Curriculum Book

and

Assessment and Evaluation Scheme

based on

Outcome Based Education (OBE)

and

Choice-Based Credit System (CBCS)

in

Master of Science in Microbiology

M. Sc. (Microbiology)

2 Year Degree Program

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

AKS University

Satna 485001, Madhya Pradesh, India

Faculty of Life Sciences and Technology
Department of Biotechnology

Dr. Kamlesh Choure
Professor & Head
Department of Biotechnology
AKS University, Satna (MP) 485001

DEAN
Faculty of Life Sciences
AKS University, Satna (M.P.)

Professor B.A. Chopade
Vice - Chancellor
AKS University
Satna, 485001 (M.P.)

Curriculum & Syllabus of M.Sc. (Microbiology) Program

(Revised as of 2023)

CONTENTS

Sr.	Item	Page No
1	Foreword	i
2	Vice Chancellor Message	ii
3	Preface	iii
4	Introduction	1
5	Vision & Mission of Biotechnology Department	1
6	Programme Educational Objectives (POE)	2
7	Programme Outcome (POs)	2
8	Program Specific Outcomes	2
9	General Course Structure and Credit Distribution	3
10	Course code and definition	4
11	Category-wise Courses	5
12	Semester-wise Course Structure	6
13	Semester-wise Course details	6-7
	A. Semester I	8-98
	B. Semester -II	99-177
	C. Semester -III	178-267
	D. Semester -IV	268-292

AKS University
Faculty of Life Sciences and Technology

Department of Biotechnology
Curriculum of M.Sc. (Microbiology) Program
(Revised as on 2023)

Foreword

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

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

With immense satisfaction, I hereby present the revised curriculum for the M. Sc. (Microbiology) 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.Sc. (Microbiology) 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/microbiology 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 microbiology 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 microbiological 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. Sc Microbiology 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 UGC. Additionally, they have maintained a total credit requirement of 92 for the M. Sc. Microbiology 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. Sc. Microbiology 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. Sc. Microbiology 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 UGC 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 UGC's directives, the total credit allocation for the M. Sc. Microbiology program is capped at 91 credits.

This curriculum is enriched with course components in alignment with UGC guidelines, encompassing various disciplines such as Basic Science Courses: 20 credits, Discipline Specific Courses: 18 credits, Core Program core Courses: 37 credits and 16 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.

INTRODUCTION

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 understanding 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 a 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:** Students will able to understand all the fundamentals of the field of biotechnology while gradually introducing them to all the essentials of the field through solid practical instruction and exposure to the most cutting-edge ideas
- **PO2:** Exhibit technical proficiency in the use and upkeep of advanced apparatus so that the student would be qualified to start a domain-related job as well as discipline-specific study.
- **PO3:** Write and present a substantial technical report/research document.
- **PO4**: Apply research-based knowledge and biotechnological methods to investigate complex biological problems related to energy, environment, health, safety, and society following ethical principles.
- **PO5:** Pursue life-long learning to enhance knowledge and skills for professional advancement

PROGAM EDUCATIONAL OBJECTIVES

- **PEO1:** Pursue prosperous employment in industry, academia, and research in the realm of Microbiology.
- **PEO2:** Use sophisticated microbial technological expertise to address industrial and research demands
- **PEO3:** Address microbial disease issues by using contemporary computational, and analytical tools and approaches.
- **PEO4:** In the context of microbiology applications, identify ethical, social, safety, and environmental concerns.
- **PEO5:** Pursue lifelong learning for professional development and societal and environmental benefits.
- **PEO6**: Engage in lifelong learning for career and professional growth for society and the environment

PROGRAM SPECIFIC OUTCOMES

- **PSO1:** Apply microbiology concepts to real-world issues that affect industry and the environment.
- **PSO2:** Contribute to the field of microbiology by identifying diseases and understand fermentation technology.
- **PSO3:** Utilize proper information about Microbiology's Applications in the Environment, Agriculture, Plant Pathology, Food, and Dairy Technologies.

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 UGC model Curriculum for the PG Degree Course in Microbiology, the total number of credits proposed for the Two-year M. Sc. (Microbiology) is kept as 92.

C. Structure of PG Program in Microbiology:

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

S. No.	Category	Breakup of Credits
2.	Basic Science Courses	20
3.	Discipline Specific Courses	18
4.	Program Core Courses (Branch specific)	37
5.	Professional Elective Courses (Branch specific)	-
6.	Open Elective Courses (from Humanities, Technical Emerging or other Subjects)	-

7.	Project work, Seminars and Internships in Industry or elsewhere, or research courses	16
	TOTAL	**91**

D. Course Code and Definition:

Course code	Definitions
L	Lecture
T	Tutorial
P	Practical
C	Credits
BSC	Basic Science Courses
ESC	Engineering Science Courses
PCC	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)

****

Department of Biotechnology

Scheme and Syllabus

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

I Semester

S. No.	**Subject Code**	**Category**	**Subject Name**	**L**	**T**	**P**	**Credit**
1	56MB101	BSC	General Microbiology	3	0	-	3
2	56MB102	BSC	Microbial Diversity and Taxonomy	3	0	-	3
3	56MB103	BSC	Advanced Biochemistry	3	0	-	3
4	56MB104	PCC	Microbial Genetics and Molecular Biology	3	0	-	3
5	56MB105	DSC	Bioinformatics and Biostatistics	2	1	-	3
6	56MB106	PCC	Bioinstrumentation	3	0	-	3
7	56MB151	BSC	General Microbiology Lab	-	-	2	1
8	56MB152	BSC	Microbial Diversity and Taxonomy lab	-	-	2	1
9	56MB153	BSC	Advanced Biochemistry lab			2	1
10	56MB154	PCC	Microbial Genetics and Molecular Biology Lab			2	1
11	56MB155	DSC	Bioinformatics and Biostatistics lab			2	1
12	56MB156	PCC	Bioinstrumentation lab			2	1
			Total				**24**

II Semester

S. No.	**Subject Code**	**Category**	**Subject Name**	**L**	**T**	**P**	**C**
1	56MB201	BSC	Microbial Physiology and Metabolism	3	0	-	3
2	56MB202	DSC	Enzyme Technology	3	1	-	4
3	56MB203	BSC	Immunology	3	0	-	3
4	56MB204	PCC	Environmental Microbiology	3	0	-	3
5	56MB205	PCC	Recent Trends in Virology and Mycology	3	0	-	3
6	56MB206	DSC	Genetic Engineering and Genomics	3	0	-	3
7	56MB251	BSC	Microbial Physiology and Metabolism Lab	-	-	2	1
8	56MB252	DSC	Enzyme Technology Lab	-	-	2	1
9	56MB253	BSC	Immunology Lab			2	1
10	56MB254	PCC	Environmental Microbiology Lab			2	1
11	56MB255	PCC	Recent Trends in Virology and Mycology Lab			2	1
12	56MB256	DSC	Genetic Engineering and Genomics Lab			2	1
13			Total				**25**

III Semester

S. No.	**Subject Code**	**Category**	**Subject Name**	**L**	**T**	**P**	**C**
1	56MB301	PCC	Medical Microbiology	3	0	-	3
2	56MB302	PCC	Food and Dairy Microbiology	3	0	-	3
3	56MB303	PCC	Industrial Microbiology and Fermentation Technology	3	1	-	4
4	56MB304	PCC	Pharmaceutical Microbiology	3	0	-	3
5	56MB305	PCC	Clinical Diagnosis of Microorganisms	3	0	-	3
6	56MB306	DSC	Scientific Writing and Patenting Process	3	1	-	4
7	56MB351	PCC	Medical Microbiology Lab	-	-	2	1
8	56MB352	PCC	Food and Dairy Microbiology Lab	-	-	2	1
9	56MB353	PCC	Industrial Microbiology and Fermentation Technology Lab			2	1
10	56MB354	PCC	Pharmaceutical Microbiology Lab			2	1
11	56MB355	PCC	Clinical Diagnosis of Microorganisms Lab			2	1
12	56MB356	DSC	Scientific Writing and Patenting Process lab			2	1
			Total				26

IV Semester

	Subject Code	**Title**	**L**	**T**	**P**	**C**
1	56MB451	Six months Dissertation or Project on any Microbiology related aspect	0	-	16	16

Total Credit: 91

Semester 1

Program Name	**Masters of Science (M.Sc.)- Microbiology**	
Semester	I	
Course Code:	56MB101	
Course title:	General Microbiology	**Curriculum Developer**: Mr. Vivek Kumar Agnihotri
Pre-requisite:	The student should have basic knowledge of Microbiology at the graduate level	
Rationale:	Microbiology is the study of a diverse group of microscopic organisms such as bacteria, viruses, fungi, and protozoa. They are generally too small to be seen without the use of a microscope and hence these life forms are called microorganisms or microbes. They are almost everywhere and affect almost all aspects of our lives. This is a general microbiology course that is intended for students to impart the knowledge of microbial life. The course structure is based on presenting the fundamentals of microbiology i.e. the biology of bacteria, fungi, viruses, and protozoa, their classification, bacterial genetics, mode of replication, bacterial photosynthesis, bacterial fermentation, microbial food spoilage, and various methods of food preservation. The students will also be introduced to the microbial pathogenesis of various infectious agents that cause diseases in humans and the prevention of the infection, host resistance immunity, etc.	
Course Outcomes (COs):	**CO1-56MB101.1.** Elucidate the fundamentals of Microbiology **CO2-56MB101.2.** Differentiate the various morphological aspects in the domain of microorganisms **CO3-56MB101.3.** Recognize the nutritional factors and mechanisms in microorganisms **CO4-56MB101.4.** Differentiate between the Prokaryotic and Eukaryotic cellular system **CO5-56MB101.5.** Analyze the staining and screening techniques for different microorganisms.	

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)	56MB101	General Microbiology	3	1	1	3	8	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	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	56MB101	**General Microbiology**	**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	**56MB151**	**General Microbiology lab**	35	5	5	5	50	50	50

Course-Curriculum:

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

Approximate Hours

Item	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)
CO1-56MB101.1: Elucidate the fundamentals of Microbiology	**SO1.1** Define the historical aspects and scope of microbiology	**LI1.1** Demonstration of basic instruments used in microbiology	**CI1.1** General characteristics and composition of Prokaryotes.	**SL1.1** Draw a well-labeled diagram of prokaryotic & Eukaryotic cell
	SO1.2 Differentiate among various cell organelles and their functions	**LI1.2** Explain and perform the basic sterilization procedures used in microbiology	**CI1.2** General characteristics and composition of Eukaryotes.	**SL1.2** Write various kingdoms of microbial classification.
	SO1.3 Elaborate the growth and nutritional factors and phases		**CI1.3** General properties of viruses	**SL1.3** Learn the ancient use of microorganisms.
	SO1.4 Compare the prokaryotic and eukaryotic cellular structures and functions.		**CI1.4** Morphology and ultrastructure of viruses.	**SL1.4** Learn the ancient use of microorganisms in your surroundings and prepare a report on it.
	SO1.5 Understanding and analyzing the staining and screening technique for different microorganisms.		**CI1.5** Classification of Microorganisms.	**SL1.5** Draw a well-labeled diagram of a bacterial cell and fungal mycelium.
	SO1.6 Haeckel's three kingdom concept.		**CI1.6** Haeckel's three kingdom concept.	
	SO1.7 Whittaker's Five Kingdom		**CI1.7** Whittaker's Five	

	Concept.		Kingdom Concept.	
	SO1.8 Three domain concept of Carl Woese's		**CI1.8** Three domain concept of Carl Woese's	
	SO1.9 Salient features of bacteria according to Berger's Manual of Determinative Bacteriology.		**CI1.9** Salient features of bacteria according to Berger's Manual of Determinative Bacteriology.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Write about the historical timeline of various discoveries that occurred in the field of Microbiology
	SW1.2 Mini Project	Write an article on "Industrially Important Microorganisms"
	SW1.3 Other Activities (Specify)	Find out some research papers reflecting the "Latest inventions in the field of Microbiology"

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)**
CO2-56MB101.2: Differentiate the various morphological aspects in the domain of microorganisms.	**SO2.1** Understand the concept of different parameters of bioreactors.	**LI2.1** Demonstration of a pH Electrode.	**CI2.1** Morphology and ultrastructure of bacteria: size, shape, and arrangement of bacteria.	**SL2.1** Find out the uses of the microscope and its historical aspects.
	SO2.2 Explain the isolation and identification of microorganisms.	**LI2.2** Perform Primary and Secondary screening.	**CI2.2** Ultrastructure of the bacterial cell wall of eubacteria and archaebacteria.	**SL2.2** Draw and label the structures of cell organelles.
	SO2.3 Outline the difference between Primary and secondary screening.		**CI2.3** Protoplast and spheroplast formation	**SL2.3** Differentiate different cell organelles in prokaryotic and eukaryotic systems.

	SO2.4 Differentiate between types of substrates used in microbial growth.		**CI2.4** L-form. Components external to cell wall.	
	SO2.5 Understand the Downstream processing.		**CI2.5** Structure and function of flagella, fimbriae and pilli, capsule- types, composition and function, slime layers, S-layers.	
			CI2.6 Archeobacteria, mesosomes	
			CI2.7 Ribosomes, cytoplasmic inclusion bodies (polyhydroxy butyrate, polyphosphate granules, oil droplets, cyanophycin granules), and the nucleoid.	
			CI2.8 Bacterial response to external stimulus and bacterial endospores.	
			CI2.9 Chemotaxis and phototaxis structure, formation, and germination of the bacterial endospore.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Explain the difference between Lyophilization and Cryopreservation.
	SW2.2 Mini Project	Write an article on "Cell Disruption Techniques with Examples"
	SW2.3 Other Activities (Specify)	Find some YouTube videos based on searching and exploring techniques like Lyophilization, Spray Drying, etc.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	04	01	05	17

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO3-56MB101.3: Recognize the nutritional factors and mechanisms in microorganisms**.**	**SO3.1** Explain the role of Nutritional factors.	**LI3.1** Demonstrate the production of bacterial biomass using different media.	**CI3.1** Basic nutritional requirements, growth factors, nutritional categories, and physical requirements of bacterial growth.	**SL3.1** Explore nutritional factors required by microbes

	SO3.2 Define the concept of bacteriological media preparation.	**LI3.2** Determine the growth kinetics using a graphical representation.	**CI3.2** Bacteriological media: types (complex, synthetic, differential, enrichment, and selective media) and their uses.	**SL3.2** Find out substrates used in the manufacture of media.
	SO3.3 Understand the steps of bacterial growth phases.		**CI3.3** Culture characteristics of bacteria on different media.	**SL3.3** Derive the mechanism for bacterial growth & cell division.
	SO3.4 Comprehend the concept of microbial culture preservation.		**CI3.4** Cultivation of bacteria: aerobic and anaerobic culture, pure culture techniques, shaker, and still culture.	**SL3.4** Design the protocol for preservation techniques of microbial cells.
	SO3.5 Examine the growth of microbes on different media.		**CI3.5** Maintenance and preservation of microbial culture.	**SL3.5** Elaborate the role of different modes of fermentation
	SO3.6 Bacterial growth: growth kinetics, growth curve.		**CI3.6** Bacterial growth: growth kinetics, growth curve.	
	SO3.7 Batch, continuous, and synchronous culture.		**CI3.7** Batch, continuous, and synchronous culture.	
	SO3.8 Measurement of growth.		**CI3.8** Measurement of growth.	
	SO3.9 Influence of environmental factors affecting growth.		**CI3.9** Influence of environmental factors affecting growth.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Elaborate the bacterial growth mechanism in both aerobic and anaerobic conditions
	SW3.2 Mini Project	How Substrates play an important role as growth factors, explain
	SW3.3 Other Activities (Specify)	Find out some YouTube videos based on fungal growth through mycelium.

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)
CO4-56MB101.4: Differentiate between the Prokaryotic and Eukaryotic cellular systems.	**SO4.1** Describe the functions of the genome.	**LI4.1** Demonstrate the production of vitamins using microorganisms.	**CI4.1** General concept of Prokaryotic genome.	**SL4.1** Collect the statistics of the Human genome.
	SO4.2 Differentiate the prokaryotic and eukaryotic genomes.	**LI4.2** Study of Prokaryotic and Eukaryotic Cells.	**CI4.2** General concept of the Eukaryotic genome.	**SL4.2** Elaborate the different kinds of plasmids.
	SO4.3 Classify the functions of different plasmids.		**CI4.3** Genome of *E. coli.*	**SL4.3** Study about E. coli as a model prokaryotic organism.
	SO4.4 Illustrate the mechanism of Bacteriophage.		**CI4.4** Genetic recombination and transformation.	
	SO4.5 Discuss the genome size of various eukaryotes and prokaryotes.		**CI4.5** Transduction: generalized and specialized transduction, phage conversion.	
			CI4.6 Plasmid: types and their significance.	
			CI4.7 Conjugation.	
			CI4.8 Chromosomal mobilization.	
			CI4.9 E. coli as model prokaryotes.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Elaborate on the structures of different plasmids used in genetic engineering as a tool
	SW4.2 Mini Project	Generalize the difference between Conjugation, Transformation, and Transduction
	SW4.3 Other Activities (Specify)	Find out literature sources on pBR322 plasmid

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

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO5-56MB101.5: Analyse the staining and screening technique for different microorganisms	**SO5.1** Identify the Staining methods used for differentiating microbes.	**LI5.1** Differentiate the gram positive and Gram-Negative Bactria using Gram's Staining protocol	**CI5.1** Staining methods: fixation, types of dyes, simple staining, differential staining (Gram and Acid-fast staining).	**SL5.1** Find out the Gram's staining mechanism.
	SO5.2 Recognize the different sterilization equipment and instruments.	**LI5.2** Perform different sterilization methods.	**CI5.2** Staining of specific structures (capsule, flagella, and spore staining).	**SL5.2** Differentiate the Gram-Positive and Gram-Negative microorganisms.
	SO5.3 Interpret the Thermal Death Time and Decimal Reduction Time.		**CI5.3** Control of microorganisms: Microbial death curve.	**SL5.3** Explore different physical and chemical methods to control microorganisms.
	SO5.4 Classify different antimicrobial agents.		**CI5.4** Concept of bio-burden, thermal death time, and decimal reduction time.	**SL5.4** Elaborate the derivation of microbial death kinetics
	SO5.5 Understand the role of bactericidal and bacteriostatic chemicals.		**CI5.5** Factors influencing the effectiveness of antimicrobial agents.	
	SO5.6 Control of microorganisms by physical agents: heat (moist and dry), filtration, and radiation.		**CI5.6** Control of microorganisms by physical agents: heat (moist and dry), filtration, and radiation.	
	SO5.7 Ecology of fungi: concept of fungistatic, fungicidal.		**CI5.7** Ecology of fungi: concept of fungistatic, fungicidal.	

	SO5.8 Halogens, phenol, and other phenolic compounds.		**CI5.8** Halogens, phenol, and other phenolic compounds.	
	SO5.9 Heavy metals, alcohols, ethylene oxide, and aldehydes.		**CI5.9** Heavy metals, alcohols, ethylene oxide, and aldehydes.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Discuss various antimicrobial agents playing an important role in the control of microorganisms
	SW5.2 Mini Project	Write the difference between bacteriostatic and Bactericidal agents with examples
	SW5.3 Other Activities (Specify)	Find out various protocols other than gram staining to differentiate bacteria based on cell cycle.

Course duration (in hours) to attain Course Outcomes:

Course Title: General Microbiology **Course Code:** 56MB101

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Sessional work (SW)**	**Self-Learning (SL)**	**Total Hours (Li+CI+SL+SW)**
CO1-56MB101.1: Elucidate the fundamentals of Microbiology	09	04	01	05	**19**
CO2-56MB101.2: Differentiate the various morphological aspects in the domain of microorganisms.	09	04	01	03	**17**
CO3-56MB101.3: Recognize the nutritional factors and mechanisms in microorganisms.	09	04	01	05	**19**
CO4-56MB101.4: Differentiate between the Prokaryotic and Eukaryotic cellular systems.	09	04	01	03	**17**
CO5-56MB101.5: Analyse the staining and screening technique for different microorganisms.	09	04	01	04	**18**
Total Hours	**45**	**20**	**05**	**20**	**90**

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

Course Title: General Microbiology **Course Code:** 56MB101

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-56MB101.1: Elucidate the fundamentals of Microbiology	2	1	1	1	**5**
CO2-56MB101.2: Differentiate the various morphological aspects in the domain of microorganisms.	2	4	2	2	**10**
CO3-56MB101.3: Recognize the nutritional factors and mechanisms in microorganisms.	3	5	5	2	**15**
CO4-56MB101.4: Differentiate between the Prokaryotic and Eukaryotic cellular systems.	2	3	3	2	**10**
CO5-56MB101.5: Analyse the staining and screening technique for different microorganisms.	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	Edition & Year
1	Textbook of Microbiology	R.C. Dubey and D. K. Maheshwari	S. Chand Publications	5 & 2022
2	Microbiology	M.J. Pelczar, E.C.S Chan and N.R. Kreig	McGraw Hill	5 & 2002
3	General Microbiology	R. Y. Stanier, E. A. Adelberg, J. L. Ingraham	Mac Millan Press	1 & 2014
4	General Microbiology	Hans G. Schlegel	Cambridge University Press	7 & 2000

B. Online

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.Sc. Microbiology
Semester: I Semester
Course Title: General Microbiology
Course Code: 56MB101

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-56MB101.1: Elucidate the fundamentals of Microbiology	2	-	-	1	2	2	1	1
CO2-56MB101.2: Differentiate the various morphological aspects in the domain of microorganisms.	-	-	-	-	-	1	2	-
CO3-56MB101.3: Recognize the nutritional factors and mechanisms in microorganisms.	-	1	1	1	-	1	1	1
CO4-56MB101.4: Differentiate between the Prokaryotic and Eukaryotic cellular systems.	-	1	1	-	2	2	1	3
CO5-56MB101.5: Analyse the staining and screening technique for different microorganisms.	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	**CO1-56MB101.1**: Elucidate the fundamentals of Microbiology	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	**LI 1** **LI 2**	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9	**1SL-1, 2, 3, 4, 5**
PO 1,2,3,4,5 PSO 1,2,3	**CO2-56MB101.2**: Differentiate the various morphological aspects in the domain of microorganisms.	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 PSO 1,2,3	**CO3-56MB101.3**: Recognize the nutritional factors and mechanisms in microorganisms.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	**LI 1** **LI 2**	3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9	**3SL-1, 2, 3, 4, 5**
PO 1,2,3,4,5 PSO 1,2,3	**CO4-56MB101.4**: Differentiate between the Prokaryotic and Eukaryotic cellular systems.	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	**CO5-56MB101.5**: Analyse the staining and screening technique for different microorganisms.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	**LI 1** **LI 2**	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9	**5SL-1, 2, 3, 4**

Curriculum Development Team

Prof. Kamlesh Choure
Prof Ashwini A. Waoo
Prof. Deepak Mishra
Er. Arpit Srivastava
Mr. Piyush Kant Rai

Program Name	**Masters of Science (M.Sc.)- Microbiology**	
Semester	I	
Course Code:	56MB102	
Course title:	Microbial Diversity and Taxonomy	**Curriculum Developer**: Mrs. Sonal Gupta, Assistant Professor
Pre-requisite:	Students should have basic information on microbiology and taxonomy	
Rationale:	The main objectives of the Microbial Diversity and Taxonomy course are to facilitate students comprehensive understanding of the students about ecology, microbial diversity and various extremophiles and their applications. The aim of the coursework is to build a strong foundation of the students the by providing all necessary knowledge on microbial diversity, taxonomy and their role in ecosystem. The course also includes basic information on various extremophiles with special reference to their natural habitat, tolerance mechanism and applications. In addition, the course also promotes expository thinking and awareness among students regarding the space microbiology, various techniques to study microbial activities in space and different space programme.	
Course Outcomes (COs):	**CO1-56MB102.1**: To learn and understand the fundamental concepts, principles of ecology and microbial diversity. **CO2-56MB102.2**: To expand the knowledge of many microbiological approaches to overcome challenges in study of various extremophiles like Thermophiles and Methanogens. **CO3-56MB102.3**: To understand the life under low and high pH conditions. **CO4-56MB102.4**: To study the various aspects of Halophiles and Barophiles. **CO5-56MB102.5**: To explore various methods and experiments to detect life in space.	

