex		**CI2.4** FLX system – Illumina Solex and	**SL2.4** Discuss the Illumina Solex
	SO2.5 Assessing the need of Solid next generation genome sequencing		**CI2.5** Solid next generation genome sequencing	
	SO2.6 Explaining he Third generation sequencing platforms		**CI2.6** Third generation sequencing platforms: Single molecular sequencing:	
	SO2.7 Explaining Helico high speed genome sequencing		**CI2.7** Helico high speed genome sequencing -	**SL2.5** Give Helico high speed genome sequencing -
	SO2.8 Understand Fourth generation sequencing platforms and future		**CI2.8** Fourth generation sequencing platforms and future	
	SO2.9 Revision and assessment		**CI2.9** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe High-Throughput Next generation sequencing (HT-NGS) platforms
	SW2.2 Mini Project	Explain the Sanger DNA sequencing.
	SW2.3 Other Activities (Specify)	Prepare chart on Helico high speed genome sequencing

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	05	19

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-55MBT101.3: Acquiring theoretical and practical knowledge in the various spectroscopy techniques	**SO3.1** Demonstrate the UV-Visible light spectroscopy	**LI1** Demonstration of Beer Lambert Law	**Unit-III** **CI3.1** Introduction to UV-Visible light spectroscopy	**SL3.1** Read about types of spectroscopy
	SO3.2 Illustration of Fluorescence spectroscopy,	**LI 2** Demonstration of UV visible spectrophotometer	**CI3.2** Fluorescence spectroscopy,	**SL3.2** Draw a fluorescence spectroscopy
	SO3.3 Apply and analyze atonic spectroscopy and luminometry		**CI3.3** luminometry, CD spectroscopy, Light scattering, atomic spectroscopy,	**SL3.3** Explain luminometry and atomic spectroscopy
	SO3.4 Evaluate IR and Raman spectroscopy		**CI3.4** IR and Raman spectroscopy,	
	SO3.5 Describe surface Plasmon resonance,		**CI3.5** surface Plasmon resonance,	
	SO3.6 Demonstrate the use of Electron paramagnetic resonance .		**CI3.6** Electron paramagnetic resonance, ,	**SL3.4** Write a note on Electron paramagnetic resonance
	SO3.7 Describe X-ray diffraction techniques, ,		**CI3.7** X-ray diffraction techniques,	**SL3.5** Diagrammatically explain X ray diffraction
	SO3.8 Analyze NMR and its applications		**CI3.8** NMR: Theory and Principle of NMR - Multi nuclear NMR- Analysis of spectra and Interpretations	
	SO3.9 Revision and assessment		**CI3.9** Revision and assessment	

	SW3.1 Assignments	Describe principles and types of spectroscopies

Suggested Sessional Work (SW): *anyone*	**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

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	06	01	05	21

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1-55MBT101.4: Studying the various chromatographic techniques.	**SO4.1** Develop understanding of GCMS	**LI 1** Virtual Demonstration of GCMS	**Unit-IV** **CI4.1** Gas chromatography with mass spectrometric detection (GC-MS),	**SL4.1** Learn about GC MS
	SO4.2 Illustrate mechanism of LC MS	**LI2** Virtual Demonstration of LCMS	**CI4.2** liquid chromatography with mass spectrometric detection (LC-MS),	**SL4.2** Discuss challenges LC mS
	SO4.3 Ananlyze key features ICPMS	**LI3** Virtual Demonstration of ICPMS	**CI4.3** inductively coupled plasma with mass spectrometric detection (ICP-MS).	**SL4.3** Video for ICPMS
	SO4.4 Understand metal analysis in different samples		**CI4.4** Metal analysis by ICP-MS;	**SL4.4** Studies related heavy metal analysis
	SO4.5 Evaluate strategies and analysis of HPLC data		**CI4.5** Analysis of data: HPLC chromatograms, Chromatographic performance parameters,	
	SO4.6 Evaluate the need of Adsorption Chromatography, partition chromatography		**CI4.6** Adsorption Chromatography, partition chromatography,	**SL4.5** Evaluate the technique of adsorption and partition chromatography
	SO4.7 Apply Ion exchange chromatography in appropriate samples		**CI4.7** Ion exchange chromatography,	
	SO4.8 Explain Molecular exclusion chromatography		**CI4.8** Molecular exclusion chromatography	
	SO4.9 Revision and assessment		**CI4.9** 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
	SW4.3 Other Activities (Specify)	Prepare list of samples and their state for analysis in GC MS, LC MS, ICP MS

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	05	19

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1-55MBT101.5: Learn the applications of flow cytometer and protein research	**SO5.1** Demonstrate working of flow cytometer	LI 1 Virtual demo of flow cytometer	**Unit-V** **CI5.1** Flow Cytometer: Introduction to flow cytometry- Fluorochromes and fluorescence,	**SL5.1** learn about principle of flow cytometer
	SO5.2 Illustrate the basics of isoelectric focusing		**CI5.2** Isoelectric focusing and 2-Dimensional,	**SL5.2** learn about isoelectric focussing and its advantages
	SO5.3 Evaluate the need of PAGE,		**CI5.3** polyacrylamide gel electrophoresis and their uses in protein research.	**SL5.3** Give role of PAGE and SDS PAGE in protein research
	SO5.4 Illustrate protein crystallization techniques		**CI5.4** Protein crystallization; Theory and methods,	**SL5.4** Learn about protein crystallization
	SO 5.5 Analyze the advantages of electrophoresis of proteins		**CI5.5** Electrophoresis of proteins and	**SL5.5** Give precautions during electrophoretic run
	SO 5.6 Describe electrophoresis of nucleic acids	LI 2 Separation of DNA on agarose gel electrophoresis	**CI5.6** nucleic acids,	
	SO 5.7 Apply the DNA computers.		**CI5.7** capillary electrophoresis,	
	SO 5.8 Evaluate the need of Nano drug delivery		**CI5.8** Microchip electrophoresis	**SL5.5** Learn role of microchip electrophoresis
	SO 5.9 Revision and assessment		**CI5.9** Revision and assessment	

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: Bioanalytical techniques **Course Code: 55MBT101**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-55MBT101.1: Understanding the basics of microscopes, SEM, TEM and newer techniques in microscopy	9	4	5	1	19
CO1-55MBT101.2: Generation wise, analyze sequencing techniques and their applications	9	0	5	1	15
CO1-55MBT101.3: Acquiring theoretical and practical knowledge in the various spectroscopy techniques	9	4	5	1	19
CO1-55MBT101.4: Studying the various chromatographic techniques.	9	6	5	1	21
CO1-55MBT101.5: Learn the applications of flow cytometer and protein research	9	4	5	1	19
Total Hours	45	18	25	05	93

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

Course Outcomes					
	A	**A**	**E**	**C**	**Total Marks**
CO1-55MBT101.1: Understanding the basics of microscopes, SEM, TEM and newer techniques in microscopy	03	01	01	01	06
CO1-55MBT101.2: Generation wise, analyze sequencing techniques and their applications	02	04	02	02	10
CO1-55MBT101.3: Acquiring theoretical and practical knowledge in the various spectroscopy techniques	03	05	05	01	14
CO1-55MBT101.4: Studying the various chromatographic techniques.	02	03	05	00	10
CO1-55MBT101.5: Learn the applications of flow cytometer and protein research	05	04	00	01	10
Total Marks	15	17	13	05	50

Course Title: Bioanalytical techniques **Course Code: 55MBT101**

Legend: A: Apply, A: Analyze E: Evaluate, C: Create

Suggested learning Resources:

(a) Books**:**

(b) Reference 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
3	Higher Education, Maidenhead,UK, 2008.
4	Freifelder D., Physical Biochemistry, "Application to Biochemistry and Molecular Biology", 2nd Edition, W.H. Freeman & Company, SanFransisco, 1982.
5	Keith Wilson and John Walker, "Principles and Techniques of Practical Biochemistry", 5th Edition, Cambridge University Press, 2000.

(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 Title: M. Tech. Biotechnology
Semester: I
Course Code: 55MBT101
Course Title: Bioanalytical techniques

Course Outcome	Program Outcomes (POs)					Program Specific Outcomes (PSOs)		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
52BT302.1	**2**	**1**	**2**	**3**	**-**	**-**	**1**	**-2**
52BT302.2	**2**	**2**	**-**	**-**	**-**	**1**	**2**	**1**
52BT302.3	**2**	**1**	**2**	**3**	**-**	**1**	**1**	**-**
52BT302.4	**2**	**-**	**-**	**1**	**-**	**-**	**-**	**2**
52BT302.5	**2**	**1**	**2**	**1**	**2**	**-**	**2**	**2**

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 PSO 1,2,3	**CO1-52BT302.1:** Understanding the basic steps of gene cloning and the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	LI1, LI2	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	**CO1-52BT302.2:** Selection of expression strategies for heterologous gene- expression in bacteria, yeast, insects, and in mammalian cells.	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-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO1-52BT302.3:** Acquiring theoretical knowledge in the techniques, tools, application and safety measures of genetic engineering and gene therapy.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	LI1, LI2,	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 PSO 1,2,3	**CO1-52BT302.4:** Studying the basics of nanotechnology, synthesis, characterization of nanoparticles.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	LI1, LI2, 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 PSO 1,2,3	**CO1-52BT302.5:** Applications of bionanotechnology in medicine, agriculture and the environment.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	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

Curriculum Development Team

Prof. Kamlesh Choure
Prof Ashwini A. Waoo
Prof. Deepak Mishra
Er. Arpit Srivastava

Program Name	**Masters of Technology (M. Tech.)- Biotechnology**	
Semester	I	
Course Code:	**55MBT102**	
Course title:	Bioreactor Engineering	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of fermentation and biochemical engineering	
Rationale:	Bioreactor engineering 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):	**CO1-55MBT102.1.** Illustrate the terminologies associated with bioreactor engineering **CO2-55MBT102.2.** Explain the kinetics and mechanism of various types of reactors **CO3-55MBT102.3.** Interpretate the different experimental data on reaction rate related to reactor engineering principles **CO4-55MBT102.4.** Analyse the Transfer of Heat and Mass with its kinetics **CO5-55MBT102.5.** Evaluate & Design numerical values for development of heterogenous reaction	

Scheme of Studies:

Board of Study	CourseCode	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 (ESC)	**55MBT102**	Bioreactor Engineering	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)		
ESC	**55MBT102**	Bioreactor 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)		
ESC	**55MBT152**	**Bioreactor Engineering lab**	**35**	**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 thecourse'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)
CO1-55MBT102.1 Illustrate the terminologies associated with bioreactor engineering	**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	**Unit-1** **Mechanical design of bioreactor and ancillary equipment** **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	**LI1.2** To perform the isolation of	**CI1.2** Vessel geometry, Bearing	**SL1.2** Search various reference

	geometry, Bearing assemblies	microorganisms from different kinds of samples	assemblies	books and study material to start the learning of microorganisms
	SO1.3 Elaborate the working mechanism of Motor drives, Aseptic seals, flow measuring device		**CI1.3** Motor drives, Aseptic seals, flow measuring device	**SL1.3** Draw a flow chart showing upstream and fermentation processing
	SO1.4 Define the Fundamental mechanism of Valves, Agitator, and Sparger Design		**CI1.4** Valves, Agitator, and Sparger Design & Numerical Problems	

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	08	06	01	03	18

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-55MBT102.2. 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	**Unit-2** **Physical methods of separation** **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	**LI2.2** To perform the experiment of microbial production of Amino acids	**CI2.2** Novel Bioreactor Stirred Tank, Airlift Bioreactor, Airlift Pressure, cycle	**SL2.2** Read the latest research in bioseparations methods

	Pressure, cycle Bioreactor, Loop Bioreactor, Bubble column Bioreactor, Packed bed and hollow fibre membrane bioreactor		Bioreactor, Loop Bioreactor, Bubble column Bioreactor, Packed bed and hollow fibre membrane bioreactor	
	SO2.3 Explain the working mechanism of CSTRs fermenter,	**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 Monod equation for chemostat, Monod Kinetics		**CI2.4** Monod equation for chemostat, Monod Kinetics	

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	04	01	02	17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-55MBT102.3 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	**Unit-3** **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	**LI3.2**	**CI3.2**	**SL3.2**

	Derive the mathematical expression for centrifugal sedimentation	To observe the growth of microbial biomass and calculate its kinetics using graph	Theories of reaction rate and temperature dependency	Derive the numerical problems associated with experimental reactor data
	SO3.3 Analyze the partition coefficient associated with phase extraction		**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	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Derive the equations for Rate of Reaction and 1st Order, 2nd 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	04	01	03	18

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-55MBT102.4 Analyse the Transfer of Heat and Mass with its kinetics	**SO4.1** Elucidate the Mechanism of heat transfer, Equipment of heat transfer	**LI4.1** To perform the production of Antibiotics using fungi in a Shake Flask reactor.	**Unit-4 Homogeneous reactions** **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	**LI4.2** To determine the peptide sequence, epitope regions for the prediction of In-silico vaccine design using The Immune Epitope Database	**CI4.2** Conduction, Heat transfer between fluids, Heat transfer coefficients, Overall Hear transfer coefficients	**SL4.2** Read the process of Heat transfer

		(IEDB) database		
	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	

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	02	01	05	18

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-55MBT102.5. 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)	**LI5.1** To perform the Column Chromatography process as Unit Operation for extraction of different compounds	**Unit-5 Heterogeneous Reactions** **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** Michles-menten Kinetics, External mass transfer, Minimizing mass transfer effect (internal and external	
	SO5.7 Define the Numerical problems associated with Heterogeneous reactions		**CI5.7** Numerical problems associated with Heterogeneous reactions	
	SO5.8 revision and assessment		**CI5.8** revision and assessment	

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 Engineering **Course Code:** 55MBT102

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-55MBT102. Illustrate the terminologies associated with bioreactor engineering	8	4	3	1	15
CO2-55MBT102. Explain the kinetics and mechanism of various types of reactors	8	6	3	1	18
CO3-55MBT102.3. Interpretate the different experimental data on reaction rate related to reactor engineering principles	10	4	2	1	17
CO4-55MBT102.4. Analyse the Transfer of Heat and Mass with its kinetics	10	4	3	1	18
CO5-55MBT102.5. Evaluate & Design numerical values for development of heterogenous reaction	8	2	5	1	16
Total Hours	44	20	16	05	84

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	
CO1-55MBT102.1. Illustrate the terminologies associated with bioreactor engineering	2	1	1	1	5
CO2-55MBT102.2. Explain the kinetics and mechanism of various types of reactors	2	4	5	1	12
CO3-55MBT102.3. Interpretate the different experimental data on reaction rate related to reactor engineering principles	3	5	5	1	14
CO4-55MBT102.4. Analyse the Transfer of Heat and Mass with its kinetics	2	3	5	1	11
CO5-55MBT102.5. 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:

(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 for fermentation technology"

(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: M. Tech. Biotechnology
Semester: I Semester
Course Title: Bioreactor Engineering
Course Code: 55MBT102

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 biologicalproduct 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	**CO1-55MBT102.1.** Illustrate the terminologies associated with bioreactor engineering	SO1.1 SO1.2SO1.3 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 1,2,3,4,5,6 PSO 1,2, 3	**CO2-55MBT102.2.** Explain the kinetics and mechanism of various types of reactors	SO2.1 SO2.2SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8	**LI 1** **LI 2** **LI 3**	2.1, 2.2, 2.3,2.4,2.5,2.6,2.7, 2.8	**2SL-1,2,3**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO3-55MBT102.3.** Interpretate the different experimental data on reaction rate related to reactor engineering principles	SO3.1 SO3.2SO3.3 SO3.4SO3.5, SO3.6 SO3.7 SO3.8 SO3.9 SO3.10	**LI 1** **LI 2**	3.1,3.2,3.3,3.4,3.5, 3.6,3.7,3.8,3.9,3.10	**3SL-1,2**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO4-55MBT102.4.** Analyse the Transfer of Heat and Mass with its kinetics	SO4.1 SO4.2SO4.3 SO4.4SO5.5 SO5.6 SO5.7 SO5.8 SO5.9 SO5.10	**LI 1** **LI 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**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO5-55MBT102.5.** Evaluate & Design numerical values for development of heterogenous reaction	SO5.1 SO5.2SO5.3 SO5.4 SO5.5 SO5.6SO5.7 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	**Masters of Technology (M.Tech.)-Biotechnology**	
Semester	I	
Course Code:	**55MBT103**	
Course title:	Genetic Engineering	**Curriculum Developer**: Mr. Paras Koshe, Assistant Professor
Pre-requisite:	Student should have basic knowledge of Biotechnology and Genetics as well as microbiology. It is recommended to have at least one other more specialized biology course such as Genetics and General Microbiology or Introduction to Biotechnology.	
Rationale:	This upper-division course will give a detailed overview of methodologies and techniques of molecular biology that allow the isolation, handling, and manipulation of DNA sequences in order to obtain a genetically modified protein or structurally alter the genome of an organism. In addition, students will explore the effects of genetic engineering applications on medicine, agriculture, biology, forensics, and other areas of technology. The discussion of potential ethical concerns of genome manipulations will also be included in this course.	
Course Outcomes (COs):	**CO1-55MBT103.1.** Explain basic concepts Genetic Engineering and its tools. **CO2-55MBT103.2.** Explain various types of cloning vectors their construction and uses. **CO3- 55MBT103.3**. Understand the Cloning Methodologies **by** giving especial emphasis on DNA libraries.. **CO4-55MBT103 4** Interpretate the role of PCR in genetic engineering and its applications. . **CO5-55MBT103. 5.** Learn about the procedure of DNA sequencing and its types and also understand how foreign DNA can be introduced into Host.	

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(PCC)	**55MBT103**	Genetic Engineering	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	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)		
PCC	**55MBT103**	Genetic Engineering	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

			Scheme of Assessment (Marks)		
			Progressive Assessment (PRA)	End	Total Marks

Board of Study	Course Code	Course Title	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)	Semester Assessment (ESA)	(PRA+ ESA)
BSC	**55MBT153**	**Genetic Engineering lab**	**35**	**5**	**5**	**5**	**50**	**50**	**100**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	00	01	03	13

	Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-55MBT103.**1.** Explain basic concepts Genetic Engineering and its tools.	**SO1.1** Summarize concept of DNA structure		**Unit 1** **CI1.1** DNA Structure and properties	**SL1.1** Learn about different types of DNA
	SO1.2 Define Restriction Enzymes and its types		**CI1.2** Restriction Enzymes	**SL1.2** History of restriction enzymes
	SO13 Understand the roleof DNA ligase in Genetic engineering.		**CI 1.3** DNA ligase .	**SL1.3** Learn about DNA probes and autoradiography
	SO1.4 students should able to learn the uses and functions of Klenow enzyme and T4 DNA polymerase		**CI 1.4** Klenow enzyme, T4 DNA polymerase	

	SO 1.5 Over viewing DNA modifying enzymes .		**CI 1.5** Polynucleotide kinase, Alkaline phosphatise	
	SO.1.6 Focus on DNA digestion by RE and vector construction		**CI1.6** Cohesive and blunt end ligation	
	SO 1.7 Illustrate how to use Linkers and Adaptors		**CI1.7** Linkers and Adaptors	
	SO1.8 Evaluate the Homopolymeric tailing and its importance in vector construction.		**CI1.8** Homopolymeric tailing	
	SO1.9 Describe the steps of Labelling of DNA.		**CI1.9 Labelling** of DNA	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	i. Elaborate the role of enzymes in genetic engineering. ii. Explain linkers and Adaptors also describe homopolymer tailing
	SW1.2 Mini Project	Make the DNA Model with new ideas
	SW1.3 Other Activities (Specify)	Write a review article on Cocktail restriction enzymes.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	06	01	04	20

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self Learning (SL)**
CO2-55MBT103. **.2.** Explain various types of cloning vectors their construction and uses.	**SO2.1** Understand Concept of cloning vectors	**LI2.1** Isolation of Genomic DNA from Bacterial cells.	**Unit-II** ***Cloning Vectors*** **CI2.1** Plasmids; Bacteriophages; M13 mp vectors.	**SL2.1** . Revise structure of bacteria
	SO2.2 Understand Concept ofPlasmid derived vectors and blue white screening.	**LI2.2** . Isolation of Plasmid DNA.	**CI2.2** PUC19 and Blue script vectors	**SL2.2** Describe different methods of constructing vectors.
	. **SO2.3** Understand Concept of Phage (virus) derived vectors	**LI2.3** Isolation of DNA from plant cells by CTAB method.	**CI2.3** Phagemids; Lambda vectors	**SL2.3** Binary vectors and co integrate vectors

	SO2.4 Understand the concept of Insertion and replacement vectors also focus on the use of cosmids.		**CI2.4** Insertion and Replacement vectors; Cosmids	
	SO2.5 Define Artificial chromosome vectors (YACs; BACs) and methods of constructing them.		**CI2.5** Artificial chromosome vectors (YACs; BACs)	**SL2.4** Learn about HAC human artificial chromosomes also
	SO2.6 Elucidate the Animal Virus derived vectors-SV-40;		**CI2.6** Animal Virus derived vectors-SV-40;	
	SO2.7 Illustrate the construction of vaccinia/bacculo & retroviral vectors;		**CI2.7** vaccinia/bacculo & retroviral vectors;	
	SO2.8 Define types and importance of Plant based vectors, Ti and Ri as vectors,		**CI2.8** Plant based vectors, Ti and Ri as vectors,	
	SO2.9 Describe Yeast vectors and Shuttle vectors		**CI2.9** Yeast vectors, Shuttle vectors	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Comparative study between cloning vectors and expression vectors
	SW2.2 Assignments	Write about different types of Artificial chromosome vectors (YACs; BACs)
	SW2.2 Mini Project	Comparative study between Plasmid and .phagemid vectors
	SW2.3 Other Activities (Specify)	Try to perform blue white screening in your lab

Item	Cl	LI	SW	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)
CO3-55MBT103:**.** Understand the Cloning Methodologies **by** giving especial emphasis on DNA libraries.	**SO3.1** Explain different types of cloning strategies and method of inserting DNA into Host cells,	**LI 3.1** Preparation of competent cells	Unit-3 **Cloning Methodologies** **CI 3.1** Insertion of Foreign DNA into Host Cells	**SL 1.1** To learn transformation recall about Griffith experiment.
	SO3.2 Learn about the utility of transformation.	**LI 3.2** To perform transformation experiment.	**CI 3.2** Transformation	**SL 1.2** learn about different types of RNA in cell and their percentage.
	SO3.3 Learn the technique of isolation of RNA	**LI 3.3** Isolation of total cellular RNA.	**CI 3.3**. , Isolation of mRNA	**SL 1.3.** compare between cDNA and genomic DNA libraries,
	SO3.4 Learn the technique of isolation of RNA		**CI 3.4** Isolation of total RNA	
	SO3.5 To learn the steps of constructing cDNA libraries and its uses.		**CI 3.5** cDNA libraries	
	SO3.6 Outline the steps of constructing Genomic DNA libraries and its uses.		**CI 3.6** genomic libraries	
	SO3.7 Explain **7** cDNA and genomic cloning		**CI 3.7** cDNA and genomic cloning	

	SO3.8 Analyze the role of Expression cloning in Genetic engineering.		**CI 3.8** Expression cloning;	
	SO3.9 Describe various types of Jumping and hopping libraries;		**CI 3.9** Jumping and hopping libraries;	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	**Assignments:** • Explain transformation experiment with diagram and focus on competent cells. • Write about different types of DNA libraries and their uses in genetic engineering.
	SW3.2 Mini Project	Prepare a chart showing cDNA cloning and DNA libraries.
	SW3.3 Other Activities (Specify)	. Try to isolate DNA from different sources such as Banana, onion and plant leaves and cheek cell by raw methods.