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)	
BSC	56MB102	Microbial Diversity and Taxonomy	3	1	1	3	8	3+0+1

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

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
PC	56MB102	Microbial Diversity and Taxonomy	**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	**56MB152**	Microbial Diversity and Taxonomy lab	35	5	5	5	50	50	50

Course-Curriculum:

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

Approximate Hours

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

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1-56MB102.1: To learn and understand the fundamental concepts, principles of ecology and microbial diversity.	**SO1.1** Understand the basic information on microbial diversity, abundance and distribution.	**LI1.1** Make a chart on biodiversity around you	**CI1.1** Introduction to microbial diversity.	**SL1.1** Study the concept of biodiversity.
	SO1.2 Various concept of ecology and ecological niche.	**LI1.2** Explain and perform the basic methods to study microorganisms in lab.	**CI1.2** Ecological niche which elaborates the role of microorganisms in their surroundings.	**SL1.2** Major domains of life.
	SO1.3 Learn in detail about the major domain of life.		**CI1.3** Major domains of life	**SL1.3** Differentiate Prokaryotic and Eukaryotic cell
	SO1.4 Describe the structural features of Archaebacteria.		**CI1.4** Structural organization of Archaebacteria.	**SL1.4** Explain ecological niche and its significance

	SO1.5 Demonstrate cell wall and cell membrane of Archaebacteria		**CI1.5** Cell wall and cell membrane composition of Archaebacteria	**SL1.5** Draw a well-labeled diagram of a bacterial cell and fungal mycelium.
	SO1.6 Describe the structural features of prokaryotes		**CI1.6** Detail structure of Prokaryotic cell.	
	SO1.7 Study the structural organization of eukaryotic cell		**CI1.7** Eukaryotic cell and its components.	
	SO1.8 Comparative account on Archea, prokaryotes and eukaryotes		**CI1.8** Compare all three major domains of life	
	SO1.9 revision and discussion		**CI1.9** revision and discussion	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe the ultrastructure of Archaebacterial cell
	SW1.2 Mini Project	Draw a well labelled diagram of Prokaryotic and Eukaryotic cell
	SW1.3 Other Activities (Specify)	Watch animation or visual presentations on microbial diversity and ecological niche available online

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

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO2-56MB102.2: To expand the knowledge of many microbiological approaches to overcome challenges in study of various extremophiles like Thermophiles and Methanogens.	**SO2.1** To understand about thermophiles	**LI2.1** Demonstrate the effect of temperature on the growth of microorganisms.	**CI2.1** Introduction of Thermophiles.	**SL2.1** Read the thermophiles and their types.
	SO2.2 To learn the various habitat for thermophiles.	**LI2.2** Isolation of thermophilic bacteria from natural resources. .	**CI2.2** Thermophilic habitat.	**Sl2.2** Learn thermophily.
	SO2.3 To describe various types of thermophiles		**CI2.3** Ecological aspects of thermophiles. .	**SL2.3** Read about Methanogens
	SO2.4 To explain thermozymes and their applications.		**CI2.4** Classification of thermophiles.	**SL2.4** Describe process of methanogenesis and its significance
	SO2.5 To describe various adaptation mechanisms in thermophiles.		**CI2.5** Thermophily or thermophilic adaptations	
	SO2.6 To elaborate methanogens.		**CI2.6** Thermozymes and their applications.	
	SO2.7 To explain mechanism of methanogenesis.		**CI2.7** Commercial aspects of thermophiles.	

	SO2.8 commercial aspects of methanogens.		**CI2.8** Methanogens and their types. .	
	SO2.9 Significance of thermophiles.		**CI2.9** Methanogenesis and its commercial importance.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe the thermophile and its types in detail.
	SW2.2 Mini Project	Explain various components used by methanogens in methanogenesis.
	SW2.3 Other Activities (Specify)	Elaborate mechanisms of thermal adaptation in thermophiles

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

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO3-56MB102.3: To understand the life under low and high pH conditions.	**SO3.1** Extremophiles on the basis of optimum pH range.	**LI3.1** Isolation of acid tolerant bacteria.	**CI3.1** Alkalophilic habitat: Soda Lake and Desert.	**SL3.1** Describe acidophiles and their various types.
	SO3.2 Learn in detail about habitats with high acidic conditions.	**LI3.2** Isolation of alkalophiles from given sample.	**CI3.2** Calcium alkalophily	**SL3.2** Discuss formation of soda lake

	SO3.3 To understand the life under high acidic pH.		**CI3.3** Alkalophiles and their types	**SL3.3** Read the classification of acidophiles and alkalophiles.
	SO3.4 Define mechanisms of Acidotolerance.		**CI3.4** Adaptation mechanisms to survive in alkaline habitat.	**SL3.4** What is alkalophile and its adaptation mechanism
	SO3.5 Define Alkalophiles.		**CI3.5** Commercial significance of Alkalophiles.	
	SO3.6 Elaborate calcium alkalophily.		**CI3.6** Acidophiles: Introduction and types	
	SO3.7 Explain the physiological profile of soda lake.		**CI3.7** Acidophilic habitats	
	SO3.8 Tolerance mechanism against alkaline conditions in alkalophiles.		**CI3.8** Acidotolerance mechanisms in acidophiles.	
	SO3.9 Commercial significance of acidophiles and alkalophiles		**CI3.9** Applications od acidophiles.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail the classification of acidophiles and alkalophiles.
	SW3.2 Mini Project	Describe the commercial significance of acidophiles and alkalophiles.
	SW3.3 Other Activities (Specify)	Prepare a detail note on various natural habitats having extreme pH conditions.

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)**
CO4-56MB102.4: To study the various aspects of Halophiles and Barophiles.	**SO4.1** Understanding about the Halophiles and	**LI4.1** Isolation of halophilic bacteria by using NaCl.	**CI4.1** Introduction on Halophiles.	**SL4.1** Learn about halophiles and their ecology
	SO4.2 halophilic habitats.	**LI4.2** Isolation of halophiles by using mannitol and sorbitol.	**CI4.2** Halophilic habitats: Dead Sea and Basins	**SL4.2** Discuss various mechanisms of halotolerance.
	SO4.3 Study that how halophiles survive in high salt conditions.		**CI4.3** Purple Membrane	**SL4.3** Describe barophiles and their tolerance mechanisms
	SO4.4 Understanding about the purple bacteria		**CI4.4** Halotolerance and Osmotolerance	
	SO4.5 Structure and function of purple membrane.		**CI4.5** Barophiles: definition and types	
	SO4.6 Introduction on barophiles.		**CI4.6** Life under high pressure	
	SO4.7 Life and death under high pressure,		**CI4.7** Pressure tolerant mechanisms in Barophiles (barophily)	

	SO4.8 Commercial significance of halophiles		**CI4.8** Commercial importance of barophiles	
	SO4.9 Commercial significance of barophiles		**CI4.9** Commercial significance of halophiles	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain life under high salt concentrations
	SW4.2 Mini Project	Describe the various adaption mechanisms in barophiles
	SW4.3 Other Activities (Specify)	Prepare an article on the industrial significance of halophiles and barophiles

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	04	01	04	19

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO5-56MB102.5: To explore various methods and experiments to detect life in space.	**SO5.1** Introduction and significance of space microbiology.	**LI5.1** Make a laboratory chart on space microbiology.	**CI5.1** 1Aim and objective of space	**SL1.1** Basic knowledge space microbiology.
	SO5.2 Understand the environment of Mars.	**LI5.2** Design a model on Viking mission.	**CI5.2** Life detection method: Gulivar experiment to evident metabolism in space.	**SL5.1** Life detection method to study life on Mars

	SO5.3 Study various methods to detect life in space.		**CI5.3** Evidence of photosynthesis in space	**SL5.3** Explain Viking mission.
	SO5.4 Learn the experiments conducted to trace life in space		**CI5.4** Evidence of ATP production in space	**SL5.4** Microflora associated with astronauts
	SO5.5 Elaborate the Viking Mission and its components.		**CI5.5** Evidence of Sulphur and phosphorus uptake in space	
	SO5.6 Describe Biology Box experiment.		**CI5.6** Martian environment Search of life on Mars	
	SO5.7 Explain gas release experiment.		**CI5.7** Viking Mission: Rover, Landers	
	SO5.8 Explain pyrolytic release experiments		**CI5.8** Biology box experiment	
	SO5.9 Describe various space mission conducted for Mars		**CI5.9** Gas exchange experiment Pyrolytic release experiment	

	SO5.10 Learn the alteration in microflora associated with astronauts.		**CI5.10** Alteration in microflora associated with astronauts.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain various life detection methods used in space microbiology
	SW5.2 Mini Project	Describe the microflora associated with astronauts
	SW5.3 Other Activities (Specify)	Prepare a model on Viking Mission

Course duration (in hours) to attain Course Outcomes:

Course Title: Microbial Diversity and Taxonomy **Course Code:** 56MB101

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Sessional work (SW)	Self-Learning (SL)	Total Hours (Li+CI+SL+SW)
CO1-56MB102.1: To learn and understand the fundamental concepts, principles of ecology and microbial diversity.	09	04	01	04	**18**
CO2-56MB102.2: To expand the knowledge of many microbiological approaches to overcome challenges in study of various extremophiles like Thermophiles and Methanogens.	09	04	01	04	**18**
CO3-56MB102.3: To understand the life under low and high pH conditions.	09	04	01	04	**18**

CO4-56MB102.4: To study the various aspects of Halophiles and Barophiles.	09	04	01	03	**17**
CO5-56MB102.5: To explore various methods and experiments to detect life in space.	10	04	01	04	**19**
Total Hours	**46**	**20**	**05**	**20**	**90**

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

Course Title: Microbial Diversity and Taxonomy **Course Code:** 56MB101

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-56MB102.1: To learn and understand the fundamental concepts, principles of ecology and microbial diversity.	2	1	1	1	**5**
CO2-56MB102.2: To expand the knowledge of many microbiological approaches to overcome challenges in study of various extremophiles like Thermophiles and Methanogens.	2	4	2	2	**10**
CO3-56MB102.3: To understand the life under low and high pH conditions.	3	5	5	2	**15**
CO4-56MB102.4: To study the various aspects of Halophiles and Barophiles.	2	3	3	2	**10**
CO5-56MB102.5: To explore various methods and experiments to detect life in space.	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	Microbial diversity and its application by S.B. Barbuddhe, R. Ramesh N.P. Singh
2	Microbial diversity in ecosystem sustainability and biotechnological applications by Tulasi satyanarayan, Bhavdish narain joshi, Subrata kumar das
3	Microbial Diversity Exploration and Bioprospecting by S. Ram Reddy, M.A. Singaracharya, S. Girisham
4	Microbiology; Lansing M Prescott, John P. Harley, Donald A Klein, Sixth edition, Mc Graw Hill Higher education.
5	Microbial diversity by James W Brown

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.Sc. Microbiology
Semester: I Semester
Course Title: Microbial Diversity and Taxonomy
Course Code: 56MB102

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-56MB102.1: To learn and understand the fundamental concepts, principles of ecology and microbial diversity.	2	-	-	1	2	2	1	1
CO2-56MB102.2: To expand the knowledge of many microbiological approaches to overcome challenges in study of various extremophiles like Thermophiles and Methanogens.	-	-	-	-	-	1	2	-
CO3-56MB102.3: To understand the life under low and high pH conditions.	-	1	1	1	-	1	1	1

CO4-56MB102.4: To study the various aspects of Halophiles and Barophiles.	-	1	1	-	2	2	1	3
CO5-56MB102.5: To explore various methods and experiments to detect life in space.	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	**CO1-56MB102.1**: To learn and understand the fundamental concepts, principles of ecology and microbial diversity.	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,	**1SL-1, 2, 3, 4, 5**
PO 1,2,3,4,5 PSO 1,2,3	**CO2-56MB102.2**: To expand the knowledge of many microbiological approaches to overcome challenges in study of various extremophiles like Thermophiles and Methanogens.	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 PSO 1,2,3	**CO3-56MB102.3**: To understand the life under low and high pH conditions.	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**
PO 1,2,3,4,5 PSO 1,2,3	**CO4-56MB102.4**: To study the various aspects of Halophiles and Barophiles.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6	**LI 1** **LI 2**	4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9	**4SL-1, 2, 3**

		SO4.7 SO4.8 SO4.9			
PO 1,2,3,4,5 PSO 1,2,3	**CO5-56MB102.5**: To explore various methods and experiments to detect life in space.	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**

Curriculum Development Team

Prof. Kamlesh Choure
Prof Ashwini A. Waoo
Prof. Deepak Mishra
Er. Arpit Srivastava
Mr. Piyush Kant Rai

Program Name	**Masters of Science (M.Sc.)- Microbiology**	
Semester	I	
CourseCode:	56MB103	
Coursetitle:	Advanced Biochemistry	**Curriculum Developer**: Mrs. Pratima Mishra, Guest Faculty
Pre-requisite:	Students should have basic knowledge of Biology and Chemistry	
Rationale:	For a successful microbiologist is it essential to learn about basic concepts of those molecules which governs the anatomical and physiological components of microbial world. This course aims to provide students with a depth of knowledge of a number of topics in biochemistry that will build upon the foundations established in earlier subjects. The main themes to be explored are, the advanced theoretical concepts and techniques of biochemistry and molecular biology that underpin the developments of molecular sciences and Microbiology. The practical component will aim to make the students highly competent in several experimental and research techniques in these areas.	
Course Outcomes (COs):	**CO1-56MB103.1:** Understanding of the components of biological systems, significant functional groups, pH and buffers, and proteins. **CO2-56MB103.2:** Learning in-depth information regarding the composition and characteristics of numerous categories of carbohydrates. **CO3-56MB103.3:** Recognize various concepts related the structure, characteristics, function and biological role of nucleic acids and central dogma. **CO4-56MB103.4:** Assess various concepts related the structure, characteristics, function and biological role of different types of lipids. **CO5-56MB103.5:** Appraise the relationship between principles molecular transport, cell junction and cell signaling in Cell and Cellular components.	

Scheme of Studies:

Board of Study	Course Code	CourseTitle	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
BSC	56MB103	Advanced Biochemistry	3	1	1	5	11	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 and Practical

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
PC	56MB103	Advanced Biochemistry (Theory)	**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	**56MB153**	Advanced Biochemistry lab	35	5	5	5	50	50	50

Course-Curriculum:

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

ApproximateHours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	08	01	05	23

Course outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Classroom Instruction(CI)**	**Self-Learning(SL)**
CO1-56MB103.1: Understanding of the components of biological systems, significant functional groups, pH and buffers, and proteins	**SO1.1** Define and Describe concept of pH and Buffer	**LI1.1** Calibration of pH meter and preparation of buffer	**Unit 1** **CI1.1** Concept of pH and buffers pKa,	**SL1.1** Search various reference books and study material to start the learning

	SO1.2 Describe about Henderson-Hasselbalch equation		**CI1.2** Henderson– Hasselbalch equation, Water	**SL1.2** Check the properties of water and buffers
	SO1.3 Explain about amino acids and its classification	**LI1.2** Identification of amino acids	**CI1.3** Amino Acids: Classification	**SL1.3** Learn about various categories of amino acids
	SO1.4 Describe structure & Properties of amino acids		**CI1.4** structure and properties	**SL1.4** Enlist the structure and properties of different amino acids and their role
	SO1.5 Study the different types of amino acids		**CI1.5** unusual and modifies amino acids,	
	SO1.6 Study of peptides.		**CI1.6** peptides,	
	SO1.7 Describe concept of Zwitter ion	**LI1.3** Determination of isoelectric point	**CI1.7** Isoelectric point, Zwitter ion,	
	SO1.8 Assess the concept of proteins	**LI1.4** Estimation of protein	**CI1.8** Proteins: Classification,	**SL1.5** Enlist the structure and properties of different proteins and their role
	SO1.9 Describe structure and function of proteins		**CI1.9** structure and functions	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail pH, buffer and water
	SW1.2 Mini Project	Draw structure of various types of amino acids
	SW1.3 Other Activities (Specify)	Collect the data about biological role of proteins and their deficiencies.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	08	01	05	23

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self Learning (SL)**
CO2-56MB103.2: Learning in-depth information regarding the composition and characteristics of numerous categories of carbohydrates.	**SO2.1** Assess the concept of carbohydrate	**LI2.1** Identification of carbohydrate	**Unit-II** **CI2.1** Carbohydrate: Classification, structure	**SL2.1** Enlist the different properties of carbohydrates

	SO2.2 Explain about properties and function of carbohydrate		**CI2.2** Properties and Function	**SL2.2** Assess biological role of carbohydrate.
	SO2.3 Explain about monosaccharides	**LI2.2** Identification of reducing sugars	**CI2.3** Aldoses, ketoses monosaccharide	**SL2.3** Learn structure and function of monosaccharide
	SO2.4 Explain about disaccharides and polyasccharides	**LI2.3** estimation of carbohydrate	**CI2.4** disaccharides, polysaccharides	**SL2.4** Learn structure and function of oligosaccharide
	SO2.5 Describe the role of hetero polysaccharides		**CI2.5** Glycosaminoglycans, homo and Hetero polysaccharides,	**SL2.5** Learn structure and function of polysaccharide
	SO2.6 Describe structure and function of starch, glycogen, chitin		**CI2.6** Starch, Glycogen, Chitin,	
	SO2.7 Describe biological role of cellutose, peptidoglycan, heparin		**CI2.7** Cellulose, Peptidoglycan, Heparin.	
	SO2.8 Describe properties of monoasccharides		**CI2.8** Optical activity, mutarotation,	
	SO2.9 Assess the concept of oxidation of monoasccharides	**LI2.4** Perform oxidation of carbohydrates.	**CI2.9** oxidation of monosaccharides	

Suggested Sessional Work (SW) : *anyone*	**SW2.1** Assignments	Describe in detail various types of carbohydrate and their biological role.
	SW2.2 Mini Project	Detection of carbohydrate in different food products and living organisms
	SW2.3 Other Activities (Specify)	Develop methods for qualitative and quantitative detection of carbohydrates.

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)**
CO3-56MB103.3: Recognize various concepts related the structure, characteristics, function and biological role of nucleic acids and central dogma.	**SO3.1** Explain the concept and structure of Nucleic acid.		**Unit-III** **CI3.1** Nucleic Acids: Structure of nucleotides.	**SL3.1** Read about various types of nucleic acids and its derivatives.

	SO3.2 Assessing the structure and function of RNA and DNA		**CI3.2** Structure of RNA and DNA	**SL3.2** Illustrate structure of different types of DNA and RNA
	SO3.3 Explaining properties of DNA		**CI3.3** properties, Variation from Watson and Crick model	**SL3.3** Study the variation in DNA structure from Watson and Crick model.
	SO3.4 Assessing different types of structure present in DNA		**CI3.4** Special types of structures present in DNA	
	SO3.5 Describe about hybridization, hypo and hyperchromic shift		**CI3.5** Hybridization, Hypo and hyperchromic shift, Tm	
	SO3.6 Assessing the role of central Dogma		**CI3.6** Concept of Central Dogma,	**SL3.4** Study the mechanism of central dogma
	SO3.7 Describe about concept of gene and its regulation		**CI3.7** Concept of genes and their regulation.	**SL3.5** Study the impact of gene regulation
	SO3.8 concept of central dogma		**CI3.8** concept of central dogma	
	SO3.9 revision and evaluation		**CI3.9** revision and evaluation	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail the structure and function of different types of nucleic acids.
	SW3.2 Mini Project	Describe the role of nucleic acids in biological systems.
	SW3.3 Other Activities (Specify)	Prepare a model to explain the structure of DNA and RNA.