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)**
CO4 55MBT103**.4**: Interpretate the role of PCR in genetic engineering and its applications.	**SO4.1**. To study the concept of Primer design	**LI 4.1** Demonstration of PCR experiment	**Unit-IV *PCR and Its Applications*** **CI 4.1** Primer design	**SL4.1** .To understand PCR well recall about the DNA replication.
	SO4.2 To learn the Fidelity of thermo stable enzymes and mechanism of action of DNA polymerases	**LI 4.1** Detection of Purity of DNA by spectrophotometer	**CI 4.2** Fidelity of thermo stable enzymes; DNA polymerases	**SL4.2** Learn different types of thermostable enzymes used in PCR
	SO4.3 Elucidate the technique of PCR and its Types.		**CI 4.3** Types of PCR – multiplex, nested,	

	SO4.4 Elucidate the technique of PCR and its Types.		**CI 4.4** reverse transcriptase, real time	
	SO4.5 To learn different variants of PCR like colony PCR.		**CI 4.5** PCR, colony PCR,	
	SO4.6 Analyze PCR products by different methods.		**CI 4.6** cloning of PCR products	
	SO4.7 Understand the role of PCR in gene recombination,		**CI 4.7** PCR in gene recombination,	
	SO4.8 Describe the role of PCR in molecular diagnostics		**CI 4.8** PCR in molecular diagnostics	
	SO4.9 Elucidate the Viral and bacterial detection. By PCR		**CI 4.9** Viral and bacterial detection	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	1. focus on the principle steps and applications of PCR. 2. Describe the variants of PCR.
	SW4.2 Mini Project	Make a chart of various types of PCR.
	SW4.3 Other Activities (Specify)	Try to perform an experiment on PCR and learn basics of PCR Also focus on electrophoresis of proteins by SDS PAGE

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)
CO5 55MBT103.5. Learn about the procedure of DNA sequencing and its types and also understand how foreign DNA can be introduced into Host.	**SO5.1**Over viewing of various Sequencing methods; Enzymatic DNA sequencing	**LI 5.1** Demonstration of transfection technique by calcium phosphate method.	**Unit-V** **CI 5.1** Sequencing methods; Enzymatic DNA sequencing	**SL 5.1** Learn about next generation sequencing methods.
	SO5.2 To know about Chemical sequencing of DNA.	**LI 5.2** Electrophoresis of DNA and their size detection and band analysis by Gel Doc system.	**CI 5.2** Chemical sequencing of DNA	**SL 5.2** Find out some animal cell lines into which foreign DNA can be introduced easily.
	SO5.3 Explain about Automated DNA sequencing		**CI 5.3** Automated DNA sequencing	
	SO5.4 To study the RNA sequencing.		**CI 5.4** RNA sequencing; Chemical Synthesis of oligonucleotides,	
	SO5.5 Describe Chemical Synthesis of oligonucleotides		**CI 5.5** RNA sequencing; Chemical Synthesis of oligonucleotides	
	SO5.6 Elucidate Introduction of DNA into mammalian cells;		**CI 5.6** Introduction of DNA into mammalian cells;	

	SO5.7 To learn Transfection techniques		**CI 5.7** Transfection techniques;	
	SO5.8 Elaborate the technique of Gene silencing and its uses.		**CI 5.8** Gene silencing techniques,	
	SO5.9 Explain Principle and application of gene silencing.		**CI 5.9** Principle and application of gene silencing.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignment	Describe in detail about Sequencing methods. and its types
	SW5.2 Assignment	Write a brief note on gene silencing techniques..
	SW5.2 Mini Project	Write an article on use of gene silencing in trasgenics and disease treatment.
	SW5.3 Other Activities (Specify)	Find out the similarities and differences between Transfection and transformation

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-55MBT103.1. Explain basic concepts Genetic Engineering and its tools.	9	0	3	1	13
CO2-55MBT103.2. Explain various types of cloning vectors their construction and uses.	9	6	4	1	20
CO3- 55MBT103.3. Understand the Cloning Methodologies **by** giving especial emphasis on DNA libraries..	9	6	3	1	19
CO4-55MBT103 4 Interpretate the role of PCR in genetic engineering and its applications. .	9	4	2	1	16
CO5-55MBT103. 5. Learn about the procedure of DNA sequencing and its types and also understand how foreign DNA can be introduced into Host.	9	4	2	1	16
Total Hours	45	20	14	5	84

Course duration (in hours) to attain Course Outcomes:

Course Title: Environmental Biotechnology **Course Code: 55MBT103**

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

Course Outcomes	**Marks Distribution**	**Total Marks**

	A	An	E	C	
CO1-55MBT103.**1.** Explain basic concepts Genetic Engineering and its tools.	2	1	1	1	5
CO2-55MBT103**.2.** Explain various types of cloning vectors their construction and uses.	2	4	2	2	10
CO3- 55MBT103.**3**. Understand the Cloning Methodologies **by** giving especial emphasis on DNA libraries..	3	5	5	2	15
CO4-55MBT103 4 Interpretate the role of PCR in genetic engineering and its applications. .	2	3	3	2	10
CO5-55MBT103**. 5.** Learn about the procedure of DNA sequencing and its types and also understand how foreign DNA can be introduced into Host.	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

Course Title: Environmental Biotechnology **Course Code:** 55MBT103

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

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 6th Edition, S.B.University Press, 2001.
2	J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001
3	Brown TA, Genomes, 3rd ed. Garland Science 2006
4	Glick B.R. and Pasternak J.J. Molecular Biotechnology: Principles and applications of recombinant DNA, 3rd ed., ASM Press, 2003
5	Lemonie, N.R. and Cooper, D.N. Gene therapy, BIOS Scientific, 1996
6	Winnacker E.L. Frome Genes to clones : Introduction to Gene Technology, Panima, 2003

(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: M.Tech. Biotechnology
Semester: I Semester
Course Title: Genetic Engineering
Course Code: 55MBT103

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-55MBT103.**1.** Explain basic concepts Genetic Engineering and its tools.	2	-	-	1	2	2	2	1
CO2-55MBT103.**2.** Explain various types of cloning vectors their construction and uses.	-	-	-	-	-	1	1	2
CO3- 55MBT103.**3**. Understand the Cloning Methodologies **by** giving especial emphasis on DNA libraries..	-	1	1	1	-	1	1	1
CO4-55MBT103 4 Interpretate the role of PCR in genetic engineering and its applications. .	-	1	1	-	2	1	1	3
CO5-55MBT103**. 5.** Learn about the procedure of DNA sequencing and its types and also understand how foreign DNA can be introduced into Host.	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	**CO1-55MBT103.1.** Explain basic concepts Genetic Engineering and its tools.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 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**
PO 1,2,3,4,5 PSO 1,2,3	**CO2-55MBT103.2.** Explain various types of cloning vectors their construction and uses.	SO2. 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-1,2,3,4**
PO 1,2,3,4,5 PSO 1,2,3	**CO3- 55MBT103.3**. Understand the Cloning Methodologies **by** giving especial emphasis on DNA libraries..	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	**LI 1** **LI 2** **LI 3**	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 PSO 1,2,3	**CO4-55MBT103** 4 Interpretate the role of PCR in genetic engineering and its applications. .	SO.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**
PO 1,2,3,4,5 PSO 1,2,3	**CO5-**55MBT103**. 5.** Learn about the procedure of DNA sequencing and its types and also understand how foreign DNA can be introduced into Host.	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**

Program Name	**M. Tech. Biotechnology**	
Semester	**I**	
Course Code:	**55MBT104**	
Course title:	Biomolecules	**Curriculum Developer**: Mrs. Keerti Samdariya, Assistant Professor
Pre-requisite:	The student should have basic knowledge of biomolecules, their chemistry, and the metabolism of biomolecules.	
Rationale:	The paper on Biochemistry in an MTech Biotechnology program explores the role of biomolecules and their metabolic activity in biological systems. The living systems synthesize four primary types of biomolecules within the body. This study enables Students to learn how biomolecules promote different biological processes necessary for life. They vary in structure and sizes. metabolism is a complex process essential for the body to function properly. Students need to understand the role of biomolecules and metabolism in maintaining a healthy body and lifestyle.	
Course Outcomes (COs):	**CO1-55MBT104.1:** Understand the Structure, classification, and properties of carbohydrates.	
	CO2-55MBT104.2: Extend biochemistry of nucleic acid, amino acids, and protein.	
	CO3-55MBT104.3: Understanding of Role and mechanism of action of coenzymes and carbohydrate metabolism.	
	CO4-55MBT104.4: To become familiar with the fundamental Metabolic activity of lipids.	
	CO5-55MBT104.5: Apply the ideas and pathways of nucleotide metabolism.	

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 (BSC)	**55MBT104**	Biomolecules	3	1	1	2	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	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 Activityany one (CAT)	Class Attendance (AT)	Total Marks (CA+CAT+CT+SA+AT)		
BSC	**55MBT104**	**Biomolecules**	**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)		
BSC	**55MBT154**	**Biomolecules**	**35**	**5**	**5**	**5**	**50**	**50**	**100**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	06	01	02	18

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1-55MBT104.1: Understand the Structure, classification, and properties of carbohydrates.	**SO1.1** Clarify the Chemical foundation of biology.	**LI1** Calibration of Ph meter.	**CI1.1** Explore Chemical foundatio of biology- Water, properties	**SL1.1** Understand the role of carbohydrates.

	SO1.2 Explains the structure of Water and its properties.	**LI2** Detect the presence of biomolecules in the given sample.	**CI1.2** Water and their properties	**SL1.2** Learn the naming system of carbohydrate and lipid
	SO1.3 Determine the structure of carbohydrates.	**LI3** To study the chemical reaction of sugar and fat molecules.	**CI1.3** Definition, Nomenclature, classification, structure, properties of carbohydrates.	
	SO1.4 Determine the properties of carbohydrates.		**CI1.4** properties of carbohydrates.	
	SO1.5 Differentiate the use of lipids and carbohydrates in biotechnology		**CI1.5** Differentiate the use of lipids and carbohydrates in biotechnology	
	SO1.6 illustrates Definition and Nomenclature, of lipid.		**CI1.6** Definition, Nomenclature, classification, structure, and properties of lipid. Structure and function of nucleotides.	
	SO1.7 Describe Classification and structure of lipid.		**CI1.7** Definition, Nomenclature, classification, structure, and properties of lipid. Structure and function of nucleotides.	
	SO1.8 Explain structure of lipid.		**CI1.8** Definition, Nomenclature, classification, structure, and properties of lipid.	
	SO1.9 Explain Structure and function of nucleotides.		**CI1.9** Definition, Nomenclature, classification, structure, and Function of nucleotides.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Differentiate between reducing and non-reducing disaccharides
	SW3.2 Mini Project	Importance of biochemistry and its applications
	SW3.3 Other Activities (Specify)	Find out some you tube videos based on chemical tests for carbohydrates and nucleotides.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	06	01	03	18

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO2-55MBT104.2: Extend biochemistry of nucleic acid, amino acids, and protein.	**SO2.1** Differentiate the Structure and function of nucleotides.	**LI 1** focuses on the structure and properties of amino acids	**Unit 2** **CI1.1** Structure and function of nucleotides.	**SL2.1** Understand the role of amino acids
	SO2.2 Elucidation of primary and higher order structures of protein	**LI 2** Discriminating the structures of protein	**CI 2.2** Elucidation of primary and higher order structures of protein.	**SL2.2** Learn the Ramachandran plot and structure & function of ribonuclease A, myoglobin, and hemoglobin.

	SO2.3 Understand Ramachandran plot, structure & function relationship in model proteins like ribonuclease A,	**LI 3** To study the chemical reaction of protein and amino acids.	**CI 2.3** Ramachandran plot, structure & function relationship in model proteins like Ribonuclease A, myoglobin, and Hemoglobin.	**SL2.3** Differentiate between DNA forms and conformations
	SO2.4 Discuss about myoglobin, and hemoglobin.		**CI 2.4** Explain role of myoglobin, and Hemoglobin.	
	SO2.5 explain structure myoglobin, and hemoglobin		**SO 2.5** explain structure myoglobin, and hemoglobin	
	SO2.6 Clarify the Structure and properties of amino acids.		**CI 2.6** DNA forms and conformations	
	SO2.7 Classify DNA forms and conformations		**CI 2.7** DNA forms and conformations	
	SO2.8 explain and Classify DNA conformations		**CI 2.8** DNA forms and conformations	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Differentiate between DNA forms
	SW2.2 Mini Project	Draw ray diagram of classification of amino-acid classification
	SW2.3 Other Activities (Specify)	Find out some you tube videos based on elucidation of primary and higher order structures of protein.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	02	01	02	13

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO3-55MBT104.3: Understanding of Role and mechanism of action of coenzymes and carbohydrate metabolism.	**SO3.1** Illustrating Role and mechanism of action of NAD+/NADP+, FAD.	**LI3.1** Chemical test for enzymes.	**Unit 3** **CI3.1** Role and mechanism of action of NAD+/NADP+, FAD.	**SL3.1** Discuss Gluconeogenesis, glycogenesis and glycogenolysis.
	SO3.2 Explaining Glycolysis, and its regulation.		**CI3.2** Glycolysis, pentose phosphate pathway and its regulation.	**SL3.2** Glycolysis, pentose phosphate pathway and its regulation.
	SO3.3 Explaining pentose phosphate pathway and its regulation.		**CI3.3** Glycolysis, pentose phosphate pathway and its regulation.	
	SO3.4 Explaining Gluconeogenesis and give its significance.		**CI3.4** Gluconeogenesis, glycogenesis and glycogenolysis,	
	SO3.5 Explaining glycogenesis, and glycogenolysis.		**CI3.5** explain glycogenesis and glycogenolysis,	

	SO3.6 Explaining Gluconeogenesis,		**CI3.6** explain pathway of Gluconeogenesis,	
	SO3.7 Explain Entner-Doudoroff pathway, and Hormonal regulation of carbohydrate metabolism.		**CI3.7** Entner-Doudoroff pathway, and Hormonal regulation of carbohydrate metabolism.	
	SO3.8 Explain glucuronate pathway. And Hormonal regulation .		**CI3.8** Explain glucuronate pathway and Hormonal regulation .	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail glycogenesis and glycogenolysis,
	SW3.2 Mini Project	Describe Isolation and purification of enzyme.
	SW3.3 other activity	Find out some you tube videos based on Energetics of metabolic cycle

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	02	01	02	13

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

CO4-55MBT104.4: To become familiar with the fundamental Metabolic activity of lipids.	**SO4.1** Explaining α-, oxidation of fatty acids	**LI4.1** Perform Chemical test for lipids.	**Unit-4** **CI 4.1** α-, ß- and ω- oxidation of fatty acids	**SL4.1** Understand the metabolic pathway - α, ß and ω- oxidation of fatty acid
	SO4.2 Explaining ß-oxidation of fatty acids		**CI 4.2** α-, ß- and ω- oxidation offatty acids	**SL4.2** Fatty acid biosynthesis, Acetyl CoA carboxylase, ACP structure and function,
	SO4.3 Explaining ω-oxidation of fatty acids		**CI 4.3** α-, ß- and ω- oxidation offatty acids	
	SO4.4 Explaining Fattyacid biosynthesis, AcetylCoA carboxylase, ACP structure and function,		**CI 4.4** Fatty acid biosynthesis,Acetyl CoA carboxylase, ACPstructure and function,	.
	SO4.5 Describe Biosynthetic pathway fortri-acylglycerols,		**CI4.5** biosynthetic pathway for tri-acylglycerols, phosphoglycerides, sphingomyelin	
	SO4.6 Describe Biosynthetic pathway forphosphoglycerides.		**CI4.6** biosynthetic pathway for tri-acylglycerols, phosphoglycerides, sphingomyelin	

	SO4.7 Describe Biosynthetic pathway forsphingomyelin.		**CI4.7** biosynthetic pathway for tri-acylglycerols, phosphoglycerides, sphingomyelin	
	SO4.8 Explain the Metabolism of cholesteroland its regulation.Energetics of fatty acid cycle.		**CI4.8** Metabolism of cholesterol and its regulation. Energetics offatty acid cycle.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	llustrating -, ß- and ω- oxidation of fatty acids
	SW4.2 Mini Project	Describe the Metabolism of cholesterol
	SW4.3 Other Activities (Specify)	Find out some you tube videos on biosynthetic pathway for tri-acylglycerols, phosphoglycerides, sphingomyelin

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	02	01	02	13

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO5-55MBT104.5: Apply the ideas and pathways of nucleotide metabolism.	**SO5.1** Elucidate Biosynthesis of purine nucleotides	**LI5.1** Detect the presence of amino acid in the given sample.	**Unit-5** **CI5.1** Biosynthesis of purine and pyrimidine nucleotides	**SL5.1** Understand Biosynthesis of purine and pyrimidine nucleotides
	SO5.2 Elucidate Biosynthesis of pyrimidine nucleotides		**CI5.2** Biosynthesis of purine and pyrimidine nucleotides	**SL5.2** Learn the Differentiation between Disorder associated with defect in carbohydrate, amino acid and lipid metabolism
	SO5.3 Explain the degradation of purine nucleotides.		**CI5.3** Degradation of purine and pyrimidine nucleotides	
	SO5.4 Explain the degradation of pyrimidine nucleotides.		**CI5.4** Degradation of purine and pyrimidine nucleotides	
	SO5.5 Explain nitrogen assimilation.		**CI5.5** nitrogen assimilation and urea cycle	
	SO5.6 Explain urea cycle.		**CI5.6** nitrogen assimilation and urea cycle	
	SO5.7 Explain Aminoacid (synthesis and degradation)		**CI5.7** Amino acid (synthesis and degradation)	

	SO5.8 Explain Aminoacid (synthesis and degradation)		**CI5.8** Amino acid (synthesis and degradation)	

Suggested SessionalWork (SW): *anyone*	**SW5.1** Assignments	llustrating Biosynthesis Degradative pathway of nucleotides.
	SW5.2 Mini Project	A disorder associated with defects in carbohydrate, amino acid and lipid metabolism
	SW5.3 Other Activities (Specify)	Prepare one article explaining the degradation of amino acid.

Course duration (in hours) to attain Course Outcomes:

Course Title: Biomlecules **Course Code: 55MBT104**

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-55MBT104.1: Understand the Structure, classification, and properties of carbohydrates.	9	6	2	1	18
CO2-55MBT104.2: Extend biochemistry of nucleic acid, amino acids, and protein.	8	6	3	1	18
CO3-55MBT104.3: Understanding of Role and mechanism of action of coenzymes and carbohydrate metabolism.	8	2	2	1	13
CO4-55MBT104.4: To become familiar with the fundamental Metabolic activity of lipids.	8	2	2	1	13
CO5-55MBT104.5: Apply the ideas and pathways of nucleotide metabolism.	8	2	2	1	13
Total Hours	41	18	11	05	75

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

Course Title: Biomolecules **Course Code: 55MBT104**

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-55MBT104.1: Understand the Structure, classification, and properties of carbohydrates.	2	1	1	1	5
CO2-55MBT104.2: Extend biochemistry of nucleic acid, amino acids, and protein.	2	4	2	2	10
CO3-55MBT104.3: Understanding of Role and mechanism of action of coenzymes and carbohydrate metabolism.	3	5	5	2	15
CO4-55MBT104.4: To become familiar with the fundamental Metabolic activity of lipids.	2	3	3	2	10
CO5-55MBT104.5: Apply the ideas and pathways of nucleotide metabolism.	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	Principles of biochemistry David L. Nelson, Michael Cox WH Freeman 7 & 2017
2	Fundamentals of biochemistry j.l.jain S.chand 6 & 2005
3	U. Satyanarayana Kindle Edition Elsevier India 5 & 2017

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: M. tech. Biotechnology
Semester: I Semester
Course Title: Biomlecules **Course Code: 55MBT104**

CO/PO/PSO Mapping

Course Outcome (Cos)	Program Outcomes (POs)					Program Specific Outcomes (PSOs)		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-55MBT104.1: Understand the Structure, classification, and properties of carbohydrates.	1	2	2	3	1	2	2	1
CO2-55MBT104.2: Extend biochemistry of nucleic acid, amino acids, and protein.	1	2	3	2	1	1	1	2
CO3-55MBT104.3: Understanding of Role and mechanism of action of coenzymes and carbohydrate metabolism.	1	2	3	2	1	1	1	1
CO4-55MBT104.4: To become familiar with the fundamental Metabolic activity of lipids.	2	1	1	3	2	1	1	3
CO5-55MBT104.5: Apply the ideas and pathways of nucleotide metabolism.	1	1	1	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)
PO 1,2,3,4,5	**CO1-55MBT104.1:** Understand the Structure, classification, and	SO1.1 SO1.2 SO1.3, SO1.4,	**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**

PSO 1,2,3	properties of carbohydrates.	SO1.5, SO1.6, SO1.7, SO1.8, SO1.9	**LI3**		
PO 1,2,3,4,5 PSO 1,2,3	**CO2-55MBT104.2:** Extend biochemistry of nucleic acid, amino acids, and protein.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5, SO2.6, SO2.7, SO2.8	**LI 1** **LI 2** **LI3**	2.1, 2.2, 2.3, 2.4,2.5,2.6,2.7,2.8	**2SL-1,2,3**
PO 1,2,3,4,5 PSO 1,2,3	**CO3-55MBT104.3:** Understanding of Role and mechanism of action of coenzymes and carbohydrate metabolism.	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**
PO 1,2,3,4,5 PSO 1,2,3	**CO4-55MBT104.4:** To become familiar with the fundamental Metabolic activity of lipids.	SO4.1 SO4.2 SO4.3 SO4.4 , SO4.5, SO4.6, SO4.7, SO4.8	**LI 1**	4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8	**4SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO5-55MBT104.5:** Apply the ideas and pathways of nucleotide metabolism.	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-1,2**

Program Name	**Master of Technology (M.Tech.)- Biotechnology**	
Semester	I	
CourseCode:	**55MBT105**	
Coursetitle:	Immunology and Vaccine Technology	**Curriculum Developer**: Dr. Deepak Mishra
Pre-requisite:	Student should have basic knowledge of Zoology, Human anatomy - physiology and biotechnology.	
Rationale:	The subject of Immunology and Vaccine Technology in M.Tech. Biotechnology programme provides students with a deep understanding of the immune system, including its components, functions, and how it responds to various pathogens and foreign substances. The course covers the principles and methods involved in the development of vaccines. This includes topics such as antigen selection, vaccine formulation, adjuvants, and delivery systems. Overall, an immunology and vaccine technologycourse equips students with the knowledge and skills necessary to contribute to the development, evaluation, and implementation of vaccines for the prevention of infectious diseases. Given the critical role of vaccines in public health, such courses play a vital role in training the next generation of scientists, healthcare professionals, and policymaker.	
Course Outcomes (COs):	**CO1-55MBT105.1:** Acquire proficiency in structure and function of the immune system, its various components and their roles in immune responses, **CO1-55MBT105.2:** familiar with immunological concepts, i.e. antigen recognition, antibody production, cytokine signaling and immune memory. **CO1-55MBT105.3:** Acquire the knowledge of bioassays for investigation of different immune-pathological conditions. And their impact. **CO1-55MBT105.4:** Critically analyze experimental data and scientific literature related to vaccine development to salve the immunological problems **CO1-55MBT105.5:** Implications of immunological research and applications, including auto immunity, immunotherapy, transplantation etc.	

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 (BSC)	**55MBT105**	Immunology and Vaccine Technology	3	2	1	5	11	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 Attendance (AT)	Total Marks (CA+CT+SA+AT)		
Program Core Course (BSC)	**55MBT105**	Immunology and Vaccine Technology	**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)		
ESC	**55MBT155**	**Immunology and Vaccine Technology lab**	**35**	**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 thecourse'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)
CO1-55MBT105.1: Acquire proficiency in structure and function of the immune system, its various components and their roles in immune responses,	**SO1.1** Define and Describe concept of cell of immune system	**LI1.1** Determination of Total leukocyte count.	**Unit 1** **CI1.1** Cells of the immune system and their development	**SL1.1** Search various reference books and study material to start the learning of immunology
	SO1.2 Describe about primary lymphoid organs	**LI1.2** Determination of differential leukocyte count	**CI1.2** primary lymphoid organs	**SL1.2** Check the function of immune system during infection
	SO 1.3 Explain about secondary lymphoid organs		**CI1.3** secondary lymphoid organs	**SL1.3** Learn about various live experiences of immunology.
	SO 1.4 Describe types of immunity		**CI1.4** types of immunity	
	SO 1.5 Study the different inflammatory response		**CI1.5** Inflammatory response	**SL1.4** Study the concept of immunity in daily life
	SO 1.6 Elaborate process of pathogen recognition		**CI1.6** Recognition of pathogens	**SL1.5** Study the concept of pathogen recognition.
	SO 1.7 Describe concept Toll like receptors		**CI1.7** activation of Toll-like receptors	
	SO 1.8 Assess the concept of complement system		**CI1.8** complement system	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Explain the mechanism of inflammatory response and complement pathways.
	SW1.2 Mini Project	Prepare live model of lymphoid organ and immune system
	SW1.3 Other Activities (Specify)	Study and compare immune systems of different organisms

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	4	1	5	20

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
CO1-55MBT105.2: familiar with immunological concepts, i.e. antigen recognition, antibody production, cytokine signaling and immune memory.	**SO2.1** Assess the concept of antibody mediated immunity	**LI2.1** Perform immune electrophoresis	**Unit-II** **CI2.1** Antibody mediated immunity	**SL2.1** Enlist the examples of immune responses duringdifferent age of development.
	SO2.2 Explain about cell mediated immunity	**LI2.2** Demonstration of FACS	**CI2.2** cell mediated immunity	**SL2.2** Assess role of immunity in specific condition
	SO2.3 Explain component of cell mediated immunity		**CI2.3** components of cell-mediated immunity	**SL2.3** Case studies on immunological responses.
	SO2.4 Explain structure and function of MHC molecules		**CI2.4** MHC – structure and function	**SL2.4** Learn about mechanism of antigen recognition.
	SO2.5 Describe antigen processing and presentation		**CI2.5** Antigen possessing and presentation	**SL2.5** Learn about clinical aspects of immune response
	SO2.6 Describe mechanism of adaptive immunity		**CI2.6** Effectors mechanism of adaptive immunity	
	SO2.7 Describe B Cell development pathway		**CI2.7** B- cell development and activation	
	SO2.8 Elaborate concept of antibody diversity		**CI2.8** Antibody diversity	
	SO2.9 Assess the concept of class switching		**CI2.9** class switching	
	SO2.10 Explain about antigenic drift		**CI2.10** Antigenic drift	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe various effectors mechanism of immunity and their effects
	SW2.2 Mini Project	Select any biological problems and investigate it immunologically
	SW2.3 Other Activities (Specify)	Prepare list of infections caused by various pathogens and associate immune responses.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	04	01	05	19

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction(LI)	Class room Instruction (CI)	Self-Learning(SL)
CO1-55MBT105.3: Acquire the knowledge of bioassays for investigation of different immune-pathological conditions. And their impact.	**SO3.1** Explore concept and role of CD markers	**LI3.1** perform HLA typing	**Unit-III** **CI3.1** Identification of lymphocytes based on CD markers	**SL 3.1** Search various reference books and study material to start the learning in computer
	SO3.2 study about FACS	**LI3.2** perform RID	**CI3.2** FACS	**SL3.2**Check the application of computer
	SO3.3 learning lymphocyte proliferation assay		**CI3.3** Lympho proliferation assay	**SL3.3**Learn about various characteristics of computer .
	SO3.4 criticizing Cr51 release assay		**CI3.4** Cr51 release assay	**SL3.4.** Learn internet model
	SO3.5 exploring cytokine bioassay		**CI3.5** cytokine bioassays-IL2	**SL3.5**Study internet and its uses
	SO3.6 exploring gamma IFN, TNF alpha concept		**CI3.6** gamma IFN, TNF alpha	
	SO3.7 explain about HLA typing		**CI3.7** HLA typing	
	SO3.8 illustrate bout immune cytochemical techniques		**CI3.8** Immunocytochemical techniques	
	SO3.9 exploring concept of flowcytometry	**LI3.4** Demonstration of flowcytometry.	**CI3.9** Immunofluorescence – Flow cytometry	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Explain the mechanism of antigen antibody interaction and their application in bioasssys..
	SW1.2 Mini Project	Prepare list of advanced immunological techniques and their application.
	SW1.3 Other Activities (Specify)	Study and compare different immunological bioassays.

Items	CI	LI	SW	SL	TOTAL
Approax hrs	10	02	01	05	18

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO1-55MBT105.4: Critically analyze experimental data and scientific literature related to vaccine development to salve the immunological problems	**SO4.1** Explain the concept of vaccine technology	**LI4.1** demonstration of vaccination concept	**CI4.1** Vaccine technology:Criteria for effective vaccine,	**SL4.1** Search study material to learn vaccine
	SO4.2 explore about live and killed vaccine		**CI4.2** Live and Killed Vaccines	**SL4.2** document national vaccination programe
	SO4.3 Describe subunit vaccine		**CI4. 3** Sub unit vaccines	
	SO4.4 Describe Recombinant		**CI4. 4** Recombinant Vaccines	**SL4.3**case studies on side effect of vaccine
	SO4.5 Explore the DNA Vaccine		**CI4.5** DNA vaccines	**SL4.4** Compare modern and traditional vaccines
	SO4.6 Describe peptide vaccine		**CI4.6** Peptide vaccines	
	SO4.7 Explain about ediblevaccine		**CI4.7** Edible vaccines	**SL4.5** study about current research of vaccines
	SO4.8 Illustrate reverse vaccinology		**CI4.8** Reverse vaccinology	
	SO4.9 illustrate method of vaccine production		**CI4.9** Traditional and modern method of vaccine production	
	SO4.10 Demonstrate about future of vaccine development.		**CI4.10** Current andfuture scenario of Vaccines	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Explain the mechanism of vaccination and its side effects.
	SW1.2 Mini Project	Prepare list of national vaccination programme and its success ratio.
	SW1.3 Other Activities (Specify)	Study and compare different vaccines and vaccination strategies.