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)
CO4- 56MB103.4: Assess various concepts related the structure, characteristics, function and biological role of different types of lipids.	**SO4.1** Exploring the concept of lipids and their types	**LI4.1** Detection of lipids	**Unit-IV** **CI4.1** Lipids: Classification,	**SL4.1** Learn about different classes of lipids
	SO4.2 Assessing role of lipids and its structure	**LI4.2** Determination of solubility of lipids	**CI4.2** structure, Types,	**SL4.2** Discuss types and structure of lipids
	SO4.3 Explaining the biological function of lipids		**CI4.3** biological functions	**SL4.3** Learn about biological function of lipids
	SO4.4 Explaining the role of oils, fats and waxes		**CI4.4** Oils, fats, waxes,	
	SO4.5 Evaluate role of fatty acids, phospholipids		**CI4.5** fatty acids, phospholipids,	**SL4.4** Learn about biological function of fatty acids
	SO4.6 Describe the impact of Sphingolipids and galactolipids		**CI4.6** Sphingolipids, galactolipids,	
	SO4.7 Describe the impact of Sulpholipids and Steroids		**CI4.7** Sulpholipids, Steroids	**SL4.5** Learn about significance of lipids
	SO4.8 Evaluate role of lipids in signal transduction		**CI4.8** Lipids in signal transduction	
	SO4.9 Revision and evaluation		**CI4.9** Revision and evaluation	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain about different categories of lipids and their biological role.
	SW4.2 Mini Project	Describe the various types of lipids its structure, properties and applications
	SW4.3 Other Activities (Specify)	Develop methods for qualitative and quantitative detection of lipids.

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

Course Outcome (CO)	SessionOutcomes(SOs)	LaboratoryInstruction(LI)	ClassroomInstruction(CI)	Self-Learning(SL)
CO5-56MB103.5: Appraise the relationship between principles molecular transport, cell junction and cell signaling in Cell and Cellular components.	**SO5.1** Define the concept of transport of molecules in the cell		**Unit-V** **CI5.1** Transport of Molecules-Active and passive	**SL5.1** learn about basic concept transport of molecules
	SO5.2 Able to execute role of diffusion and group translocation		**CI5.2** diffusion, Group translocation,	**SL5.2**Review concept of diffusion and group translocation
	SO5.3 Apply the role of ionophore and membrane protein		**CI5.3** Ionophore. Membrane proteins,	**SL5.3**learn how to membrane proteins works.
	SO5.4 Evaluate the role of cell junctions.		**CI5.4** Cell Junctions,	
	SO5.5 Assess the molecular mechanism of signal transduction pathways		**CI5.5** Molecular mechanism of signal transduction pathways	
	SO5.6 Apply the role of PKC,PLC, GPCR		**CI5.6** PKC PLC, GPCR	**SL5.4** Learn about signalling pathways
	SO5.7 Explore about Signalling pathways		**CI5.7** Insulin Glucagon signalling	
	SO5.8 Elaborate the role of endotoxins and exotoxins		**CI5.8** Endotoxins and exotoxins.	**SL5.5** Learn about endotoxins and exotoxins
	SO5.9 Revision and assessment		**CI5.9** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general mechanism of cell signalling pathways.
	SW5.2 Mini Project	Describe the various components and types of membrane transport
	SW5.3 Other Activities (Specify)	Prepare one model for showing mechanism of cell signalling

Course duration (in hours) to attain Course Outcomes:

Course Title: Advance Biochemistry **Course Code:**56MB103

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-56MB103.1: Understanding of the components of biological systems, significant functional groups, pH and buffers, and proteins.	9	8	5	1	23
CO2-56MB103.2: Learning in-depth information regarding the composition and characteristics of numerous categories of carbohydrates.	9	8	5	1	23
CO3-56MB103.3: Recognize various concepts related the structure, characteristics, function and biological role of nucleic acids and central dogma.	9	0	5	1	15
CO4-56MB103.4: Assess various concepts related the structure, characteristics, function and biological role of different types of lipids.	9	4	5	1	19
CO5-56MB103.5: Appraise the relationship between principles molecular transport, cell junction and cell signaling in Cell and Cellular components.	9	0	5	1	15
Total Hours	45	20	25	05	95

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

Course Title: Advanced Biochemistry **Course Code:**56MB103

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-56MB103.1: Understanding of the components of biological systems, significant functional groups, pH and buffers, and proteins.	2	1	1	1	5
CO2-56MB103.2: Learning in-depth information regarding the composition and characteristics of numerous categories of carbohydrates.	2	4	2	2	10
CO3-56MB103.3: Recognize various concepts related the structure, characteristics, function and biological role of nucleic acids and central dogma.	3	5	5	2	15
CO4-56MB103.4: Assess various concepts related the structure, characteristics, function and biological role of different types of lipids.	2	3	3	2	10
CO5-56MB103.5: Appraise the relationship between principles molecular transport, cell junction and cell signaling in Cell and Cellular components.	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	Biochemistry by G. Zubey.
2	Biochemistry, D. Freifilder, W.H. Freeman & Company.
3	Harper's Biochemistry, Murray et al., Mc Graw Hill.
4	Principles of Biochemistry, Lehininger, Nelson and Cox.
5	Clinical Biochemistry by MN Chaterji and Rana Shinde

(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. Sc. Microbiology
Semester: I Semester
Course Title: Advanced Biochemistry
Course Code: 56MB103

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-56MB103.1: Understanding of the components of biological systems, significant functional groups, pH and buffers, and proteins.	3	3	1	3	1	2	2	1
CO2-56MB103.2: Learning in-depth information regarding the composition and characteristics of numerous categories of carbohydrates.	3	1	1	3	2	1	2	2
CO3-56MB103.3: Recognize various concepts related the structure, characteristics, function and biological role of nucleic acids and central dogma.	3	1	1	3	2	1	2	3
CO4-56MB103.4: Assess various concepts related the structure, characteristics, function and biological role of different types of lipids.	2	1	1	2	2	2	2	3
CO5-56MB103.5: Appraise the relationship between principles molecular transport, cell junction and cell signaling in Cell and Cellular components.	1	1	1	2	2	2	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	**CO1-56MB103.1:** Understanding of the components of biological systems, significant functional groups, pH and buffers, and proteins.	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,	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8, 1.9	1SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO2-56MB103.2:** Learning in-depth information regarding the composition and characteristics of numerous categories of carbohydrates.	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	2.1, 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	**CO3-56MB103.3:** Recognize various concepts related the structure, characteristics, function and biological role of nucleic acids and central dogma.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	3.1,3.2,3.3,3.4,	3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8, 3.9	3SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO4-56MB103.4:** Assess various concepts related the structure, characteristics, function and biological role of different types of lipids.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	4.1,4.2,4.3,4.4,	4.1,4.2,4.3,4.4, 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	**CO5-56MB103.5:** Appraise the relationship between principles molecular transport, cell junction and cell signaling in Cell and Cellular components.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	5.1,5.2,5.3	5.1,5.2,5.3,5.4,5.5, 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
Mr. Piyush Kant Rai

Program Name	**Masters of Science (M.Sc.)- Microbiology**	
Semester	I	
CourseCode:	56MB104	
Course title:	Microbial Genetics and Molecular Biology	**Curriculum Developer**: Shaily Mishra, Assistant Professor
Pre-requisite:	Student should have basic knowledge of biology, biological activity and processes in organisms.	
Rationale:	The paper on Microbial genetics and Molecular Biology in an M.sc Microbiology program aims to impart knowledge and understanding of various biological, molecular synthesis as well as its modification, mechanism and interaction taking place within and outside the cell at the molecular level. The course enlightens the students about the various processes such as DNA replication, recombination, gene expression, regulation and advances in the topics in recent research.	
Course Outcomes (COs):	**CO1-56MB104.1:** Understand the structural and functional organization of genome and molecular bases of mutation in gene. **CO1-56MB104.2:** Students are being knowledgeable with the nucleic acid structure, replication, damage and repair mechanism. **CO1-56MB104.3:** Students have been able to understand mechanism of synthesis of RNA molecules from DNA and its transcriptional modification. **CO1-56MB104.4:** Understand the molecular concept of genetic code, protein synthesis and process involved in post translational modification and protein targeting. **CO1-56MB104.5:** Understand the regulation of gene function and associated phenomena both in prokaryotic and eukaryotic organisms.	

Scheme of Studies:

Board of Study	Course Code	CourseTitle	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)	
PCC	56MB104	Microbial Genetics and Molecular Biology	3	1	1	3	8	4

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

Scheme of Assessment:Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)		
			Progressive Assessment (PRA)	End Semester Assessment (ESA)	Total Marks

			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		(PRA+ ESA)
PC	56MB104	Microbial Genetics and Molecular Biology	**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)		
PCC	56MB154	Microbial Genetics and Molecular Biology Lab	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx.Hrs** | 09 | 04 | 02 | 02 | 17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-56MB104.1: Understand the structural and functional organization of genome and molecular bases of mutation in gene.	**SO1.**1 Understand the packaging of genetic material in prokaryotes.	**LI1.1** Isolation of genomic DNA from bacteria	**Unit-1 Organization of genetic material** **CI1.1** Organization of genetic material in prokaryotes.	**SL1.1** Types of nucleic acids.
	SO1.2 Understand the packaging of genetic material in eukaryotes.	**LI1.2** Isolation of plasmid DNA from bacteria	**CI1.2** Organization of genetic material in eukaryotes.	
	SO1.3 Concept of gene and genome.		**CI1.3** Concept of gene, genome, genome size, C-value, and C-value paradox.	**SL1.2** Structure of prokaryotic and eukaryotic cell.

	SO1.4 Role of nucleic acid in transmission of information.		**CI1.4** Nucleic acid as a genetic information carriers; experimental evidence.	**SL1.3** Structure of gene and experiments that proves DNA as hereditary material.
	SO1.5 Learn about gene as unit of mutation and recombination.		**CI1.5** Gene is a unit of mutation and recombination.	
	SO1.6 Understand the molecular basis of mutations.		**CI1.6** Molecular basis of mutations	
	SO1.7 Causes of mutations and effects of mutagens on gene.		**CI1.7** Physical and chemical mutagens, spontaneous and induced mutation,	
	SO1.8 Selection of mutant		**CI1.8** Selection of mutant.	
	SO1.9 revision and assessment		**CI1.9** Revision and assessment	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Describe the molecular basis of mutation and effect of various types of mutagens.
	SW1.2 Mini Project	Ray diagram of different types of mutations and their effect in an organisms.
	SW1.3 Other Activities (Specify)	Find out some you tube videos based on organization of genome in different organisms.

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)
CO1-56MB104.2: Students are being knowledgeable with the nucleic acid structure, replication, damage and repair mechanism.	**SO2.1** Understand the structure of DNA	**LI2.1** Restriction digestion analysis.	**Unit-2 DNA structure, replication, damage and repair** **CI2.1** Structure of DNA	**SL2.1** Chemical structure of DNA.
	SO2.2 Concept of DNA helicity, linking number, topological properties and function of topoisomerase.	**LI2.2** Determination of molecular weight of DNA	**CI2.2** Helicity of DNA, linking number, topological properties and role of topoisomerase.	**SL2.2** Different forms of DNA
	SO2.3 Learn about DNA denaturation and renaturation		**CI2.3** DNA denaturation and renaturation.	
	SO2.4 Causes and agents involved in damage of DNA.	.	**CI2.4** DNA damage and types of DNA damage (deamination, oxidative damage, alkylation and pyrimidine diamers.)	.
	SO2.5 Understand the mechanism involved in repair of DNA.		**CI2.5** Repair mechanism; mismatch repair, nucleotide excision repair, recombination repair, SOS repair.	

	SO2.6 Study of molecular phenomena of DNA replication.		**CI2.6** DNA replication: general principle, various mode of replication, unwinding of DNA helix, continuous and discontinuous synthesis of leading and lagging strands.	
	SO2.7 Role of enzymatic machinery involved in replication of prokaryotic DNA.		**CI2.7** Enzymes of DNA replication in prokaryotes; DNA polymerases, DNA ligase, primase. .	
	SO2.8 Role of enzymatic machinery involved in replication of eukaryotic DNA.		**CI2.8** Enzymes of DNA replication in eukaryotes; DNA polymerases, DNA ligase, primase.	
	SO2.9 Mechanism of prokaryotic DNA replication		**CI2.9** Steps involved in DNA replication.	
	SO2.10 Mechanism of eukaryotic DNA replication		**CI2.10** Steps involved in DNA replication	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Describe causes of DNA damage and its repair mechanism.
	SW1.2 Mini Project	Diagrammatic representation of mechanism and modes of DNA replication.
	SW1.3 Other Activities (Specify)	Find out some research paper based on effect of DNA damage in humans.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	04	01	01	15

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-56MB104.3: Students have been able to understand mechanism of synthesis of RNA molecules from DNA and its transcriptional modification.	**SO3.1** Understand the structure of different types of RNA. .	**LI3.1** Southern hybridization study.	**Unit-3** **RNA structure, transcription and splicing process** **CI3.1** Structural features of RNA (rRNA, tRNA, mRNA) and polycistronic and monocistronic RNA.	**SL3.1** Structure of different types of RNA.
	SO3.2 Study the process involved in synthesis of RNA from DNA.	**LI3.2** Western blotting.	**CI3.2** Transcription: general principle and processes of transcription; initiation, elongation and termination.	**SL3.2** Role of DNA binding proteins and their interaction with DNA
	SO3.3 Study the structure and role of different RNA polymerases.		**CI3.3** Types of RNA polymerases	
	SO3.4 Learn about inhibitors of transcription		**CI3.4** Inhibitors of RNA synthesis.	
	SO3.5 Transcriptional control by polymerase and various factors		**CI3.5** Control of Transcription by interaction between RNA polymerases and promoter region, use of alternate sigma factors,	

	SO3.6 Mechanism of regulation of transcription termination in prokaryotes		**CI3.6** Controlled termination; Rho dependent and Rho independent.	
	SO3.7 Post transcriptional modification of synthesized RNA.		**CI3.7** Post-transcriptional modification, maturation and splicing of RNA transcripts,	
	SO3.8 Understand the mechanism of action of catalytic RNA.		**CI3.8** Catalytic RNA.	
	SO3.9 revision and assessment		**CI3.9** revision and assessment	

Suggested Sessional Work (SW):*anyone*	**SW3.1** Assignments	1. Describe mechanism and factors involved in transcription of DNA 2. Write short note on Post transcriptional modifications.
	SW3.2 Mini Project	Describe diagrammatically role of RNA polymerase in synthesis of RNA.
	SW3.3 Other Activities (Specify)	Prepare list of inhibitors that interfere with synthesis of RNA.

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

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-56MB104.4: Understand the molecular concept of genetic code, protein synthesis and process involved in post translational modification and protein targeting	**SO4.1** Study of genetic code and wobble hypothesis.	**LI4.1** Transformation	**Unit-4** **Genetic Code and Post-translational modification** **CI4.1** Genetic code: nature of genetic code, codon, anticodon, wobble hypothesis.	**SL4.1** Primary, secondary, tertiary structure of protein.
	SO4.2 Understand therole of different machinery involved in protein synthesis.	**LI4.2** Conjugation	**CI4.2** Machinery involved in protein synthesis.	
	SO4.3 Steps involved in process of protein synthesis.		**CI4.3** Protein synthesis: steps, details of initiation, elongation and termination.	**SL4.2** Role of proteins in biological activities
	SO4.4 Steps involved in process of protein synthesis.		**CI4.4** Protein synthesis: steps, details of initiation, elongation and termination.	
	SO4.5 Effect of inhibitors of protein synthesis.		**CI4.5** Inhibitors of protein synthesis: signal hypothesis.	

	SO4.6 Molecular basis of Post -translational modification.		**CI4.6** Post-translational modification-covalent modification,phosphorylation, glycosylation,and methylation.	
	SO4.7 Understand the mechanism of post-translational modification		**CI4.7** Mechanism of post-translational modification.	
	SO4.8 Mechanism of protein targeting and sorting in and outside of the cell.		**CI4.8** Protein targeting	
	SO4.9 revision and assessment		**CI4.9** revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe the mechanism of protein targeting in the cell and outside of it.
	SW4.2 Mini Project	Diagrammatic representation of post-translational modification.
	SW4.3 Other Activities (Specify)	Draw a ray diagram to show protein targeting in the cell.

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)
CO1-56MB104.5: Understand the regulation of gene function and associated phenomena both in prokaryotic and eukaryotic organisms.	**SO5.1** Understand the operon concept in prokaryotes.	**LI5.1** PCR amplification study using thermal cycler.	**Unit-5 Regulation of gene expression** **CI5.1** Regulation of gene expression: operon concept.	**SL5.1** Structure of structural genes in prokaryotes.
	SO5.2 Role of activator, operator and repressor in control of gene expression.	**LI 5.2** to perform PCR amplification of the gDNA	**CI5.2** Regulatory and structural gene, operator, promoter, repressor, induction and repression, positive and negative control.	**SL5.2** Role of regulatory proteins in control of gene expression
	SO5.3 Study about lactose and arabinose operon in prokaryotes		**CI5.3** *Lac*-operon, *ara*-BAD operon,	
	SO5.4 Study about tryptophan operon in prokaryotes		**CI5.4** *trp* operon, attenuation	
	SO5.5 Understand the mechanism of regulation of gene expression.		**CI5.5** Mechanism of regulation of transcription	
	SO5.6		**CI5.6**	

	Understand the mechanism of regulation of gene expression in eukaryotes.		Regulation of gene expression in eukaryotes: Britton and Davidson's model of regulation involve HCP and NHCP and hormones.	
	SO5.7 Study about transposable elements in prokaryotes		**CI5.7** Transposable elements in prokaryotes	
	SO5.8 Study about transposable elements in eukaryotes		**CI5.8** Transposable elements in eukaryotes	
	SO5.9 Study the mechanism of transposition in prokaryotes		**CI5.9** Mechanism of transposition in prokaryotes	
	SO5.10 Study the mechanism of transposition in eukaryotes		**CI5.10** Mechanism of transposition in eukaryotes	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Describe the molecular basis of transposable elements.
	SW5.2 Mini Project	Diagrammatic representation of regulation of gene expression in prokaryotes.
	SW5.3 Other	Watch some you tube videos regarding regulation of gene expression.

	Activities (Specify)	

Course duration (in hours)to attain Course Outcomes:

Course Title: Microbial Genetics and Molecular Biology **Course Code:**56MB104

Course Outcomes(COs)	**Class lecture (CI)**	**Laboratory Instruction(LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-56MB104.1: Understand the structural and functional organization of genome and molecular bases of mutation in gene.	09	04	02	02	17
CO1-56MB104.2: Students are being knowledgeable with the nucleic acid structure, replication, damage and repair mechanism.	10	04	01	02	17
CO1-56MB104.3: Students have been able to understand mechanism of synthesis of RNA molecules from DNA and its transcriptional modification.	09	04	01	01	15
CO1-56MB104.4: Understand the molecular concept of genetic code, protein synthesis and process involved in post translational modification and protein targeting.	09	04	02	02	17
CO1-56MB104.5: Understand the regulation of gene function and associated phenomena both in prokaryotic and eukaryotic organisms.	10	04	01	02	17

Total Hours	47	20	07	09	83

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

Course Title: Microbial Genetics and Molecular Biology **Course Code:**56MB205

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-56MB104.1: Understand the structural and functional organization of genome and molecular bases of mutation in gene.	02	01	01	01	05
CO1-56MB104.2: Students are being knowledgeable with the nucleic acid structure, replication, damage and repair mechanism.	02	04	02	02	10
CO1-56MB104.3: Students have been able to understand mechanism of synthesis of RNA molecules from DNA and its transcriptional modification.	03	05	05	02	15
CO1-56MB104.4: Understand the molecular concept of genetic code, protein synthesis and process involved in post translational modification and protein targeting.	03	03	03	01	10
CO1-56MB104.5: Understand the regulation of gene function and associated phenomena both in prokaryotic and eukaryotic organisms.	05	04	01	00	10
Total Marks	15	17	12	06	50

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

Suggested learning Resources:

(a) Books:

(b)

S.No.	**Title/Author/Publisher details**
1	Genes V by Benjamin Lewin, Oxford University Press, New York,1994.
2	Gene IX, Benjamin Lewin Oxford University Press, New York,2006.
3	Principles of Genetics, Snustad and Simmons, Seventh Edition, John Wiley and Sons, Inc.,2015.
4	Molecular Cell Biology, Lodish et.al., W. H. Freeman and Company,Eighth Edition,2016.

5	Genomes 5 by T.A. Brown, John Wiley and sons (Asia)PTE LTD, New York, Fifth Edition2023

(c) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Industrial plant of Biotech-based organizations
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: M. Sc. Microbiology
Semester:I Semester
Course Title: Microbial Genetics and Molecular Biology
Course Code: 56MB104

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-56MB104.1: Understand the structural and functional organization of genome and molecular bases of mutation in gene.	**2**	**2**	**-**	**-**	**1**	**2**	**2**	**1**
CO1-56MB104.2: Students are being knowledgeable with the nucleic acid structure, replication, damage and repair mechanism.	**3**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
CO1-56MB104.3: Students have been able to understand mechanism of synthesis of RNA	**2**	**2**	**-**	**1**	**-**	**1**	**1**	**3**

molecules from DNA and its transcriptional modification.								
CO1-56MB104.4: Understand the molecular concept of genetic code, protein synthesis and process involved in post translational modification and protein targeting.	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**3**
CO1-56MB104.5: Understand the regulation of gene function and associated phenomena both in prokaryotic and eukaryotic organisms.	**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 PSO 1,2,3	**CO1-56MB104.1:** Understand the structural and functional organization of genome and molecular bases of mutation in gene.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	**LI 1** **LI 2**	1.1,1.2,1.3,1.4,1.5, 1.6,1.7,1.8, 1.9	**1SL-1,2,3**
PO 1,2,3,4,5 PSO 1,2,3	**CO1-56MB104.2:** Students are being knowledgeable with the nucleic acid structure, replication, damage and repair mechanism.	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, 2.5,2.6,2.7,2.8,2.9,2.10	**2SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO1-56MB104.3:** Students have been able to understand mechanism of synthesis of RNA molecules from DNA and its transcriptional	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**

	modification.				
PO 1,2,3,4,5 PSO 1,2,3	**CO1-56MB104.4:** Understand the molecular concept of genetic code, protein synthesis and process involved in post translational modification and protein targeting.	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**
PO 1,2,3,4,5 PSO 1,2,3	**CO1-56MB104.5:** Understand the regulation of gene function and associated phenomena both in prokaryotic and eukaryotic organisms.	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**

Curriculum Development Team

Prof. Kamlesh Choure

Prof Ashwini A. Waoo

Prof. Deepak Mishra

Er. Arpit Srivastava

Mr. Piyush Kant Rai

Program Name	**M.Sc. Microbiology**	
Semester	**Ist**	
Course Code:	**56MB105**	
Course title:	**Bioinformatics and biostatistics**	**Curriculum Developer**: Mr. Piyush Kant Rai, Assistant professor
Pre-requisite:	Basic understanding of biology, statistics, and programming to effectively engage in the integrated analysis of biological data and draw meaningful statistical inferences.	
Rationale:	In biology, statistics, and programming for Bioinformatics and Biostatistics ensures a comprehensive foundation. This prepares students to navigate complex biological datasets, apply statistical methodologies, and contribute meaningfully to interdisciplinary research, aligning with the dynamic demands of data-driven advancements in biology and healthcare.	
Course Outcomes (COs):	**CO-1-56MB105.1: Comprehend the components, ideas, and various computer kinds, as well as the operating system, computer CO- viruses, and computer network.** **CO-2-56MB105.2: Receive hands-on instruction in a variety of computer programs and their uses.** **CO-3-56MB105.3: Phylogenetic analysis, alignment types, and primer construction are covered in CO3.** **CO-4-56MB105.4: The unit covers descriptive statistics, correlation, regression, and ANOVA with practical regression-based exercises.** **CO-5-56MB105.5: Apply biostatistics to fundamental issues and gauges of central tendency in CO 5 Statistical software and survival analysis.**	

Scheme of Studies:

Board of Study	CourseCode	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=2:0:1)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
DSC	56MB105	Bioinformatics and biostatistics	2	1	1	3	2+1+1+3=7	3

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

Scheme of Assessment: Theory

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

(PCR)	**56MB105**	**Bioinformatics and biostatistics**	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)		
DSC	**56MB155**	Bioinformatics and Biostatistics lab	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx. Hrs** | 15 | 04 | 01 | 02 | 22

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-56MB105.1: Comprehend the components, ideas, and various computer kinds, as well as the operating system, computer viruses, and computer network.	**SO1.1** Definition and Scope of Computational Biology	**LI1.1** Review the steps involved in performing a BLAST search	**CI1.1** Understanding Computational Biology	**SL1.1** Explain the basic principles of sequence alignment and homology.
	SO1.2 Definition and Scope of Bioinformatics	**LI1.2** how to download sequence form the genbank	**CI1.2** Introduction to Bioinformatics	**SL1.2** interpret BLAST search results, including E-values, alignments, and sequence identities.
	SO1.3 Historical Review of Bioinformatics		**CI1.3** Historical Review of Bioinformatics	

	SO1.4 Overview of Biological Sequence Databases		**CI1.4** Overview of Biological Sequence Databases	
	SO1.5 Exploration of Primary Databases		**CI1.5** Exploration of Primary Databases	
	SO1.6 Overview of Secondary Databases		**CI1.6** Overview of Secondary Databases	
	SO1.7 Biological Databases: Definition and Types		**CI1.7** Biological Databases: Definition and Types	
	SO1.8 Nucleic Acid Sequence Databases		**CI1.8** Nucleic Acid Sequence Databases	
	SO1.9 Protein Sequence Databases		**CI1.9** Protein Sequence Databases	
	SO1.10 Database Searching Techniques		**CI1.10** Database Searching Techniques	
	SO1.11 BLAST: Theory and Applications		**CI1.11** BLAST: Theory and Applications	
	SO1.12 FASTA: Theory and Applications		**CI1.12** FASTA: Theory and Applications	
	SO1.13 Database Management and Integration		**CI1.13** Database Management and Integration	

	SO1.14 Data Mining and Analysis Techniques		**CI1.14** Data Mining and Analysis Techniques	
	SO1.15 Future Directions in Bioinformatics		**CI1.15** Future Directions in Bioinformatics	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Summarizes biological databases.
	SW1.2 Mini Project	Demonstrate how to use BLAST
	SW1.3 Other Activities (Specify)	correlate the BLAST and FASTA algorithm

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	4	1	2	**17**

Course Outcome (CO)	**Session Outcomes (SOs)**	**LaboratoryInstruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-56MB105.2: Receive hands-on instruction in a variety of computer programs and their uses.	**SO2.1** Introduction to Sequence Alignment	**LI2.1** Apply sequence alignment using bioinformatics tools in a laboratory setting.	**CI2.1** Introduction to Sequence Alignment	**SL2.1** Practice sequence alignment algorithm
	SO2.2 Pairwise Sequence Alignment Algorithms	**LI2.2** Apply phylogenetic analysis techniques using bioinformatics tools in a	**CI2.2** Pairwise Sequence Alignment Algorithms	**SL2.2** Recall types of phyloegenetic tree

		laboratory setting.		
	SO2.3 Statistical Significance of Sequence Alignment		**CI2.3** Statistical Significance of Sequence Alignment	
	SO2.4 Introduction to Multiple Sequence Alignment		**CI2.4** Introduction to Multiple Sequence Alignment	
	SO2.5 Progressive Alignment Methods		**CI2.5** Progressive Alignment Methods	
	SO2.6 Phylogenetic Analysis: Basics		**CI2.6** Phylogenetic Analysis: Basics	
	SO2.7 Tree Building Methods		**CI2.7** Tree Building Methods	
	SO2.8 Phylogenetic Software		**CI2.8** Phylogenetic Software	
	SO2.9 Gene Finding and Gene Scan		**CI2.9** Gene Finding and Gene Scan	
	SO2.10 Practical Applications and Case Studies		**CI2.10** Practical Applications and Case Studies	

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

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	4	1	2	**17**

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO3-56MB105.3: Phylogenetic analysis, alignment types, and primer construction are covered in CO3.	**SO3.1** Introduction to Biostatistics	**LI3.1** Collecting and categorizing data from a sample population.	**CI3.1** Introduction to Biostatistics	**SL3.1** Learn how to do tabulation, graphical representation
	SO3.2 Basic Definitions in Biostatistics and Sampling Techniques	**LI3.2** Designing a sampling strategy for a hypothetical healthcare data.	**CI3.2** Basic Definitions in Biostatistics and Sampling Techniques	**SL3.2** Applications in epidemiology, genetics, clinical trials.
	SO3.3 Sample Size Determination		**CI3.3** Sample Size Determination	
	SO3.4 Data Collection Methods		**CI3.4** Data Collection Methods	
	SO3.5 Methods of Data Presentation		**CI3.5** Methods of Data Presentation	
	SO3.6 Graphical Representation: Histograms		**CI3.6** Graphical Representation: Histograms	
	SO3.7 Graphical Representation: Polygon and Ogive Curves		**CI3.7** Graphical Representation: Polygon and Ogive Curves	
	SO3.8 Graphical Representation: Pie Diagrams		**CI3.8** Graphical Representation: Pie Diagrams	

	SO3.9 Comparative Analysis of Graphical Representations		**CI3.9** Comparative Analysis of Graphical Representations	
	SO3.10 Practical Applications of Data Presentation		**CI3.10** Practical Applications of Data Presentation	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Write about application of data reprensentation.
	SW3.2 Mini Project	Make a flow chart of steps of Graphical Representation: Polygon and Ogive Curves
	SW3.3 Other Activities (Specify)	How many types of data Collection Methods used generally find with the help of internet.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	8	4	**1**	2	**15**

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO4-56MB105.4: The unit covers descriptive statistics, correlation, regression, and ANOVA with practical regression-based exercises.	**SO4.1** Measures of Central Tendency	**LI4.1** Basics of Mean median and mode	**CI4.1** Microbiology & Man: - Pathogen	**SL4.1** Learn Linear regression
	SO4.2 Measures of Variability	**LI4.2** Draw flow chart of Correlation regression	**CI4.2** Measures of Variability	**SL4.2** remember ANOVA
	SO4.3 Correlation and Regression		**CI4.3** Correlation and Regression	
	SO4.4 ANOVA (Analysis of Variance)		**CI4.4** ANOVA (Analysis of Variance)	
	SO4.5 Central Tendency and Variability		**CI4.5** Central Tendency and Variability	
	SO4.6 Simple Linear Regression		**CI4.6** Simple Linear Regression	

	SO4.7 Multiple Linear Regression		**CI4.7** Multiple Linear Regression	
	SO4.8 Advanced Regression Analysis		**CI4.8** Advanced Regression Analysis	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Write about Regression analysis.
	SW4.2 Mini Project	
	SW4.3 Other Activities (Specify)	Search and learn via YouTube about ANNOVA.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	9	4	1	2	16

Course Outcome (CO)	**Session Outcomes (SOs)**	**LaboratoryInstruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO5- 56MB105.5: Apply biostatistics to fundamental issues and gauges of central tendency in CO5 Statistical software and survival analysis.	**SO5.1** Introduction to Statistical Tests	**LI5.1** How to perform Explanation of Z-test principles and assumptions.	**CI5.1** Introduction to Statistical Tests	**SL5.1** Learn Assumptions and Application
	SO5.2 Probability Theory and Distributions	**LI5.2** Calculation exercises for Pearson's correlation coefficient.	**CI5.2** Probability Theory and Distributions	**SL5.2** Practice Standard deviation calculation
	SO5.3 Computer-Oriented Statistical Techniques		**CI5.3** Computer-Oriented Statistical Techniques	
	SO5.4 Frequency Tables and Bubble Spot Diagrams		**CI5.4** Frequency Tables and Bubble Spot Diagrams	
	SO5.5 Mean, Variance, and Standard Deviation		**CI5.5** Mean, Variance, and Standard	

	Computation		Deviation Computation	
	SO5.6 T-test		**CI5.6 T-test**	
	SO5.7 Correlation Coefficient		**CI5.7** Correlation Coefficient	
	SO5.8 Small Sample Tests		**CI5.8** Small Sample Tests	
	SO5.9 Large Sample Test (Z-test)		**CI5.9** Large Sample Test (Z-test)	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Write about Z-test
	SW5.2 Mini Project	
	SW5.3 Other Activities (Specify)	Try to learn and apply Correlation coefficient in the test data.

Course duration (in hours) to attain Course Outcomes:

Course Title: Bioinformatics and Biostatistics **Course Code: 56MB105**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-56MB105.1: Comprehend the components, ideas, and various computer kinds, as well as the operating system, computer viruses, and computer network.	15	4	2	1	22
CO2-56MB105.2: Receive hands-on instruction in a variety of computer programs and their uses.	10	4	2	1	17

CO3-56MB105.3: Phylogenetic analysis, alignment types, and primer construction are covered in CO3.	10	4	2	1	17
CO4-56MB105.4: The unit covers descriptive statistics, correlation, regression, and ANOVA with practical regression-based exercises.	8	4	2	1	15
CO5-56MB105.5: Apply biostatistics to fundamental issues and gauges of central tendency in CO 5 Statistical software and survival analysis.	9	4	2	1	16
Total Hours	52	20	11	05	87

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

Course Title: Bioinformatics and biostatistics **Course Code: 56MB105**

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-56MB105.1: Comprehend the components, ideas, and various computer kinds, as well as the operating system, computer viruses, and computer network.	02	03	04	1	10
CO2-56MB105.2: Receive hands-on instruction in a variety of computer programs and their uses.	03	04	02	1	10
CO3-56MB105.3: Phylogenetic analysis, alignment types, and primer construction are covered in CO3.	02	05	02	1	10
CO4-56MB105.4: The unit covers descriptive statistics, correlation, regression, and ANOVA with practical regression-based exercises.	02	05	02	1	10
CO5-56MB105.5: Apply biostatistics to fundamental issues and gauges of central tendency in CO 5 Statistical software and survival analysis.	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: Methods and Applications: Genomics, Proteomics and Drug Discovery	Namita Mendiratta , Parag Rastogi, S.C. Rastogi	**PHI Learning**	**2022**
2	Mahajan's Methods in Biostatistics for Medical Students and Research Workers	Bratati Banerjee	Jaypee Brothers Medical Publishers	2018
3	Principles and Practice of Biostatistics	B Antonisamy, Prasanna S. Premkumar, Solomon Christopher	Elsevier India	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 bioinformatics lab
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: M.Sc. Microbiology
Semester: Ist Sem
Course Title: Bioinformatics and Biostatistics
Course Code: 56MB105

Course Outcome (Cos)	Program Specific Outcomes (PSOs)							
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-56MB105.1: Comprehend the components, ideas,	1	2	3	2	1	**3**	**3**	**1**

and various computer kinds, as well as the operating system, computer viruses, and computer network.								
CO2-56MB105.2: Receive hands-on instruction in a variety of computer programs and their uses.	1	1	2	1	1	**1**	**1**	**2**
CO3-56MB105.3: Phylogenetic analysis, alignment types, and primer construction are covered in CO3.	1	1	1	2	1	**1**	**1**	**1**
CO4-56MB105.4: The unit covers descriptive statistics, correlation, regression, and ANOVA with practical regression-based exercises.	**-**	**1**	**1**	1	**2**	**1**	**2**	**3**
CO5-56MB105.5: Apply biostatistics to fundamental issues and gauges of central tendency in CO 5 Statistical software and survival analysis.	**1**	**1**	**1**	**-**	1	**1**	**-**	**2**

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2, 3	**CO1-56MB105.1: Comprehend the components, ideas, and various computer kinds, as well as the operating system, computer viruses, and computer network.**	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10 SO1.11 SO1.12 SO1.13 SO1.14 SO1.15	**IL 1** **IL 2**	1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8, 1.9,1.10, 1.11,1.12,1.13,1.14,1.15	**1SL-1,2,3**
PO 1,2,3,4,5 PSO 1,2, 3	**CO2-56MB105.2: Receive hands-on instruction in a variety of computer programs and their uses.**	SO2.1 SO2.2 SO2.3 SO2.4 , SO 2.5., SO 2.6, SO2.7 SO2.8 SO2.9 SO2.10	**IL 1** **IL 2**	2.1, 2.2, 2.3, 2.4.2.5,2.6,2.7,2.8,2.9, 2.10	**2SL-1,2**
PO 1,2,3,4,5 PSO 1,2, 3	**CO3-56MB105.3: Phylogenetic analysis, alignment types, and primer construction are covered in CO3.**	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6.SO3.7 SO3.8 SO3.9 SO3.10	**IL 1** **IL 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 2,3,4,5 PSO 1,2, 3	**CO4-56MB105.4: The unit covers descriptive statistics, correlation, regression, and ANOVA with practical regression-based exercises.**	SO4.1 SO4.2 SO4.3 SO4.4,SO 4.5,SO4.6 SO4.7 SO4.8	**IL 1** **IL 2**	4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8,4.9,4.10	**4SL-1,2**
PO 1,2,3,5 PSO 1, 3	**CO5-56MB105.5: Apply biostatistics to fundamental issues and gauges of central tendency in CO 5 Statistical software and survival analysis.**	SO5.1 SO5.2 SO5.3 SO5.4,SO5.5, SO5.6,SO5.7,SO5.8, SO5.9	**IL 1** **IL 2**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9	**5SL-1,2**

Curriculum Development Team

Prof. Kamlesh Choure
Prof Ashwini A. Waoo
Prof. Deepak Mishra
Er. Arpit Srivastava
Mr. Piyush Kant Rai

Program Name	**Master of Science (M. Sc)- Microbiology**	
Semester	I	
Course Code:	56MB106	
Course title:	Bioinstrumentation	**Curriculum Developer**: Dr. Ashwini A. Waoo, Professor
Pre-requisite:	Student should have basic knowledge of physics, chemistry and analytical techniques.	
Rationale:	The paper on Bioinstrumentation in an MSc Microbiology program explores the critical role of specialized tools in analyzing microbial systems. It delves into the use of precise instruments for monitoring and analyzing microbial behavior, contributing to advanced research in microbial biology and diagnostics. This study enables students to understand how bioinstrumentation enhances microbiological studies, shaping their grasp of analytical techniques and their application in microbiology.	
Course Outcomes (COs):	**CO1-56MB106.1:** Recognise various microscope types and prepare specimens properly. **CO2-56MB106.2:** Students are being knowledgeable with all bioanalytical techniques including chromatography **CO3-56MB106.3:** Evaluate the techniques used to find out some information from biological samples by using electrophoresis **CO4-56MB106.4:** Understand and analyze principle instrumentation, types, and applications of spectroscopy. **CO5-56MB106.5:** Understand and analyze principle instrumentation, types, and applications of centrifugation and radioisotope techniques.	

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 (PCC)	56MB106	Bioinstrumentation	3	01	1	1	3+1+1+1=6	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)		
PCC	56MB106	Bioinstrumentation	**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)		
PCC	56MB156	Bioinstrumentation lab	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx. Hrs** | 09 | 04 | 01 | 05 | 19

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI) 98BT155	Class room Instruction (CI)	Self-Learning (SL)
CO1-56MB106.1: Recognise various microscope types and prepare specimens properly.	**SO1.1** Understand history and basic principles of microscopy	LI 1 Calibration of an ocular micrometer for different objectives of the microscope.	**Unit-1** **CI1.1** History and principles of microscopy, properties of light, magnification power, resolution limit, resolving power, numerical aperture.	**SL1.1** Study of parts of research binocular microscope
	SO1.2 Illustration of types of microscopy, light microscopy, bright field, dark field		**CI1.2** Principles and applications of light microscopy, bright field, dark field,	**SL1.2** What are types of microscopes
	SO1.3 Understand use of microscope according to need of study, Phase Contrast		**CI1.3** phase contrast	**SL1.3** Write mechanism of phase contrast
	SO1.4 Understand use of microscope according to need of study, fluorescence		**CI1.4** fluorescent microscopy.	
	SO1.5 Learn and measure size of microorganisms e. g. Bacterial cell	LI 2 Measurement of microorganisms by the use of an ocular micrometer	**CI1.5** Determination of size of microorganisms by micrometery.	**SL1.4** What is micrometry ?
	SO1.6 Electron microscopy, difference between SEM and TEM		**CI1.6** Principles and application of electron microscopy- transmission and scanning electron microscopy. Fixation and staining techniques in electron Microscopy.	
	SO1.7 Knowledge about the Newer techniques in mocroscopy		**CI1.7** Newer techniques in microscopy-confocal microscopy,	
	SO1.8 Knowledge about		**CI1.8** Knowledge about scanning	

	scanning tunneling microscope and atomic force microscope		tunneling microscope and atomic force microscope	
	SO1.9 Knowledge about scanning tunneling microscope and atomic force microscope		**CI1.9** Knowledge about scanning tunneling microscope and atomic force microscope	**SL1.5** List out advantages of newer techniques of microscopy

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Differentiate between SEM and TEM
	SW1.2 Mini Project	Ray diagram of all microscope you studied with neat labelling. And their applications
	SW1.3 Other Activities (Specify)	Find out some you tube videos based on working mechanisms of advanced microscopes.

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

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO1-56MB106.2: Students are being knowledgeable with all bioanalytical techniques including chromatography	**SO2.1** Understand the basic principles of chromatography		**Unit-II** **CI2.1** Principles, types and applications of partition, paper and thin layer chromatography.	**SL2.1** Learn types and principles of chromatography
	SO2.2 Illustration of adsorption chromatography		**CI2.2** Adsorption chromatography	**SL2.2** List of compounds analyzed by chromatography

	SO2.3 Understand use of gel filtration chromatography for biological analysis of compounds.		**CI2.3** Gel filtration chromatography: Principle, matrix, column packing and applications.	**SL2.3** Learn about Gel filtration technique
	SO2.4 Understand use of affinity chromatography for biological analysis of compounds.		**CI2.4** Affinity chromatography	**SL2.3** Discuss the applications of affinity chromatography
	SO2.5 Assessing the need of ion exchange chromatography		**CI2.5** ion exchange chromatography	
	SO2.6 Explaining the principle of gas chromatography		**CI2.6** Gas chromatography: Principle and applications	
	SO2.7 Explaining HPLC		**CI2.7** High performance liquid chromatography (HPLC) and	**SL2.5** 4. Differences between HPLC and FPLC
	SO2.8 Understand FPLC		**CI2.8** FPLC: Principle Instrumentation (Reservoirs, pumps, columns) and applications	
	SO2.9 Revision and assessment		**CI2.9** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe principles and types of chromatography
	SW2.2 Mini Project	Prepare complete draft on mechanism, instrumentation and applications of HPLC in detail.
	SW2.3 Other Activities (Specify)	Prepare list of compounds detected and analysed using chromatographic techniques and their purpose of analysis.