Item	CI	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)
CO1-55MBT105.5: Implications of immunological research and applications, including auto immunity, immunotherapy, transplantation etc.	**SO5.1** Study about immunodeficiency disease	**LI5.1** perform ELISA to detect AIDS	**Unit-V** **CI5.1** Immunodeficiency diseases	**SL5.1** prepare a chart showing mechanism of hyper sensitivity
	SO5.2 Demonstrate mechanism of allergy and hypersensitivity	**LI5.2** Perform skin irritation test	**CI5.2** Allergy and hypersensitivity -asthma	**SL5.2** perpare a chart showing mode of allergy
	SO5.3 Illustrate about auto immunity		**CI5.3** Auto immune diseases	
	SO5.4 Explain mechanism ofpathogenesis		**CI5.4** pathogenicmechanisms	
	S05.5 study mechanism of transplantation		**CI5.5** Transplantation mechanism - graft rejection	**SL5.3** case study ontransplantation
	S05.6 study concept of tumor immunology		**CI5.6** Tumour immunology	**SL5.4** case study about graft rejection
	S05.7 study immune responseagainst tumor		**CI5.7** immuneresponseagainst tumours	
	S05.8 study about immune evasion by tumor		**CI5.8** Immune evasion by tumours.	**SL5.5** clinical case studies on tumors and cancer

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Explain the mechanism of auto immunity and transplantation
	SW1.2 Mini Project	Prepare list of immune deficiency diseases and their epidemiology
	SW1.3 Other Activities (Specify)	Study and compare different types of transplantation mechanisms and its success ratio.

Course duration (in hours) to attain Course Outcomes:

Course Title: Immunology and Vaccine Technology **Course Code:55MBT105**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (LI+CI+SL+SW)
CO1-55MBT105.1: Acquire proficiency in structure and function of the immune system, its various components and their roles in immune responses,	8	4	5	1	18
CO1-55MBT105.2: familiar with immunological concepts, i.e. antigen recognition, antibody production, cytokine signalling and immune memory.	10	4	5	1	20
CO1-55MBT105.3: Acquire the knowledge of bioassays for investigation of different immune-pathological conditions. And their impact.	9	4	5	1	19
CO1-55MBT105.4: Critically analyze experimental data and scientific literature related to vaccine development to salve the immunological problems	10	2	5	1	18
CO1-55MBT105.5: Implications of immunological research and applications, including auto immunity, immunotherapy, transplantation etc.	8	4	5	1	18
Total Hours	45	73 18	25	5	93

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

Course Title: Immunology and Vaccine Technology **Course Code:55MBT105**

Course Outcomes					
	A	**A**	**E**	**C**	**Total Marks**
CO1-55MBT105.1: Acquire proficiency in structure and function of the immune system, its various components and their roles in immune responses,	2	1	1	1	5
CO1-55MBT105.2: familiar with immunological concepts, i.e. antigen recognition, antibody production, cytokine signaling and immune memory.	2	4	2	2	10
CO1-55MBT105.3: Acquire the knowledge of bioassays for investigation of different immune-pathological conditions. And their impact.	2	3	3	2	10
CO1-55MBT105.4: Critically analyze experimental data and scientific literature related to vaccine development to salve the immunological problems	3	5	5	2	15
CO1-55MBT105.5: Implications of immunological research and applications, including auto immunity, immunotherapy, transplantation etc.	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

Legend: A: Apply, A: Analyze E: Evaluate, C: Create

Suggested learning Resources:

(a) Books:

(b)

S.No.	Title
1	A.K. Chakravarty, "*Immunology and Immunotechnolog"y*, Oxford University Press, 2006.
2	Janeway, Kenneth Murphy, Paul Travers, Mark Walport, "*Immunobiology* 7th"Edition, Garland Science, 2008.
3	TakMak and ME Saunders, "*The immune response: Basic and Clinical principles",* Elseiver, 2005.
4	Peter Wood, "*Understanding Immunology"*, 2nd Edition, Pearson Education Ltd, 2006.
5	B.M Hannigan, C.B.T. Moore and D.G.Quinn, "*Immunology"*, 2nd Edition, Viva Books.

(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 Title: M. Tech. Biotechnology
Semester: I
Course Code: 55MBT105
Course Title: Immunology and Vaccine Technology

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-55MBT105.1: Acquire proficiency in structure and function of the immune system, its various components and their roles in immune responses,	1	2	3	2	1	2	2	3
CO1-55MBT105.2: familiar with immunological concepts, i.e. antigen recognition, antibody production, cytokine signalling and immune memory.	1	1	2	2	1	2	3	3

CO1-55MBT105.3: Acquire the knowledge of bioassays for investigation of different immune-pathological conditions. And their impact.	1	2	2	3	1	1	2	3
CO1-55MBT105.4: Critically analyze experimental data and scientific literature related to vaccine development to salve the immunological problems	1	1	3	3	2	1	2	3
CO1-55MBT105.5: Implications of immunological research and applications, including auto immunity, immunotherapy, transplantation etc.	1	1	3	3	2	1	2	2

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 PSO 1,2,3	**CO1-55MBT105.1:** Acquire proficiency in structure and function of the immune system, its various components and their roles in immune responses,	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8	1.1,1.2,	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 PSO 1,2,3	**CO1-55MBT105.2:** familiar with immunological concepts, i.e. antigen recognition, antibody production, cytokine signalling and immune memory.	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-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO1-55MBT105.3:** Acquire the knowledge of bioassays for investigation of different immune-pathological conditions. And their	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6	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

	impact.	SO3.7 SO3.8 SO3.9			
PO 1,2,3,4,5 PSO 1,2,3	**CO1-55MBT105.4:** Critically analyze experimental data and scientific literature related to vaccine development to salve the immunological problems	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10	4.1	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 PSO 1,2,3	**CO1-55MBT105.5:** Implications of immunological research and applications, including auto immunity, immunotherapy, transplantation etc.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8	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

Curriculum Development Team

Prof. Deepak Mishra

Semester II

Program Name	**Master of Technology (M. Tech)- Biotechnology**	
Semester	II	
Course Code:	**55MBT201**	
Course title:	Industrial Enzymes and Its Application	**Curriculum Developer**: Dr. Ashwini A. Waoo, Professor
Pre-requisite:	Student should have basic knowledge of enzymes	
Rationale:	Industrial enzymes are pivotal in biotechnology, offering diverse applications across sectors like food, pharmaceuticals, and biofuels. Understanding their function and application is crucial in optimizing production processes, reducing environmental impact, and enhancing product quality. Exploring industrial enzymes in an M.Tech Biotech program equips students with practical knowledge essential for innovation and efficiency in various industries, fostering a deeper understanding of biocatalysis and its real-world applications	
Course Outcomes (COs):	**CO1-55MBT201.1:** Develop a comprehensive understanding of enzymology, encompassing enzyme structure, function, and classification. **CO1-55MBT201.2:** Students will demonstrate a comprehensive understanding of enzyme kinetics, including factors affecting enzyme activity, substrate specificity, and inhibition. **CO1-55MBT201.3:** Acquire proficiency in selecting, designing, and implementing industrial enzymes for specific biotechnological processes. **CO1-55MBT201.4:** Attain proficiency in various immobilization techniques such as adsorption, entrapment, covalent binding, and encapsulation, enabling students to select and apply suitable methods. **CO1-55MBT201.5:** Develop expertise in identifying, designing, and implementing enzymes for diverse applications in industries like food, pharmaceuticals, biofuels, and environmental biotechnology.	

Scheme of Studies:

Board of Study	CourseCode	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 (ESC)	**55MBT201**	Industrial Enzymes and Its Application	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 (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 Core (ESC)	**55MBT201**	Industrial Enzymes and Its Application	**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)		
ESC	**55MBT251**	**Industrial Enzymes and Its Application lab**	**35**	**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 thecourse's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	06	01	05	21

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-55MBT201.1: Develop a comprehensive understanding of enzymology, encompassing enzyme structure, function, and classification.	**SO1.1** Understand basics of enzymology		**Unit-1** **CI1.1** Introduction to Enzymes,	**SL1.1** Study of history and scope of enzymology
	SL1.2 Illustrate the nomenclature of enzyme		**CI1.2** enzyme nomenclature,	**SL1.2** Discuss rules of nomenclature of enzymes
	SL1.3 Give classification of enzymes	LI1 Isolation of papain from papaya	**CI1.3** classification of enzymes.	**SL1.3** Write a brief on classification of enzymes
	SL1.4 Describe Isolation and purification of enzymes.	LI 2 Isolation of amylase	**CI1.4** Isolation and purification of enzymes,	**SL1.4** Write short note on Isolation and purification of enzymes,
	SL1.5 Describe preparation of purification chart		**CI1.5** preparation of purification chart,	**SL1.5** Prepare preparation of purification chart.
	SL1.6 Illustrate the techniqueof Specimen preparation for SEM	LI3 Demonstrate the effect of temp, pH, substrate concentration on enzyme activity	**CI1.6** Enzyme activity,	
	SL1.7 Learn Specific activity and turn over number,		**CI1.7** Specific activity and turn over number,	
	SL1.8 Knowledge about marker enzymes		**CI1.8** Marker enzymes	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe nomenclature and classification of enzymes
	SW1.2 Mini Project	Describe techniques used in isolation and purification of enzymes .
	SW1.3 Other Activities (Specify)	Find out list of marker enzymes used in reserch

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)
CO1-55MBT201.2: Students will demonstrate a comprehensive understanding of enzyme kinetics, including factors affecting enzyme activity, substrate specificity, and inhibition.	**SO2.1** Illustration of enzyme kinetics		**Unit-II** **CI2.1** Enzyme Kinetics	**SL2.1** Learn enzyme kinetics
	SO2.2 Illustration of steady state kinetics		**CI2.2** Steady state,	**SL2.2** Explain steady state kinetics
	SO2.3 Understand pre-steady state,		**CI2.3** pre-steady state,	**SL2.3** Learn pre-steady state,
	SO2.4 Acquire knowledge about equilibrium kinetics		**CI2.4** equilibrium kinetics,	**SL2.4** Discuss the equilibrium kinetics
	SO2.5 Assessing the need and significance of Michaelis and Menten Equation and its derivation		**CI2.5** Michaelis and Menten Equation and its derivation,	**SL2.5** Give a brief note on enzyme inhibition
	SO2.6 Explaining Different methods to calculate the Km and Vmax		**CI2.6** Different methods to calculate the Km and Vmax and their significance.	
	SO2.7 Explaining Inhibition and its type		**CI2.7** Inhibition and its type.	
	SO2.8 Understand Fourth generation sequencing platforms and future		**CI2.8** Kinetics of multi substrate reactions	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe High-Throughput Next generation sequencing (HT-NGS) platforms
	SW2.2 Mini Project	Explain the Sanger DNA sequencing.
	SW2.3 Other Activities (Specify)	Prepare chart on Helico high speed genome sequencing

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	05	19

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-55MBT201.3: Acquire proficiency in selecting, designing, and implementing industrial enzymes for specific biotechnological processes.	**SO3.1** Demonstrate the Structure and function of enzymes lysozyme	**LI1** Demonstration of industrial production of chymotrypsin	**Unit-III** **CI3.1** Structure and function of enzymes: Lysozyme,	**SL3.1** Read about enzyme sources
	SO3.2 Illustration of structure, mode of action and applications of chymotrypsin.	**LI 2** Demonstration of allosteric enzymes via model making	**CI3.2** chymotrypsin,	**SL3.2** Draw a diagram ofstructure and active site of chymotrypsin
	SO3.3 Analyze the role of DNA polymerase		**CI3.3** DNA polymerase,	**SL3.3** Explain DNA polymerase
	SO3.4 Evaluate types and applications of RNase		**CI3.4** RNase	**SL 3.4** Write a note on enzyme regulation
	SO3.5 Describe applications of proteases		**CI3.5** proteases	**SL 3.5** Diagrammatically explain allosteric mechanism
	SO3.6 Demonstrate the Enzyme regulation		**CI3.6** Enzyme regulation and control of their activity.	
	SO3.7 Describe mechanisms and examples of allosteric enzymes		**CI3.7** Introduction to allosteric enzymes and	
	SO3.8 Analyze isozymes and its applications		**CI3.8** isozymes	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe sources, structure, applications of lysozyme and its industrial production
	SW3.2 Mini Project	Describe the significance of allosteric enzymes in metabolism
	SW3.3 Other Activities (Specify)	Prepare list of enzymes used in industry and their production companies.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	05	19

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1-55MBT201.4: Attain proficiency in various immobilization techniques such as adsorption, entrapment, covalent binding, and encapsulation, enabling students to select and apply suitable methods.	**SO4.1** Develop understanding of Immobilization of enzymes,	**LI 1** Immobilize given enzyme sample by sodium alginate method	**Unit-IV** **CI4.1** Enzyme Technology: Immobilization of enzymes,	**SL4.1** Learn about GC MS
	SO4.2 Illustrate mechanism of whole cell immobilization	**LI2** Immobilize given enzyme sample by gelatin method	**CI4.2** whole cell immobilization and their application,	**SL4.2** Discuss challenges and advantages of enzyme immobilization
	SO4.3 Analyze key parameters of commercial production of enzymes		**CI4.3** commercial production of enzymes,	**SL4.1** Learn video for commercial production of enzymes,
	SO4.4 Understand RNA-catalysis,		**CI4.4** RNA-catalysis,	**SL4.4** Studies related ribozyme
	SO4.5 Evaluate strategies and analysis of HPLC data		**CI4.5** Catalytic antibodies,	
	SO4.6 Evaluate the applications and mechanism of abzymes		**CI4.6** abzymes	**SL4.5** Evaluate the mechanism and applications also examples of abzymes
	SO4.7 Discuss protein and Enzyme engineering:		**CI4.7** Protein and Enzyme engineering:	
	SO4.8 Explain design and construction of novel enzymes		**CI4.8** Design and construction of novel enzymes	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe principles and strategies of immobilization of enzymes
	SW4.2 Mini Project	Describe the techniques of protein engineering
	SW4.3 Other Activities (Specify)	Prepare list of abzymes prepared or isolated yet

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

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1-55MBT201.5: Develop expertise in identifying, designing, and implementing enzymes for diverse applications in industries like food, pharmaceuticals, biofuels, and environmental biotechnology.	**SO5.1** Demonstrate industrial applications of enzymes		**Unit-V** **CI5.1** Applications of Enzymes, Industrial,	**SL5.1** learn about applications of enzymes
	SO5.2 Illustrate the analytical purpose applications of enzymes		**CI5.2** Analytical and Diagnostic purposes,	**SL5.2** learn about analytical enzymes
	SO5.3 Evaluate the role of enzymes in food technology		**CI5.3** commercial applications of enzymes in food,	**SL5.3** Give role of enzymes in food
	SO5.4 Illustrate pharmaceutical and other industries, enzymes applications		**CI5.4** pharmaceutical and other industries, enzymes	**SL5.4** Learn about pharmaceutical and other industries, enzymes
	SO 5.5 Analyze the advantages of enzyme diagnostic kits		**CI5.5** for diagnostic applications	**SL5.5** Give example of enzymes used in diagnostics

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Describe industrial applications of enzymes
	SW5.2 Mini Project	Describe the applications of enzymes in pharmaceutical
	SW5.3 Other Activities (Specify)	Prepare list of enzymes used in food technology

Course duration (in hours) to attain Course Outcomes:

Course Title: Industrial Enzymes and Its Application **Course Code: 55MBT201**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-55MBT201.1: Develop a comprehensive understanding of enzymology, encompassing enzyme structure, function, and classification.	9	6	5	1	21
CO1-55MBT201.2: Students will demonstrate a comprehensive understanding of enzyme kinetics, including factors affecting enzyme activity, substrate specificity, and inhibition.	9	0	5	1	15
CO1-55MBT201.3: Acquire proficiency in selecting, designing, and implementing industrial enzymes for specific biotechnological processes.	9	4	5	1	19
CO1-55MBT201.4: Attain proficiency in various immobilization techniques such as adsorption, entrapment, covalent binding, and encapsulation, enabling students to select and apply suitable methods.	9	4	5	1	19
CO1-55MBT201.5: Develop expertise in identifying, designing, and implementing enzymes for diverse applications in industries like food, pharmaceuticals, biofuels, and environmental biotechnology.	8	0	5	1	14
Total Hours	44	14	25	05	88

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

Course Title: Industrial Enzymes and Its Application **Course Code: 55MBT201**

Course Outcomes					
	A	**A**	**E**	**C**	**Total Marks**
CO1-55MBT201.1: Develop a comprehensive understanding of enzymology, encompassing enzyme structure, function, and classification.	03	01	01	01	06
CO1-55MBT201.2: Students will demonstrate a comprehensive understanding of enzyme kinetics, including factors affecting enzyme activity, substrate specificity, and inhibition.	02	04	02	02	10
CO1-55MBT201.3: Acquire proficiency in selecting, designing, and implementing industrial enzymes for specific biotechnological processes.	03	05	05	01	14
CO1-55MBT201.4: Attain proficiency in various immobilization techniques such as adsorption, entrapment, covalent binding, and encapsulation, enabling students to select and apply suitable methods.	02	03	05	00	10
CO1-55MBT201.5: Develop expertise in identifying, designing, and implementing enzymes for diverse applications in industries like food, pharmaceuticals, biofuels, and environmental biotechnology.	05	04	00	01	10
Total Marks	15	17	13	05	50

Legend: A: Apply, A: Analyze E: Evaluate, C: Create

Suggested learning Resources:

(a) 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
3	Higher Education, Maidenhead,UK, 2008.
4	Freifelder D., Physical Biochemistry, "Application to Biochemistry and Molecular Biology", 2nd Edition, W.H. Freeman & Company, SanFransisco, 1982.
5	Keith Wilson and John Walker, "Principles and Techniques of Practical Biochemistry", 5th Edition, Cambridge 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 virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Title: M. Tech. Biotechnology
Semester: II
Course Code: 55MBT201
Course Title: Industrial Enzymes and Its Application

Course Outcome	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
55MBT201.1	**2**	**1**	**2**	**3**	**-**	**-**	**1**	**-2**
55MBT201.2	**2**	**2**	**-**	**-**	**-**	**1**	**2**	**1**
55MBT201.3	**2**	**1**	**2**	**3**	**-**	**1**	**1**	**-**
55MBT201.4	**2**	**-**	**-**	**1**	**-**	**-**	**-**	**2**
55MBT201.5	**2**	**1**	**2**	**1**	**2**	**-**	**2**	**2**

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 PSO 1,2,3	**CO1-55MBT201.1:** Understanding the basic steps of gene cloning and the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8, SO1.9	LI1, LI2, 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 PSO 1,2,3	**CO1-55MBT201.2:** Selection of expression strategies for heterologous gene- expression in bacteria, yeast, insects, and in mammalian cells.	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	2SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO1-55MBT201.3:** Acquiring theoretical knowledge in the techniques, tools, application and safety measures of genetic engineering and gene therapy.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8, SO3.9	LI1, LI2,	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	**CO1-55MBT201.4:** Studying the basics of nanotechnology, synthesis, characterization of nanoparticles.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 , SO4.8, SO4.9	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 PSO 1,2,3	**CO1-55MBT201.5:** Applications of bionanotechnology in medicine, agriculture and the environment.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6		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
Er. Arpit Srivastava

Program Name	**Master of Technology (M. Tec)- Biotechnology**	
Semester	II	
Course Code:	**55MBT202**	
Course title:	Entrepreneurship and Bioethics	**Curriculum Developer**: Mr. Dhirendra Mishra Teaching Associate
Pre-requisite:	Course Assessment methods (Continuous (CT)and end assessment (EA))	
Rationale:	Existing normative takes on entrepreneurship can be broadly inferred from approaches to business ethics, which can be classified into two main categories: one sees entrepreneurship as an emergent product of individuals' interactions within the boundaries of people's existing rights.	
Course Outcomes (COs):	**55MBT202.1:** To educate about various societal, governance and regulatory issues in biotechnology. **55MBT202.2:** To educate about entrepreneurial skill attainment in customer development, customer validation, competitive analysis of the real-world problems and projects and market survey. **55MBT202.3:** To build managerial capacity in value creation through company formation, intellectual property licensing of biopharmaceutical products **55MBT202.4:** To raise awareness about the ethical implications and safety rules in biopharma and GMO production management. **55MBT202.5:** Evaluate applications and ethical concern in Entrepreneurship and Bioethics	

Scheme of Studies:

Board of Study	CourseCode	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 (PE)	55MBT202	Entrepreneurship and Bioethics	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 outcom

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)		
ProgramCore (PE)	55MBT202	Entrepreneurship and Bioethics	**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)		
ESC	**55MBT252**	**Entrepreneurship and Bioethics lab**	**35**	**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 thecourse's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx.Hrs** | 10 | 02 | 01 | 05 | 18

Course outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Class room Instruction(CI)**	**Self-Learning(SL)**
CO1-55MBT202.1: Educate about various societal, governance and regulatory issues in biotechnology.	**SO1.1** Understand ethics conflicts in biotechnology	**LI1.1 Case** study **On** ethics conflicts in biotechnology	**Unit-1** **CI1.1** Biotechnology and Bioethics: ethics conflicts in biotechnology- interference withnature.	**SL1.1** Study Biotechnology and Bioethics
	SO1.2 Categorize unequal distribution RISK in biotechnology.		**CI1.2** fear of unknown, unequal distribution of risks and benefits of biotechnolog	**SL1.2** What are various fear of unknown risks and benefits of biotechnology
	SO1.3 Know unequal distribution of benefits in biotechnology.		**CI1.3** fear of unknown, unequal distribution of benefits of biotechnology	**SL1.3** What are various fear of unknownbenefits of biotechnology
	SO1.4 Understand bioethicsvs, business ethics		**CI1.4** bioethics vs, business ethics	**SL1.4** Write about business ethics
	SO1.5 Understand Benefits of biotechnology		**CI1.5** Benefits of biotechnology	**SL1.5** Write about Benefits of biotechnology
	SO1.6 Describe ELSI of biotechnology.		**CI1.6** ELSI of biotechnology	
	SO1.7 Illustrate the recombinant therapeutic products for human health care		**CI1.7** recombinant therapeutic products for human health care.	

	SO1.8 Evaluate various factorsfor food consumption		**CI1.8** genetic modifications and food consumption	
	SO1.9 Evaluate various factorsfor genetic modifications		**CI1.9** food consumption	
	SO1.10 Knowledge about release of genetically engineered organisms		**CI1.10** release of genetically engineeredorganisms	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Explain various types of ELSI of biotechnology
	SW1.2 Mini Project	Describe genetic modifications and food consumption
	SW1.3 Other Activities (Specify)	Find out differences between bioethics vs, business ethics.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	10	02	01	04	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-55MBT202.2: To educate about entrepreneurial skill attainment in customer development, customer validation, competitive analysis of the real-world problems and projects and market survey.	**SO2.1**Illustration of techniques of Patent	**LI2.1** Debate on the topic of patent and trademark	**Unit-II CI2.1**Patent and Trademark	**SL2.1** Learn about Patent
	SO2.2 Illustration of techniques Trademark		**CI2.2** Trademark	
	SO2.3 Illustration of Biotechnology products and processes		**CI2.3** Biotechnology products and processes	**SL2.2** Describe examples of Biotechnology products
	SO2.4 Illustration of Biotechnology processes		**CI2.4**Biotechnology processes	
	SO2.5 Understand Intellectual property rights		**CI2.5** Intellectual property rights	**SL2.3** Learn about Intellectual property rights
	SO2.6 Describe Plant breeder's rights		**CI2.6** Plant breeder's rights	**SL2.4** Discuss the Plant breeder's rights
	SO2.7 Assessing the need of biotechnology in developing countries		**CI2.7** biotechnology in developing countries	
	SO2.8 Discuss Biosafety		**CI2.8**Bio safety and its implementation	
	SO2.9 Bio safety and its implementation		**CI2.9** its implementation	
	SO2.10 understand the Quality control in Biotechnology		**CI2.10** Quality control in Biotechnology	

Suggested Sessional Work (SW):*anyone*	**SW2.1** Assignments	Describe various techniques of Biosafety and its implementation
	SW2.2 Mini Project	Explain the biotechnology in developing countries.
	SW2.3 Other Activities (Specify)	Prepare list of Quality control in Biotechnology

Item	Cl	LI	SW	SL	Total
Approx.Hrs	10	02	01	04	16

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-55MBT202.3: To build managerial capacity in value creation through company formation, intellectual property licensing of biopharmaceutical products	**SO3.1** Demonstrate the Entrepreneurship.	**LI3.1** Group Discussion on the topic of bio entrepreneurs	**Unit-III** **CI3.1** Entrepreneurship definition, factors necessary	**SL3.1** Read about factors necessary for entrepreneurship
	SO3.2 Understand the meaning of Entrepreneurship.		**CI3.2** Meaning of entrepreneurship	**SL3.2** Write a note on start-up
	SO3.3 Know the factors of Entrepreneurship.		**CI3.3** Entrepreneurship factors necessary	**SL3.3** Describe Mistakes to be avoided in Start-up
	SO3.4 Illustration of Desirables in a start-up		**CI3.4** Desirables in a start-up	**SL3.4** Describe Pillars of bio-entrepreneurship,
	SO3.5 Understand mistakes to be avoided in start-up		**CI3.5** Mistakes to be avoided,	
	SO3.6 Evaluate Pillars of bio-entrepreneurship		**CI3.6** Pillars of bio-entrepreneurship,	
	SO3.7 Describe Promoting bio-entrepreneurship, ,		**CI3.7** Promoting bio-entrepreneurship,	
	SO3.8 Demonstrate the Biotech company roadmap, ,		**CI3.8** Biotech company roadmap, ,	
	SO3.9 Describe Biotech company legal.		**CI3.9** Legal,	
	SO3.10 Analyze Regulatory and other business factors.		**CI3.10** Regulatory and other business factors..	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe types of Entrepreneurs
	SW3.2 Mini Project	Describe the significance of bio-entrepreneurship
	SW3.3 Other Activities (Specify)	Prepare list of Start-up

Item	Cl	LI	SW	SL	Total
Approx.Hrs	10	02	01	04	16

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO1-55MBT202.4 To raise awareness about the ethical implications and safety rules in biopharma and GMO production management.	**SO4.1** Know about Funding of biotech business	**LI4.1** Group discussion on the title of funding Agencies of biotech	**Unit-IV** **CI4.1** Funding of biotech business	**SL4.1** Discuss Funding of biotech business
	SO4.2 Illustrate opportunities & challenges Financing alternatives		**CI 4.2** Financing alternatives,	**SL4.2** Learn about financial alternatives
	SO4.3 Analyze key requirements of VC Funding		**CI 4.3** VC Funding	**SL4.1** Video for VC funding
	SO4.4 Understand Funding for biotech in India,		**CI 4.4** Funding for biotech in India,	**SL4.3** Studies related livestock management
	SO4.5 Evaluate Exit strategy		**CI 4.5** Exit strategy	
	SO4.6 Know the need of Licensing strategies,		**CI 4.6** Licensing strategies,	**SL4.4** Explain Licensing strategies
	SO4.7 Know the procedures valuation of funding		**CI 4.7** valuation	
	SO4.8 Understand Support mechanisms for entrepreneurship		**CI 4.8** Support mechanisms for entrepreneurship	
	SO4.9 Bio-entrepreneurship efforts in India,		**CI 4.9** (Bio-entrepreneurship efforts in India,	
	SO4.10 Difficulties in India experienced.		**CI 4.10** Difficulties in India experienced.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe requirements of Support mechanisms for entrepreneurship
	SW4.2 Mini Project	Describe the Bio-entrepreneurship efforts in India,
	SW4.3 Other Activities (Specify)	**CI4.1** Write short notes on VC Funding

Item	Cl	LI	SW	SL	Total
Approx.Hrs	08	04	01	05	15

Course Outcome (CO)	SessionOutcomes(SOs)	LaboratoryInstruction (LI)	ClassroomInstruction(CI)	Self-Learning(SL)
CO1-55MBT202.5: Evaluate applications and ethical concern in Entrepreneurship and Bioethics	**SO5.1** Describe Organizations supporting biotech growth	**LI5.1** case study on the topic of Organizations supporting biotech growth	**Unit-V** **CI5.1** Organizations supporting biotech growth,	**SL5.1** learn about Organizations supporting biotech growth
	SO5.2 Illustrate the areas of biotech industry		**CI5.2** areas	**SL5.2** Prepare list of areas of scope of biotech Industry
	SO5.3 Illustrate the areas of scope of biotech industry		**CI5.3** he areas of scope of biotech industry	
	SO5.4 Evaluate the need of funding agencies in India		**CI5.4** funding agencies in India,	**SL5.3** Prepare list of areas of scope of biotech Industry
	, **SO5.5** Describe biotech policy initiatives		**CI5.5** biotech policy initiatives),	**SL5.4**Give role of cell culture based vaccine
	SO5.6 Analyze the Role of knowledge centres like universities and research institutions		**CI5.6** Role of knowledge centres And R&D (knowledge centres like universities and research institutions	**SL5.5** Learn about biotech policy initiatives
	SO5.7 Analyze the Role of knowledge centres like research institutions	**LI5.2** Group discussion on the topic of Analyze the Role of knowledge centres like research institutions	**CI5.7** Role of knowledge centres And R&D (knowledge centres research institutions	
	SO5.8 Describe ethical role of technology and up gradation in biotech industry		**CI5.8** role of technology and up gradation,,	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Describe role of technology and up gradation,,
	SW5.2 Mini Project	Describe the Organizations supporting biotech growth,
	SW5.3 Other Activities (Specify)	Role of technology and up gradation in biotech field

Course duration (in hours) to attain Course Outcomes:

Course Title: Entrepreneurship and Bioethics **Course Code: 55MBT202**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-55MBT202.1: To educate about various societal, governance and regulatory issues in biotechnology.	10	2	5	1	18
CO1-55MBT202.2: To educate about entrepreneurial skill attainment in customer development, customer validation, competitive analysis of the real-world problems and projects and market survey.	10	2	4	1	17
CO1-55MBT202.3: To build managerial capacity in value creation through company formation, intellectual property licensing of biopharmaceutical products	10	2	4	1	17
CO1-55MBT202.4: To raise awareness about the ethical implications and safety rules in biopharma and GMO production management	10	2	4	1	17
CO1-55MBT202.5: Evaluate applications and ethical concern in Entrepreneurship and Bioethics	8	4	5	1	18
Total Hours	48	12	22	05	87

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

Course Title: Entrepreneurship and Bioethics **Course Code: 55MBT202**

Course Outcomes					
	A	**A**	**E**	**C**	**Total Marks**
CO1-55MBT202.1: To educate about various societal, governance and regulatory issues in biotechnology	03	03	01	03	10
CO1-55MBT202.2: To educate about entrepreneurial skill attainment in customer	02	05	01	02	10

development, customer validation, competitive analysis of the real-world problems and projects and market survey.					
CO1-55MBT202.3: To build managerial capacity in value creation through company formation, intellectual property licensing of biopharmaceutical products	04	03	03	01	10
CO1-55MBT202.4: To raise awareness about the ethical implications and safety rules in biopharma and GMO production management	04	01	03	02	10
CO1-55MBT202.5: Evaluate applications and ethical concern in Entrepreneurship and Bioethics	04	01	04	01	10
Total Marks	15	17	13	05	50

Legend: A: Apply, A: Analyze E: Evaluate, C: Create

Suggested learning Resources:

(a) Books:

(b)

S. No.	Title
1	Craig Shimasaki, Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies,Academic Press, 2014
2	James F. Jordan, Innovation, Commercialization, and Start-Ups in Life Sciences, CRC Press; 1 edition 2014
3	Frank S. David, The Pharmagellan Guide to Biotech Forecasting and Valuation, Pharmagellan; 1st edition,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 virology lab (BSL-3)

7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Title: M. Tech. Biotechnology
Semester: II
Course Code: 55MBT202
Course Title: Entrepreneurship and Bioethics

Course Outcome	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
55MBT202.1	**1**	**1**	**-**	**3**	**3**	**2**	**1**	**-**
55MBT202.2	**2**	**1**	**2**	**2**	**3**	**2**	**1**	**1**
55MBT202.3	**-**	**3**	**-**	**1**	**2**	**1**	**2**	**-**
55MBT202.4	**2**	**2**	**1**	**3**	**3**	**2**	**-**	**-**
55MBT202.5	**3**	**1**	**1**	**3**	**2**	**2**	**2**	**-**

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 PSO 1,2,3	**CO1-55MBT202.1:** To educate about various societal, governance and regulatory issues in biotechnology	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8, SO1.9, SO1.10	LI 1 LI 2	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8	1SL-1,2,3,4
PO 1,2,3,4,5 PSO 1,2,3	**CO1-55MBT202.2:** To educate about entrepreneurial skill attainment in customer development, customer validation, competitive analysis of the real-world problems and projects and market survey.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7, SO2.8, SO2.9, SO2.10	LI 1 LI 2	2.1, 2.2, 2.3, 2.4, 2.5,2.6,2.7,	2SL-1,2,3,4
PO 1,2,3,4,5 PSO 1,2,3	**CO1-55MBT202.3:** To build managerial capacity in value creation through company formation, intellectual property licensing of biopharmaceutical products	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7, SO3.8, SO3.9, SO3.10	LI 1 LI 2	3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8	3SL-1,2,3,4
PO 1,2,3,4,5 PSO 1,2,3	**CO1-55MBT202.4:** To raise awareness about the ethical implications and safety rules in biopharma and GMO production management	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO3.8, SO4.9, SO4.10	LI 1 LI 2	4.1,4.2,4.3,4.4, 4.5,4.6, 4.7, 8,9,10	4SL-1,2,3,4
PO 1,2,3,4,5 PSO 1,2,3	**CO1-55MBT202.5:** Evaluate applications and ethical concern in Entrepreneurship and Bioethics	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7, SO5.8	LI 1 LI 2 LI 3 LI 4	5.1,5.2,5.3,5.4,5.5, 5.6,5.7	5SL-1,2,3,4,5

Curriculum Development Team

Prof. Kamlesh Choure
Prof Ashwini A. Waoo
Prof. Deepak Mishra
Er. Arpit Srivastava

Program Name	**Masters of Technology (M. Tech.)- Biotechnology**	
Semester	**II**	
Course Code:	**55MBT203**	
Course title:	Bioprocess Equipment Design	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of fermentation and bioprocess engineering	
Rationale:	Bioprocess Equipment 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. 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):	**CO1-55MBT203.1.** Illustrate the terminologies associated with bioprocessing and its equipment **CO2-55MBT203.2.** Explain the importance of microbes and mutants in bioprocessing **CO3-55MBT203.3.** Interpretate the different kinds of sterilization process on the basis of its kinetics **CO4-55MBT203.4.** Analyze the difference between heat and mass transfer **CO5-55MBT203.5.** Evaluate the rheological properties & Design Downstream processing for various kinds of products	

Scheme of Studies:

Board of Study	CourseCode	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 (PCC)	**55MBT203**	Bioprocess Equipment Design	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)		
PCC	**55MBT203**	Bioprocess Equipment 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)		
PCC	**55MBT253**	**Bioprocess Equipment Design lab**	**35**	**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 thecourse's conclusion.

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	8	04	01	03	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-55MBT203.1. Illustrate the terminologies associated with bioprocessing and its equipment	**SO1.1** Explain concept of Media required in fermentation	**LI1.1** To Demonstrate the working of a Bench Top bioreactor with all its parts	**Unit-1** **CI1.1** Criteria for good medium, medium requirements for fermentation processes	**SL1.1** Find out some examples of bioprocess technique used in ancient India
	SO1.2 Determine the basic ingredients used in media	**LI1.2** To perform the isolation of microorganisms from different kinds of samples	**CI1.2** carbon, nitrogen, minerals, vitamins and other complex nutrients, oxygen requirements. Medium formulation for optimal	**SL1.2** Search various reference books and study material to start the learning of microorganisms

			growth and product formation	
	SO1.3 Describe the different types of media		**CI1.3** Examples of simple and complex media, design of various commercial media for industrial fermentations	**SL1.3** Draw a flow chart showing upstream and fermentation processing
	SO1.4 Explain the process of media optimization in fermentation process		**CI1.4** Medium optimization methods. Raw materials and media design for fermentation Process	

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	08	04	01	03	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-55MBT203.2. Explain the importance of microbes and mutants in bioprocessing	**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	**Unit-2** **CI2.1** The isolation of industrially important micro-organisms	**SL2.1** Find out more conventional cell disruption techniques
	SO2.2 Explain the working mechanism of preservation techniques of microorganisms	**LI2.2** To perform the experiment of microbial production of Amino acids	**CI2.2** The preservation of industrially important micro-organisms	**SL2.2** Read the fundamental techniques used in the process of preservation
	SO2.3 Explain the microbial strains		**CI2.3** The improvement of industrial	**SL2.3** Write down few points on

	improvement strategies		micro-organisms, The isolation of -resistant mutants	biological product's properties
	SO2.4 Describe mutants, its types and metabolite production		**CI2.4** Auxotrophic mutants, revertant mutants, Concept for overproduction of metabolites	

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	04	01	02	17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-55MBT203.3. Interpretate the different kinds of sterilization process on the basis of its kinetics	**SO3.1** Elucidate the Growth and Death kinetics of Microorganisms	**LI3.1** To perform the microbial production of Secondary metabolites using shake flask fermentation method	**Unit-3** **CI3.1** Growth and Death kinetics of Microorganisms	**SL3.1** Derive the numerical problems associated with Elementary and Non-Elementary reactions
	SO3.2 Derive the batch and continuous sterilization	**LI3.2** To observe the growth of microbial biomass and calculate its kinetics using	**CI3.2** Design of batch and continuous sterilization	**SL3.2** Derive the numerical problems associated with experimental reactor data

		graph		
	SO3.3 Analyze the Filter sterilization of liquid media		**CI3.3** Filter sterilization of liquid media	
	SO3.4 Describe the process of Air sterilization		**CI3.4** Air sterilization	
	SO3.5 Evaluate Numerical problem associated with batch and continuous sterilization		**CI3.5** Numerical data on DEL factor, associative factors of sterilization	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Derive the equations for Batch and Continuous Sterilization
	SW3.2 Mini Project	Describe the role of mass and heat transfer and its kinetics
	SW3.3 Other	Prepare one Power point presentation on "Growth and Death Kinetics of microorganisms"

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)
CO4-55MBT203.4. **Analyze the difference between heat and mass transfer**	**SO4.1** Elucidate the Mechanism of heat transfer, Equipment of heat transfer	**LI4.1** To perform the production of Antibiotics using fungi in a Shake Flask reactor.	**Unit-4** **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	**LI4.2** To determine the peptide sequence, epitope regions for the prediction of In-silico vaccine design using The Immune Epitope Database (IEDB) database	**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		**CI4.3** Design equation for Heat transfer, Calculations of Heat	**SL4.3** Find out the role of oxygen transfer in reactors

	of Heat transfer coefficients		transfer coefficients	
	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	

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	04	01	05	20

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-55MBT203.5 Evaluate the rheological properties & Design Downstream processing for various kinds of products	**SO5.1** Elucidate the fundamentals of Fluid flow and mixing	**LI5.1** To perform the mixing using impellers and to calculate the mixing time	**Unit-5 Heterogeneous Reactions** **CI5.1** Fluid flow and mixing; Reynolds Number; Newtonian & Non-Newtonian fluid derivations	**SL5.1** Find out the industrial applications of Fluidity
	SO5.2 Describe the Rheological Properties of Fermentation Broths	**LI5.2** To determine the viscosity of different rheological compounds	**CI5.2** Rheological Properties of Fermentation Broths; Factors Affecting Broth Viscosity	**SL5.2** Solve the numerical problems associated with Rheology
	SO5.3 Analyze how the Power is required in mixing		**CI5.3** Power Requirements for Mixing; Power number calculation; Effect of Rheological Properties	**SL5.3** Solve the numerical problems associated with Reynold's number; Power

			on Mixing	number
	SO5.4 Analyze the Downstream Processing and associative Unit Operations		**CI5.4** Downstream Processing and associative Unit Operations	**SL5.4** Solve the numerical problems associated with viscosity
	SO5.5 Derive the Filtration; Centrifugation and Aqueous Two-Phase Extraction		**CI5.5** Filtration; Centrifugation and Aqueous Two-Phase Extraction	**SL5.5** Solve the numerical problems associated with unit operations
	SO5.6 Describe the entire steps used in Downstream processing of various products		**CI5.6** Microbial Production of Polysaccharides; Therapeutic compounds; Solvents; Fermented food products	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Derive the numerical problems for different Unit operations
	SW5.2 Mini Project	Describe the process of Viscosity with examples and applications
	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: Bioprocess Equipment Design **Course Code:** 55MBT203

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-55MBT203.1. Illustrate the terminologies associated with bioprocessing and its equipment	8	4	3	1	16
CO2-55MBT203.2. Explain the importance of microbes and mutants in bioprocessing	8	4	3	1	16
CO3-55MBT203.3. Interpretate the different kinds of sterilization process on the basis of its kinetics	10	4	2	1	17
CO4-55MBT203.4. Analyze the difference between heat and mass transfer	10	4	3	1	18
CO5-55MBT203.5. Evaluate the rheological properties & Design Downstream processing for various kinds of products	10	4	5	1	20
Total Hours	46	20	16	05	87

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	
CO1-55MBT203.1. Illustrate the terminologies associated with bioprocessing and its equipment	2	1	1	1	5
CO2-55MBT203.2. Explain the importance of microbes and mutants in bioprocessing	2	4	5	1	12
CO3-55MBT203.3. Interpretate the different kinds of sterilization process on the basis of its kinetics	3	5	5	1	14
CO4-55MBT203.4. Analyze the difference between heat and mass transfer	2	3	5	1	11
CO5-55MBT203.5. Evaluate the rheological properties & Design Downstream processing for various kinds of products	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 for fermentation technology"

(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: M. Tech. Biotechnology
Semester: I Semester
Course Title: Bioreactor Engineering
Course Code: 55MBT102

CO/PO/PSO Mapping									
Course Outcome (Cos)	**Program Outcomes (POs)**						**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1-55MBT203.1. Illustrate the terminologies associated with bioprocessing and its equipment	2	-	-	1	2	1	2	2	1
CO2-55MBT203.2. Explain the importance of microbes and mutants in bioprocessing	1	-	1	1	-	1	1	1	2
CO3-55MBT203.3. Interpretate the different kinds of sterilization process on the basis of its kinetics	1	1	1	1	-	1	1	1	1

CO4-55MBT203.4. Analyze the difference between heat and mass transfer	1	-	1	-	2	1	1	1	3
CO5-55MBT203.5. Evaluate the rheological properties & Design Downstream processing for various kinds of products	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	**CO1-55MBT203.1.** Illustrate the terminologies associated with bioprocessing and its equipment	SO1.1 SO1.2 SO1.3 SO1.4	**LI 1 LI 2 LI 3 LI 4**	1.1,1.2,1.3,1.4	**1SL-1,2,3**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO2-55MBT203.2.** Explain the importance of microbes and mutants in bioprocessing	SO2.1 SO2.2 SO2.3 SO2.4	**LI 1 LI 2 LI 3**	2.1, 2.2, 2.3, 2.4	**2SL-1,2,3**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO3-55MBT203.3.** Interpretate the different kinds of sterilization process on the basis of its kinetics	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**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO4-55MBT203.4.** Analyze the difference between heat and mass transfer	SO4.1 SO4.2 SO4.3 SO4.4 SO5.5	**LI 1 LI 2**	4.1,4.2,4.3,4.4, 4.5	**4SL-1,2,3**

PO 1,2,3,4,5,6 PSO 1,2, 3	**CO5-55MBT203.5.** Evaluate the rheological properties & Design Downstream processing for various kinds of products	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6	**LI 1** **LI 2** **LI 3**	5.1,5.2,5.3,5.4,5.5, 5.6	**5SL-1,2,3,4,5**

Program Name	**Masters of Technology (M.Tech.)- Biotechnology**	
Semester	II	
Course Code:	**55MBT204**	
Course title:	Research Methodology and Biostatistics	**Curriculum Developer**: Dr. Deepak Mishra, Professor
Pre-requisite:	Student should have basic knowledge of Biotechnology, Genetic Engineering and practical as well as research skills. Student also have the knowledge of mathematical tools used to solve biological problems.	
Rationale:	The paper on Research Methodology and Biostatistics in an MTech Biotechnology program explores the critical role of specialized research and scientific tools in analyzing biotechnology. It delves into the use of precise instruments for monitoring and analyzing data and literature, development of scientific writing skills and research aptitudes. This study enables students to understand how systematicresearch process helps us for doing any research in a systematic manner along with data publication. Biostatistics serves as the cornerstone of evidence-based decision-making in the fields of biotechnology by providing rigorous methods for data analysis, study design, and interpretation. It enables researchers and practitioners to extract meaningful insights from complex biological and health-related data, facilitating advancements in disease prevention, diagnosis, and treatment.	
Course Outcomes (COs):	**CO1-55MBT204.1:** Development of skills with essentials research methods through various tools available for scientific research. **CO2-55MBT204.2:** Development of critical thinking skills for evaluating scientific literature and identifying research problems **CO3-55MBT204.3:** Proficiency in communicating research findings through various written forms. **CO4-55MBT204.4:** Acquire proficiency in fundamental statistical concepts, methods, and techniques relevant to biostatistics, **CO5-55MBT204.5:** **A**pply statistical methods to analyze biological data sets, interpret results, and draw meaningful conclusions	

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 (BSC)	**55MBT204**	Research Methodology and Biostatistics	3	2	1	5	11	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	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	**55MBT204**	Research Methodology and Biostatistics	**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)		
BSC	55MBT254	Research Methodology and Biostatistics lab	35	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 thecourse'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)
CO1-55MBT204.1: Development of skills with essentials research methods through various tools available for scientific research.	**SO1.1** Define and Describe concept of scientific research and its types	**LI1.1** design the research problem and create objectives	**Unit-1** **CI1.1** 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
	SO1.3 Explain about methods and sources of literature	**LI1.2** Literature collection	**CI1.3** Literature survey: Different sources,	**SL1.3** Searching and literature on different online resources.
	SO1.4 Describe about concept of data collection		**CI1.4** Data Collection	
	SO1.5 Study of about types of data		**CI1.5** Secondary Data, Primary Data,	**SL1.4** collection of scientific data related to different research problems
	SO1.6 Study of data collection methods		**CI1.6** Methods of Collection,	
	SO1.7 Describe concept of data analysis and hypothesis testing		**CI1.7** Data analysis and hypothesis testing	**SL1.5** Setting up the Hypothesis and their application in research
	SO1.8 Illustrate about structure of thesis		**CI1.8** Structure of thesis;	

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

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)
55MBT204.2: Development of critical thinking skills for evaluating scientific literature and identifying research problems	**SO2.1** Explaining the steps of research process		**Unit-II** **CI2.1** Research Process: selection of problems:	**SL2.1** Search various contents for writing a review article
	SO2.2 Explaining the stages of execution of research		**CI2.2** stages in the execution of research	**SL2.2** Designing of a research article
	SO2.3 Reflecting about different types of research designs.		**CI2.3** Research Designs.	**SL2.3** Learn about contents of an ideal book
	SO2.4 Explain about contents of an ideal thesis		**CI2.4** Scaling Techniques Concepts and types,	**SL2.4** Searching and literature on different online resources.
	SO2.5 Assessing the technique of review and journal article writing		**CI2.5** Writing reviews and journal articles	
	SO2.6 Explore about books and monographs		**CI2.6** Books, and monographs	**SL2.5** Use of research process to solve different research problems
	SO2.7 Explain about bibliography and journals		**CI2.7** Bibliography, Journals	
	SO2.8 explaining standard of research journals		**CI2.8** Standard of research journals	
	SO2.9 Explaining impact factor and citation index.		**CI2.9** Impact factor - citation index	

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.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	04	01	05	19

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction (CI)	Self-Learning(SL)
CO3-55MBT204.3: Proficiency in communicating research findings through various written forms.	**SO3.1** Explain the role of sampling methods and sampling errors	**LI3.1** Solve the numerical Problems related to Central Tendency	**Unit-III** **CI3.1** Sampling and sampling errors	**SL3.1** Search various reference books and study material to start the learning of biostatistics
	SO3.2 Assessing different measures of central tendency		**CI3.2** Measures Central Tendency - Mean	
	SO3.3 Explaining concept median	**LI3.2** Solve the numerical Problems of biostatistics	**CI3.3** Measures Central Tendency - Median	**SL3.2** Study the biological problems by application of measure of centraltendency
	SO3.4 Assessing concept of mode		**CI3.4** Measures Central Tendency - Made	
	SO3.5 Describe about measures of dispersion		**CI3.5** Dispersion-	**SL3.3** Study the biological problems by application of measure of dispersion
	SO3.6 Assessing about skewness And kurtosis		**CI3.6** Skewness and Kurtosis.	
	SO3.7 Describe about concept of probability		**CI3.7** Probability – Concept ,theorems	**SL3.4** Study the biological problems by application of probability
	SO3.8 Describe about Binomial distribution		**CI3.8** Basic Statistical Distributions- Binomial	**SL3.5** Study the biological problems by probability distribution
	SO3.9 Describe about Poisson and normal distribution		**CI3.9** Poisson and Normal Distributions	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Explain various types of probability distribution.
	SW3.2 Mini Project	Describe the concept and application of measures of central tendency
	SW3.3 Other Activities (Specify)	Find out examples of measures of central tendency in different biological processes

Item	Cl	LI	SW	SL	Total
Approx.Hrs	07	04	01	05	16

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO4-55MBT204.4: Acquire proficiency in fundamental statistical concepts, methods, and techniques relevant to biostatistics,	**SO4.1** Exploring the concept of correlation	**LI4.1** Find out regression equation X on Y	**Unit-IV** **CI4.1** Correlation – Simple Correlation.	**SL4.1** Enlist the different biological problem related for statistical analysis.
	SO4.2 Assessing the partial and multiple correlation	**LI4.2** Problems related to correlation.	**CI4.2** Partial and Multiple correlation	**SL4.2** Assess role of regression and correlation
	SO4.3 Describe about regression		**CI4.3** Regression	**SL4.3** Learn about different regression model
	SO4.4 Explaining the concept of regression model		**CI4.4** Simple Repression Models	**SL4.4** Learn about application of test of significance.
	SO4.5 Explaining the multiple regression		**CI4.5** Multiple regression models	**SL4.5** Learn about different parametric tests.
	SO4.6 Evaluate the chi square test		**CI4.6** Chi-square Distribution	
	SO4.7 Describe the small sample test.	**LI4.3** Problems related to chi square test	**CI4.7** Small Sample Tests ,	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe various techniques used for study relationship of variables
	SW4.2 Mini Project	Select any biological problems and investigate it statistically.
	SW4.3 Other Activities (Specify)	Prepare list of application of hypothesis testing

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

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO5-55MBT204.5: Apply statistical methods to analyze biological data sets, interpret results, and draw meaningful conclusions	**SO5.1** Define the concept, types and objective of Hypothesis	**LI5.1** Draw a hypothesis and test it using suitable test.	**Unit-V** **CI5.1** Hypothesis : Concept and types	**SL5.1** learn about basic concept & requirement of hypothesis testing
	SO5.2 Able to execute methods of hypothesis testing	**LI5.2** Problems related to T test.	**CI5.2** methods for hypothesis testing	**SL5.2**Review different methods of hypothesis testing
	SO5.3 Apply the role of Non parametric methods		**CI5.3** Non-Parametric Methods	**SL5.3** study the biological problems related to hypothesis testing
	SO5.4 Apply the one sample and two sample test		**CI5.4** One sample and two sample tests	
	SO5.5 Evaluate the analysis of variance		**CI5.5** Analysis of variance	**SL5.4** study the biological problems related to ANOVA
	SO5.6 Describe principle of experimentation		**CI5.6** Principles of experimentation	**SL5.4** Learn about design of experiments
	SO5.7 Describe about basic experimental design		**CI5.7** Basic Experimental designs,	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain about methods of hypothesis testing and its significance
	SW5.2 Mini Project	Describe the Role of ANOVA in biological problems
	SW5.3 Other Activities (Specify)	Prepare a detail details of parametric test along withexamples

Course duration (in hours) to attain Course Outcomes:

Course Title: Research Methodology and Biostatistics **Course Code:**55MBT204

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-55MBT204.1: Development of skills with essentials research methods through various tools available for scientific research.	8	4	5	1	18
CO2-55MBT204.2: Development of critical thinking skills for evaluating scientific literature and identifying research problems	9	0	5	1	15
CO3-55MBT204.3: Proficiency in communicating research findings through various written forms	9	4	5	1	19
CO4-55MBT204.4: Acquire proficiency in fundamental statistical concepts, methods, and techniques relevant to biostatistics,	7	4	5	1	17
CO5-55MBT204.5: Apply statistical methods toanalyze biological data sets, interpret results, and draw meaningful conclusions	7	4	5	1	17
Total Hours	40	16	25	05	86