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)**
CO1-56MB106.3: Evaluate the techniques used to find out some information from biological samples by using electrophoresis	**SO3.1** Illustrate the basic principles, types, and factors affecting electrophoresis		**Unit-III** **CI3.1** Principle, types, and applications of Paper, Starch gel and	**SL3.1** Read about electrophoresis
	SO3.2 Illustration of agarose gel electrophoresis	LI 1 Separation of DNA on Agarose gel electrophoresis	**CI3.2** Agarose gel electrophoresis.	**SL3.2** Draw a diagram of electrophoretic apparatus
	SO3.3 Understand PAGE and SDS PAGE	LI 2 Demonstration of PAGE	**CI3.3** Polyacrylamide Gel Electrophoresis: Native PAGE and SDS PAGE	**SL3.3** Illustration about differences in PAGE and SDS PAGE
	SO3.4 Evaluate the need of Isoelectric focusing, immunoelectrophoresis	LI 3 Kit-based demonstration of immunoelectrophoresis	**CI3.4** Isoelectric focusing, Immunoelectrophoresis	
	SO3.5 Describe isotachophoresis		**CI3.5** Isotachophoresis and	
	SO3.6 Illustrate gradient electrophoresis		**CI3.6** gradient gel electrophoresis.	**SL3.4** Write a note on gradient electrophoresis
	SO3.7 Describe 2 D electrophoresis		**CI3.7** Two dimensional gel electrophoresis	**SL3.5** Diagrammatically explain 2 D gel electrophoresis
	SO3.8 Analyze the advantages pulse field gel electrophoresis,		**CI3.8** and pulse field gel electrophoresis	
	SO3.9 revision and assessment		**CI3.9** revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe principles and types of electrophoresis
	SW3.2 Mini Project	Describe the significance of electrophoresis in DNA fingerprinting and DNA sequencing

	SW3.3 Other Activities (Specify)	Describe the pulse field electrophoresis working

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)**
CO1-56MB106.4: Understand and analyze principle instrumentation, types, and applications of spectroscopy.	**SO4.1** Understand the basic of colorimetry	LI 1 Demonstration of Beer-Lambert's Law	Unit-IV **CI4.1** Laws of absorption, Principles, instrumentation and applications of colorimetry,	Learn about terms used in genetics
	SO4.2 Illustrate instrumentation and applications of UV visible spectroscopy	LI2 Quantitative estimation of proteins using UV visible spectrophotometer	**CI4.2** UV-visible spectroscopy. Principles, instrumentation and applications	Discuss multiple alleles and examples
	SO4.3 Understand Infrared.		**CI4.3** Infrared spectroscopy	Learn about examples of incomplete dominance
	SO4.4 Understand fluorescence Spectroscopy.		**CI4.4** and fluorescence Spectroscopy.	SL4.4 Studies related to lethal genes and their effects
	SO4.5 Evaluate the need of NMR		**CI4.5** Principles, instrumentation and applications of NMR and	
	SO4.6 Evaluate the need of ESR		**CI4.6** ESR	SL4.5 Evaluate the phenomenon of epistasis
	SO4.7 Analyze the advantages Mass spectroscopy		**CI4.7** Principle, instrumentation and applications Mass Spectroscopy (types of ion source, analyzers and detectors),	

	SO4.8 Analyze the advantages and GC-MS in current research.		**CI4.8** GC-MS, MALDI-TOF	
	SO4.9 revision and assessment		**CI4.9** revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe principles and types of spectroscopies
	SW4.2 Mini Project	Describe the GC-MS in detail and its applications
	SW4.3 Other Activities (Specify)	Prepare list of compounds detected and analysed using spectroscopy

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)**
CO1-56MB106.5: Understand and analyze principle instrumentation, types, and applications of centrifugation and radioisotope techniques	**SO5.1** Understand the basic of centrifugation and its types	LI 1 Separation of bacterial cells by centrifugation	**Unit-V** **CI5.1** Sedimentation coefficient, factors affecting sedimentation coefficient.	**SL5.1** learn about principle of centrifuge
	SO5.2 Illustrate instrumentation and applications of ultracentrifuge	LI2 Demonstration of density gradient	**CI5.2** Ultracentrifuges: analytical and preparative with application.	**SL5.2** learn about analytical centrifuge
	SO5.3 Understand types of rotors	LI3 Study of rotors in centrifuge	**CI5.3** Rotors: types and applications.	**SL5.3** Give role of rotors its capacity range and applications

	SO5.4 SO5.3 Understand radioisotope techniques		**CI5.4** Radioisotope techniques: half-life, radioactive decay,	**SL5.4** Learn about the properties of radioisotopes
	SO5.5 Analyze the advantages Geiger- Muller counter, liquid scintillation counter and gamma counter and autoradiography		**CI5.5** radioactive assay methods based on ionization and excitation of gases-Geiger Muller counter,	Give diagrammatic representation of the Geiger Muller's counter
	SO5.6 Describe autoradiography		**CI5.6** Autoradiography- principle and applications. .	
	SO5.7 Describe process of quenching		**CI5.7** Quenching	
	SO5.8 Evaluate the need of radioisotopes in biology research		**CI5.8** application of radioisotopes in biological systems	**SL5.5** Learn role of radioisotopes
	SO5.9 Review and assessment		**CI5.9** Review and assessment	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Describe principles and types of centrifugations
	SW5.2 Mini Project	Describe the applications of radioisotopes in biology research
	SW5.3 Other Activities (Specify)	Prepare list of hazards occurred due to improper use and dispose of radioisotopes.

Course duration (in hours) to attain Course Outcomes:

Course Title: Bioinstrumentation **Course Code: 56MB106**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-56MB106.1: Recognise various microscope types and prepare specimens properly.	9	4	5	1	19
CO2-56MB106.2: Students are being knowledgeable with all bioanalytical techniques including chromatography	9	0	5	1	15
CO3-56MB106.3: Evaluate the techniques used to find out some information from biological samples by using electrophoresis	9	6	5	1	21
CO4-56MB106.4: Understand and analyze principle instrumentation, types, and applications of spectroscopy.	9	4	5	1	19
CO5-56MB106.5: Understand and analyze principle instrumentation, types, and applications of centrifugation and radioisotope techniques.	9	6	5	1	21
Total Hours	45	20	25	05	95

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

Course Title: Bioinstrumentation **Course Code: 56MB106**

Course Outcomes				
	A	An	E	Total Marks
CO1-56MB106.1: Recognise various microscope types and prepare specimens properly.	02	02	01	05
CO2-56MB106.2: Students are being knowledgeable with all bioanalytical techniques including chromatography	03	05	02	10

CO3-56MB106.3: Evaluate the techniques used to find out some information from biological samples by using electrophoresis	05	05	05	15
CO4-56MB106.4: Understand and analyze principle instrumentation, types, and applications of spectroscopy.	04	03	03	10
CO5-56MB106.5: Understand and analyze principle instrumentation, types, and applications of centrifugation and radioisotope techniques.	05	04	01	10
Total Marks	19	19	12	50

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

Suggested learning Resources:

(a) Books:

(b)

S. No.	Title	Author	Publisher	Edition & Year
1	A Biologist Guide to Principles and Techniques of Practical Biochemistry,	Wilson and Goulding	Hodder	1981
2	Physical Biochemistry: Applications to Biochemistry and Molecular Biology	David Frefelder,	W.H.Freeman & Co Ltd	1982
3	Microbiology	Lansing M Prescott, John P. Harley, Donald A Klein, Sixth edition,	Mc Graw Hill Higher education.	2017
4	Principles of Instrumental Analysis	Skoog and West	Brooks/Cole	2017
5	Principles and Techniques of Biochemistry and Molecular Biology	Wilson Keith and Walker	Cambridge University Press	2010

(c) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Title: M. Sc. Microbiology
Semester: I
Course Code: 56MB106
Course Title: Bioinstrumentation

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
98BT506-A.1	-	-	-	1	2	2	2	-	1	2	2	3	3	3	1
98BT506-A.2	-	-	-	-	-	-	3	-	2	2	3	3	1	1	2
98BT506-A.3	-	1	1	1	-	-	2	-	3	1	1	2	1	1	1
98BT506-A.4	-	1	1	-	2	2	2	3	-	1	-	-	1	2	3
98BT506-A.5	1	1	1	-	-	2	3	3	1	2	2	2	1	-	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	**CO1-98BT704-B.1:** Identify the different types of bioremediation techniques, mechanisms and microbes for bioremediation	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	**CO2-98BT704-B.2:** Differentiate criteria of types of bioremediations and their detailed process.	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	**CO3-98BT704-B.3:** Evaluate the roles of Biosorption & Bioleaching, and phytoremediation.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	LI1, LI2, LI3	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	**CO4-98BT704-B.4:** Use of bioremediation of phenols, cyanides, dyes, and understanding biodegradation through pathway engineering.	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, 4.8, 4.9	4SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO5-98BT704-B.5:** Case study and demonstration of bioremediation plan for industrial waste.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	LI1, LI2, LI3	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
Mr. Piyush Kant Rai

Semester II

Program Name	**Masters of Science (M.Sc.)- Microbial physiology**	
Semester	II	
Course Code:	56MB201	
Course title:	Microbial Physiology	**Curriculum Developer**: Mrs. Keerti Samdariya, Assistant Professor
Pre-requisite:	The student should have basic knowledge of biomolecules, their chemistry, their metabolism in microbes, and nitrogen metabolism.	
Rationale:	The paper on Microbial physiology in an MSc Microbiology program explores the role of biomolecules and their metabolic activity in microbial 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, which are necessary for life. They vary in structures and sizes. metabolism is a complex process that is essential for the body to function properly.	
Course Outcomes (COs):	**CO1-56MB201.1:** Understand the basic concepts of metabolism and Bioenergetics.	
	CO2-56MB201.2: Extend metabolic pathways of Carbohydrate metabolism and fermentation.	
	CO3-56MB201.3: Understanding photosynthesis and lipid metabolism.	
	CO4-56MB201.4: To become familiar with the Metabolism of amino acids and nucleic acid.	
	CO5-56MB201.5: Apply the ideas and concept of Nitrogen metabolism.	

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 (PCC)	56MB201	Microbial Physiology	3	1	1	1	6	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 any one (CAT)	Class Attendance (AT)	Total Marks (CA+CAT+CT+SA+AT)			
PCC	56MB201	Microbial Physiology	**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	56MB251	Microbial Physiology and Metabolism Lab	35	5	5	5	50	50	50

Course-Curriculum:

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

Approximate Hours

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

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1-56MB201.1: Understand the basic concepts of metabolism and Bioenergetics.	**SO1.1** Clarify the Basic concepts of the First law of thermodynamics.	**LI1.1** To determine the enthalpy change (ΔH) of a reaction using calorimetry and understand the concept of enthalpy in the context of the first law of thermodynamics.	**Unit 1** **CI1.1** Basic concepts. First and second law of thermodynamics, concept of free energy, entropy and enthalpy.	**SL1.1** Understand the role of law of thermodynamics

	SO1.2 Clarify the Basic concepts of second law of thermodynamics.	**LI1.2** To measure the free energy change (ΔG) during the hydrolysis of ATP	**CI1.2** Basic concepts. First and second law of thermodynamics, concept of free energy, entropy and enthalpy.	**SL1.2** Learn the Biological redox reactions, biological reducing power and its role in biological system.
	SO1.3 concept of free energy, entropy and enthalpy.		**CI1.3** Basic concepts. First and second law of thermodynamics, concept of free energy, entropy and enthalpy.	
	SO1.4 Determine the High energy phosphate compounds, the role of ATP, ATP cycle,		**CI1.4** High energy phosphate compounds, role of ATP, ATP cycle, structural basis of free energy change during hydrolysis of ATP.	
	SO1.5 Determine the High energy phosphate compounds, the role of ATP, ATP cycle,		**CI1.5** High energy phosphate compounds, role of ATP, ATP cycle, structural basis of free energy change during hydrolysis of ATP.	
	SO1.6 Explain the structural basis of free energy change during hydrolysis of ATP.		**CI1.6** ATP cycle, structural basis of free energy change during hydrolysis of ATP.	
	SO1.7 Biological redox reactions, Biological reducing power and		**CI1.7** Biological redox reactions, biological reducing power and its role in biological system.	
	SO1.8 biological redox reaction role in the biological system.		**CI1.8** biological redox reaction role in the biological system.	
	SO1.9 revision and assessment		**CI1.9** revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Differentiate between First and second law of thermodynamics.
	SW3.2 Mini Project	Biological redox reactions, biological reducing power and its role in biological system.
	SW3.3 Other Activities (Specify)	Find out some you tube videos structural basis of free energy change during hydrolysis of ATP.

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)
CO2-56MB201.2: Extend metabolic pathways of Carbohydrate metabolism and fermentation.	**SO2.1** Explain glycolysis and its regulation, homo and heterolactic fermentation.	**LI2.1** To examine the process of glycolysis and its regulation in a biological system	**Unit 2** **CI 1.1** glycolysis and its regulation, Feeder pathway of glycolysis and carbohydrate –homo and heterolactic fermentation	**SL2.1** Understand glycolysis and its regulation, homo and heterolactic fermentation.
	SO2.2 Elucidation of Glycogenesis, Glycogenolysis and regulation.	**LI2.2** to measure ATP synthesis via substrate-level and oxidative phosphorylation	**CI 2.2** Glycogenesis, Glycogenolysis and regulation,.	**SL2.2** Learn the Electron transport system in Mitrochondria, Electron cariers and multienzyme complex I to IV.
	SO2.3 Elucidation of Gluconeogenesis.		**CI 2.3** Gluconeogenesis. Pentose phosphate pathway, E-D pathway, Kreb's cycle, and glyoxalate pathway	**SL2.3** Significance of Pentose phosphate pathway
	SO2.4 Understand Pentose phosphate pathway, E-D pathway, Kreb's cycle and glyoxalate pathway.		**CI 2.4** Gluconeogenesis. Pentose phosphate pathway, E-D pathway, Kreb's cycle, and glyoxalate pathway	
	SO2.5 Understand E-D pathway, Kreb's cycle and glyoxalate pathway.		**CI 2.5** E-D pathway, Kreb's cycle, and glyoxalate pathway	

	SO2.6 Explain Electron transport system in Mitrochondria, Electron cariers and multienzyme complex I to IV. .		**CI2.6** Electron transport system in Mitrochondria, Electron cariers and multienzyme complex I to IV. .	
	SO2.7 Explain Electron transport system in Mitrochondria, Electron cariers and multienzyme complex I to IV. .		**CI2.7** Electron transport system in Mitrochondria, Electron cariers and multienzyme complex I to IV. .	
	SO2.8 explaining ATP synthesis: substrate level and oxidative phosphorylation and un-couplers, inhibitors of oxidative phosphorylation.		**CI2.8** ATP synthesis: substrate level and oxidative phosphorylation and un-couplers, inhibitors of oxidative phosphorylation.	
	SO2.8 explaining ATP synthesis: substrate level and oxidative phosphorylation and un-couplers, inhibitors of oxidative phosphorylation		**CI2.8** ATP synthesis: substrate level and oxidative phosphorylation and un-couplers, inhibitors of oxidative phosphorylation	
	SO2.9 Revision and assessment		**CI2.9** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Explain Electron transport system in Mitrochondria, Electron cariers and multienzyme complex I to IV.
	SW2.2 Mini Project	Draw ray diagram of oxidative phosphorylation.
	SW2.3 Other Activities (Specify)	Find out some you tube videos based on oxidative phosphorylation

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

urse outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO3-56MB201.3: Understanding photosynthesis and lipid metabolism.	**SO3.1** Illustrating Oxygenic and an-oxygenic microorganisms,	**LI3.1** To compare the processes of oxygenic and anoxygenic photosynthesis in microorganisms	**Unit 3** **CI 3.1** Oxygenic and an-oxygenic microorganisms, photolysis of water and photophosphorylation	**SL3.1** Discuss Oxygenic and an-oxygenic microorganisms, structure of chloroplast
	SO3.2 Illustrating structure of chloroplast, light reaction, photolysis of water and photophosphorylation	LI3.2 To study the biosynthesis and degradation of lipids in microorganisms	**CI 3.2** structure of chloroplast, light reaction, photolysis of water and photophosphorylation	**SL3.2** Read Biosynthesis of lipids and fatty acids, triglycerol and phospholipids and their regulation.
	SO3.3 Illustrating light reaction, photolysis of water and photophosphorylation		**CI 3.3** light reaction, photolysis of water and photophosphorylation	
	SO3.4 Explaining C3 and C4 pathway of carbon fixation.		**CI3.4** Explaining C3 and C4 pathway of carbon fixation.	
	SO3.5 Explaining Nutritional classification of microorganisms.		**CI3.5** Explaining Nutritional classification of microorganisms.	
	SO3.6 Explaining Energy generation in cyanobacteria, green bacteria, purple sulphur bacteria and chemolithotrops.		**CI3.6** Explaining Energy generation in cyanobacteria, green bacteria, purple sulphur bacteria and chemolithotrops.	
	SO3.7 Biosynthesis of lipids and fatty acids, triglycerol and phospholipids and their regulation		**CI3.7** Biosynthesis of lipids and fatty acids, triglycerol and phospholipids and their regulation	

	SO3.8 Biosynthesis of phospholipids and their regulation		**CI3.8** Biosynthesis of lipids and fatty acids, triglycerol and phospholipids and their regulation	
	SO3.9 Degradation of Lipids, oxidation of unsaturated, saturated, fatty acids.		**CI3.9** Degradation of Lipids, oxidation of unsaturated, saturated, even and odd chain fatty acids, ketone bodies.	
	SO3.10 oxidation of even and odd chain fatty acids, ketone bodies.		**CI3.10** Degradation of Lipids, oxidation of unsaturated, saturated, even and odd chain fatty acids, ketone bodies.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail on Classification and nomenclature of enzymes
	SW3.2 Mini Project	Describe Biosynthesis of lipids and fatty acids.
	SW3.3 other activity	Find out some you tube videos based on Energy generation in cyanobacteria, green bacteria, purple sulphur bacteria and chemolithotrops.

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

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO4-56MB201.4: To become familiar with the Metabolism of amino acids and nucleic acid.	**SO4.1** Illustrating Biosynthetic families of amino acids.	LI4.1 To investigate the detection of amino acids in bacteria	**Unit-4** **CI 4.1** Biosynthetic families of amino acids.	**SL4.1** Learn Biosynthesis of purines and pyrimidines nucleotides by de novo and salvage pathways.

.	**SO4.2** Explaining Catabolism of amino acids.	**LI4.2** to check the urease activity of microtganism	**CI 4.2** Catabolism of amino acids. Breakdown of amino acids into six common intermediates.	**SL4.2** Learn Catabolism of amino acids. Breakdown of amino acids into six common intermediates. .
	SO4.3 Explaining Breakdown of amino acids into six common intermediates.		**CI 4.3** Catabolism of amino acids. Breakdown of amino acids into six common intermediates.	
	SO4.4 Differentiate urea cycle and relationship with TCA cycle .		**CI4.4** urea cycle and relationship with TCA cycle.	
	SO4.5 Explain Biosynthesis of purines nucleotides by de novo pathways.		**CI4.5** Biosynthesis of purines and pyrimidines nucleotides by de novo and salvage pathways.	
	SO4.6 Explain Biosynthesis of pyrimidines nucleotides by de novo pathways.		**CI4.5** Biosynthesis of purines and pyrimidines nucleotides by de novo and salvage pathways	
	SO4.7 Explain Biosynthesis of purines nucleotides by salvage pathways.		**CI4.6**Biosynthesis of purines and pyrimidines nucleotides by de novo and salvage pathways.	
	SO4.8 Explain Biosynthesis of pyrimidines nucleotides by salvage pathways.		**CI4.6**Biosynthesis of purines and pyrimidines nucleotides by de novo and salvage pathways.	
	SO4.9 Explain Degradation of Purines nucleotides		**CI4.7** Degradation of Purines nucleotides	
	SO4.10 Explain Degradation of Pyrimidines nucleotides		**CI4.8** Degradation of Pyrimidines nucleotides	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	llustrating urea cycle and relationship with TCA cycle.
	SW4.2 Mini Project	Describe the Catabolism of amino acids. Breakdown of amino acids into six common intermediates.

	SW4.3 Other Activities (Specify)	Find out some you tube videos based on metabolic activity of carbohydrates

Item	Cl	LI	SW	SL	Total
Approx. Hrs	07	04	01	02	14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO5-56MB201.5: Apply the ideas and concept of Nitrogen metabolism.	**SO5.1** Elucidate Nitrification, denitrification,	LI5.1 to measure the levels of nitrate and ammonia assimilation in microbial cultures.	**Unit-5** **CI5.1** Nitrification, denitrification, Nitrate and ammonia assimilation pathways.	**SL5.1** Understand the metabolic role of lipids
	SO5.2 Elucidate Nitrate and ammonia assimilation pathways.	LI5.2 To study the biochemistry of nitrogen fixation by bacteria	**CI5.2** Nitrate and ammonia assimilation pathways.	
,	**SO5.3** Explain Nitrogen cycle. Diazotrophs		**CI5.3** Nitrogen cycle. Diazotrophs	**SL5.2** Learn the Differentiation between Disorder associated with defect in carbohydrate, amino acid and lipid metabolism
	SO5.4 Explain Biochemistry of nitrogen fixation, Structure of nitrogenase complex.		**CI5.4** Explain Biochemistry of nitrogen fixation, Structure of nitrogenase complex.	
	SO5.5 explain Regulation of nitrogenase complex by oxygen and combined nitrogen sources.		**CI5.5** Regulation of nitrogenase complex by oxygen and combined nitrogen sources.	
	SO5.6 Regulation of nitrogenase complex by oxygen and combined nitrogen sources.		**CI5.6** Regulation of nitrogenase complex by oxygen and combined nitrogen sources. *Nif* genes and their regulation.	

	SO5.7 Describe *Nif* genes and their regulation.		**CI5.7** Regulation of *Nif* genes and their regulation	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	llustrating Biochemistry of nitrogen fixation, Structure of nitrogenase complex.
	SW5.2 Mini Project	Explain Nitrification, denitrification, Nitrate and ammonia assimilation pathways.
	SW5.3 Other Activities (Specify)	Prepare one article explaining *Nif* genes and their regulation.