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

Course Title: Research Methodology and Biostatistics **Course Code:**55MBT204

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-55MBT204.1: Development of skills with essentials research methods through various tools available for scientific research.	2	1	1	1	5
CO2-55MBT204.2: Development of critical thinking skills for evaluating scientific literature and identifying research problems	2	4	2	2	10
CO3-55MBT204.3: Proficiency in communicating research findings through various written forms	2	3	3	2	10
CO4-55MBT204.4: Acquire proficiency in fundamental statistical concepts, methods, and techniques relevant to biostatistics,	3	5	5	2	15
CO5-55MBT204.5: Apply statistical methods to analyze biological data sets, interpret results, and draw meaningful conclusions	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	S. C. Gupta and V. K. Kapoor, "Fundamentals of MathematicalStatistics", 8th Edition, Sultan Chand & Sons, Delhi, 2003.
2	S. C. Gupta and V. K. Kapoor, "Applied Statistics", 8th Edition, Sultan Chand & Sons, Delhi, 2003.
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	Marcello Pagano and Kimberley Gauvreau, "Principles of Bio- Statistics", 1st Edition, Duxbury: Thomson Learning, USA, 2000.
6	B. L. Agrawal, "Programmed Statistics", 2nd Edition, New Age International (P) Ltd., New Delhi, 199

(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: M. Tech. Biotechnology
Semester: II Semester
Course Title: Research Methodology and Biostatistics
Course Code: 55MBT204

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-55MBT204.1: Development of skills with essentials research methods through various tools available for scientific research.	2	1	3	3	2	2	2	3
CO2-55MBT204.2: Development of critical thinking skills for evaluating scientific literature and identifying research problems	2	1	3	2	3	1	3	3
CO3-55MBT204.3: Proficiency in communicating research findings through various written forms	1	2	3	2	3	1	2	2
CO4-55MBT204.4: Acquire proficiency in fundamental statistical concepts, methods, and techniques relevant to biostatistics,	1	1	3	3	2	1	3	3
CO5-55MBT204.5: Apply statistical methods to analyze biological data sets, interpret results, and draw meaningful conclusions	1	1	3	3	2	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	**CO1-55MBT204.1:** Students are being knowledgeable with essentials of scientific writing and research methods through various tools available for scientific research.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8	LI1.1 LI1.2	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 PSO 1,2,3	**CO2-55MBT204.2:** 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 SO2.7 SO2.8 SO2.9		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	**CO3-55MBT204.3:** Proficiency in communicating research findings through various written forms.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7	LI3.1 LI3.2	3.1,3.2,3.3,3.4,3.5, 3.6, 3.7,	3SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO4-55MBT204.4:** Recognize various issues related to RDT research and analyze the regulatory frameworks, law and legislations related to biotechnological research.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7	LI4.1 LI4.2	4.1,4.2,4.3,4.4, 4.5, 4.6, 4.7, 4.8, 4.9	4SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO5-55MBT204.5:** Understanding of patenting process, laws, and drafting patent applications.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7	LI5.1 LI5.2	5.1,5.2,5.3,5.4,5.5, 5.6, 5.7, 5.8	5SL-1,2,3,4,5

Program Name	**M.Tech. BIOTECHNOLOGY**	
Semester	**IInd**	
Course Code:	**55MBT205-A**	
Course title:	**Bioinformatics and Molecular Modelling**	**Curriculum Developer**: Mr. Piyush Kant Rai, Assistant professor
Pre-requisite:	To excel in Computational Biology & Bioinformatics, a strong foundation in molecular biology, genetics, is essential. Understanding algorithms, especially dynamic programming, and familiarity with bioinformatics tools like NCBI databases are advantageous. Exposure to structural biology and molecular modeling concepts, sequence analysis, alignment methods, and phylogenetics is valuable. Skills in molecular modeling software and techniques further enhance comprehension of advanced topics.	
Rationale:	The proposed syllabus are critical for students embarking on a Computational Biology & Bioinformatics course due to its interdisciplinary nature. Proficiency in molecular biology, genetics, programming, and statistical analysis is fundamental for effective biological data interpretation and computational analysis. Familiarity with bioinformatics tools and databases enables efficient data handling and retrieval, while understanding algorithms enhances students' ability to develop and optimize bioinformatics algorithms. Exposure to structural biology concepts provides insights into molecular modeling techniques, essential for drug discovery and protein structure prediction. Overall, these prerequisites equip students with the necessary knowledge and skills to tackle complex biological problems using computational approaches.	
Course Outcomes (COs):	**55MBT205-A.1: Learning computational skills to examine biological information** **55MBT205-A.2: Learning and developing computational tools for analysis of large biological data** **55MBT205-A.3: To understand the models of biological systems constructed from experimental measurements** **55MBT205-A.4: Learn about machine learning and statistical tools to construct models from large existing datasets** **55MBT205-A.5: Analyze the molecular modelling and with specification of protein structure modelling and molecular docking studies.**	

Scheme of Studies:

Board of Study	CourseCode	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 (PCE)	**55MBT205-A**	**Bioinformatics and Molecular Modelling**	3	2	1	2	8	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 Attendance (AT)	Total Marks (CA+CT+SA+AT)		
(PCE)	**55MBT205-A**	**Bioinformatics and Molecular Modelling**	**15**	**20**	**5**	**10**	**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)**		
BSC	**55MBT255-A**	**Bioinformatics and Molecular Modelling lab**	**35**	**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 thecourse'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)	Class room Instruction (CI)	Self-Learning (SL)
CO1-55MBT205-A.1: Learning computational skills to examine biological information	**SO1.1** Understand the NCBI data model .	**LI1.1** Learn how to use databases	**CI1.1** Introduction to the NCBI data model.	**SL1.1** Visit EMBL database site
	SO1.2 EMBL		**CI1.2** EMBL	**SL1.2** Explore NCBI website
	SO1.3 DDBJ, swissprot.		**CI1.3** DDBJ, swissprot	
	SO1.4 Quality of GENBANK		**CI1.4** GENBANK	
	SO1.5 What is Entrez,		**CI1.5** Entrez	
	SO1.6 Features of Unigene		**CI1.6** Unigene.	
	SO1.7 Understanding the Databases and rapid sequence analysis.		**CI1.7** Understanding the Databases and rapid sequence analysis.	
	SO1.8 Understand sequence alignment algorithm		**CI1.8** Sequence alignment; Local and global alignment method	
	SO1.9 Understand Homologous sequences		**CI1.9** Homologous sequences	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Summarizes the GenBank, EMBL and DDBJ.
	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	2	1	2	14

Course Outcome (CO)	Session Outcomes (SOs)	LaboratoryInstruction (LI)	Class room Instruction (CI)	Self Learning (SL)
CO2-55MBT205-A.2: Learning and developing computational tools for analysis of large biological data	**SO2.1** How Dynamic programming works 1	**LI2.1** Discuss how to analyze raw reads of DNA/RNA.	**CI2.1** Dynamic programming 1	**SL2.1** Practice sequence Dynamic programming algorithm method
	SO2.2 How Dynamic programming works 1		**CI2.2** Dynamic programming 1	**SL2.2** Recall Dynamic smith-Watermann algorithm
	SO2.3 How dynamic programming based alignment by hidden Markov models,		**CI2.3** dynamic programming algorithms, alignment based hidden Markov models,	
	SO2.4 Understanding consensus word analysis,		**CI2.4** consensus word analysis	
	SO2.5 How dynamic programming based alignment by hidden Markov models 2		**CI2.5** How dynamic programming based alignment by hidden Markov models 2	
	SO2.6 more complex scoring.		**CI2.6** more complex scoring.	
	SO2.7 Pattern searching programs,		**CI2.7** Pattern searching programs,	
	SO2.8 family and superfamily representation		**CI2.8** family and superfamily representation	
	SO2.9 Explain progressive alignment method		**CI2.9** Progressive alignment method	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Justify the role of dynamic programming in alignment.
	SW2.2 Mini Project	Interpret the MSA result concerning the DNA.
	SW2.3 Other Activities (Specify)	Incorporate some youtube videos based on features of how to do MSA.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	**09**	4	1	2	16

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-55MBT205-A.3: To understand the models of biological systems constructed from experimental measurements	**SO3.1** Show Trees-splits and metrices on trees, tree interpretation	**LI3.1** Basics of tree metrices and tree splits	**CI3.1** Trees-splits and metrices on trees, tree interpretation	**SL3.1** Learn steps of phylogenetic tree generation
	SO3.2 Learn the , Distance – additive, ultrameric and nonadditive distances, tree building methods	**LI3.2** Interpretation of phylogenetic tree	**CI3.2** Distance – additive, ultrameric and nonadditive distances, tree building methods	**SL3.2** Practice Phylip software
	SO3.3 How to do phylogenetic analysis, parsimony		**CI3.3** phylogenetic analysis, parsimony, tree evaluation,	
	SO3.4 tree evaluation,		**CI3.4** tree evaluation	
	SO3.5 maximum likelihood trees		**CI3.5** maximum likelihood trees	
	SO3.6 tree evaluation,		**CI3.6** tree evaluation	
	SO3.7 Estimating the rate of change		**CI3.7** Estimating the rate of change	
	SO3.8 Estimate likelihood and trees		**CI3.8** Estimate likelihood and trees	
	SO3.9 Bayesian statistical analysis		**CI3.9** Bayesian statistical analysis	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Write about distance matrix.
	SW3.2 Mini Project	Make a flow chart of steps of phylogenetic tree generations

	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**	4	1	2	**16**

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO4-55MBT205-A.4: Learn about machine learning and statistical tools to construct models from large existing datasets	**SO4.1** Features of ESTs – databases	**LI4.1** Basics of CADD	**CI4.1** ESTs – databases	**SL4.1** Learn techniques of gene discovery
	SO4.2 What is clustering, gene discovery and identification,	**LI4.2** How to search any suitable drug	**CI4.2** clustering, gene discovery and identification	**SL4.2** remember docking
	SO4.3 How to do gene discovery and identification		**CI4.3** gene discovery and identification	
	SO4.4 explain methods of Protein identification and its physical properties		**CI4.4** Protein identification and its physical properties	
	SO4.5 Describe chou fasman method		**CI4.5** chou fasman method	
	SO4.6 Describe GOR method		**CI4.6** GOR method	
	SO4.7 What is docking and its types		**CI4.7** docking and its types	
	SO4.8 How molecular visualization and QSAR can be done		**CI4.8** molecular visualization and QSAR	
	SO4.9 Elaborate structure classification		**CI4.9** Structure classification	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Write about genetic algorithms.
	SW4.2 Mini Project	
	SW4.3 Other Activities (Specify)	Search and learn via YouTube how to calculate chou-fasman and GOR method.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	6	1	3	19

Course Outcome (CO)	Session Outcomes (SOs)	LaboratoryInstruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO5-55MBT205-A.5: Analyze the molecular modelling and with specification of protein structure modelling and molecular docking studies.	**SO5.1** Features of PDB and MMDB	**LI5.1** How to search and download any protein structures	**CI5.1** PDB and MMDB	**SL5.1** Learn how protein functions
	SO5.2 What is advance structure modeling.	**LI5.2** Basics of drug and protein interactions	**CI5.2** advance structure modeling	**SL5.2** Classify different types of modelling techniques
	SO5.3 Distinguish Internal and external co-ordinate system, cartesian and cylindrical polar co-ordinate system	**LI5.3** How to do homology modelling	**CI5.3** Internal and external co-ordinate system, cartesian and cylindrical polar co-ordinate system	**SL5.3** How many types of molecular force fields used in the MMDD
	SO5.4 Convey Potential energy calculations using semiempirical potential energy function		**CI5.4** Potential energy calculations using semiempirical potential energy function	
	SO5.5 What is Molecular mechanics and dynamics		**CI5.5** Molecular mechanics and dynamics	
	SO5.6 Features of knowledge based structure prediction		**CI5.6** knowledge based structure prediction	
	SO5.7 What is Molecular Design, structure similarity searching		**CI5.7** Molecular Design, structure similarity searching; Secondary structure prediction in proteins	
	SO5.8 Secondary structure prediction in proteins		**CI5.8** Secondary structure prediction in proteins	

	SO5.9 Elaborate Prediction of buried residues in proteins.		**CI5.9** prediction of buried residues in proteins.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Write about Lipinski rule of five
	SW5.2 Mini Project	
	SW5.3 Other Activities (Specify)	Try to learn and apply protein homology modelling using virtual lab.

Course duration (in hours) to attain Course Outcomes:

Course Title: Bioinformatics and Molecular Modelling **Course Code: 55MBT205-A**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-55MBT205-A.1: Learning computational skills to examine biological information.	9	2	2	1	14
CO2-55MBT205-A.2: Learning and developing computational tools for analysis of large biological data	9	2	2	1	14
CO3-55MBT205-A.3: To understand the models of biological systems constructed from experimental measurements	9	4	2	1	16
CO4-55MBT205-A.4: Learn about machine learning and statistical tools to construct models from large existing datasets	9	4	2	1	16
CO5-55MBT205-A.5: Analyze the molecular modelling and with specification of protein structure modelling and molecular docking studies.	9	6	3	1	19
Total Hours	45	18	11	5	79

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

Course Title: Bioinformatics and Molecular Modelling **Course Code: 55MBT205-A**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-55MBT205-A.1: Learning computational skills to examine biological information.	02	03	04	1	10
CO2-55MBT205-A.2: Learning and developing computational tools for analysis of large biological data	03	04	02	1	10
CO3-55MBT205-A.3: To understand the models of biological systems constructed from experimental measurements	02	05	02	1	10
CO4-55MBT205-A.4: Learn about machine learning and statistical tools to construct models from large existing datasets	02	05	02	1	10
CO5-55MBT205-A.5: Analyze the molecular modelling and with specification of protein structure modelling and molecular docking studies.	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:

(b)

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

(c) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: M.Tech. Biotechnology
Semester: II[nd] Sem
Course Title: Bioinformatics and Molecular Modelling
Course Code: 55MBT205-A

Course Outcome (Cos)	Program Specific Outcomes (PSOs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1-55MBT205-A.1: Learning computational skills to examine biological information.	3	3	3	1	-	2
CO2-55MBT205-A.2: Learning and developing computational tools for analysis of large biological data	-	3	-	1	1	2
CO3-55MBT205-A.3: To understand the models of biological systems constructed from experimental measurements	-	3	3	2	-	2
CO4-55MBT205-A.4: Learn about machine learning and statistical tools to construct models from large existing datasets	3	-	-	1	1	2
CO5-55MBT205-A.5: Analyze the molecular modelling and with specification of protein structure modelling and molecular docking studies.	**3**	**-**	**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 1,2,3,4,6	**CO1-55MBT205-A.1: Learning computational skills to examine biological information.**	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	**IL 1**	1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9	**1SL-1,2**
PO 2,4,5,6	**CO2-55MBT205-A.2: Learning and**	SO2.1 SO2.2 SO2.3	**144** **IL 1**	2.1, 2.2, 2.3,	**2SL-1,2**

	developing computational tools for analysis of large biological data	SO2.4 , SO 2.5., SO 2.6, SO2.7, SO2.8, SO2.9		2.4.2.5,2.6,2.7,2.8,2.9	
PO 2,3,4,6	**CO3-55MBT205-A.3: To understand the models of biological systems constructed from experimental measurements**	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 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 1,4,5,6	**CO4-55MBT205-A.4: Learn about machine learning and statistical tools to construct models from large existing datasets**	SO4.1 SO4.2 SO4.3 SO4.4,SO 4.5,SO4.6, SO4.7,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 1,3,4,5,6	**CO5-55MBT205-A.5: Analyze the molecular modelling and with specification of protein structure modelling and molecular docking studies.**	SO5.1 SO5.2 SO5.3 SO5.4,SO5.5, SO5.6,SO5.7,SO5.8, SO5.9	**IL 1** **IL 2** **IL 3**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9	**5SL-1,2,3**

Program name	Master of Technology (M. Tech.)- Biotechnology	
Semester	IInd	
Course Code:	**55MBT205-B**	
Course title:	Tissue Culture and Stem Cell Engineering (Elective-2) (Group A)	**Curriculum Developer**: Dr. Monika Soni, Assistant Professor
Pre-requisite:	Students should have basic knowledge of tissue culture and stem cell engineering.	
Rationale:	The subject aims to provide an overview of tissue culture and stem cell engineering that offers a multifaceted approach to advancing medical research and therapy development. By combining these techniques, students can create sophisticated models of human tissues, study disease processes, and develop innovative treatments with the potential to revolutionize healthcare.	
Course Outcomes (COs):	**CO1-55MBT205-B.1**: To understand the principles and techniques of tissue culture media preparation and laboratory practices. **CO2-55MBT205-B.2**: To understand the historical development and key techniques in plant tissue culture research. **CO3-55MBT205-B.3**: To understand the comprehensive knowledge of history, techniques, and applications in animal cell culture. **CO4-55MBT205-B.4**: To develop a comprehensive understanding of stem cell biology, including their properties, techniques, and applications. **CO5-55MBT205-B.5**: To develop a comprehensive understanding of tissue engineering & regenerative medicines approaches for reconstructing various tissues & organs, as well as the underlying mechanisms of cancer development and progression.	

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)	
Programme Elective (**PE**)	55BT206	Tissue Culture and Stem Cell Engineering	3	2	1	2	8	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	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	55MBT205-B	Tissue Culture and Stem Cell Engineering	**15**	**20**	**5**	**5**	**5**	**50**	**100**	**150**

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	**55MBT255-B**	**Bioinformatics and Molecular Modelling lab**	**35**	**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.

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)
CO1-55MBT205-B.1: To understand the principles and techniques of tissue culture media preparation and laboratory practices.			**Unit-1**	
	SO1.1 Describe & define the tissue culture media.		**CI1.1** Brief in detail introduction to tissue culture media.	**SL1.1** Search various reference books and other study material to start the learning about tissue culture & stem cell engineering.
	SO1.2 Explain in detail the ingredients of tissue culture media.	**LI1.1** To prepare and sterilize tissue culture media for plant and animal cell cultures.	**CI1.2** Describe the ingredients of tissue culture media.	**SL1.2** Learn about the different types of tissue culture media used for plant and animal cell cultures, along with their compositions and applications.
	SO1.3 Describe & define the physiological properties of tissue culture media.		**CI1.3** Describe the physiological properties of tissue culture media.	**SL1.3** Understand the physiochemical properties of tissue culture media and their significance in cell culture experiments.
	SO1.4 Explain in detail the temperature and balanced salt solutions.		**CI1.4** Study the temperature and balanced salt solutions.	
	SO1.5 Describe & define the antibiotics & growth supplements.		**CI1.5** Describe & define the antibiotics & growth supplements.	**SL1.4** Learn about antibiotics, growth supplements, and other reagents commonly used in cell culture experiments and their roles in supporting cell growth and viability.
	SO1.6 Describe & define the conditioned media & other cell culture reagents.		**CI1.6** Describe & define the conditioned media & other cell culture reagents.	

	SO1.7 Explain in detail the preparation & sterilization of tissue culture media.		**CI1.7** Study the preparation & sterilization of tissue culture media.	
	SO1.8 Describe the common instruments used in tissue culture laboratories.	**LI1.2** To familiarize with the common instruments and glassware used in tissue culture laboratories.	**CI1.8** Describe the common instruments used in tissue culture laboratories.	**SL1.5** Gain proficiency in using common instruments and glassware essential for tissue culture experiments.
	SO1.9 Describe the glassware used in tissue culture laboratories.		**CI1.9** Describe the glassware used in tissue culture laboratories.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignment	Describe in detail to tissue culture media.
	SW1.2 Mini Project	Describe & define the antibiotics, growth supplements, and other reagents used in cell culture media.
	SW1.3 Other Activities (Specify)	Explain the common instruments & glassware used in tissue culture laboratories.

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)
CO2-55MBT205-B.2: To understand the historical development and key techniques in plant tissue culture research.			**Unit-2**	
	SO2.1 Describe & define the introduction of plant tissue culture.		**CI2.1** Brief in detail to introduction of plant tissue culture.	**SL2.1** Search various reference books and other study material to start the learning about plant tissue culture.
	SO2.2 Describe & define the plant tissue culture media & sterilization.		**CI2.2** Describe & define the plant tissue culture media & sterilization.	**SL2.2** Study the plant tissue culture media & sterilization techniques.
	SO2.3 Explain in detail the culture initiation & totipotency.	**LI2.1** To understand and practice the principles of sterilization in plant tissue culture and initiate cultures from explants.	**CI2.3** Study the culture initiation & totipotency.	**SL2.3** Understanding totipotency & cellular differentiation.
	SO2.4 Explain in detail the callus culture & cell suspension culture.	**LI2.2** To observe callus formation and organogenesis in plant tissue culture.	**CI2.4** Explain in detail the callus culture & cell suspension culture.	**SL2.4** Exploring different types of plant tissue culture.
	SO2.5 Explain in detail the single cell culture & embryo culture.		**CI2.5** Study the single cell culture & embryo culture.	
	SO2.6 Explain in detail the embryo rescue & meristem culture.		**CI2.6** Study the embryo rescue & meristem culture.	
	SO2.7 Discuss the organ culture & differentiation/dedifferentiation.		**CI2.7** Discuss the organ culture & differentiation/dedifferentiation.	

	SO2.8 Explain in detail the organogenesis & somatic embryogenesis.		**CI2.8** Study the organogenesis & somatic embryogenesis.	
	SO2.9 Discuss the acclimatization.		**CI2.9** Discuss the acclimatization.	**SL2.5** Exploring the acclimatization & ex-vitro culture techniques.

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignment	Describe in detail the callus culture & cell suspension culture.
	SW1.2 Mini Project	Discuss the organ culture & differentiation/dedifferentiation.
	SW1.3 Other Activities (Specify)	Write a one review article on callus culture of any explant material.

Item	CI	LI	SW	SL	Total
Approx. Hours	9	4	1	4	18

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO3-55MBT205-B.3: To understand thecomprehensive knowledge of history,techniques, and			**Unit-3**	
	SO3.1 Describe & define theanimal cell culture.		**CI3.1** Brief in detail to introductionof animal cell culture.	**SL3.1** Search various referencebooks and other study materialto start the learning about animal cell culture.

applications in animal cell culture.				
	SO3.2 Describe & define the tissue culture techniques and primary culture.	**LI3.1** To familiarize students with basic techniques in animal cell culture.	**CI3.2** Describe & define the tissue culture techniques and primary culture.	**SL3.2** Study the types of animal cell culture techniques.
	SO3.3 Explain in detail chicken embryo fibroblast culture.		**CI3.3** Study the chicken embryo fibroblast culture.	
	SO3.4 Explain in detail the secondary culture & trypsinization.		**CI3.4** Explain in detail the secondary culture & trypsinization.	
	SO3.5 Discuss the cell separation & suspension culture.		**CI3.5** Discuss the cell separation & suspension culture.	
	SO3.6 Explain in detail the organ culture & behaviour of cells in culture conditions.		**CI3.6** Explain in detail the organ culture & behaviour of cells in culture conditions.	**SL3.3** Exploring the cell behaviour & metabolism in culture conditions.
	SO3.7 Discuss the development of animal cell lines & cryopreservation.		**CI3.7** Discuss the development of animal cell lines & cryopreservation.	
	SO3.8 Discuss the application of animal cell culture in drug testing.		**CI3.8** Discuss the application of animal cell culture in drug testing.	
	SO3.9 Discuss the ethical issues, current trends & applications in animal tissue culture.	**LI3.2** To explore advanced applications of animal cell culture and discuss ethical considerations.	**CI3.9** Discuss the ethical issues, current trends & applications in animal tissue culture.	**SL3.4** Exploring the current trends & applications in animal tissue culture.

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignment	Describe in details secondary culture & trypsinization.
	SW3.2 Mini Project	Explain in detail the development of animal cell lines & cryopreservation.
	SW3.3 Other Activities (Specify)	Prepare one review article on animal 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)
CO4-55MBT205-B.4: To develop a comprehensive understanding of stem cell biology, including their properties, techniques, and applications.			**Unit-4**	
	SO4.1 Describe and define the stem cells.		**CI4.1** Brief in detail to introduction of stem cells.	**SL4.1** Search various reference books and other study material to start the learning about stem cells & therapy.
	SO4.2 Discuss the stem cell proliferation & culture.	**LI4.1** To learn techniques for the culture and characterization of stem cells.	**CI4.2** Discuss the stem cell proliferation & culture.	**SL4.2** Understand the stem cell biology and culture techniques.
	SO4.3 Discuss the medical applications of stem cells.		**CI4.3** Study the medical applications of stem cells.	**SL4.3** Exploring the medical applications of stem cells.
	SO4.4 Discuss the ethical & legal issues in stem cell research.		**CI4.4** Discuss the ethical & legal issues in stem cell research.	**SL4.4** Examine the ethical & legal issues in stem cell research.
	SO4.5 Explain in detail the types of stem cells:		**CI4.5** Explain in detail the types of stem cells: embryonic Vs adult stem cells.	

	embryonic Vs adult stem cells.			
	SO4.6 Explain in detail the stem cell biology & therapy.		**CI4.6** Explain in detail the stem cell biology & therapy.	
	SO4.7 Discuss the culture & potential benefits of stem cell technology.		**CI4.7** Discuss the culture & potential benefits of stem cell technology.	
	SO4.8 Discuss the regulatory frameworks for stem cell & gene therapy.	**LI4.2** To explore the ethical and regulatory aspects of stem cell research and therapy.	**CI4.8** Discuss the regulatory frameworks for stem cell & gene therapy.	
	SO4.9 Discuss the assessing human stem cell safety & future directions.		**CI4.9** Discuss the assessing human stem cell safety & future directions.	**SL4.5** Explore the assessing safety & genetic modification of stem cells.

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe & define the stem cells.
	SW4.2 Mini Project	Explain in detail the stem cell biology & therapy.
	SW4.3 Other Activities (Specify)	One case study for gene therapy using stem cells.

Item	CI	LI	SW	SL	Total
Approx. Hours	9	4	1	4	18

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO5-55MBT205-B.5: To develop a comprehensive understanding of tissue engineering & regenerative medicines approaches for reconstructing various tissues & organs, as well as the underlying mechanisms of cancer development and progression.			**Unit-5**	
	SO5.1 Describe & define the tissue engineering.		**CI5.1** Brief in detail to introduction of tissue engineering.	**SL5.1** Search various reference books and other study material to start the learning about tissue engineering & cancer biology.
	SO5.2 Explain in detail the reconstruction of skeletal tissues.	**LI5.1** To explore tissue engineering techniques for the reconstruction of skeletal and cardiac muscle tissues.	**CI5.2** Study the reconstruction of skeletal tissues.	**SL5.2** Explore the tissue engineering for skeletal & muscular tissues.
	SO5.3 Explain in detail the reconstruction of muscular tissues.		**CI5.3** Study the reconstruction of muscular tissues.	
	SO5.4 Explain in detail the reconstruction of soft tissues.		**CI5.4** Study the reconstruction of soft tissues.	
	SO5.5 Explain in detail the reconstruction of specialized tissues.	**LI5.2** To explore tissue engineering approaches for the reconstruction of organs such as the urinary bladder, liver, and cornea.	**CI5.5** Study the reconstruction of specialized tissues.	**SL5.3** Study the organ reconstruction through tissue engineering.
	SO5.6 Describe & define the cancer biology.		**CI5.6** Brief in detail to introduction of cancer biology.	**SL5.4** Gain an understanding of cancer biology & stem cell origin.