Course duration (in hours) to attain Course Outcomes:

Course Title: Microbial physiology **Course Code:** 56MB201

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-56MB201.1: Understand the basic concepts of metabolism and Bioenergetics.	9	4	2	1	16
CO2-56MB201.2: Extend metabolic pathways of Carbohydrate metabolism and fermentation.	9	4	3	1	17
CO3-56MB201.3: Understanding photosynthesis and lipid metabolism.	10	4	2	1	17
CO4-56MB201.4: To become familiar with the Metabolism of amino acids and nucleic acid.	10	4	2	1	17
CO5-56MB201.5: Apply the ideas and concept of Nitrogen metabolism.	7	4	2	1	14
Total Hours	45	20	11	05	81

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

Course Title: Microbial physiology **Course Code:** 56MB201

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-56MB201.1: Understand the basic concepts of metabolism and Bioenergetics.	2	1	1	1	5
CO2-56MB201.2: Extend metabolic pathways of Carbohydrate metabolism and fermentation.	2	4	2	2	10
CO3-56MB201.3: Understanding photosynthesis and lipid metabolism.	3	5	5	2	15
CO4-56MB201.4: To become familiar with the Metabolism of amino acids and nucleic acid.	2	3	3	2	10
CO5-56MB201.5: Apply the ideas and concept of Nitrogen 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
4	Microbial Physiology by Albert G. Moat and John W. Foster. Third edition, John Wiley and Sons; 2002

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. Sc. Microbiology
Semester: II Semester
Course Title: Microbial physiology
Course Code: 56MB201

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-56MB201.1: Understand the basic concepts of metabolism and Bioenergetics.	1	2	2	3	1	2	2	1
CO2-56MB201.2: Extend metabolic pathways of Carbohydrate metabolism and fermentation.	1	2	3	2	1	1	1	2
CO3-56MB201.3: Understanding photosynthesis and lipid metabolism.	1	2	3	2	1	1	1	1
CO4-56MB201.4: To become familiar with the Metabolism of amino acids and nucleic acid.	-	1	1	-	2	1	1	3
CO5-56MB201.5: Apply the ideas and concept of Nitrogen metabolism.	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	**CO1-56MB201.1:** Understand the basic concepts of metabolism and Bioenergetics.	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**
PO 1,2,3,4,5 PSO 1,2,3	**CO2-56MB201.2:** Extend metabolic pathways of Carbohydrate metabolism and fermentation.	SO2.1 SO2.2 SO2.3 SO2.4, SO2.5, SO2.6 SO2.7, SO2.8 SO2.9	**LI1** **LI2**	2.1, 2.2, 2.3, 2.4,2.5,2.6,2.7,2.8, 2.9	**2SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO3-56MB201.3:** Understanding photosynthesis and lipid metabolism.	SO3.1 SO3.2 SO3.3 SO3.4, SO3.5, SO3.6, SO3.7, SO3.8, SO3.9, SO3.10	**LI1** **LI2**	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 PSO 1,2,3	**CO4-56MB201.4:** To become familiar with the Metabolism of amino acids and nucleic acid.	SO4.1 SO4.2 SO4.3 SO4.4, SO4.5, SO4.6, SO4.6, SO4.7, SO4.8, SO4.9, SO4.10.	**LI1** **LI2**	4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8,4.9,4.10	**4SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO5-56MB201.5:** Apply the ideas and concept of Nitrogen metabolism.	SO5.1 SO5.2 SO5.3, SO5.4, SO5.5, SO5.6, SO5.7, SO5.8, SO5.9	**LI1** **LI2**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8, 5.9	**5SL-1,2**

Curriculum Development Team

Prof. Kamlesh Choure
Prof Ashwini A. Waoo
Prof. Deepak Mishra
Er. Arpit Srivastava
Mr. Piyush Kant Rai

Program Name	**Masters of Science (M.Sc.)- Microbiology**	
Semester	II	
CourseCode:	56MB202	
Coursetitle:	Enzyme Technology	**Curriculum Developer**: Mrs. Pratima Mishra, Guest Faculty
Pre-requisite:	Student should have basic knowledge of Biochemistry and metabolism.	
Rationale:	The paper on Enzyme Technologyserves as a cornerstone in microbiology due to its pivotal role in catalyzing biochemical reactions essential for life processes. By understanding the structure, function, and regulation of enzymes, microbiologists can harness their biocatalytic power for a myriad of applications spanning biotechnology, medicine, environmental science, and beyond. Enzymes offer unparalleled specificity, efficiency, and sustainability, making them indispensable tools for bioprocessing, drug development, environmental remediation, and diagnostic assays. Moreover, ongoing advancements in enzyme engineering and synthetic biology continually expand the scope and versatility of enzyme technology, promising innovative solutions to pressing global challenges. Thus, studying enzyme technology within the framework of an M.Sc. microbiology program provides students with a comprehensive understanding of enzymatic mechanisms and applications, empowering them to contribute to scientific advancements and address real-world problems effectively.	
CourseOutcomes (COs):	**CO1-56MB202.1:** Familiarization with the structure, functions, and mechanism of action of enzymes, as well as the kinetics of enzyme-catalyzed processes and the mechanisms by which enzymes are inhibited. **CO2-56MB202.2:** Development of critical skills for microbial sources for screening of enzymes and different categories of enzyme assays. **CO3-56MB202.3:**Acquired Skills of microbial enzyme isolation and purification for their potential future usage. **CO4-56MB202.4:** Recognize various methodsfor characterization of enzyme isolated from different sources. **CO5-56MB202.5:** Explore application of microbial enzymes for improvement and development of novelproducts.	

Scheme of Studies:

Board ofStudy	CourseCode	CourseTitle	Scheme ofstudies (Hours/Week)					Total Credits(C) (L:T:P=0:4:0)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
DSC	56MB202	Enzyme Technology	3	1	1	5	10	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)		
DSC	**56MB202**	Enzyme 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)		
DSC	56MB252	Enzyme Technology Lab	35	5	5	5	50	50	50

Course-Curriculum:

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

Approximate Hours

Item	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)**
56MB202.1: Familiarization with the structure, functions, and mechanism of action of enzymes, as well as the kinetics of enzyme-catalyzed processes and the mechanisms by which enzymes are inhibited..	**SO1.1** Define and Describe concept of enzymes	**LI1.1** Determination of presence of enzymes	**Unit-1** **CI1.1** Introduction to enzymes	**SL1.1** Search various reference books and study material to start the learning of enzymes
	SO1.2 Describe about different classes of enzymes		**CI1.2** Enzyme Classification	**SL1.2** Identification of enzyme on the basis of enzyme commission numbers.
	SO1.3 Explain about nomenclature of enzymes	**LI1.2** Isolation of microbial enzymes	**CI1.3** Enzyme Nomenclature	**SL1.3** To optimize characteristics of enzyme

	SO1.4 Describe about characteristics of enzymes		**CI1.4** Characteristics of enzymes	
	SO1.5 Study the concept of mechanism of action of enzymes		**CI1.5** Mode of Action	**SL1.4** To analyze impact of enzyme on different biological systems
	SO1.6 Study of kinetics of enzymatic reactions.		**CI1.6** Kinetics of enzyme catalyzed reaction (Km, Vmax)	
	SO1.7 Describe concept of enzyme inhibition		**CI1.7** Types of enzyme inhibition	**SL1.5** To optimize protocols for enzyme isolation
	SO1.8 Study about mechanism of inhibition.		**CI1.8** mechanism of enzyme inhibition	
	SO1.9 Describe the importance of enzyme		**CI1.9** Microbial importance of enzymes	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail enzymes and their biological role.
	SW1.2 Mini Project	Standardize the protocols of isolation of enzymes
	SW1.3 Other Activities (Specify)	Collection of enzymes from different sources.

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)**
56MB202.2: Development of critical skills for microbial sources for screening of enzymes and different categories of enzyme assays.	**SO2.1**Explore the concept and techniques of identification of microbial enzymes from different sources	**LI2.1** Isolation of microbial enzyme and determination of enzyme activity	**Unit-II** **CI2.1**Microbial sources of enzymes,	**SL2.1** Search various contents for microbial sources of enzymes
	SO2.2 Reflecting about protocols of primary screening of microbes	**LI2.2** Perform qualitative assay of enzymes	**CI2.2** Primary screening of microorganisms for enzyme	**SL2.2** design the protocol for screening of microbes for enzyme

			production;	production
	SO2.3 Reflecting about protocols of primary screening of microbes		**CI2.3** secondary screening of microorganisms for enzyme production	
	SO2.4 Explain about assays of enzyme activity		**CI2.4** Qualitative and quantitative assay of enzyme activity	**SL2.3** tolearn about mechanism of enzyme assay
	SO2.5 Assessing the role of amylase and cellulase.		**CI2.5** Enzymes units Amylases, Cellulases,	**SL2.4** standardize the protocol for enzyme production
	SO2.6 Assessing the role of hemicellulases and protease		**CI2.6**Hemicellulases, Proteases.	**SL2.5** to learn the methods of enzyme production
	SO2.7 Assessing the substrate for enzyme assay		**CI2.7** Natural and synthetic substrates for enzyme assay	
	SO2.8 Revision and discussion		**CI2.8** Revision and discussion	
	SO2.9 Assessment		**CI2.9 A**ssessment	

Suggested Sessional Work (SW):*anyone*	**SW2.1** Assignments	Describe in detail about different stages of enzyme production.
	SW2.2 Mini Project	Designing of a protocol for enzyme assays
	SW2.3 Other Activities (Specify)	Isolate and produce industrially important microbial enzymes in the laboratory.

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)
CO3-56MB202.3: Acquired Skills of microbial enzyme isolation and purification for their potential future usage.	**SO3.1** Explain the role of microbes in enzyme production.	**LI3.1**demonstration of enzyme production process.	**Unit-III** **CI3.1** Microbial enzyme production ,	**SL3.1** Read about various types offermentors used for microbial enzyme productrion
	SO3.2 Assessing the concept of SSF		**CI3.2** submerged and solid state fermentation (SSF).	**SL3.2** Study the components and operation of a fermentor
	SO3.3 Explaining important parameters of enzyme production		**CI3.3** Important parameters in enzyme production	**SL3.3** Illustration about mechanism of enzyme production
	SO3.4 Assessing different methods of purification		**CI3.4** Enzyme purification Technique	
	SO3.5 Describe about precipitation		**CI3.5** Precipitation	**SL3.4** Study of different methods used for purification
	SO3.6 Assessing the role of gel filtration chromatography		**CI3.6** chromatographic separation-gel filtration	**SL3.5** Assess role of chromatography for enzyme purification
	SO3.7 Describe about ion exchange chromatography	**LI3.3**to perform chromatography for enzyme purification	**CI3.7** anion and cation exchange	
	SO3.8 Describe about concept of zymography		**CI3.8** zymograph y.	
	SO3.9 Revision and assessment		**CI3.9** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail purification methods of enzyme
	SW3.2 Mini Project	Describe the role of different factors affecting enzyme production
	SW3.3 Other Activities (Specify)	Optimization of fermentation process for enzyme production

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)
CO4-56MB202.4: Recognize various methodsfor characterization of enzyme isolated from different sources.	**SO4.1** Exploring the concept of characterization of enzyme	**LI4.1** Demonstration of SDS PAGE	**Unit-IV** **CI4.1** .Techniques used in characterization of enzymes,	**SL4.1** Learn about different categories of enzyme
	SO4.2 Assessing role of Molecular weight.	**LI4.2** Demonstration of Gel filtration chromatography	**CI4.2** determination of molecular weight	**SL4.2** Compare characteristics of enzyme
	SO4.3 Explaining the concept of SDSPAGE and gel filtration		**CI4.3** (SDSPAGE, Gel filtration),	**SL4.3** Learn about various techniques of enzyme characterization
	SO4.4 Explaining the role of Isoelectric point on enzyme.		**CI4.4** Isoelectric point	**SL4.4** Analysis of stability of enzyme.
	SO4.5 Explaining the role of pH on enzyme.		**CI4.5** pH optimization	
	SO4.6 Explaining the role of temperature on enzyme.		**CI4.6** temperature optimization	
	SO4.7 Evaluate impact of inhibition pattern		**CI4.7** -stability Inhibitionpattern,	**SL4.5** analysis of enzyme activity
	SO4.8 Describe the impact of TLC		**CI4.8** Product analysis of enzyme action using TLC,	
	SO4.9 Describe the impact of HPLC.		**CI4.9** Product analysis of enzyme action using HPLC,	
	SO4.10 Describe the impact of MALDI-TOF		**CI4.10** Product analysis of enzyme action using MALDI-TOF	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain about different methods of enzyme characterization
	SW4.2 Mini Project	Describe the various techniques used in enzyme production and characterization.
	SW4.3 Other Activities	Prepare one article on enzyme production

	(Specify)	

Item	Cl	LI	SW	SL	Total
Approx.Hrs	08	04	01	05	1

Course Outcome (CO)	SessionOutcomes(SOs)	LaboratoryInstruction(LI)	ClassroomInstruction(CI)	Self-Learning(SL)
CO5-56MB202.5: Explore application of microbial enzymes for improvement and development of novel products.	**SO5.1** Define the concept of molecular biology of enzyme.	**LI5.1** Demonstration of site directed mutagenesis	**Unit-V** **CI5.1** Molecular biology of enzymes- ..	**SL5.1** learn about basic concept of molecular structure of enzyme
	SO5.2 Able to execute role of amino acid sequencing		**CI5.2** amino acid sequencing,	**SL5.2**Reviewconcept of amino acid sequencing
	SO5.3 Apply the concept of structural and functional relationship	**LI5.2** study the effect of various factors on enzyme activity	**CI5.3** structure and function relationship,	**SL5.3**learn how to apply RDT for enzyme production
	SO5.4 Apply the Protein engineering for development of new enzymes		**CI5.4** Protein engineering	**SL5.4**learn how to apply RDT for enzyme production
	SO5.5 Study directed mutagenesis		**CI5.5** directed evolution	
	SO5.6 Apply the RDT for development of novel enzymes		**CI5.6** Cloning of microbial enzymes inheterologous host	
	SO5.7 Apply the RDT for expression of novel enzymes		**CI5.7** over expression of microbial enzymes inheterologous host	
	SO5.8 Revision and discussion		**CI5.8** Revision and discussion	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain application of protein engineering for production of novel enzymes
	SW5.2 Mini Project	Describe the role of amino acid sequencing for enzyme production
	SW5.3 Other Activities (Specify)	Prepare a detail document on genetic engineering for novel enzyme and protein production

Course duration (in hours)to attain Course Outcomes:

Course Title: Enzyme Technology **Course Code:**56MB202

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-56MB202.1: Familiarization with the structure, functions, and mechanism of action of enzymes, as well as the kinetics of enzyme-catalyzed processes and the mechanisms by which enzymes are inhibited.	9	4	5	1	19
CO2-56MB202.2: Development of critical skills for microbial sources for screening of enzymes and different categories of enzyme assays	9	4	5	1	19
CO3-56MB202.3: Acquired Skills of microbial enzyme isolation and purification for their potential future usage.	9	4	5	1	19
CO4-56MB202.4: Recognize various methodsfor characterization of enzyme isolated from different sources.	10	4	5	1	20
CO5-56MB202.5: Explore application of microbial enzymes for improvement and development of novel products.	8	4	5	1	18
Total Hours	45	20	25	05	95

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

Course Title: Enzyme Technology **Course Code:**56MB202

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-56MB202.1: Familiarization with the structure, functions, and mechanism of action of enzymes, as well as the kinetics of enzyme-catalyzed processes and the mechanisms by which enzymes are inhibited.	2	1	1	1	5
CO2-56MB202.2: Development of critical skills for microbial sources for screening of enzymes and different categories of enzyme assays	2	4	2	2	10
CO3-56MB202.3: Acquired Skills of microbial enzyme isolation and purification for their potential future usage.	2	3	3	2	10

CO4-56MB202.4: Recognize various methodsfor characterization of enzyme isolated from different sources.	3	5	5	2	15
CO5-56MB202.5: Explore application of microbial enzymes for improvement and development of novel products.	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	Fersht A. 1985. Enzyme Structure and Mechanism. 2nd ed. W.H. Freeman andCo., New York.
2	Gutfruend H. 1972. Enzyme: Physical Principles. Wiley-Intescience, New York.
3	Price N.C., Stevens L. 1982. Fundamentals of Enzymology. Oxford UniversityPress, Oxford
4	Sumner J.B., Somers G.F. 1953. Chemistry and Methods of Enzymes. Academic Press,Inc., New York
5	Principles of Biochemistry, Lehininger, Nelson and Cox

(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. Sc. Microbiology
Semester:II Semester
Course Title: Enzyme Technology
Course Code:56MB202

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-56MB202.1: Familiarization with the structure, functions, and mechanism of action of enzymes, as well as the kinetics of enzyme-catalyzed processes and the mechanisms by which enzymes are inhibited.	2	1	3	2	2	2	3	3
CO2-56MB202.2: Development of critical skills for microbial sources for screening of enzymes and different categories of enzyme assays	3	2	2	2	2	2	3	3
CO3-56MB202.3: Acquired Skills of microbial enzyme isolation and purification for their potential future usage.	2	1	2	3	1	2	3	3
CO4-56MB202.4: Recognize various methodsfor characterization of enzyme isolated from different sources.	2	2	3	3	2	2	2	3
CO5-56MB202.5: Explore application of microbial enzymes for improvement and development of novel products.	2	2	3	3	2	2	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	**CO1-56MB202.1:** Familiarization with the structure, functions, and mechanism of action of enzymes, as well as the kinetics of enzyme-catalyzed processes and the mechanisms by which enzymes are inhibited.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	1.1,1.2,1.3,	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8, 1.9	1SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO2-56MB202.2:** Development of critical skills for microbial sources for screening of enzymes and different categories of enzyme assays	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	2.1, 2.2, 2.3,	2.1, 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	**CO3-56MB202.3:**Acquired Skills of microbial enzyme isolation and purification for their potential future usage.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	3.1,3.2,3.3,	3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8, 3.9	3SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO4-56MB202.4:** Recognize various methodsfor characterization of enzyme isolated from different sources.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10	4.1,4.2,4.3	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	**CO5-56MB202.5:** Explore application of microbial enzymes for improvement and development of novel products.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8	5.1,5.2,5.3	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
Mr. Piyush Kant Rai

Program name	**Master of Science (M.Sc.)- Microbiology**	
Semester	I	
Course Code:	56MB203	
Course title:	Immunology	Developer: Kamlesh Kumar Soni
Pre-requisite:	Students should have basic knowledge of biology and biochemistry	
Rationale:	The paper on "Immunology" in the MSc Microbiology program gives the opportunity to predict the working principle and application of numerous cells involved in defense responses. This subject will build up the basic and advanced mechanisms of immune responses during different stresses.	
Course Outcomes (COs):	CO1-56MB203.1: Understand the essential ideas and immune system cells CO2-56MB203.2: Know the fundamentals of immunoglobulins, antigens, and their classifications CO3-56MB203.3: In-depth study about the action of immune responses and their regulations CO4-56MB203.4: Discuss the various immunodeficiency-related diseases and the functionality of the immune system CO5-56MB203.5: Recognize the various immunization techniques as well as the various vaccinations	

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)	
BSC	56MB203	Immunology	3	1	1	3	8	4

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

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 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)		
BSC	56MB203	Immunology	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	56MB253	Immunology Lab	35	5	5	5	50	50	50

Unit-I: Fundamental of the Immune System

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

Approximate Hours

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

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-56MB203.1: Understand the essential ideas and immune system cells	SO 1.1: Able to define the immune system	LI 1.1: Demonstration of T-cell mediated immunity diagrammatically and with the help of animation in detail	CI 1.1: Introduction	SL 1.1: Study about the basics of the immune system
	SO 1.2: Correlate the immune system in lower and higher organisms	LI 1.2: Blood coagulation time checking of various organisms	CI 1.2: Phylogeny of the immune system	SL 1.2: Learn about defense mechanisms in lower organisms
	SO 1.3: In-depth study of specific and non-specific immune systems	LI 1.3: Microscopic observation of innate immune cells	CI 1.3: Immunity - Innate and acquired	SL 1.3: Read the working principle of the non-specific immune system
	SO 1.4: Correlate the structure of lymphoid organs		CI 1.4: Organization and structure of lymphoid organs	SL 1.4: Draw the structure of lymphoid organs and their locations in the body
	SO 1.5: Basic and advanced understanding of B and T cells		CI 1.5: Cells of the immune system	SL 1.5: Compare B-cells and T-cells
	SO 1.6: Learn the process of blood cell formation		CI 1.6: Hematopoiesis	SL 1.6: Study the stages of hematopoiesis
	SO 1.7: Understand the regulation of the immune response		CI 1.7: Regulation of the immune response	SL 1.7: Read about cytokines and their roles in immune regulation
	SO 1.8: Analyze the immune response to pathogens		CI 1.8: Immune response to pathogens	SL 1.8: Study different types of pathogens and immune response mechanisms
	SO 1.9: Review and assess knowledge of the immune		CI 1.9: Comprehensive review of immune system concepts	SL 1.9: Self-assessment and revision of all topics covered

	system			

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Describe in details the action of B-cells on defence system
	SW1.2 Mini Project	Draw well labelled diagram of different lymphoid organs
	SW1.3 Other Activities (Specify)	Watch animation on mode of action of first line of defense

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

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-56MB203.2: Know the fundamentals of immunoglobulins, antigens, and their classifications	SO 2.1: Discuss the properties of antigens and types	LI 2.1: Demonstration of Antibody-antigen interaction	CI 2.1: Antigen- properties and types	SL 2.1: Fundamental structure of immunoglobins
	SO 2.2: Comprehension of heptane and antigen	LI 2.2: To demonstrate the principles of antigen-antibody interaction and quantify the amount of antigen or antibody present in a sample using the Enzyme-Linked Immunosorbent Assay (ELISA).	CI 2.2: Super antigen, heptane carrier system	SL 2.2: Basic information about Protein-protein interaction
	SO 2.3: Build up the concept about the antibody's structures and classes		CI 2.3: Structure, classes of Immunoglobin	SL 2.3: Read the working principle of non-specific immune system
	SO 2.4: Gain the mechanism of action of immunoglobin		CI 2.4:Function of immunoglobin	SL 2.4: Read in details about the monoclonal and polyclonal antibody
	SO 2.5: How antibody is modified to get specific result		CI 2.5: Antibody engineering,	
	SO 2.6: Annotating the application of antibody modification, its specificity		CI 2.6: Hybridoma secreting monoclonal antibodies	
	SO 2.7: Learn how antibody capture the specific antigen and kills the foreign particles		CI 2.7: Antigen antibody interaction,	
	SO 2.8: Get to know how Plasma proteins fight against		CI 2.8: Complement system	

	the infection to protect the body			
	SO2.9 Revision and assessment		CI2.9 Revision and assessment	

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Describe in hybridoma technology
	SW1.2 Mini Project	Draw well labelled diagram of immunoglobin and mention their types
	SW1.3 Other Activities (Specify)	Watch animation on Antibody-antigen interaction mechanism

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	4	01	02	16

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO3-56MB203.3: In-depth study about the action of immune responses and their regulations	SO 3.1: Discuss about how immune cell are activated	LI3.1: To investigate the activation of B lymphocytes in vitro using specific antigens and measure the proliferation and antibody production of the activated B cells.	CI 3.1: Regulation of immune response-introduction	SL 3.1: Figure out the fundamental differences between humoral and cell mediated immune responses
	SO 3.2: Able to summarize the working of immune system	Li3.2 prepare the reagent to get check the WBC count	CI 3.2: Generation of humoral immune system	SL 3.2: Advance the knowledge of regulation of B & T cell on exposure to the antigens
	SO 3.3: Distinguish the humoral and cell mediated system		CI 3.3: Generation of cell mediated immune system	
	SO 3.4: Able to explain about B cells and their role in immunity		CI 3.4: Activation of B lymphocytes	
	SO 3.5: Interpret the T cell mediated immunity		CI 3.5: Activation of T lymphocytes	
	SO 3.6: Able to visualize the mechanism of. activation of immune cells		CI 3.6: Cytokines and its function	
	SO 3.7: Learn how antibody capture the specific antigen and kills the foreign particles		CI 3.7: Regulation of B & T cell	
	SO 3.8: How MHC plays a key role during antigen exposures		CI 3.8: Structure and function of MHC molecules	

	SO3.9 Revision and assessment		CI3.9 Revision and assessment	

Suggested Sessional Work (SW): *anyone*	Assignments:	Discuss about cytokines and their role in immune responses
	Mini Project:	Draw structure of MHC and its mechanism of action
	Other Activities (Specify):	Watch animation on explaining the functionality of cell mediated immune system

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

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO4-56MB203.4: Discuss about the various immunodeficiency related diseases and functionality of immune system	SO 4.1: Discuss about the immunogenic response on allergens exposure	LI 4.1: Learn the mechanism of CD4 associated with cancer cell lines	CI 4.1: Hypersensitivity-Introduction	SL 4.1: Learn the hypersensitivity
	SO 4.2: Classify the differences delayed and immediate hypersensitivity	LI 4.2: To detect the presence of autoantibodies in patient serum samples using the indirect immunofluorescence technique.	CI 4.2: Delayed and immediate hypersensitivity	SL 4.2: Mode of action of HIV
	SO 4.3: able to brief on fundamental of autoimmunity		CI 4.3: Autoimmunity-Introduction	SL 4.3: Details study about T-cells role in helping B-cells
	SO 4.4: able to understand the various diseases and their mechanism of origin		CI 4.4: Types of autoimmune diseases	
	SO 4.5: Understand how programmed cells death occurs		CI 4.5: Mechanism of CD-4+	
	SO 4.6: Gain the subjective information on advance mechanism of autoimmunity		CI 4.6: Mechanism T-cell in autoimmunity	
	SO 4.7: Able to summarize the mechanism of MHC class -I & class-II for autoimmunity		CI 4.7: Mechanism MHC and TCR in autoimmunity	
	SO 4.8: Discuss various immune attacking diseases		CI 4.8: AIDS and immunodeficiency disorder	

	SO4.9 Revision and assessment		CI4.9 Revision and assessment	

Suggested Sessional Work (SW): *anyone*	Assignments:	Differentiate the CD4 from CD8
	Mini Project:	Describe the AIDS in details
	Other Activities (Specify):	Watch animation on Antibody-antigen interaction mechanism

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

Course outcome (COs)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO5-56MB203.5: Recognize the various immunization techniques as well as the various vaccinations	SO 5.1: Explain body fight against the infection	LI 5.1: Learn the mechanism of CD4 associated with cancer cell lines	CI 5.1: Immunity to infection	SL 5.1: Apply idea of Infection to suppress the immunity to human health
	SO 5.2: illustrate the function of immunity against the tumor cells.	LI 5.2: To perform an Enzyme-Linked Immunosorbent Assay (ELISA) to detect and quantify the presence of specific antibodies in a sample.	CI 5.2: Immunity to tumors	SL 5.2: Rerevise the ELSIA for several diseases' diagnosis
	SO 5.3: Illustrate the vaccine technology		CI 5.3: Vaccinology- Introduction	
	SO 5.4: learn the immunization methods		CI 5.4: Active and passive immunization	
	SO 5.5: Able to related various types of vaccine's mechanisms		CI 5.5: Live, killed & subunit vaccine,	
	SO 5.6: Get to know how RDT help to create the new vaccines		CI 5.6: Recombinant and protein-based vaccine and	
	SO 5.7: Learn how plant can be exploited to develop the vaccines		CI 5.7: Plant-based vaccine.	
	SO 5.8: Demonstrate about various techniques related to disease detection		CI 5.8: Immunoassay- RIA, ELISA, ELISPOT assay	
	SO 5.9: How blotting		CI 5.9: Western blotting and	

	techniques is used to identify the sample		immunofluoroscense	

Suggested Sessional Work (SW): Anyone	Assignments:	Detail explanation of principle of vaccine production
	Mini Project:	Discuss about the western blotting techniques and it application in infection detection
	Other Activities (Specify):	How ELISA functioning different from RIA ; Study in details

Course duration (in hours) to attain Course Outcomes
(Course title: Immunology) (Course code: 56MB203)

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1: Understand the essential ideas and immune system cells	9	4	5	1	19
CO2: Know the fundamentals of immunoglobulins, antigens, and their classifications	9	4	4	1	18
CO3: In-depth study about the action of immune responses and their regulations	9	4	2	1	16
CO4: Discuss about the various immunodeficiency related diseases and functionality of immune system	9	4	3	1	17
CO5: Recognize the various immunization techniques as well as the various vaccinations	9	4	2	1	16
Total Hours	45	20	16	05	86

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome: (Course title: Immunology) (Course code: 56MB203)					
Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-56MB303.1: Understand the essential ideas and immune system cells	2	1	1	1	5
CO2-56MB303.2: Know the fundamentals of immunoglobulins, antigens, and their classifications	2	4	2	2	10
CO3-56MB303.3: In-depth study about the action of immune responses and their regulations	3	5	5	2	15
CO4-56MB303.4: Discuss about the various immunodeficiency related diseases and functionality of immune system	2	3	3	2	10
CO5-56MB303.5: Recognize the various immunization techniques as well as the various vaccinations	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**
Legend: A-Apply, A- Analyze, E- Evaluate, C- Create					

Suggested learning Resources:

S.no.	Title	Author	Publisher	Edition & Year
1	Cellular and Molecular Immunology	Abbas AK, Lichtman AH, Pillai S.	Saunders Publication, Philadelphia	10 & 2019
2	Roitt's Essential Immunology	Delves P, Martin S, Burton D, Roitt IM.	Wiley- Blackwell Scientific Publication, Oxford	13 & 2017
3	Kuby Immunology	Jenni Punt, Sharon Stranford, Patricia Jones	Macmillan · Imprint, WH Allen	8 & 2018

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Cement Plant
7. Demonstration

8. ICT Based teaching Learning (Video Demonstration/Tutorials CBT, Blog, Facebook, Twitter, WhatsApp, Mobile, Online sources)
9. Brainstorming

CO/PO Mapping (Range 1: Low, 2: Medium, 3:High)								
Course Outcomes	Program Outcomes (POs)					Program Specific Outcomes (PSOs)		
COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3
CO1-56MB302.1: Understand the essential ideas and immune system cells	1	1	-	1	1	1	2	3
CO2-56MB302.2: Know the fundamentals of immunoglobulins, antigens, and their classifications	2	2	1	2	1	1	2	3
CO3-56MB302.3: In-depth study about the action of immune responses and their regulations	1	2	-	2	1	1	1	3
CO4-56MB302.4: Discuss about the various immunodeficiency related diseases and functionality of immune system	1	2	-	1	1	1	1	3
CO5-56MB302.5: Recognize the various immunization techniques as well as the various vaccinations	-	3	1	3	2	1	3	3

CO, PO and PSO Mapping

Program Title: M. Sc. Microbiology, 1st Sem
Course Code: 56MB203
Course Title: Immunology

Course Curriculum Map:					
POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	56MB203.1: Understand the essential ideas and immune system cells of microscopy	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	1 SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	56MB203.2: Know the fundamentals of immunoglobulins, antigens, and their classifications	SO2.1 SO2.2 SO2.3 SO2.4, SO2.5, SO2.6 SO2.7, SO2.8 SO2.9	LI 1 LI2	2.1, 2.2, 2.3, 2.4,2.5,2.6,2.7,2.8, 2.9	2 SL-1,2,3,4
PO 1,2,3,4,5 PSO 1,2,3	56MB203.3: In-depth study about the action of immune responses and their regulations	SO3.1 SO3.2 SO3.3 SO3.4, SO3.5, SO3.6, SO3.7, SO3.8, SO3.9, SO3.10	LI 1 LI 2	3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9,3.10.	3 SL-1,2
PO 1,2,3,4,5 PSO 1,2,3	56MB203.4. Discuss about the various immunodeficiency related diseases and functionality of immune system	SO4.1 SO4.2 SO4.3 SO4.4, SO4.5, SO4.6, SO4.6, SO4.7, SO4.8, SO4.9, SO4.10.	LI 1 LI2	4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8,4.9,4.10	4 SL-1,2,3
PO 1,2,3,4,5 PSO 1,2,3	56MB203.5. Recognize the various immunization techniques as well as the various vaccinations	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	5 SL-1,2

Curriculum Development Team
Prof. Kamlesh Choure
Prof Ashwini A. Waoo
Prof. Deepak Mishra
Er. Arpit Srivastava
Mr. Piyush Kant Rai

Program Name	**Masters of Science (M.Sc.)-Microbiology**	
Semester	II	
Course Code:	56MB204	
Course title:	Environmental Microbiology	**Curriculum Developer**: Mr. Paras Koshe, Assistant Professor
Pre-requisite:	Student should have basic knowledge of Environmental science and Biotechnology	
Rationale:	The Environmental Microbiology course aims to introduce and elaborate the fundamental concepts and applications of microbiology in all aspects of environment including its protection, restoration and sustainability. Considering the rising challenges of climate change, energy and environmental crisis, this course will emphasize upon the recent development of microbiology for harnessing microbial potential in environmental applications. The course is structured to provide the students with fundamental concepts of environmental microbiology, highlighting the importance of microbial ecology, their metabolism, and methods for their characterization and scopes for implementation. Bioremediation and biodegradation principles, processes and applications will be discussed along with advanced applications in wastewater, oil recovery, bio hydrometallurgy, bio fuel, carbon storage and capture, etc. This course will offer the students a broad sense of understanding on how modern biotechnology is developed to achieve better environmental protection and sustainability through the use of microbes and microbial communities in pollution abatement to mitigation of climate change, bio energy, and biomaterial to enzyme discovery.	
Course Outcomes (COs):	**CO1-**56MB204.**1:** Understand background knowledge and scope of microbial ecology**,** microbial interaction**,** population ecology and regulation. **CO2-**56MB204..**2:** Acquire knowledge about Microbiology of air and to explain the significance of Air micro flora **CO3-** 56MB204.**3**: Student will able to understand the microbiology of soil and process and application of bioleaching. **CO4** 56MB204.**4**: To understand the microbiology of water and learn about the different methods of water analysis and water borne diseases and their control measures. **CO5-**56MB204**. 5:** Learn about Microbiology of waste water and different waste water treatment techniques and : physiology, morphology, biochemistry of microbial biofilms	

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)	
PCC	56MB204	Environmental Microbiology	3	1	1	3	8	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)		
PC	56MB204	Environmental Microbiology	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	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		

			7 marks each (CA)						
PCC	56MB254	Environmental Microbiology Lab	35	5	5	5	50	50	50

Course curriculum:

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

Approximate Hours

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

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-56MB204.**1.** Understand background knowledge and scope of microbial ecology , microbial interaction, population ecology and regulation	**SO1.1** Summarize the basic concepts and types of microbial habitats		**Unit 1 Microbial ecology** **CI1.1** Basic concepts, types and microbial habitats	**SL1.1** Role of Microbiology in environment
	SO1.2 Define the various factors affecting microbial population.		**CI1.2** factors affecting microbial population	**SL1.2** Find out new approaches of bioremediation and use of microorganisms in bioremediation
	SO13 Learn about		**CI 1.3** Microbial	**SL1.3** Understand the basic

	the microbial interactions and their types.		interactions: competition and commensalism .	knowledge of biodegradation and correlate with bioremediation.
	SO1.4 Describe different examples of parasitism and mutualism.		**CI 1.4** parasitism and mutualism	
	SO 1.5 Describe different examples commensalisms and synergism.		**CI1.5** commensalisms, synergism	
	SO.1.6 Over viewing population ecology and various characteristics of populations.		**CI1.6** Population ecology: characteristics of population,	
	SO 1.7 Focus on population growth curves with reference to r and k selection.		**CI1.7**population growth curves (r and k selection) population regulation	
	SO1.8 Evaluate the Conservation and management of microbial diversity		**CI1.8** Conservation and management of microbial diversity	
	SO1.9 Describe the steps and mechanism of Over viewing Ethanol production		**CI1.9** biodeterioration and Biodegradation.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	i. Write about the Environmental Microbiology and its role in human welfare. ii. Write different methods of Conservation and management of microbial diversity.
	SW1.2 Mini Project	Collect the photos of r and k species and compare their characteristics?
	SW1.3 Other Activities (Specify)	visit any bioremediation plant and make a rough sketch of microbial interaction on chart

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	6	01	02	18

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
CO2-56MB204.2. Acquire knowledge about Microbiology of air and to explain the significance of Air micro flora	**SO2.1** Understand microbiology of air and know the various types of microorganism present in Air.	**LI2.1** Isolation of microorganisms from air	**Unit-II Microbiology of air** **CI2.** microorganism of air	**SL2.1** Find out various diseases caused by bacteria virus and fungi.
	SO2.2 Learn the method to enumerate or count number of microorganism present in air.	**LI2.2** Staining of bacteria .	**CI2.2** Enumeration of air micro flora	
	SO2.3 Understand air borne transmission of bacteria	**LI 2.3** Staining of fungus	**CI2.4** Brief account of air borne transmission of bacteria	**SL2.2** Find out the various ways of preventing air borne diseases and relate it with air pollution.
	SO2.5 Understand air borne transmission of fungi		**CI2.5** Brief account of air borne transmission of fungi	
	SO2.6 Understand air borne transmission of pollens		**CI2.6** Brief account of air borne transmission of pollens	
	SO2.7 Understand air borne transmission of viruses.		**CI2.7** Brief account of air borne transmission of viruses	
	SO2.8 Describe various types of Air borne diseases.		**CI2.8** Air borne diseases	
	SO2.9 Illustrate different methods of preventing air borne diseases.		**CI2.9** Prevention of Air borne diseases	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Comparative study between transmission of Bacteria viruses and fungi.

	SW2.2 Assignments	Write brief account on air borne diseases.
	SW2.2 Mini Project	Try to isolate microorganism present in air from different places of your university.
	SW2.3 Other Activities (Specify)	Focus different methods of sterilization of air. Write an article on the quality of air in urban and rural areas

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

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO3-56MB204 Student will able to understand the microbiology of soil and process and application of bioleaching.	**SO3.1** Learn about the micro flora of soil.	**LI3.1:**Isolation of microorganism fro soil sample.	**Unit-3 Soil microbiology** **CI 3.1** : Micro flora of soil	SL3.1: Explore the basic concepts of soil formation and types of soil.
	SO3.2 Describe the role of microorganism with respect to soil and plants.		**CI 3.2** soil microorganisms associated with plants: rhizosphere, mycorrhizae.	SL3.2: Learn different other techniques to study quality of soil.
	SO3.3 Understand the use of microorganism in matter decomposition.		**CI3.3**. Role of microorganisms in organic matter decomposition (cellulose, hemi cellulose, lignin)	SL3.3 Identify strain of microorganism used for bioleaching and try to culture and extract.
	SO3.4 To study about bioleaching .		**CI3.4** , Bioleaching; introduction, application of bacterial leaching	
	SO3.5 Elucidate the process of Bioleaching and its steps		**CI3.5** Leaching techniques	
	SO3.6 Outline the Properties of bioleaching		**CI3.6** Properties of bioleaching	
	SO3.7 Define Microbial degradation of xenobiotics		**CI3.7** Microbial degradation of xenobiotics	
	SO3.8 Analyze the role of living Bio things in environmental decay behaviours		**CI3.8** petroleum and oil spills in environmental decay behaviors	

	SO3.9 Describe various types of environmental decay behaviors and degradative plasmid.		**CI3.9** environmental decay behaviours and degradative plasmid.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	**Assignments:** • Explain soil microorganisms associated with plants. • Explain the process of bioleaching
	SW3.2 Mini Project	Write an article on plant growth promoters.
	SW3.3 Other Activities (Specify)	Find out some Bioremediation sites in your area or nearby cities, Also find microorganism and plant species found in your lab or area which can be used as bioleaching and bioremediation.

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)**
CO456MB204 **.4**: To understand the microbiology of water and learn about the different methods of water analysis and water borne diseases and their control measures.	**SO4.1**. To study the concept of Water microbiology	**LI4.1**Determination of dissolved oxygen of water sample.	**Unit-IV** **CI 4.1** Water microbiology	**SL4.1** Learn various water conservation strategies
	SO4.2 To learn about various types of aquatic microorganisms.	**LI4.2** Determination of biological oxygen demand	**CI 4.2** Aquatic microorganisms	**SL4.2** Understand the importance of water and learn about water borne diseases.
	SO4.3 To learn the types of fresh water and sea water microflora	**LI4.3** Determination of chemical oxygen demand (COD) of water sample.	**CI 4.3** fresh water and sea water microflora	
	SO4.4 Elucidate role of microorganisms in water quality		**CI 4.4** Microorganisms and water quality,	

	SO4.5 Analyze various aspects of water pollution and its causes.		**CI 4.5** water pollution.	
	SO4.6 To study about Water purity test and indicator organisms,		**CI 4.6** Water purity test and indicator organisms	
	SO4.7 To learn about different methods in studying water quality control. BOD		**CI 4.7** method used in environmental studies – BOD	
	SO4.8 To learn about different methods in studying water quality control. DO and COD		**CI 4.** method used in environmental studies – COD and DO	
	SO4.9 Elucidate the Common water born disease and their control measure.		**CI 4.9** Common water born disease and their control measure	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	1. Explain fresh water and sea water micro flora 2. Describe the various causes of water pollution.
	SW4.2 Mini Project	Try to find out the BOD values of different water samples of your university
	SW4.3 Other Activities (Specify)	Prepare one article on water quality of your locality.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	06	01	01	17

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction(LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO456MB204. **5** Learn about Microbiology of waste water and different waste water treatment techniques and : physiology, morphology, biochemistry of microbial biofilms	**SO5.1**Over viewing of Microbiology of waste water and effluent treatments	**LI5.1** to isolate bacteria from water sample	**Unit-V** **CI5.1**Microbiology of waste water and effluent treatments	**SL5.1** Remember microbiology of waste water and effluent treatments
	SO5.2 To know about aerobic process	L**I5.2** to check the metabolite production capacity of bacteria	aerobic process	

	SO5.3 Explain about primary, secondary and tertiary treatment	**LI5.3** To check the BOD and Cod of the water sample	**CI5.2** primary, secondary and tertiary treatment	
	SO5.4 To study role of trickle filter, oxidation ponds and stabilization ponds in waste water treatments.		**CI5.3**trickle filter ,oxidation ponds and stabilization ponds.	
	SO5.5 Describe the importance and Principle of aerobic digestion.		**CI5.4** Principle of aerobic digestion.	
	SO5.6 To learn the biodegradation of various compounds		**CI5.5** Bioremediation of contaminations.	
	SO5.7 To learn about microbes with adaptation and application in ecosystem.		**CI5.6** Extremophiles – acidophilic, alkalophilic, thermophilic microbes with adaptation and application in ecosystem.	
	SO5.8 Explain about Microbial biofilms: physiology, morphology, and biochemisty of microbial biofilms		**CI5.7** Microbial biofilms: physiology, morphology, biochemisty of microbial biofilms	
	SO5.9 To learn the process Mechanism of microbial adherence and harmful role of biofilms.		**CI5.8** Mechanism of microbial adherence, beneficial and harmful role of biofilms.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Describe waste water treatment in detail.
	SW5.2 Mini Project	Make chart on extremophilic microorganism and their application
	SW5.3 Other Activities (Specify)	Write an article on biofilms and their role in environment.