	SO5.7 Explain in detail the stem cell origin of cancer.		**CI5.7** Study the stem cell origin of cancer.	
	SO5.8 Explain in detail the pathways involved in cancer stem cells.		**CI5.8** Discuss the pathways involved in cancer stem cells.	
	SO5.9 Discuss the tumor angiogenesis & pericytes.		**CI5.9** Discuss the tumor angiogenesis & pericytes.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain in detail about tissue engineering.
	SW5.2 Mini Project	Explain in detail the cancer stem cells & their pathways.
	SW5.3 Other Activities (Specify)	Prepare one review article on cancer stem cells.

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)

CO1-55MBT205-B.1: To understand the principles and techniques of tissue culture media preparation and laboratory practices.	9	4	5	1	19
CO2-55MBT205-B.2: To understand the historical development and key techniques in plant tissue culture research.	9	4	5	1	19
CO3-55MBT205-B.3: To understand the comprehensive knowledge of history, techniques, and applications in animal cell culture.	9	4	4	1	18
CO4-55MBT205-B.4: To develop a comprehensive understanding of stem cell biology, including their properties, techniques, and applications.	9	4	5	1	19
CO5-55MBT205-B.5: To develop a comprehensive understanding of tissue engineering & regenerative medicines approaches for reconstructing various tissues & organs, as well as the underlying mechanisms of cancer development and progression.	9	4	4	1	18
Total Hours	45	20	23	05	93

Course Title: Tissue Culture and Stem Cell Engineering **Course Code:** 55MBT205-B

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

Course Title: Tissue Culture and Stem Cell Engineering **Course Code:** 55MBT205-B

***Legend*: R,** Remember; **U,** Understand; **A,** Apply; **A,** Analyze; **E,** Evaluate; **C,** Create

Course Outcomes	**Marks Distribution**	**Total Marks**

	R	U	A	A	E	C	
CO1-55MBT205-B.1: To understand the principles and techniques of tissue culture media preparation and laboratory practices.	3	3	3	4	3	3	19
CO2-55MBT205-B.2: To understand the historical development and key techniques in plant tissue culture research.	4	4	4	3	3	3	21
CO3-55MBT205-B.3: To understand the comprehensive knowledge of history, techniques, and applications in animal cell culture.	3	3	4	3	3	3	19
CO4-55MBT205-B.4: To develop a comprehensive understanding of stem cell biology, including their properties, techniques, and applications.	3	4	4	3	3	3	20
CO5-55MBT205-B.5: To develop a comprehensive understanding of tissue engineering & regenerative medicines approaches for reconstructing various tissues & organs, as well as the underlying mechanisms of cancer development and progression.	3	3	3	4	4	4	21
Total Marks	**16**	**17**	**18**	**17**	**16**	**16**	**100**

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1.	Stewart Sell, Stem Cells Handbook: Human Press, 2010.
2.	Asok Mukhopadyay, Animal Cell Technology, IK Intl. Ltd, Text Book
3.	S. Indumathi, Stem cell therapy for organ failures, Springer Verlag, 2015.
4.	B. R. C. Murthy, V. S. T. Sai, Botany-Plant tissue culture and its biotechnological applications, Venkateswara Publications, Guntur, 2017

(b) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: M. Tech. Biotechnology

Semester: IInd Semester

Course Title: Tissue Culture and Stem Cell Engineering

Course Code: 55MBT205-B

CO/PO/PSO Mapping									
Course Outcome (Cos)	**Program Outcomes (POs)**						**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1-55MBT205-B.1: To understand the principles and techniques of tissue culture media preparation and laboratory practices.	3	1	2	2	-	-	1	-	2
CO2-55MBT205-B.2: To understand the historical development and key techniques in plant tissue culture research.	-	2	-	-	-	-	-	-	1
CO3-55MBT205-B.3: To understand the comprehensive knowledge of history, techniques, and applications in animal cell culture.	3	1	2	2	1	-	1	1	1
CO4-55MBT205-B.4: To develop a comprehensive understanding of stem cell biology, including their properties, techniques, and applications.	3	2	2	2	2	1	-	2	3
CO5-55MBT205-B.5: To develop a comprehensive understanding of tissue engineering & regenerative medicines approaches for reconstructing various tissues & organs, as well as the underlying mechanisms of cancer development and progression.	2	1	-	2	2	2	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 PSO 1,2,3	**CO1-55MBT205-B.1**: To understand the principles and techniques of tissue culture media preparation and laboratory practices.	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 PSO 1,2,3	**CO2-55MBT205-B.2**: To understand the historical development and key techniques in plant tissue culture research.	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 PSO 1,2,3	**CO3-55MBT205-B.3**: To understand the comprehensive knowledge of history, techniques, and applications in animal cell culture.	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
PO1,2,3,4,5,6 PSO 1,2,3	**CO4-55MBT205-B.4**: To develop a comprehensive understanding of stem cell biology, including their properties, techniques, and applications.	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 PSO 1,2,3	**CO5-55MBT205-B.5**: To develop a comprehensive understanding of tissue engineering & regenerative medicines approaches for reconstructing various tissues & organs, as well as the underlying mechanisms of cancer development and progression.	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-1,2,3,4

Program Name	**Masters of Technology (M. Tech.)- Biotechnology**	
Semester	II	
Course Code:	**55MBT206-A**	
Course title:	Food Process Engineering	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of food science, and food processing	
Rationale:	Food process engineers, also known as agricultural and food scientists, combine engineering concepts with microbiology, chemistry and other sciences to create the best ways to make processed foods tasty, healthy and safe. They're responsible for every step of food production, from production to distribution. Food process engineering involves a variety of operations utilized in transforming raw agricultural commodities into shelf-stable, easy-to-use, nutritious, and safe foods. This field of study is based on an understanding of the physics and biology of food preservation processes, evolving into a widely sought specialty of engineering. The history of the field of food engineering is a story of engineers, typically untrained in the biological sciences; they developed an understanding of and quantified the chemical and biological changes associated with food spoilage, resulting in the development of processes to control them.	
Course Outcomes (COs):	**CO1-55MBT206-A.1.** Explain advanced concepts and principles of food processing engineering **CO2-55MBT206-A.2.** Describe and demonstrate freezing engineering properties of food **CO3-55MBT206-A.3.** Describe and demonstrate drying engineering properties of food **CO4-55MBT206-A.4.** Define working principle of various techniques used in food preservation methods **CO5-55MBT206-A.5.** Differentiate and interpretate the working mechanisms of various unit operations used in food industries	

Scheme of Studies:

Board of Study	CourseCode	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)	55MBT206-A	Food Process Engineering	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 Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		
PE	55MBT206-A	Food Process Engineering	**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	55MBT256-A	Food Process Engineering lab	35	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	03	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-55MBT206-A.1. Explain advanced concepts and principles of food processing engineering	**SO1.1** Explain concept, Objectives, functions and principles of food processing and preservation	**LI 1.1** To perform the fermentation process of Wine production using fruits	**Unit-1Food Processing** **CI1.1** Food processing and preservation principles	**SL1.1** Find out some examples of ancient practices of Food process engineering used in India
	SO1.2 Determine the basic difference	**LI 1.2** To determine the complete	**CI1.2** Method of preservation:	**SL1.2** List down the food industries

	among Pasteurization and Sterilization	sterilization process using Autoclave	pasteurization (definition, time-temperature combination and equipment) sterilization (definition, time temperature combination and equipment)	where blanching is used
	SO1.3 Elaborate the working mechanism Blanching and Canning		**CI1.3** Blanching (definition, time-temperature combination and equipment, adequacy in blanching), canning (definition, time-temperature combination and equipment)	**SL1.3** Draw a flow chart showing how Canning is done in food industries
	SO1.4 Define the Fundamental significance of Packaging in food industries		**CI1.4** Packaging (Introduction, Metal Containers, Glass Containers, Rigid Plastic Containers, Reportable Pouches)	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail "How Good Packaging Practices followed in Indian Food Industries"
	SW1.2 Mini Project	Draw various types of Industrial layouts of food processing plants as per Indian norms
	SW1.3 Other Activities (Specify)	Make a power point presentation on "Blanching and Canning"

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)
CO2-55MBT206-A.2. Describe and demonstrate freezing engineering properties of food	**SO2.1** Explain the Operational Mode of Freezing and its significance	**LI2.1** To demonstrate the effect of freezing on different food items	**Unit-2 Freezing** **CI2.1** Food Freezing and thawing process: Introduction	**SL2.1** Write down the name of food products you used at home that can be freeze mandatorily
	SO2.2 Explain the working of Freezing and thawing process	**LI2.2** To demonstrate the Cryogenic freezing	**CI2.2** Freezing point and freezing rate, comparison of Freezing and thawing process	**SL2.2** Read the protocols to maintain optimum freezing for perishable and non-perishable food items

	SO2.3 Explain the working mechanism of different types of freezing	**LI2.3** To perform the statistical analysis to obtain a freezing curve	**CI2.3** Freezing methods: Air freezing, plate freezing, liquid immersion freezing and cryogenic freezing	**SL2.3** Write down few points on Cryogenic freezing
	SO2.4 Describe quality changes of food and effect of freezing curve		**CI2.4** Freezer selection, Advantages and disadvantages of freezing. Freezing curve	
	SO2.5 Elaborate the advantages and disadvantages of freezing and changes in food		**CI2.5** Freezer selection, advantages and disadvantages of freezing and changes in food during freezing storage	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe Freezer engineering in food processing
	SW2.2 Mini Project	Make a project on different kinds of freezers used in food industries
	SW2.3 Other Activities (Specify)	Make Power point presentation on Freeze Curve

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	08	01	02	21

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO3-55MBT206-A.3. Describe and demonstrate drying engineering properties of food	**SO3.1** Elucidate the fundamentals of drying in food processing	**LI3.1** To demonstrate the effect of drying on different food items	**Unit-3 Drying** **CI3.1** Food Drying/Dehydration: Definition	**SL3.1** Study different kinds of dryers used in food industry

	SO3.2 Describe the effects of moisture in food	**LI3.2** To demonstrate the Water activity on various food items	**CI3.2** Free and bound moisture, concept of water activity, factors affecting drying, Drying curve (constant rate period and falling rate period)	**SL3.2** List down different drying methods used conventionally in India
	SO3.3 Explain different types of drying methods	**LI3.3** To calculate the moisture content on various food items	**CI3.3** Equilibrium moisture content, Drying methods and equipment: sun/solar drying	
	SO3.4 Differentiate the working mechanism of various types of dryers used in food industry	**LI3.4** To determine the different nutritional parameters getting effected due to drying	**CI3.4** Cabinet drying, tunnel dryer, spray dryer, freeze dryer, fluidized bed dryer	
	SO3.5 Interpretate the nutritional and physicochemical changes occurring in food		**CI3.5** Nutritional, physicochemical changes during drying	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Prepare a report on "Effect of Drying and Moisture Content in food items"
	SW3.2 Mini Project	Describe different types of Nutraceutical changes and Physicochemical properties effected by drying
	SW3.3 Other	Prepare one Power point presentation on "Freeze Drying"

Item	Cl	LI	SW	SL	Total
Approx. Hrs	8	02	01	03	14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-55MBT206-A.4. Define working principle of various techniques used in food preservation methods	**SO4.1** Elucidate the role of food concentration & evaporations	**LI4.1** To perform the process of Crystallization in Ice-cream	**Unit-4 Concentration** **CI4.1** Food Concentration: Evaporation- Definition	**SL4.1** List down the different kind of Evaporators used in food industries
	SO4.2 Explain working mechanisms of different kinds of evaporators		**CI4.2** Types of evaporators (single effect, double effect and multiple effect evaporator)	**SL4.2** Read the process of Crystallization and its significance in food

				industries
	SO4.3 Differentiate and define the process of crystallizations		**CI4.3** Freeze concentration- General principles and applications, basic elements, ice crystal nucleation, growth and	**SL4.3** Find out the role of crystallization in ice-cream
	SO4.4 Describe the process of Crystallization in food items		**CI4.4** Crystallization, separation techniques (filtration and wash column)	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Write down the role of Crystallization in Food industry
	SW4.2 Mini Project	Prepare a report on historical developments and timeline of different kinds of food industries in India
	SW4.3 Other Activities (Specify)	Participate at least one Webinar/Seminar in the field of Food Processing

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	02	01	05	18

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-55MBT206-A.5. Differentiate and interpretate the working mechanisms of various unit operations used in food industries	**SO5.1** Elucidate the Membrane processing and its importance	**LI5.1** To perform the carbohydrate metabolism to understand the mechanism of fermentation	**Unit-5 Unit Operations in Food processing** **CI5.1** Membrane Processing: General principles and advantages	**SL5.1** Find out the significance of membrane processing
	SO5.2 Describe the working		**CI5.2** Dead end and cross flow,	**SL5.2** List down the filtration

	mechanisms of various filtration methods		Classification of membrane system: Reverse Osmosis, Nano Filtration, Ultra Filtration, Micro Filtration, Electro-dialysis and Pervaporation	methods and its significance
	SO5.3 Explain the role of Membranes used in food industries		**CI5.3** Membrane technology comparison chart, Membrane application in the food industries	**SL5.3** List down the role of Microwave technology in food processing
	SO5.4 Define the membrane filtration processing		**CI5.4** Membrane performance, and Limitation of membrane processes	**SL5.4** Write down the regulations for food processing
	SO5.5 Describe the advancement in food fermentation technology		**CI5.5** Food Fermentations: Introduction, Mechanism, Metabolism, Examples, Applications	**SL5.5** Prepare one report on any two processed Food manufactured in India

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Describe the Fermentation Food Processing technique
	SW5.2 Mini Project	Prepare a report on Membrane Processing in Food industries
	SW5.3 Other Activities (Specify)	Prepare a presentation on "Filtration units used in Food industries"

Course duration (in hours) to attain Course Outcomes:

Course Title: Food Process Engineering **Course Code:** 55MBT206-A

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (CI+LI+SL+SW)
CO1-55MBT206-A.1. Explain advanced concepts and principles of food processing engineering	8	4	3	1	16
CO2-55MBT206-A.2. Describe and demonstrate freezing engineering properties of food	10	6	3	1	20
CO3-55MBT206-A.3. Describe and demonstrate drying engineering properties of food	10	8	2	1	21
CO4-55MBT206-A.4. Define working principle of various techniques used in food preservation methods	8	2	3	1	14
CO5-55MBT206-A.5. Differentiate and interpretate the working mechanisms of various unit operations used in	10	2	5	1	18

food industries					
Total Hours	46	21	16	05	89

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

Course Title: Food Process Engineering **Course Code:** 55MBT206-A

Course Outcomes (COs)	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-55MBT206-A.1. Explain advanced concepts and principles of food processing engineering	2	1	1	1	5
CO2-55MBT206-A.2. Describe and demonstrate freezing engineering properties of food	2	4	5	1	12
CO3-55MBT206-A.3. Describe and demonstrate drying engineering properties of food	3	5	5	1	14
CO4-55MBT206-A.4. Define working principle of various techniques used in food preservation methods	2	3	5	1	11
CO5-55MBT206-A.5. Differentiate and interpretate the working mechanisms of various unit operations used in food industries	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	Food Processing: Principles and Applications by Ramaswamy H. & Marcotte M. Taylor & Francis
2	Food Science by Norman N Potter and Joseph H. Hotchkiss, CBS Publishers and Distributors
3	Singh RP & Heldman DR. 1993. Introduction to Food Engineering. Academic Press
4	Krammer, A. and Twigg, B.A. (1970). Quality Control for the Food Industry. 3rd Edn. AVI, Westport
5	Rekha, S. Singhal, Pushpa R. Kulkarni, Dananesh V. Rege, (1997). Hand Book of Indices of food Quality and Authenticity, wood head Publishing Ltd
6	Introduction to Food Engineering, Singh and Heldman (fifth edition), Academic Press, 2014
7	David, J.R.D., Graves R.H., and Carlson V.R. (1996). Aseptic Processing and Packaging of Food. Boca Raton, FL: CRC Press, 257 pp.

8	Nickerson J.T.R. and Sinsky A.J. (1972). Microbiology of Foods and Food Processing. New York: Elsevier
9	D.G. Rao. Fundamental of Food Engineering. PHI Learning Pvt. Ltd., 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 any Food Processing plant
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: M. Tech. Biotechnology
Semester: II Semester
Course Title: Food Process Engineering
Course Code: 55MBT206-A

CO/PO/PSO Mapping									
Course Outcome (Cos)	**Program Outcomes (POs)**						**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1-55MBT206-A.1. Explain advanced concepts and principles of food processing engineering	2	-	-	1	2	1	2	2	1
CO2-55MBT206-A.2. Describe and demonstrate freezing engineering properties of food	1	-	-	1	-	1	1	1	2
CO3-55MBT206-A.3. Describe and demonstrate drying engineering properties of food	-	1	1	1	1	1	1	1	1
CO4-55MBT206-A.4. Define working principle of various techniques used in food preservation methods	1	1	-	1	2	2	1	1	3
CO5-55MBT206-A.5. Differentiate and interpretate the working mechanisms of various unit operations used in food industries	1	1	1	-	1	2	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	**CO1-55MBT206-A.1.** Explain advanced concepts and principles of food processing engineering	SO1.1 SO1.2 SO1.3 SO1.4	**LI1.1, LI1.2, LI1.3**	1.1,1.2,1.3,1.4	**1SL-1,2,3**
PO 1,2,3,4,5,6	**CO2-55MBT206-A.2.** Describe and	SO2.1 SO2.2	**LI2.1, LI2.2, LI2.3**	2.1, 2.2, 2.3, 2.4,	**2SL-1,2,3**

PSO 1,2, 3	demonstrate freezing engineering properties of food	SO2.3 SO2.4 SO2.5		2.5	
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO3-55MBT206-A.3.** Describe and demonstrate drying engineering properties of food	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5	**LI3.1, LI3.2, LI3.3, LI3.4**	3.1,3.2,3.3,3.4,3.5	**3SL-1,2**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO4-55MBT206-A.4.** Define working principle of various techniques used in food preservation methods	SO4.1 SO4.2 SO4.3, SO4.4	**LI4.1**	4.1,4.2,4.3, 4.4	**4SL-1,2,3**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO5-55MBT206-A.5.** Differentiate and interpretate the working mechanisms of various unit operations used in food industries	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5	**LI5.1**	5.1,5.2,5.3,5.4,5.5	**5SL-1,2,3,4,5**

Program Name	**Master of Technology (M.Tech.)- Biotechnology**	
Semester	II	
Course Code:	**55MBT206-B**	
Course title:	Dairy Technology	**Curriculum Developer**: Mrs. Sonal Gupta, Assistant Professor
Pre-requisite:	Students should have basic information on microbiology and fermentation technology.	
Rationale:	Dairy technology is a division of engineering that deals with the processing of milk and its products. Dairy technology study involves processing, storage, packaging, distribution, and transportation of dairy products by implying the science of bacteriology, nutrition, and biochemistry. The aim of the course is to gain knowledge about fermentation techniques used in dairy industry, role of microorganisms in fermentation and to gain skills to control fermentation process.	
Course Outcomes (COs):	**55MBT206-B.1:** Understand the concept of management, organization, planning, staffing. **55MBT206-B.2:** Understand the importance of Directing and controlling, leadership styles, Communication, Coordination and Controlling. **55MBT206-B.3:** Understand the role of entrepreneurs in economic development, and barriers, Identification of business opportunities, feasibility studies. **55MBT206-B.4:** Understand the contents of project report, ERP and project. **55MBT206-B.5:** Understand Ethics and institutional support in entrepreneurship, Case Study of Entrepreneurs.	

Scheme of Studies:

Board of Study	CourseCode	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 (PE)	**55MBT206-B**	Dairy Technology	3	2	2	3	8	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 teachers to achieve course outcomes.

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	**55MBT206-B**	Dairy Technology	**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	**55MBT256-B**	**Food Process Engineering lab**	**35**	**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	10	04	01	05	20

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO1-55MBT206-B.1 Understand the concept of management, organization, planning, staffing.	**SO1.1** Describe Milk and its Physical-Chemical properties.	**LI1.1** Demonstration of basic instruments used in Dairy microbiology	**CI1.1** an overview on the properties of milk.	**SL1.1** Study various types of milk products.
	SO1.2 Define milk products and milk byproducts.	**LI1.2** Isolation of microorganisms from milk.	**CI1.2** Describe various types of milk products.	**SL1.2** Role of water in dairy industry.
	SO1.3 Explain dairy waste.		**CI1.3** Elaborate waste produced during dairy processing.	**SL1.3** Differentiate fermented and non-fermented milk products.
	SO1.4 Elaborate Chemical and physical changes which occur in making each product.		**CI1.4** Describe various types of physiochemical changes carried out in dairy	**SL1.4** Learn the ancient use of microorganisms in your surroundings and prepare a report on it.

			products.	
	SO1.5 Explain Water analysis, water softening knowledge, its application in dairy operations like (solutions, suspensions, emulsions, mixtures, pH, oxidation reduction potential, viscosity, surface tension, forming, freezing point, boiling point, crystallization, coagulation, desiccation).		**CI1.5** Describe water analysis and softening, explain various applications of water in dairy industry.	**SL1.5** Draw a well-labeled diagram of a bacterial cell and fungal mycelium.
	SO1.6 Describe super heating and supercooling.		**CI1.6** Explain superheating and supercooling, also describe their significance in dairy operations.	
	SO1.7 Elaborate milk products. Fermented and Non-Fermented Dairy products.		**CI1.7** Describe fermented and non-fermented milk products.	
	SO1.8 Describe Starter Culture.		**CI1.8** what is starter culture.	
	SO1.9		**CI1.9**	

	Concept of probiotic starters and their application in probiotic dairy food.		Elaborate probiotic and its importance in food industry.	
	SO1.10 Explain the Legal standards used for milk and milk products.		**CI1.10** Describe legal standards applied in production of milk and milk products.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe various types of physical and chemical properties of milk.
	SW1.2 Mini Project	Make a chart on different types of milk products.
	SW1.3 Other Activities (Specify)	Make a visual probiotic and its significance.

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)
55MBT206-B.2: Understand the importance of Directing and controlling, leadership styles, Communication, Coordination and Controlling.	**SO2.1** Microorganisms associated with milk & milk products. Microflora of raw milk. Hygienic milk production methods for milk preservation	**LI2.1** Demonstration of a test used to check milk quality.	**CI2.1** Explain microflora associated with milk and milk products.	**SL2.1** Write a note on microflora associated with milk and milk products.
	SO2.2 Effect of processing treatments on the microflora of raw milk.	**LI2.2** To isolate microorganisms from milk products like curd and cheese.	**CI2.2** Describe the impact of milk processing methods on the microbial inhabitants of milk and milk products.	**SL2.2** Explain different microbiological techniques used to check quality of milk.
	SO2.3 Mastitic milk and its suitability for dairy processing.		CI2.3 Elaborate mastitic milk and its suitability to produce milk products.	**SL2.3** Describe various diseases transmitted by milk and milk products.
	SO2.4 Microbiology of market milk and milk product Starter culture technology.		CI2,4 Elaborate the microflora of market milk. Explain the starter culture technology.	
	SO2.5 Control of the Dairy Plant: The HACCP concept.		CI2.6 Explain HACCP concept and its significance.	
	SO2.6 Microbiological Quality Sanitation of Dairy Plant equipment & environment. Importance of microbiological quality of water.		CI2.7 Describe the sanitization techniques used for dairy plant, equipment, and environment.	

	SO2.7 Microbiological testing of milk & milk Products. Diseases transmitted via milk & milk products).		CI2.8 An overview on microbiological testing of water. Elaborate disease transmitted via milk and milk products.	
	SO2.8 Microbiological standards recommended for milk & milk products. Introduction to Aseptic Techniques		CI2.9 Explain microbiological standards used for dairy products.	
	SO2.9 Types of fermentations processes.		**CI2.1** Explain fermentation processes used in dairy industry.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe impact of milk associated microflora on dairy industry.
	SW2.2 Mini Project	Explain various types of fermentation processes used in dairy industry.
	SW2.3 Other Activities (Specify)	What is aseptic technique, and their significance in dairy industry.

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)
CO3-55MBT206-B.3: Understand the role of entrepreneurs in economic development, and barriers, Identification of business opportunities, feasibility studies.	**SO3.1** Power requirement, care and maintenance of homogenizers, aseptic homogenizers.	**LI3.1** Demonstrate the properties of various milk products.	**CI3.1** Homogenization: its Classification, single stage and two stage homogenizer pumps.	**SL3.1** An overview on sterilization techniques used in dairy industry.
	SO3.2 Homogenization: Classification, single stage and two stage homogenizer pumps.	**LI3.2** Demonstrate various laboratory instruments used in dairy industry.	**CI3.2** Describe power requirement, care and maintenance of homogenizers, aseptic homogenizers.	**SL3.2** Discuss the instrument and process used for cheese production.
	SO3.3 Pasteurization: Batch, flash and continuous (HTST) pasteurizers, Pasteurizer control.		**CI3.3** An overview on Pasteurization: Batch, flash and continuous (HTST) pasteurizers, Pasteurizer control.	**SL3.3** Read the various types of homogenizers. Write detailed process of butter and ghee making.
	SO3.4 Different type of sterilizers, in bottle sterilizers, autoclaves, continuous sterilization plant, UHT sterilization,		**CI3.4** Explain different type of sterilizers, in bottle sterilizers, autoclaves, continuous sterilization plant, UHT sterilization,	
	SO3.5 Aseptic packaging and equipment.		**CI3.5** Describe aseptic packaging and equipment used for it.	

	SO3.6 Butter and Ghee making machine,		**CI3.6** Explain Butter and Ghee making machine in detail.	
	SO3.7 Ice cream and Cheese making equipment's.		**CI3.7** An introduction on Ice cream and Cheese making equipment's.	
	SO3.8 Packaging machines for milk & milk products.		**CI3.8** Describe packaging machines for milk & milk products.	
	SO3.9 Membrane Processing: Ultra filtration, Reverse Osmosis. Materials for membrane construction, Ultra filtration of milk. Membranes for electro dialysis.		**CI3.9** Elaborate membrane Processing: Ultra filtration, Reverse Osmosis. Materials for membrane construction, Ultra filtration of milk. Describe membranes used for electro dialysis.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe membrane filtration techniques and its types.
	SW3.2 Mini Project	Explain instrument used for the packaging of milk products.
	SW3.3 Other Activities (Specify)	Prepare a detail note on pasteurization and its types.

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)
CO4-55MBT206-B.4: Understand the contents of project report, ERP and project.	**SO4.1** Introduction of Dairy Plant design and layout, basis of dairy layout.	**LI4.1** Demonstrate the production of vitamins using microorganisms.	**CI4.1** An introduction of Dairy Plant design and layout, basis of dairy layout.	**SL4.1** Learn detailed designing and layout of dairy plant.
	SO4.2 Importance of planning, principles of dairy layout Classification of dairy plants	**LI4.2** Study of Prokaryotic and Eukaryotic Cells.	**CI4.2** Explain importance of planning, principles of dairy layout Classification of dairy plants.	**SL4.2** Discuss the perishable nature of dairy products.
	SO4.3 Development and presentation of layout, model planning, use of planning table in developingplot plant and detailed layout.		**CI4.3** Describe development and presentation of layout, model planning, use of planning table in developing plot plant and detailed layout.	**SL4.3** Describe process of ice cream production.
	SO4.4 Location of plant, location		**CI4.4** An overview on location of	SL4.4 Explain different types of

	problems, selection of site		plant, location problems, selection of site.	dairies.
	SO4.5 Dairy building planning		**CI4.5** Define dairy building planning.	
	SO4.6 Space requirements for dairy plants		**CI4.6** Elaborate space requirements for dairy plants.	
	SO4.7 Choice of building construction materials, floors, general requirement of dairy floor finishes, floors for different section of dairy.		**CI4.7** Explain choice of building construction materials, floors, general requirement of dairy floor finishes, floors for different section of dairy.	
	SO4.8 Process schedule, estimation of service requirements including peak load consideration.		**CI4.8** Describe process schedule, estimation of service requirements including peak load consideration.	
	SO4.9 Type of dairies, perishable nature of milk, reception flexibility.		**CI4.9** Elaborate type of dairies, perishable nature of milk, reception flexibility.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain the building designing of dairy plant.
	SW4.2 Mini Project	Describe the important point to choose a suitable location for dairy plant.
	SW4.3 Other Activities (Specify)	Prepare an article on the designing of dairy plant.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	07	04	01	04	16

Course Outcome (CO)	Session Outcomes (SOs)	LaboratoryInstruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO5-55MBT206-B.5: Understand Ethics and institutional support in entrepreneurship, Case Study of Entrepreneurs.	**SO5.1** Current awareness on quality and safety of dairy, their Microbial quality of water and environmental hygiene in dairy plant	**LI5.1** Differentiate the gram positive and Gram-Negative Bactria using Gram's Staining protocol	**CI5.1** Explain current awareness on quality and safety of dairy, their Microbial quality of water and environmental hygiene in dairy plant.	**SL5.1** 1. Explain quality and safety parameters of dairy industry.
	SO5.2 Consumer awareness and their demands for safe foods.	**LI5.2** Perform different sterilization methods.	**CI5.2** Describe consumer awareness and their demands for safe foods.	**SL5.2** Write an overview on Codex alimentations commission (CAC).
	SO5.3 Role of Codex Alimentations Commission		**CI5.3** Explain role of Codex Alimentations Commission	**SL5.3** Explain the methods to

	(CAC) in harmonization of international standards: quality (ISO 9001:2000) and food safety		(CAC) in harmonization of international standards: quality (ISO 9001:2000) and food safety.	maintain hygiene in dairy plant.
	SO5.4 HACCP system and their application during milk production and processing.		**CI5.4** HACCP system and their application during milk production and processing.	**SL5.4** Write a detailed note on HACCP concept.
	SO5.5 Foods National and international food regulatory standards: BIS, PF A, ICMSF, IDF etc.		**CI5.5** Elaborate various type of foods National and international food regulatory standards: BIS, PF A, ICMSF, IDF etc.	
	SO5.6 Role in the formulation of standards for controlling the quality and safety of dairyfoods.		**CI5.6** Describe the role in the formulation of standards for controlling the quality and safety of dairy foods.	
	SO5.7 Microbial toxins in dairy products (other than aflatoxins) and their significance in public health		**CI5.7** Explain microbial toxins in dairy products (other than aflatoxins) and their significance in public health.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain various microbial toxin associated with milk and milk products.
	SW5.2 Mini Project	Describe the consumer awareness for the safe milk products.

	SW5.3 Other Activities (Specify)	Prepare a presentation on various standards used to maintain quality and safety in dairy products.

Course duration (in hours) to attain Course Outcomes:

Course Title: Dairy Technology **Course Code: 55MBT206-B**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Sessional work (SW)	Self-Learning (SL)	Total Hours (Li+CI+SL+SW)
CO1 55MBT206-B.1: Understand the concept of management, organization, planning, staffing	10	04	01	05	**20**
CO2 55MBT206-B.2: Understand the importance of Directing and controlling, leadership styles, Communication, Coordination and Controlling.	09	04	01	03	**17**
CO3 55MBT206-B.3: Understand the role of entrepreneurs in economic development, and barriers, Identification of business opportunities, feasibility studies.	09	04	01	03	**17**
CO4 55MBT206-B.4: Understand the contents of project report, ERP and project.	09	04	01	03	**17**
CO5 55MBT206-B.5: Understand Ethics and institutional support in entrepreneurship, Case Study of Entrepreneurs.	07	04	01	04	**16**
Total Hours	**44**	**20**	**05**	**18**	**87**

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

Course Title: General Microbiology **Course Code: 55MBT206-B**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1 55MBT206-B.1: Understand the concept of management, organization, planning, staffing	2	1	1	1	**5**
CO2 55MBT206-B.2: Understand the importance of Directing and controlling, leadership styles, Communication, Coordination and Controlling.	2	4	2	2	**10**
CO3 55MBT206-B.3: Understand the role of entrepreneurs in economic development, and barriers, Identification of business opportunities, feasibility studies.	3	5	5	2	**15**
CO4 55MBT206-B.4: Understand the contents of project report, ERP and project.	2	3	3	2	**10**
CO5 55MBT206-B.5: Understand Ethics and institutional support in entrepreneurship, Case Study of Entrepreneurs.	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	De, Sukumar (1980). Outlines of dairy technology, Oxford University Press, Delhi.
2	Webb B.H. and Johnson, A.H (1979) Fundamentals of Dairy Chemistry, AVI Publishing Co, Connecticut, USA
3	Burton, H. (1988). Ultra-high-temperature processing of milk and milk products. Elsevier Applied Science, London
4	De, Sukumar (1980). Outlines of dairy technology, Oxford University Press, Delhi.
5	Webb B.H. and Johnson, A.H (1979) Fundamentals of Dairy Chemistry, AVI Publishing Co, Connecticut, USA

B. Online

C. Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Roleplay
6. Visit the Microbiology lab
7. Demonstration
8. ICT Based Teaching Learning
9. Brainstorming

CO, PO, and PSO Mapping

Program Name: M.Tech. Microbiology
Semester: I Semester
Course Title: Dairy Technology
Course Code: 55MBT206-B

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1 55MBT206-B.1: Understand the concept of management, organization, planning, staffing	2	-	-	1	2	2	1	1
CO2 55MBT206-B.2: Understand the importance of Directing and controlling, leadership styles, Communication, Coordination and Controlling.	-	-	-	-	-	1	2	-
CO3 55MBT206-B.3: Understand the role of entrepreneurs in economic development, and barriers, Identification of business opportunities, feasibility studies.	-	1	1	1	-	1	1	1
CO4 55MBT206-B.4: Understand the contents of project report, ERP and project.	-	1	1	-	2	2	1	3
CO5 55MBT206-B.5: Understand Ethics and institutional support in entrepreneurship, Case Study of Entrepreneurs.	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 55MBT206-B.1:** Understand the concept of management, organization, planning, staffing	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10	**LI 1** **LI 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, 4, 5**
PO 1,2,3,4,5 PSO 1,2,3	**CO2 55MBT206-B.2:** Understand the importance of Directing and controlling, leadership styles, Communication, Coordination and Controlling.	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	**CO3 55MBT206-B.3:** Understand the role of entrepreneurs in economic development, and	SO3.1 SO3.2 SO3.3 SO3.4	**LI 1** **LI 2**	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	barriers, Identification of business opportunities, feasibility studies.	SO3.5 SO3.6 SO3.7 SO3.8 SO3.9		3.9	
PO 1,2,3,4,5 PSO 1,2,3	**CO4 55MBT206-B.4:** Understand the contents of project report, ERP and project.	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 PSO 1,2,3	**CO5 55MBT206-B.5:** Understand Ethics and institutional support in entrepreneurship, Case Study of Entrepreneurs.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7	**LI 1** **LI 2**	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7	**5SL-1, 2, 3, 4**

Semester III

Program Name	**Masters of Technology (M. Tech.)- Biotechnology**	
Semester	III	
Course Code:	55MBT301-A	
Course title:	Quality Control Management in Biotechnology	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of biotechnology and basic training certification in QC Management	
Rationale:	Quality control measures are of the utmost importance for biotech product brands. Quality control (QC) identifies and corrects defects in finished products and is a reactive process. To achieve constant customer satisfaction, the sources of quality problems must be identified and eliminated. India has a growing biotech industry with increasing demand for processed and value-added products. Biotechnologists are in demand to innovate, develop new products, and improve processing techniques. Quality Management Systems are indispensable in each sector of the biotech industry, to ensure safe, quality products for the consumer. The number of businesses in the biotech industry which adopt QMS in order to enhance their competitiveness in the global market is continually rising.	
Course Outcomes (COs):	**CO1-55MBT301-A.1.** Explain the various terminologies associated with quality control measures used in biotech industries **CO2-55MBT301-A.2.** Describe the biotech-based safety labels, regulations and acts associated with it **CO3-55MBT301-A.3.** Elaborate the role of Quality assurance in biotech-based industries **CO4-55MBT301-A.4.** Define the management and organizational structure designed for biotech industries **CO5-55MBT301-A.5.** Interpretate the Quality management reports by ensuring the role of quality by design	

Scheme of Studies:

Board of Study	CourseCode	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)	55MBT301-A	Quality Control Management in Biotechnology	3	0	1	3	7	3+0=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+CAT+SA+AT)		
PE	55MBT301-A	Quality Control Management in Biotechnology	**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	10	00	01	03	14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-55MBT301-A.1. Explain the various terminologies associated with quality control measures used in biotech industries	**SO1.1** Explain concept, Objectives, functions and principles of quality control		**Unit-1** **CI1.1** Objectives, functions and principles of quality control	**SL1.1** Find out some examples of Quality Control procedures in India
	SO1.2 Determine the basic difference among biotech quality control and quality assurance, assessment of raw materials and finished products		**CI1.2** Difference between biotech quality control and quality assurance, assessment of raw materials and finished products	**SL1.2** List down GMP SPOs for biotech industries
	SO1.3 Elaborate the working mechanism of GMP Personal hygiene – occupational health		**CI1.3** Good Manufacturing Practices - Personal hygiene – occupational health and safety specification	**SL1.3** Draw a flow chart showing how TQM works in Biotech
	SO1.4 Define the Fundamental significance of Biotech Plant Sanitation Management and its features		**CI1.4** Biotech Plant Sanitation Management - Plant facilities construction and maintenance - exterior of the building- interior of the building- equipment	
	SO1.5 Describe the procedures related to Storage and Transportation		**CI1.5** Storage and transportation	
	SO1.6 Describe the procedures related to Traceability and Recalling Procedures		**CI1.6** Traceability and Recalling Procedures	
	SO1.7 Describe the process related to		**CI1.7** Training for QCM	

	Training for QCM			
	SO1.8 Interpret the Basic Concepts of TQM		**CI1.8** Basic Concepts of TQM	
	SO1.9 Interpret the Framework of TQM		**CI1.9** Framework of TQM	
	SO1.10 Describe the Barriers to TQM Cost of Quality		**CI1.10** Barriers to TQM Cost of Quality	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail "How Good Manufacturing Practices followed in Indian Biotech Industries"
	SW1.2 Mini Project	Draw various types of Industrial layouts of biotech processing plants as per Indian norms
	SW1.3 Other Activities (Specify)	Make a power point presentation on "Storage and Transportation of biotech products 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 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	00	01	03	12

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-55MBT301-B.2. Describe the biotech-based safety labels, regulations and acts associated with it	**SO2.1** Explain the Operational Mode of Reactors: Batch, Fed batch, Continuous cultivation		**Unit-2** **CI2.1** Lab safety and Biotech labelling, Biotech laws and regulations, concepts of Codex Alimentarius	**SL2.1** Find out more Biotech products and list down the different labels present on it.
	SO2.2 Explain the working of HACCP, ISO series, GMP, GHP, 5S, SOP, audit system, documentation		**CI2.2** HACCP, ISO series, GMP, GHP, 5S, SOP, audit system, documentation	**SL2.2** Read the protocols to maintain and follow 5S and Kaizen protocols
	SO2.3 Explain the working mechanism of CSTRs fermenter, Monod equation for chemostat, Monod Kinetics		**CI2.3** Biotech standard and safety act: salient provisions and prospects, role of various Biotech standards in India- PFA, FPO and BIS	**SL2.3** Write down few points on PFA, FPO and BIS
	SO2.4 Describe development in Biotech quality regulation, MOFPI and schemes for establishing biotech industries in India		**CI2.4** Recent development in Biotech quality regulation, MOFPI and schemes for establishing biotech industries in India	
	SO2.5 Interpret Continuous process improvement PDCA cycle		**CI2.5** Continuous process improvement PDCA cycle	
	SO2.6 Interpret 5s, Kaizen protocols		**CI2.6** 5s, Kaizen protocols	
	SO2.7 Interpret Supplier partnership		**CI2.7** Supplier partnership	
	SO2.8 Interpret Supplier selection, Supplier Rating		**CI2.8** Supplier selection, Supplier Rating	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe Codex Alimentarious in detail
	SW2.2 Mini Project	Make a project on different kinds of Indian Biotech Industrial Laws
	SW2.3 Other Activities (Specify)	Make Power point presentation on BIS (The Bureau of Indian Standards)

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	00	01	02	11

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-55MBT301-B.3. Elaborate the role of Quality assurance in biotech-based industries	**SO3.1** Elucidate the laws and regulation associated with		**Unit-3** **CI3.1** The Structure of Regulation What Should be Regulated	**SL3.1** Study different kinds of labels used in Biotech industry
	SO3.2 Describe the effects of contamination and adulteration in Biotech		**CI3.2** Laws and Regulations to Prevent Adulteration and Cross Contamination, Microbial Contamination	**SL3.2** List down different ISO certificates used in Biotech industries
	SO3.3 Explain the terminologies of hygiene practice and standardization used in biotech industries		**CI3.3** Hygienic Practice, Chemical and Environmental Contamination safety measures in biotech industry	
	SO3.4 Define ISO certificates 9001:2000/2008, Clause wise Interpretation of ISO 9001:2000, Case Studies		**CI3.4** An Overview and structure of 9001:2000/2008, Clause wise Interpretation of ISO 9001:2000, Case Studies	
	SO3.5 Interpret Quality circles		**CI3.5** Quality circles	
	SO3.6 Interpret Quality Function Deployment (QFD)		**CI3.6** Quality Function Deployment (QFD)	
	SO3.7 Interpret Taguchi quality loss function		**CI3.7** Taguchi quality loss function	
	SO3.8 Interpret TPM – Concepts, improvement needs, Performance measures		**CI3.8** TPM – Concepts, improvement needs, Performance measures	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Prepare a report on any Biotech based product associating all rules, regulations, symbols, labels with it.
	SW3.2 Mini Project	Describe different types of ISO certificates
	SW3.3 Other	Prepare one Power point presentation on “Microbial Contamination of Food/Pharma”

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	00	01	03	12

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO4-55MBT301-A.4. Define the management and organizational structure designed for biotech industries	**SO4.1** Elucidate the organization's standard Maintenance and leading of team		**Unit-4** **CI4.1** Introduction to organization standard Maintenance and leading of team	**SL4.1** List down the different kinds codes associated of Biotech packets
	SO4.2 Define the role of QA manager in Biotech organization		**CI4.2** Professional and personal attribute as QA-manager, organization's policies, statutory and regulatory norms	**SL4.2** Read the process of quality assurance in Biotech industries
	SO4.3 Differentiate and define the basic laws associated with Biotech industries		**CI4.3** The seven traditional tools of quality	**SL4.3** Find out the role of 5S in maintaining the quality standards of any biotech-based organizations
	SO4.4 Reporting New management tools used in QCM of Biotech industry		**CI4.4** New management tools used in QCM of Biotech industry	
	SO4.5 Interpret Failure Mode and Effects Analysis (FMEA) and its stages		**CI4.5** FMEA Stages	
	SO4.6 Interpret Bench Marking in QCM of Biotech industries		**CI4.6** Bench Marking in QCM of Biotech industries	
	SO4.7 Interpret Applications of Bench Marking in QCM of Biotech industries		**CI4.7** Applications of Bench Marking in QCM of Biotech industries	
	SO4.8 Highlighting the Role of IT in QCM of Biotech industries		**CI4.8** Role of IT in QCM of Biotech industries	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Write down the role of Department of Biotechnology (Govt. of India) in India
	SW4.2 Mini Project	Prepare a report on historical developments and timeline of different kinds of biotechnology products
	SW4.3 Other Activities (Specify)	Complete at least one month workshop/ skill training program in Industrial Production Worker- Biotech Processing; FIC/Q9005; Quality Assurance Manager; FIC/Q7602; Supervisor- Biotech Processing Industries; FIC/Q9009

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	00	01	05	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-55MBT301-A.5. Interpretate the Quality management reports by ensuring the role of quality by design	**SO5.1** Elucidate the role of Need for ISO 9000, ISO 9000,2000 Quality System		**Unit-5** **CI5.1** Need for ISO 9000, ISO 9000,2000 Quality System	**SL5.1** Find out the Biotech materials of different packaging materials
	SO5.2 Describe the functions of QC Elements and its Documentation		**CI5.2** Elements, Documentation	**SL5.2** List down the machines used in bakery
	SO5.3 Analyze the report creation on Quality Auditing		**CI5.3** Quality Auditing	**SL5.3** List down the different quality parameters used in Biotech industry
	SO5.4 Interpret the role of QS 9000 – ISO 14000 – Concepts, Requirements and Benefits		**CI5.4** QS 9000 – ISO 14000 – Concepts, Requirements and Benefits	**SL5.4** Write down the importance of FIFO-FEFO
	SO5.5 Elucidate Quality Council – Leadership		**CI5.5** Quality Council – Leadership	**SL5.5** Write down the importance of inventory management
	SO5.6 Elaborate the role of Employee involvement and activities for Motivation		**CI5.6** Employee involvement, Motivation	
	SO5.7 Interpret Empowerment, Team and Teamwork		**CI5.7** Empowerment, Team and Teamwork	
	SO5.8 Describe Introduction to ICH guidelines and their usage		**CI5.8** Recognition and Reward	
	SO5.9		**CI5.9**	

	Explain Introduction to ICH guidelines and their usage		Introduction to ICH guidelines and their usage	
	SO5.10 Describe Principles and Application of QBD principles in Biotech product development		**CI5.10** Principles and Application of QBD principles in Biotech product development	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Describe the different types of packaging material used in Biotech industries
	SW5.2 Mini Project	Prepare a report on FIFO-FEFO
	SW5.3 Other Activities (Specify)	Prepare a presentation on “Machinery and tools used in bakery industry”

Course duration (in hours) to attain Course Outcomes:

Course Title: Quality Control Management in Biotechnology **Course Code:** 55MBT301-A

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-55MBT301-A.1. Explain the various terminologies associated with quality control measures used in biotech industries	10	0	3	1	14
CO2-55MBT301-A.2. Describe the biotech-based safety labels, regulations and acts associated with it	8	0	3	1	12
CO3-55MBT301-A.3. Elaborate the role of Quality assurance in biotech-based industries	8	0	2	1	11
CO4-55MBT301-A.4. Define the management and organizational structure designed for biotech industries	8	0	3	1	12
CO5-55MBT301-A.5. Interpretate the Quality management reports by ensuring the role of quality by design	10	0	5	1	16
Total Hours	44	00	16	05	65

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

Course Title: Quality Control Management in Biotechnology **Course Code:** 55MBT301-A

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-55MBT301-A.1. Explain the various terminologies associated with quality control measures used in biotech industries	2	1	1	1	5
CO2-55MBT301-A.2. Describe the biotech-based safety labels, regulations and acts associated with it	2	4	5	1	12
CO3-55MBT301-A.3. Elaborate the role of Quality assurance in biotech-based industries	3	5	5	1	14
CO4-55MBT301-A.4. Define the management and organizational structure designed for biotech industries	2	3	5	1	11
CO5-55MBT301-A.5. Interpretate the Quality management reports by ensuring the role of quality by design	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	cGMP starter guide: Principles in Good Manufacturing Practices for Beginners, Emmet P. Tobin, Createspace Independent Publishing Platform, April 2016.
2	Good Manufacturing Practices for Pharmaceuticals: GMP in Practice, B Cooper, Createspace Independent Publishing Platform, July 2017
3	Sarwar Beg and Md Saquib Hasnain, Pharmaceutical Quality by design: Principles and application, Academic press, March 2019
4	Ron S. Kenett, Shelemyahu Zacks, Daniele Amberti, Modern Industrial Statistics: with applications in R, MINITAB and JMP, 2nd Edition, Wiley, January 2014.
5	Gajendra Singh, Gaurav Agarwal an Vipul Gupta, Drug regulatory affairs, CBS publication, 2005.
6	"Biotechnology – Questioning the Reasons", Book Rivers Publication Ltd. 1st Ed. (2022)/2nd Ed. (2024)

(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: M. Tech. Biotechnology
Semester: III Semester
Course Title: Quality Control Management in Biotechnology
Course Code: 55MBT301-A

CO/PO/PSO Mapping									
Course Outcome (Cos)	**Program Outcomes (POs)**						**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1-55MBT301-A.1. Explain the various terminologies associated with quality control measures used in biotech industries	2	-	-	1	2	1	2	2	1
CO2-55MBT301-A.2. Describe the biotech-based safety labels, regulations and acts associated with it	-	-	-	-	-	1	1	1	2
CO3-55MBT301-A.3. Elaborate the role of Quality assurance in biotech-based industries	-	1	1	1	-	1	1	1	1
CO4-55MBT301-A.4. Define the management and organizational structure designed for biotech industries	-	1	1	-	2	2	1	1	3
CO5-55MBT301-A.5. Interpretate the Quality management reports by ensuring the role of quality by design	1	1	1	-	-	2	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	**CO1-55MBT301-A.1.** Explain the various terminologies associated with quality control measures used in biotech industries	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6, SO1.7, SO1.8, SO1.9, SO1.10	**LI0**	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 PSO 1,2, 3	**CO2-55MBT301-A.2.** Describe the biotech-based safety labels, regulations and acts associated with it	SO2.1 SO2.2 SO2.3 SO2.4, SO2.5, SO2.6, SO2.7 SO2.8	**LI0**	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8	**2SL-1,2,3**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO3-55MBT301-A.3.** Elaborate the role of Quality assurance in biotech-based industries	SO3.1 SO3.2 SO3.3 SO3.4 SO2.5, SO2.6, SO2.7 SO2.8	**LI0**	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 PSO 1,2, 3	**CO4-55MBT301-A.4.** Define the management and organizational structure designed for biotech industries	SO4.1 SO4.2 SO4.3, SO3.4 SO2.5, SO2.6, SO2.7 SO2.8	**LI0**	4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8	**4SL-1,2,3**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO5-55MBT301-A.5.** Interpretate the Quality management reports by ensuring the role of quality by design	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5, SO1.6, SO1.7, SO1.8, SO1.9, SO10.0	**LI0**	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 5.10	**5SL-1,2,3,4,5**

Program Name	**Masters of Technology (M. Tech.)- Biotechnology**	
Semester	III	
Course Code:	55MBT301-B	
Course title:	Quality Control Management in Food Technology and Industry	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of food science, and food processing	
Rationale:	Quality control measures are of the utmost importance for food brands. Quality control (QC) identifies and corrects defects in finished products and is a reactive process. To achieve constant customer satisfaction, the sources of quality problems must be identified and eliminated. India has a growing food industry with increasing demand for processed and value-added food products. Food technologists are in demand to innovate, develop new products, and improve food processing techniques. Quality Management Systems are indispensable in each sector of the food industry, to ensure safe, quality food for the consumer. The number of businesses in the food industry which adopt QMS in order to enhance their competitiveness in the global market is continually rising.	
Course Outcomes (COs):	**CO1-55MBT301-B.1.** Explain the various terminologies associated with quality control measures used in food industries **CO2-55MBT301-B.2.** Describe the food safety labels, regulations and acts associated with it **CO3-55MBT301-B.3.** Elaborate the role of Quality assurance in food-based industries **CO4-55MBT301-B.4.** Define the management and organizational structure designed for food industries **CO5-55MBT301-B.5.** Differentiate among food packaging regulations, norms and materials	

Scheme of Studies:

Board of Study	CourseCode	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)	55MBT301-B	Quality Control Management in Food Technology and Industry	3	0	1	3	7	3+0=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+CAT+SA+AT)		
PE	55MBT301-B	Quality Control Management in Food Technology and Industry	**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** | 10 | 00 | 01 | 03 | 14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-55MBT301-B.1. Explain the various terminologies associated with quality control measures used in food industries	**SO1.1** Explain concept, Objectives, functions and principles of quality control		**Unit-1** **CI1.1** Objectives, functions and principles of quality control	**SL1.1** Find out some examples of Quality Control procedures in India
	SO1.2 Determine the basic difference among food quality control and quality assurance, assessment of raw materials and finished products		**CI1.2** Difference between food quality control and quality assurance, assessment of raw materials and finished products	**SL1.2** List down GMP SPOs for food industries
	SO1.3 Elaborate the working mechanism of GMP Personal hygiene – occupational health		**CI1.3** Good Manufacturing Practices - Personal hygiene – occupational health and safety specification	**SL1.3** Draw a flow chart showing how food industry plants can be designed
	SO1.4 Define the Fundamental significance of Food Plant Sanitation Management and its features		**CI1.4** Food Plant Sanitation Management - Plant facilities construction and maintenance - exterior of the building- interior of the building- equipment	
	SO1.5 Describe the procedures related to Storage, transportation, traceability, recalling procedures, training		**CI1.5** Storage, transportation, traceability, recalling procedures, training	

Suggested Sessional Work (SW): *anyone*		
	SW1.1 Assignments	Describe in detail “How Good Manufacturing Practices followed in Indian Food Industries”
	SW1.2 Mini Project	Draw various types of Industrial layouts of food processing plants as per Indian norms
	SW1.3 Other Activities (Specify)	Make a power point presentation on “Storage and Transportation of Food products 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 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	8	00	01	03	12

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-55MBT301-B.2. Describe the food safety labels, regulations and acts associated with it	**SO2.1** Explain the Operational Mode of Reactors: Batch, Fed batch, Continuous cultivation		**Unit-2** **CI2.1** Food safety and food labelling, Food laws and regulations, concepts of Codex Alimentarius	**SL2.1** Find out more food products and list down the different labels present on it.
	SO2.2 Explain the working of HACCP, ISO series, GMP, GHP, 5S, SOP, audit system, documentation		**CI2.2** HACCP, ISO series, GMP, GHP, 5S, SOP, audit system, documentation	**SL2.2** Read the protocols to maintain and follow HACCP
	SO2.3 Explain the working mechanism of CSTRs fermenter, Monod equation for chemostat, Monod Kinetics		**CI2.3** Food standard and safety act: salient provisions and prospects, role of various food standards in India- PFA, FPO, AGMARK and BIS	**SL2.3** Write down few points on PFA, FPO, AGMARK and BIS
	SO2.4 Describe development in food quality regulation, MOFPI and schemes for establishing food industries in India		**CI2.4** Recent development in food quality regulation, MOFPI and schemes for establishing food industries in India	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe Codex Alimentarious in detail
	SW2.2 Mini Project	Make a project on different kinds of Indian Food laws
	SW2.3 Other Activities (Specify)	Make Power point presentation on HACCP

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** | 8 | 00 | 01 | 02 | 11

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-55MBT301-B.3. Elaborate the role of Quality assurance in food-based industries	**SO3.1** Elucidate the laws and regulation associated with food		**Unit-3** **CI3.1** The Structure of Food Law, Food Regulation What Should be Regulated	**SL3.1** Study different kinds of labels used in food industry
	SO3.2 Describe the effects of contamination and adulteration in food		**CI3.2** Laws and Regulations to Prevent Adulteration and Cross Contamination, Microbial Contamination	**SL3.2** List down different ISO certificates used in food industries
	SO3.3 Explain the terminologies of hygiene practice and standardization of food		**CI3.3** Hygienic Practice, Chemical and Environmental Contamination, Food Additives, Labelling, Trends in Food Standardization	
	SO3.4 Define ISO certificates 9001:2000/2008		**CI3.4** An Overview and structure of 9001:2000/2008, Clause wise Interpretation of ISO 9001:2000, Case Studies	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Prepare a report on any FMGC based food product associating all rules, regulations, symbols, labels with it.
	SW3.2 Mini Project	Describe different types of ISO certificates
	SW3.3 Other	Prepare one Power point presentation on “Microbial Contamination of Food”

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** | 8 | 00 | 01 | 03 | 12

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-55MBT301-B.4. Define the management and organizational structure designed for food industries	**SO4.1** Elucidate the organization's standard Maintenance and leading of team		**Unit-4** **CI4.1** Introduction to organization standard Maintenance and leading of team	**SL4.1** List down the different kinds codes associated of food packets
	SO4.2 Define the role of QA manager in food organization		**CI4.2** Professional and personal attribute as QA-manager, organization's policies, statutory and regulatory norms	**SL4.2** Read the process of quality assurance in food industries
	SO4.3 Differentiate and define the basic laws associated with food industries		**CI4.3** HACCP, ISO, FSSAI, 4M, 5S, AIB, six sigma, GMP, PCI	**SL4.3** Find out the role of 5S in maintaining the quality standards of any food-based organizations
	SO4.4 Assessment		**CI4.4** Assessment	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Write down the role of FSSAI in India
	SW4.2 Mini Project	Prepare a report on historical developments and timeline of different kinds of food-based laws
	SW4.3 Other Activities (Specify)	Complete atleast one month workshop/ skill training program in Industrial Production Worker-Food Processing; FIC/Q9005; Quality Assurance Manager; FIC/Q7602; Supervisor-Food Processing Industries; FIC/Q9009

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	00	01	05	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-55MBT301-B.5. Differentiate among food packaging regulations, norms and materials	**SO5.1** Elucidate the Internal mass transfer and steady state shell mass balance (assumption and derivation)		**Unit-5** **CI5.1** Introduction to different raw material, packaging material	**SL5.1** Find out the food materials of different packaging materials
	SO5.2 Describe the Concentration profile for first order kinetics and spherical geometry		**CI5.2** Machinery and tools used in bakery industry and their maintenance Function of materials	**SL5.2** List down the machines used in bakery
	SO5.3 Analyze the Concentration profile for zero order kinetics and spherical geometry		**CI5.3** Testing and maintenance of quality parameter, their storage norms	**SL5.3** List down the different quality parameters used in food industry
	SO5.4 Analyze the Concentration profile for Michles-menten kinetics and spherical geometry		**CI5.4** FIFO, FEFO, sampling-procedure, importance, precaution to be taken, stock maintenance	**SL5.4** Write down the importance of FIFO-FEFO
	SO5.5 Evaluate the Thiele modulus and effectiveness factor for first order, Zero order		**CI5.5** Bin card, inventory management, different tools and techniques and machinery like mixing, oven, cooling system, packaging machines, instrument handling and their working procedure of laboratory	**SL5.5** Write down the importance of inventory management

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Describe the different types of packaging material used in food industries
	SW5.2 Mini Project	Prepare a report on FIFO-FEFO
	SW5.3 Other Activities (Specify)	Prepare a presentation on “Machinery and tools used in bakery industry”

Course duration (in hours) to attain Course Outcomes:

Course Title: Quality Control Management in Food Technology and Industry **Course Code:** 55MBT302-B

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-55MBT301-B.1. Explain the various terminologies associated with quality control measures used in food industries	10	0	3	1	14
CO2-55MBT301-B.2. Describe the food safety labels, regulations and acts associated with it	8	0	3	1	12
CO3-55MBT301-B.3. Elaborate the role of Quality assurance in food-based industries	8	0	2	1	11
CO4-55MBT301-B.4. Define the management and organizational structure designed for food industries	8	0	3	1	12
CO5-55MBT301-B.5. Differentiate among food packaging regulations, norms and materials	10	0	5	1	17
Total Hours	44	00	16	05	66

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

Course Title: Quality Control Management in Food Technology and Industry **Course Code:** 55MBT302-B

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-55MBT301-B.1. Explain the various terminologies associated with quality control measures used in food industries	2	1	1	1	5
CO2-55MBT301-B.2. Describe the food safety labels, regulations and acts associated with it	2	4	5	1	12
CO3-55MBT301-B.3. Elaborate the role of Quality assurance in food-based industries	3	5	5	1	14
CO4-55MBT301-B.4. Define the management and organizational structure designed for food industries	2	3	5	1	11
CO5-55MBT301-B.5. Differentiate among food packaging regulations, norms and materials	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	Early, R. (1995): Guide to Quality Management Systems for the Food Industry, Blackie, Academic and professional, London
2	Gould, W.A and Gould, R.W. (1998). Total Quality Assurance for the Food Industries, CTI Publications Inc. Baltimore
3	Bryan, F.L. (1992): Hazard Analysis Critical Control Point Evaluations A Guide to Identifying Hazards and Assessing Risks Associated with Food Preparation and Storage. World Health Organization, Geneva
4	Krammer, A. and Twigg, B.A. (1970). Quality Control for the Food Industry. 3rd Edn. AVI, Westport
5	Rekha, S. Singhal, Pushpa R. Kulkarni, Dananesh V. Rege, (1997). Hand Book of Indices of food Quality and Authenticity, wood head Publishing Ltd

(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: M. Tech. Biotechnology
Semester: III Semester
Course Title: Quality Control Management in Food Technology and Industry
Course Code: 55MBT301-B

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	2
CO3-56MB303.3: Elaborate the working mechanism of upstream and downstream processing	-	1	1	1	-	1	1	1	1
CO4-56MB303.4: Interpretate the mechanism of fermentation process in industry	-	1	1	-	2	2	1	1	3
CO5-56MB303.5: Examine the mechanism of biological product development using microbes	1	1	1	-	-	2	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	**CO1-55MBT301-B.1.** Explain the various terminologies associated with quality control measures used in food industries	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5	**LI0**	1.1,1.2,1.3,1.4,1.5	**1SL-1,2,3**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO2-55MBT301-B.2.** Describe the food safety labels, regulations and acts associated with it	SO2.1 SO2.2 SO2.3 SO2.4	**LI0**	2.1, 2.2, 2.3, 2.4	**2SL-1,2,3**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO3-55MBT301-B.3.** Elaborate the role of Quality assurance in food-based industries	SO3.1 SO3.2 SO3.3 SO3.4	**LI0**	3.1,3.2,3.3,3.4	**3SL-1,2**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO4-55MBT301-B.4.** Define the management and organizational structure designed for food industries	SO4.1 SO4.2 SO4.3	**LI0**	4.1,4.2,4.3	**4SL-1,2,3**
PO 1,2,3,4,5,6 PSO 1,2, 3	**CO5-55MBT301-B.5.** Differentiate among food packaging regulations, norms and materials	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5	**LI0**	5.1,5.2,5.3,5.4,5.5	**5SL-1,2,3,4,5**

Program Name	**Master of Technology (M. Tech.)- Biotechnology**	
Semester	III	
Course Code:	55MBT302	
Course title:	Waste Management	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of environmental science & waste treatment	
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):	**CO1-55MBT302.1.** Identify different strategies of Waste treatment and its management **CO2-55MBT302.2.** Apply technical methods to get best out of waste **CO3-55MBT302.3.** Analyze various equipment used in anaerobic waste treatment **CO4-55MBT302.4.** Design effective strategies to implement metabolic flux to determine metabolic pathways **CO5-55MBT302.5.** Describe, design and develop systematic approach to remediate waste using technical advancement	

Scheme of Studies:

Board of Study	CourseCode	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)	55MBT302	Waste Management	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	**55MBT302**	Waste Management	**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** | 10 | 06 | 01 | 05 | 22

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-55MBT302.1. 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 Describe the meaning of Hazardous Waste		**CI1.6** Hazardous Waste	
	SO1.7 Classify different types of HW		**CI1.7** Types of Hazardous Waste	
	SO1.8 Justify the impact of HW on climate		**CI1.8** Impact of Hazardous Waste on Climate Change	

	SO1.9 Describe all UN Sustainable Goals		**CI1.9** UN Sustainable Goals	
	SO1.10 Interpretate the impact of waste on our ecosystem with new case studies		**CI1.10** Impact of Waste on Ecosystem (New Case Studies)	

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

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)**
CO2-55MBT302.2. 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 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 conversion technologies	
	SO2.6 Interpret the method of Chemical conversion technologies		**CI2.6** Chemical conversion technologies	
	SO2.7 Outline the stabilization steps for hazardous waste		**CI2.7** Stabilization of hazardous wastes	
	SO2.8 Interpret the new case studies on Biomedical waste		**CI2.8** New Case studies on Hazardous waste (Biomedical)	

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

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)**
CO3-55MBT302.3. 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 Summarize the term Environmental Metagenomics		**CI3.6** Introduction to Environmental Metagenomics	
	SO3.7 Illustrate the different metabolites form environmental samples		**CI3.7** Exploring metabolites form environmental samples	
	SO3.8 Contrast the Case studies on critical Indian rivers effected due to waste disposal		**CI3.8** Case studies on critical Indian rivers effected due to waste disposal	

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 PowerPoint presentation on “Effluent Treatment Plant”

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)**
CO4-55MBT302.4 Design effective strategies to implement waste management	**SO4.1** Distinguish among different types of waste water	**LI4.1** To perform the Oil separation method using aqueous two-phase extraction method	**Unit-4** **CI4.1** Sources and types of industrial wastewater, Environmental impacts	**SL4.1** 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 Illustrating the case studies on ETPs (Indian scenario)		**CI4.6** Case studies on ETPs (Indian scenario)	
	SO4.7 Describing Heavy metals accumulation in fresh water (Indian rivers)		**CI4.7** Heavy metals accumulation in fresh water (Indian rivers)	
	SO4.8 Summarizing Carbon footprinting		**CI4.8** Carbon footprinting	

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

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	05	20

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO5-55MBT302.5. 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	**SL5.1** Explore Anaerobic digestion
	SO5.2 Distinguish among Sedimentation and thickening in waste treatment	**LI5.2** To remediate the contaminations 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 industries		**CI5.4** Waste generation from different industries	**SL5.4** List down the surrounding industries and type of waste 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 Summarize the term Anaerobic Respiration		**CI5.6** Anaerobic Respiration	
	SO5.7 Interpret the term Anaerobic digestion		**CI5.7** Anaerobic digestion	
	SO5.8 Describe the major attributes of Fermentation		**CI5.8** Fermentation - Introduction	
	SO5.9 Analyse the process of methane gas		**CI5.9** Production of Methane Gas	

	production			
	SO5.10 Summarize the terms Green House Gases (GHGs) and Global Warming		**CI5.10** GHGs and Global Warming	

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 Management **Course Code:** 55MBT302

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-55MBT302.1. Identify different strategies of Waste treatment and its management	10	6	5	1	22
CO2-55MBT302.2. Apply technical methods to get best out of waste	8	4	4	1	17
CO3-55MBT302.3. Analyze various equipment used in anaerobic waste treatment	8	4	3	1	16
CO4-55MBT302.4. Design effective strategies to implement waste management	8	2	4	1	15
CO5-55MBT302.5. Describe, design and develop systematic approach to remediate waste using technical advancement	10	4	5	1	20
Total Hours	44	20	21	05	90

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

Course Title: Waste Managment **Course Code:** 55MBT302

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-55MBT302.1. Identify different strategies of Waste treatment and its management	2	1	1	1	5
CO2-55MBT302.2. Apply technical methods to get best out of waste	2	4	5	1	12
CO3-55MBT302.3. Analyze various equipment used in anaerobic waste treatment	3	5	5	1	14
CO4-55MBT302.4. Design effective strategies to implement waste management	2	3	5	1	11
CO5-55MBT302.5. 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:

(a) Books:

(b)

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.
4	Biotechnology – Questioning the Reasons, 2nd Edition – 2024, Book Rivers 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 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: M. Tech. Biotechnology
Semester: III Semester
Course Title: Waste Management
Course Code: 55MBT302

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**
CO1-55MBT302.1. Identify different strategies of Waste treatment and its management	-	1	-	1	2	2	3	-	3	2	2	3	1	1	2
CO2-55MBT302.2. Apply technical methods to get best out of waste	-	1	-	-	1	-	3	1	2	2	3	3	2	-	2
CO3-55MBT302.3. Analyze various equipment used in anaerobic waste treatment	-	1	1	1	-	1	1	-	2	1	1	2	3	2	-
CO4-55MBT302.4. Design effective strategies to implement waste management	1	-	1	-	2	2	2	3	-	1	3	3	2	1	3
CO5-55MBT302.5. 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	**CO1-55MBT302.1.** Identify different strategies of Waste treatment and its management	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10	**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	**1SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-55MBT302.2.** Apply technical methods to get best out of waste	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	**CO3-55MBT302.3.** Analyze various equipment used in anaerobic waste treatment	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-1,2,3**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-55MBT302.4.** Design effective strategies to implement waste management	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8	**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	**CO5-55MBT302.5.** Describe, design and develop systematic approach to remediate waste using technical advancement	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9 SO5.10	**LI 1** **LI 2**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9,5.10	**5SL-1,2,3,4,5**

Semester IV

Course Code:	55MBT451
Course Title:	Project, Dissertation and Training
Course Outcomes:	
55MBT451.1	Analyze complex biotechnological problems by applying advanced theoretical and practical knowledge.
55MBT451.2	Evaluate current research literature to identify gaps and propose innovative solutions in biotechnology.
55MBT451.3	Design and implement experimental protocols to address specific biotechnological research questions.
55MBT451.4	Synthesize and interpret experimental data to draw meaningful conclusions and contribute to the field.
55MBT451.5	Communicate research findings effectively through written dissertations and oral presentations to diverse audiences.

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AKS UNIVERSITY

DEPARTMENT OF BIOTECHNOLOGY

Guideline for Project/Dissertation/Industrial Internship

Guidelines and Format
for
M. Tech. Biotechnology
Thesis Preparation

AKS UNIVERSITY
SATNA (M.P.)

For internal use only

April 2022

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PART 1: MUST-KNOW ISSUES

1. Enrolment and Pre-requisites

Your research project begins in your last semester. The project/dissertation is considered as a credit course which must be completed within the same semester to qualify for M. Tech. Biotechnology degree. 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 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 independent research and should be capable in it.

3. Duration and workload

The research project comprises a credit module equivalent to 12 working months of final year which includes 3rd and 4th sem. 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.

S. No.	Nomenclature for M. Tech. degree program	Duration
1	Dissertation (Final Year)	12 Months

Industrial training/Internship/Apprentice Program

Students who are getting opportunity to initiate their project/internship/apprentice/dissertation for 12-month program, can apply by getting a recommendation letter against the acceptance from any biotechnology/food/pharma/dairy or relevant industry. The department will accept the work on the basis of its relevance and their evaluation can be done on the basis of the work given or presented by the student. Department of Biotechnology of AKS University has a Life Membership of **LSSSDC** program of Skill India and students will also get an opportunity in this sector would be consider as their project/internship/apprentice/dissertation for 12-month program.

4. Scope

Projects should be original laboratory, field-based or survey research on a topic proposed an 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 is interested in the same project. The supervisor has the right to select the most suitablestudent 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. Viva-Voce can be conducted in which student have to present his/her work in form of PowerPoint presentation 15-20 slides, on the basis of presentation, quality of work and viva, the assessment can be done through external and internal members of evaluation committee.

7. Importance

The student will gain extensive exposure to scientific instruments, their handling, and the ability to easily set up a research pipeline that will assist them in completing project work on the topics assigned to them. The in-house training program is known as CEBRT, and students can contact the Head of the Department directly for more information. The format and guidelines presented here are for 12 months dissertation program; students are advised to follow the entire structure of guidelines so that they can easily proceed. Students from other colleges and universities must present an official recommendation letter signed by the concerned authority or Head of the Department of their university or college; they are welcomed under the domain of CEBRT; they must also follow the same procedure outlined in this guideline once they contact the training coordinator and Head of the Department.

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 becertified 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., 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 defense.
- After a successful defense, 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 (hard binding is required) and a and the electronic versions of the thesis (in both .doc and /pdf formats) and the presentation in PowerPoint.

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
- Certificate
- Index including (List of Figures, Tables)
- Main body: paper-styled, including
    - *Title, student name and affiliation* (internal cover page same as main cover page)
    - *Abstract*
    - *Introduction*
    - *Review of Literature*
    - *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 inyour 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 anexample 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 ordeveloped 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, ofthe 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 summarized 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

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 understandingof 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; Heading and Sub Headings can be typed as in Time New Roman, Bold and 14 font size in numbers like 1, 1.1, 1.1.2 etc.
- 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 center of the bottom of the page. No header/footer is allowed.
- Hard Binding is accepted for 12 months dissertation project 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 ideally 50-70 pages approx. for 12-month dissertation. When needed the addition of few more pages are allowed, but the total number of pages of the main body should not exceed 100.
- 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

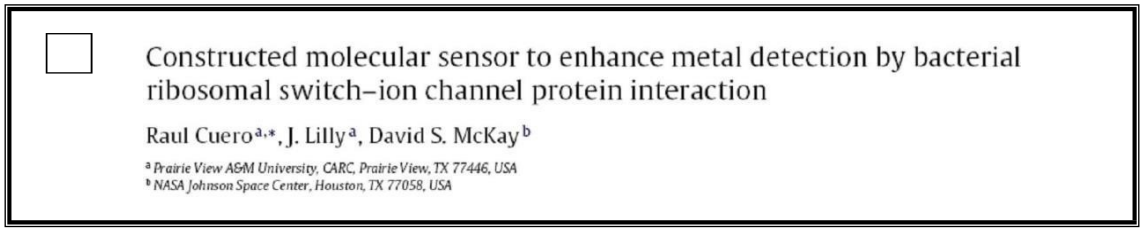
Author name(s) and affiliation

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. Conclusion

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

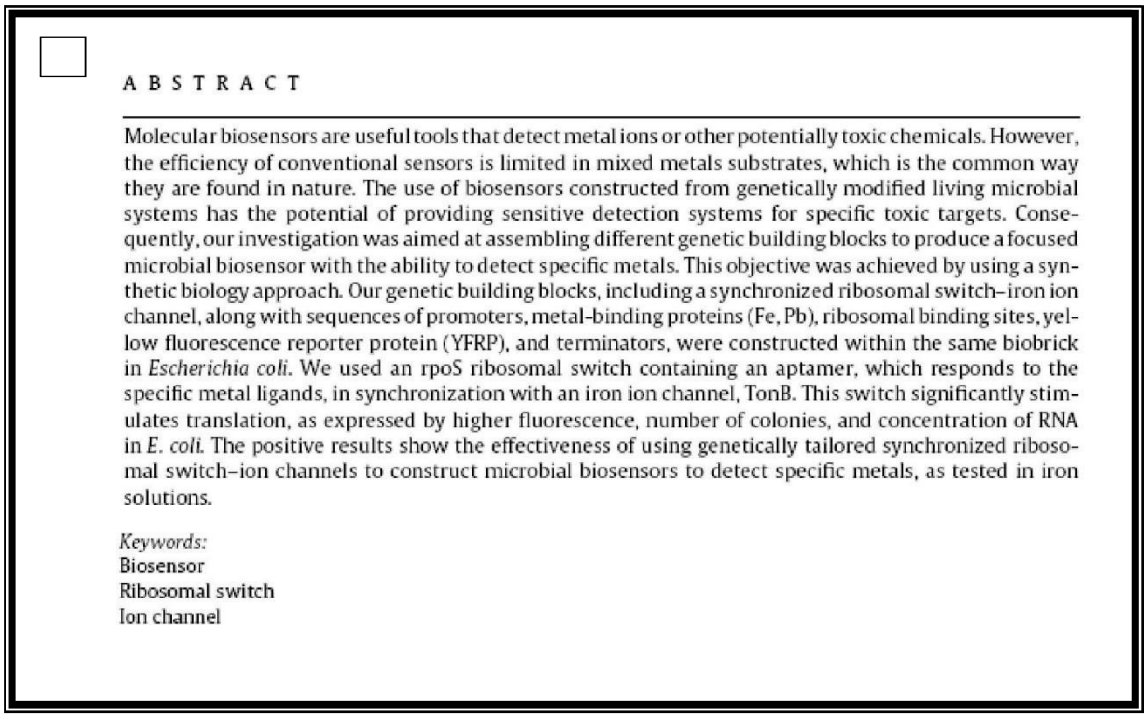
TITLE PAGE INFORMATION (see the example above)

- 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., adouble 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.



ABSTRACT

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 superscriptlowercase letters. Avoid vertical rules.
- Be sparing in the use of tables and ensure that the data presented in tables donot 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:

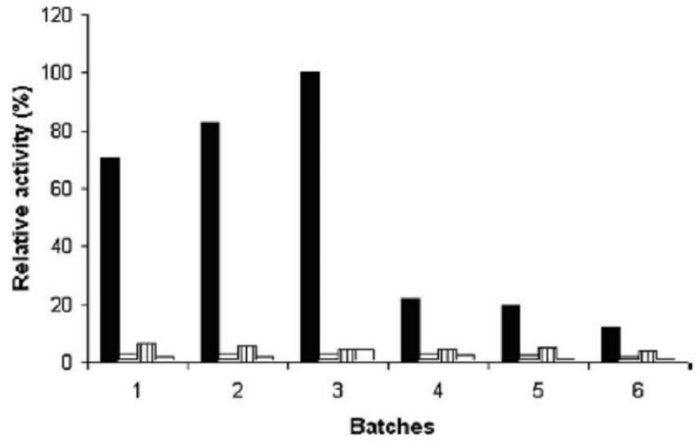


Fig. 5. Relative glucosyltransferase activity of the different low methoxyl pectin microcapsules containing glucosyltransferase after six batches of 30 min each of conversion of sucrose into isomaltulose. (■) Microcapsules with fat; (▤) microcapsules without fat; (◧) lyophilized microcapsules with fat; and (□) lyophilized microcapsules without fat.

CITATION IN TEXT

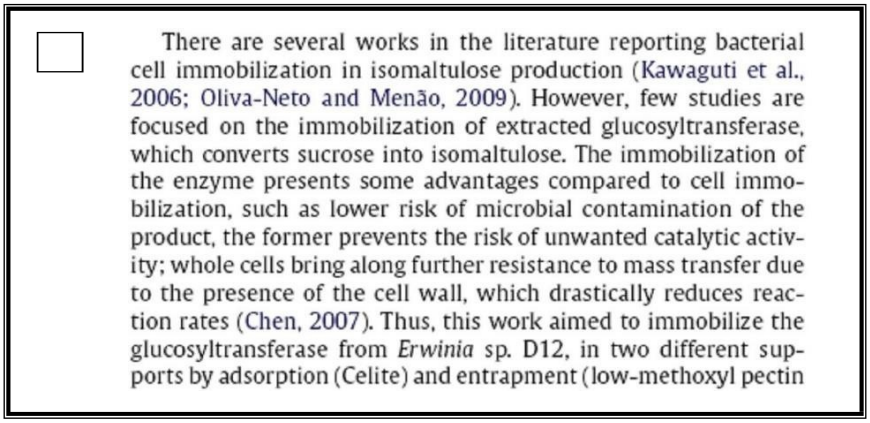
Please ensure that every reference cited in the text is also present in the reference list and vice versa. Any references cited in the abstract must be given in full. Unpublished results and personal communications are not recommended in the reference list, but may bementioned in the text. If these references 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 areference 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 theyear 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 ofpublication.

Citations may be made directly (or parenthetically). Groups of references should belisted 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 (APA Format)

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 scientificarticle. 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.I., 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, mislabeled 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 thatall information, photos, figures and tables are properly acknowledged. Less Than 5% plagiarism is accepted only as per the authenticate software used. DO NOT COPY/PASTE ANY CONTENT FORM WEB OR RESEARCH PAPERS, the project can be disqualified once it found with unfair means. Therefore, no evaluation can be done for the dame.

Citations

You must always acknowledge your sources of factual information and diagrams you wish touse. This is known as a *citation*.

PART 4: THESIS DEFENCE

PRESENTATION

- Presentation should last up to 15 minutes with another 15 minutes for questions andanswers
- Slides should be prepared using Microsoft PowerPoint and presented from a disk.
- Rehearse your presentation and anticipate questions that may be asked by theEvaluation Committee.
- If you are not sure about the pronunciation of certain terminologies, be sure to ask aknowledgeable person before your defense.
- 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 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 advisable 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
M.Tech. in …….

(6 lines)

Student name: Full name of student – Student Code.
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 No 1: Thesis registration	19
Form No 2: Thesis progress report	20
Form No 3: Academic Adviser	22
Form No 4: Thesis Reviewer	23
Form No 5: For Examiner Of The Scientific Committee	24
Form No 6: Thesis Evaluation Memo	25
Form No 7: Report on thesis revision	27

Form **BT01**

THESIS REGISTRATION

1. (Student's name) ..... (ID) .....
2. (Department) .....
3. (Thesis title) .....

.....

.....

4. (Objectives) .....

.....

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.....

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 .....

.....

SECTION A: 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.

_____

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)

_____

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