Course duration (in hours) to attain Course Outcomes:

Course Title: Environmental Microbiology **Course Code:** 56MB204

Course Outcomes (COs)	Class lecture (Cl)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+Cl+SL+SW)
CO1-56MB204.**1:** Understand background knowledge and scope of microbial ecology**,** microbial interaction**,** population ecology and regulation.	9	0	3	1	13
CO2-56MB204..**2.** Acquire knowledge about Microbiology of air and to explain the significance of Air micro flora	9	6	2	1	18
CO3- 56MB204 3 Student will able to understand the microbiology of soil and process and application of bioleaching.	9	2	3	1	15
CO4 56MB204 4.To understand the microbiology of water and learn about the different methods of water analysis and water borne diseases and their control measures.	9	6	2	1	18
CO5-56MB204**. 5** Learn about Microbiology of waste water and different waste water treatment techniques and : physiology, morphology, biochemistry of microbial bio films	9	6	1	1	17
Total Hours	45	20	11	05	81

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	
CO1-56MB204.**1:** Understand background knowledge and scope of microbial ecology**,** microbial interaction**,** population ecology and regulation.	2	1	1	1	5
CO2-56MB204..**2.** Acquire knowledge about Microbiology of air and to explain the significance of Air micro flora	2	4	2	2	10
CO3- 56MB204 3 Student will able to understand the microbiology of soil and process and application of bioleaching.	3	5	5	2	15
CO4 56MB204 4.To understand the microbiology of water and learn about the different methods of water analysis and water borne diseases and their control measures.	2	3	3	2	10
CO5-56MB204**. 5** Learn about Microbiology of waste water and different waste water treatment techniques and : physiology, morphology, biochemistry of microbial biofilms	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

CO, PO and PSO Mapping

Program Name: M.Sc. Microbiology

Semester: III Semester

Course Title: Environmental Microbiology

Course Code: 56MB204

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-56MB204.**1:** Understand background knowledge and scope of microbial ecology**,** microbial interaction**,** population ecology and regulation.	2	-	-	1	2	2	2	1
CO2-56MB204..**2.** Acquire knowledge about Microbiology of air and to explain the significance of Air micro flora	-	-	-	-	-	1	1	2
CO3- 56MB204 3 Student will able to understand the microbiology of soil and process and application of bioleaching.	-	1	1	1	-	1	1	1
CO4 56MB204 4.To understand the microbiology of water and learn about the different methods of water analysis and water borne diseases and their control measures.	-	1	1	-	2	1	1	3
CO5-56MB204**. 5** Learn about Microbiology of waste water and different waste water treatment techniques and : physiology, morphology, biochemistry of microbial bio films	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-**56MB204.**1**: Understand background knowledge and scope of microbial ecology**,** microbial interaction**,** population ecology and regulation.	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**
PO 1,2,3,4,5 PSO 1,2,3	**CO2-**56MB204..**2.** Acquire knowledge about Microbiology of air and to explain the significance of Air micro flora	SO2.1 SO2.2 SO2.3 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, 2.7,2.8,2.9	**2SL-1,2**

		SO2.9			
PO 1,2,3,4,5 PSO 1,2,3	**CO3-** 56MB204 3 Student will able to understand the microbiology of soil and process and application of bioleaching.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	**LI 1**	3.1,3.2,3.3,3.4,3.5,3.6,3.7, 3.8,3.9	**3SL-1,2,3**
PO 1,2,3,4,5 PSO 1,2,3	**CO4** 56MB204 4.To understand the microbiology of water and learn about the different methods of water analysis and water borne diseases and their control measures.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	**LI 1** **LI 2** **LI 3**	4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8,4.9	**4SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO5-**56MB204**. 5** Learn about Microbiology of waste water and different waste water treatment techniques and : physiology, morphology, biochemistry of microbial bio films	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	**LI 1** **LI 2** **LI 3**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9	

Curriculum Development Team
Prof. Kamlesh Choure
Prof Ashwini A. Waoo
Prof. Deepak Mishra
Er. Arpit Srivastava
Mr. Piyush Kant Rai

Program name	Masters of Science (M.Sc.)- Microbiology	
Semester	II	
Course Code:	56MB205	
Course title:	Recent Trends in Virology and Mycology	**Developer**: Mrs. Sonal Gupta, Assistant Professor
Pre-requisite:	Students should have basic knowledge of microbiology	
Rationale:	The world is facing tremendous challenges from emerging viral and fungal diseases; hence, it is essential to learn the basic concepts of virology and mycology. Based on the basic understanding handling of pathogenic viruses and fungi students surely make their career in this area of research for developing proper treatments and cures to reduce the impact of contagious diseases. There is a continual demand for skilled virologists and mycologists in industry and research. Career opportunities in the area of virology for postgraduate students are available in the manufacturing industry and research institutes at a technical level. This course allows the student to be skilled in virus culture techniques as well as the handling of pathogenic fungal diseases.	
Course Outcomes (COs):	**CO1-56MB205.1**: To Interpret the complex interactions between viruses and host cells and the relationships between viruses **CO2-56MB205.2**: To perform various virus cultivation and isolation and identification techniques. **CO3-56MB205.3**: Correlation among various plant viruses and animal viruses and vectors and their role in disease development. **CO4-56MB205.4**: To relate different types of viral growth curves and growth patterns by different examples of viruses and bacteriophages **CO5-56MB205.5**: To compare various classes of fungi, specific culture media for growth and role and relationship of fungi in the environment	

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)	
PCC	56MB255	Recent Trends in Virology and Mycology Lab	3	1	1	3	8	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	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
PC	56MB205	Recent Trends in Virology and Mycology	**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)		
PCC	56MB255	Recent Trends in Virology and Mycology Lab	35	5	5	5	50	50	50

Course-Curriculum:

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

Approximate Hours

Item	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)**
CO1-56MB205.1: To Interpret the complex interactions between viruses and host cells	**SO1.1** Define and describe discovery of viruses	**LI1.1** Demonstration of viral particles diagrammatically and with the help of animation in detail	**CI1.1** General characteristics and composition of Prokaryotes.	**SL1.1** Search various reference books and study material to start the learning of viruses
	SO1.1 Explain the general properties and	**LI1.2** Diagrammatic evaluation of viral replication in host cell	**CI1.2** General characteristics and composition of Eukaryotes.	**SL1.1** Virus structure study based on electron microscopy
	SO1.2 Elaborate ultrastructure of viruses		**CI1.3** General properties of viruses	**SL1.3** Prepare and draw ultra structure of virus and practice it .
	SO1.3 Differentiating the viruses based on genetic constituents		**CI1.4** Morphology and ultrastructure of viruses.	**SL1.4** Learn about various human viral infection
	SO1.5 Understanding and analyzing the staining and screening technique for different microorganisms.		**CI1.5** Classification of Microorganisms.	**SL1.5** Practice to draw different types of capsid arrangements
	SO1.6 Explain in details mode of replication of viruses: Lytic cycle		**CI1.6** Haeckel's three kingdom concept.	

	SO1.7 Lysogenic replication of virus		**CI1.7** Whittaker's Five Kingdom Concept.	
	SO1.8 Revision		**CI1.8** Revision	
	SO1.9 Assessment		**CI1.9** Assessment	

Assignments:	Describe in detail ultrastructure of virus
Mini Project:	Draw various types of capsid arrangements in virus
Other Activities (Specify):	Watch animation of virus particles and capsid arrangements available online

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

Course Outcome (CO)	Session Outcomes (SOs)	LaboratoryInstruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO2-56MB205.2: To perform various virus cultivation and isolation and identification techniques.	**SO2.1** To perform cultivation of virus: Chick embryonic egg method	**LI2.1** To perform virus cultivation techniques.	**CI2.1** Cultivation of viruses- in embryonated eggs	SL2.1 Read the cultivation methods of viruses
	SO2.2 Explain the isolation of viruses by animal inoculation	**LI2.2** To perform various serological techniques to detect viral diseases.	**CI2.2** Cultivation of viruses- in experimental animals	**SL2.2** Role of cell lines for virus culture.
	SO2.3 Isolation of viruses by animal cell culture		**CI2.3** Cultivation of viruses- By animal tissue culture	**SL2.3** Various assays used for virus detection
	SO2.4 Define and describe cell lines and differentiate between primary, and secondary cell lines.		**CI2.4** cell lines; primary and secondary cell lines, diploid cell culture.	**SL2.4** Learn various serological methods to detect viral disease
	SO2.5 To describe various virus detection methods: Plaque method		**CI2.5** Assay of viruses: physical and chemical methods, plaque method, pock counting and end point method.	**SL2.5** Read about various purification techniques
	SO2.6 To describe and perform various serological tests for identification of viral diseases.		**CI2.6** Serological methods: hemagglutination, hemagglutination inhibition, neutralization test, complement fixation, ELISA, RIA.	
	SO2.7 Describe about various methods		**CI2.7** Purification of viruses: gradient	

	and techniques used to purify viruses.		centrifuge, electrophoresis, and chromatography.	
	SO2.8 Revision		**CI2.8** Revision	
	SO2.9 Assessment		**CI2.9** Assessment	

Assignments:	Describe in detail cultivation of viruses.
Mini Project:	Various serological methods to detect the viral diseases.
Other Activities (Specify):	How do we develop serological methods to detect various viral diseases?

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)**
CO3-56MB205.3: Correlation among various plant viruses and animal viruses and vectors and their role in disease development.	**SO3.1** Explain the plant viruses.	**LI3.1** Demonstrate symptoms of viral diseases in the plants. **SO3.2**	**CI3.1** Plant viruses: recent advance in classification of plant viruses.	**SL3.1** Read about various types of plant diseases caused by viruses.
	SO3.2 Classification of plant viruses	**LI3.1** 2. Perform the production of organic acids using microbes	**CI3.2** Classify plant viruses	**SL3.2** Discuss various types of vectors

				involved in transmission of plant viral diseases.
	SO3.3 Define ultrastructure of TMV		**CI3.3** Elaborate Structure of TMV.	**SL3.3** Read the classification of animal viruses.
	SO3.4 Explain pathogenicity of TMV		**CI3.4** Pathogenicity of TMV	**SL3.4** What is cyanophage.
	SO3.5 Describe the transmission of plant viruses		**CI3.5** Transmission of plant viruses with vector (insect, nematodes and fungi) and without vector (contact, seed and pollens).	**SL3.5** Elaborate Mycophage in detail.
	SO3.6 Explain various biochemical changes induced by plant viruses		**CI3.6** Biochemical changes induced by virus in plant cell.	
	SO3.7 Introduction on Animal viruses		**CI3.7** Animal viruses: nomenclature	
	SO3.8 Classification of animal viruses		**CI3.8** Classification of animal viruses.	
	SO3.9 General idea about Cyanophage		**CI3.9** General introduction of Cyanophages	

	SO2.10 Explain Mycophages.		**CI3.10** Overview on Mycophages	

Assignments:	Describe in detail the nomenclature and classification of plant and animal viruses.
Mini Project:	Describe the role of vectors in the transmission of animal viral diseases.
Other Activities (Specify):	Prepare one article on the diversity of the different types of plant viruses and their involvement in various plant viral diseases.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	10	04	01	03	18

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO4-56MB205.4: To relate different types of viral growth curves and growth patterns by different examples of bacteriophages	**SO4.1** Describe the classification of bacteriophage.	**LI4.1** To analyze the bacteriophage isolated from water samples.	**CI4.1** Bacteriophage: classification	**SL4.1** Learn about morphology and ultrastructure of bacteriophage
	SO4.2 Explain the morphology and ultrastructure of bacteriophage.	**LI4.2** To develop a model of the lytic and lysogenic cycle of bacteriophage	**CI4.2** Morphology and ultrastructure of bacteriophage	**SL4.2** Discuss mode of replication of bacteriophages based on self-study
	SO4.3 Evaluate the one-step growth		**CI4.3** One step growth curve (latent	**SL4.3** Learn about various types of

	curve of bacteriophage		period, eclipse period, and burst of size.)	bacteriophages and their applications
	SO4.4 Define and describe the lytic cycle of bacteriophage.		**CI4.4** Life cycle: lytic cycle of bacteriophages	
	SO4.5 Define and describe the lysogenic cycle of bacteriophage.		**CI4.5** Life cycle: lysogenic cycle of bacteriophages.	
	SO4.6 Describe the M13.		**CI4.6** Explain M-13 bacteriophage in detail.	
	SO4.7 Explain Mu		**CI4,7** Overview on Mu bacteriophage.	
	SO4.8 Define T4 bacteriophage structure		**CI4.8** Elaborate T4 Bacteriophage.	
	SO4.9 Explain the application of Ø x174		**CI4.9** Describe Ø x174 in detail.	
	SO4.10 Explain lambda phage		**CI4.10** Explain Lambda phage in detail	

Assignments:	Explain life cycle of bacteriophage
Mini Project:	Describe the various types of bacteriophages and their applications
Other Activities (Specify):	Prepare one article on the diversity of bacteriophages

Item	Cl	LI	SW	SL	Total
Approx. Hrs	11	04	01	04	20

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO5-56MB205.5: To compare various classes of fungi, specific culture media for growth and role and relationship of fungi in the environment	**SO5.1** Explain the classification of Fungi	**LI5.1** Isolation of fungus from natural resources.	**CI5.1** Structure of fungi.	**SL5.1** Find out the role of mycorrhiza as biofertilizers
	SO5.2 reproduction methods in fungi	**LI5.2** Collect the samples of mycorrhiza and lichen from your area.	**CI5.2** Reproduction and classification of fungi,	**SL5.2** Explore the various kinds of symbiotic association made by fungus
	SO5.3 Describe general characteristics of major classes of fungi		**CI5.3** General characteristics of Zygomycetes, Ascomycetes, Basidiomycetes, and Deuteromycetes.	**SL5.3** Make a chart on fungal classification
	SO5.4 **3** Understand the various methods of cultivation of fungi,		**CI5.4** Cultivation methods of fungi.	**SL5.4** Elaborate Lichen.
	SO5.5 Explain culture media for fungal cultivation		**CI5.5** Describe various culture media for fungal growth	
	SO5.6 Describe various factors affecting fungal growth		**CI5.6** Effects of environmental factors on growth	
	SO5.7		**CI5.7**	

	Understand various methods of fungal identification		Isolation and identification of fungi.	
	SO5.8 Various methods of fungus preservation		**CI5.8** Preservation methods for fungi	
	SO5.9 Understand general characteristics, morphology and reproduction methods in dimorphic fungi		**CI5.9** Dimorphic fungi, yeast morphology, general characteristics and reproduction.	
	SO5.10 Explain Mycorrhiza, Lichen and Actinomycetes		**CI5.10** Elaborate Lichens, Mycorrhiza, and Actinomycetes.	
	SO5.11 Explore the concept of fungicidal and fungistatic		**CI5.11** Ecology of fungi: concept of fungistatic and Fungicides	

Assignments:	Describe in detail the nomenclature and classification of fungi.
Mini Project:	Describe the concept of fungicidal and fungistatic.
Other Activities (Specify):	Prepare one article on the isolation, identification and preservation of fungi.

Course duration (in hours) to attain Course Outcomes:

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

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Sessional work (SW)	Self-Learning (SL)	Total Hours (Li+CI+SL+SW)
CO1-56MB205.1: To Interpret the complex interactions between viruses and host cells and the relationships between viruses	09	04	01	05	**19**
CO2-56MB205.2: To perform various virus cultivation and isolation and identification techniques.	09	04	01	03	**19**
CO3-56MB205.3: Correlation among various plant viruses and animal viruses and vectors and their role in disease development.	10	04	01	05	**20**
CO4-56MB205.4: To relate different types of viral growth curves and growth patterns by different examples of viruses and bacteriophages	10	04	01	03	**18**
CO5-56MB205.5: To compare various classes of fungi, specific culture media for growth and role and relationship of fungi in the environment	11	04	01	04	**20**
Total Hours	**47**	**20**	**05**	**20**	**92**

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

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

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-56MB205.1: To Interpret the complex interactions between viruses and host cells and the relationships between viruses	2	1	1	1	**5**
CO2-56MB205.2: To perform various virus cultivation and isolation and identification techniques.	2	4	2	2	**10**
CO3-56MB205.3: Correlation among various plant viruses and animal viruses and vectors and their role in disease development.	3	5	5	2	**15**
CO4-56MB205.4: To relate different types of viral growth curves and growth patterns by different examples of viruses and bacteriophages	2	3	3	2	**10**
CO5-56MB205.5: To compare various classes of fungi, specific culture media for growth and role and relationship of fungi in the environment	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	Edition & Year
1	Virology	Renato Dulbecco and Harold S. Ginsberg	J.B. Lippincott Company, USA	Fourth edition
2	An Introduction to viruses	S. B. Biswas and	Vikas Publishing	Fourth edition

		Amita Biswas	House PVT LTD New Delhi	
3	Textbook of Microbiology	Ananthnarayanan and Paniker	Universities Press	eighth edition
4	Microbiology	Lansing M Prescott, John P. Harley, Donald A Klein	Sixth edition	Mc Graw Hill Higher education
5	Introductory Mycology	Alexopoulos, C. Jr	Second edition	Wiley, New York.

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.Sc. Microbiology
Semester: I Semester
Course Title: Recent Trends in Virology and Mycology
Course Code: 56MB205

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-56MB205.1: To Interpret the complex interactions between viruses and host cells and the relationships between viruses	2	-	-	1	2	2	1	1
CO2-56MB205.2: To perform various virus cultivation and isolation and identification techniques.	-	-	-	-	-	1	2	-
CO3-56MB205.3: Correlation among various plant viruses and animal viruses and vectors and their role in disease development.	-	1	1	1	-	1	1	1
CO4-56MB205.4: To relate different types of viral growth curves and growth patterns by different examples of viruses and bacteriophages	-	1	1	-	2	2	1	3
CO5-56MB205.5: To compare various classes of fungi, specific culture media for growth and role and relationship of fungi in the environment	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	**CO1-56MB205.1**: To Interpret the complex interactions between viruses and host cells and the relationships between viruses	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, 2.8, 2.9	**1SL-1, 2, 3, 4, 5**
PO 1,2,3,4,5 PSO 1,2,3	**CO2-56MB205.2**: To perform various virus cultivation and isolation and identification techniques.	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	**CO3-56MB205.3**: Correlation among various plant viruses and animal viruses and vectors 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	their role in disease development.	SO3.5 SO3.6 SO3.7 SO3.8 SO3.9 SO3.10		3.9, 3.10	
PO 1,2,3,4,5 PSO 1,2,3	**CO4-56MB205.4**: To relate different types of viral growth curves and growth patterns by different examples of viruses and bacteriophages	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10	**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 PSO 1,2,3	**CO5-56MB205.5**: To compare various classes of fungi, specific culture media for growth and role and relationship of fungi in the environment	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9 SO5.10 SO5.11	**LI 1** **LI 2**	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 5.10, 5.11	**5SL-1, 2, 3, 4**

Curriculum Development Team
Prof. Kamlesh Choure
Prof Ashwini A. Waoo
Prof. Deepak Mishra
Er. Arpit Srivastava
Mr. Piyush Kant Rai

Program Name	**Master of Science (M. Sc)- Microbiology**	
Semester	II	
Course Code:	56MB206	
Course title:	Genetic Engineering and Genomics	**Curriculum Developer**: Dr. Ashwini A. Waoo, Professor
Pre-requisite:	Student should have basic knowledge of DNA, Genome, Vector etc.	
Rationale:	Genetic engineering and genomics in microbiology enable precise manipulation of microorganisms for diverse applications like medicine, agriculture, and biotechnology. Understanding the genetic makeup through genomics aids in studying microbial diversity, evolution, and potential pathways for novel product development. These fields offer insight into disease mechanisms, facilitating targeted therapies and vaccine development. They also contribute to enhancing crop yield and sustainability through genetically modified organisms (GMOs). Studying genetic engineering and genomics is pivotal for advancing microbiology and its applications in various industries.	
Course Outcomes (COs):	**CO1-56MB206.1:** Understanding the basic steps of gene cloning and the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering. **CO1-56MB206.2:** Getting detailed knowledge of identifying suitable hosts for cloning and learning gene libraries **CO1-56MB206.3:** Acquiring theoretical knowledge in the techniques, tools, application of genetic engineering. **CO1-56MB206.4:** Describes the genome mapping and sequencing and methods and DNA fingerprinting **CO1-56MB206.5:** Evaluate applications of recombinant technology in Medicine, agriculture and other filelds.	

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 (PCC)	56MB206	Genetic Engineering and Genomics	3	01	1	1	6	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)		
DSC	56MB206	Genetic Engineering and Genomics	**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)		
DSC	56MB256	Genetic Engineering and Genomics Lab	35	5	5	5	50	50	50

Curriculum detail

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

Approximate hrs.

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

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-56MB206.1: Understanding the basic steps of gene cloning and the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering.	**SO1.1** Understand Enzymes used in DNA technology: Restriction and modification enzymes,	LI1.1 Preparation reagent and gel for DNA extraction	**Unit-1** **CI1.1** Enzymes used in DNA technology: Restriction and modification enzymes,	Study of DNA modifying enzymes
	SO1.2 Illustration of		**CI1.2** nucleases, polymerases, ligase,	**1.2** What are linkers and adaptors

	nucleases, polymerases, ligase, kinases and phosphatases. Linkers and adapters		kinases and phosphatases. Linkers and adapters.	
	SO1.3 Understand use and types of Cloning vectors		**CI1.3** Cloning vectors: Plasmids, Phages (Lamda and M13) Phagmids, Cosmids and Expression vectors.	**1.3** Write ideal features of best cloning
	SO1.4 Understand Cloning vectors for Yeast		**CI1.4** Cloning vectors for Yeast (shuttle vector and YAC) and	
	SO1.5 Learn cloning vector for animal cells		**CI1.5** cloning vector for animal cells: SV 40, Vaccinia and Retroviruses.	**1.4** What is micrometry ?
	SO1.6 Demonstration of Cloning techniques: DNA isolation	LI1.2 DNA Isolation from Bacteria	**CI1.6** Cloning techniques: DNA isolation (Bacteria, Fungi, Plant and animal),	
	SO1.7 Knowledge about the Insert preparation, Ligation		**CI1.7** Insert preparation, Ligation,	
	SO1.8 Knowledge about Transformation methods		**CI1.8** Transformation methods (chemical methods, Electroporation and microinjection), Transfection.	**SL1.5** List out advantages of newer techniques of microscopy
	SO1.9 Revision and assessment		**CI1.9** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Prepare chart of all DNA modifying enzymes and their mode of action and application
	SW1.2 Mini Project	Prepare a draft on types of cloning vectors
	SW1.3 Other Activities (Specify)	Find out transformation methods, their advantages and disadvantages.

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)
CO1-56MB206.2: Getting detailed knowledge of identifying suitable hosts for cloning and learning gene libraries	**SO2.1** Understand the basic principles Genomic and cDNA library.	**LI2.1** to create cDNA library	**Unit-II** **CI2.1** Genomic and cDNA library.	**SL2.1** Learn types gene library
	SO2.2 Illustration of Screening of clones from libraries	**LI2.2** to perform ADRA-PCR	**CI2.2** Screening of clones from libraries:	**SL2.2** List of techniques of screening
	SO2.3 Understand use of Expression based screening		**CI2.3** Expression based screening,	**SL2.3** Learn about Gel filtration technique
	SO2.4 Understand use of Interaction based screening		**CI2.4** Interaction based screening.	**SL2.3** Discuss the applications of Interaction based screening
	SO2.5 Assessing the need of Expression vectors,		**CI2.5** Gene Expression: Expression vectors,	
	SO2.6 Explaining the factors affecting expression of cloned gene in E. coli.		**CI2.6** factors affecting expression of cloned gene in E. coli.	
	SO2.7 Explaining Mutagenesis		**CI2.7** Mutagenesis: Site directed mutagenesis,	**SL2.5** Study mutagenesis in detail
	SO2.8 Understand Transposon mutagenesis		**CI2.8** Transposon mutagenesis.	
	SO2.9 Revision and assessment		**CI2.9** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe principles and types gene library
	SW2.2 Mini Project	Prepare complete draft on expression vectors and screening methods
	SW2.3 Other Activities (Specify)	Describe site directed mutagenesis with diagram

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)
CO1-56MB206.3: Acquiring theoretical knowledge in the techniques, tools, application of genetic engineering.	**SO3.1** Illustrate the basic principle of DNA Sequencing:		**Unit-III** **CI3.1** DNA Sequencing: Sangers method, Maxmam Gilbert method,	**SL3.1** Read recent DNA sequencing techniques
	SO3.2 Illustration of Thermo cycle sequencing	LI3.1 Demonstration of PCR	**CI3.2** Thermo cycle sequencing and Pyrosequencing Principles of hybridization and	**SL3.2** Explain Thermo cycle sequencing
	SO3.3 Understand hybridization based techniques		**CI3.3** hybridization based techniques: Colony, plaque, in-situ Hybridization,	**SL3.3** Illustration about Colony, plaque, in-situ Hybridization,
	SO3.4 Evaluate the applications of Southern, Northern, Western blotting.	LI 3.2 Kit based demonstration of southern blotting	**CI3.4** Southern, Northern, Western blotting.	
	SO3.5 Describe Oligonucleotide synthesis, Restriction mapping,		**CI3.5** Oligonucleotide synthesis, Restriction mapping, S1 nuclease and RNase mapping.	
	SO3.6 Illustrate gradient electrophoresis		**CI3.6** Polymerase Chain Reaction (PCR): Principle, Types and	**SL3.4** Write a note on PCR
	SO3.7 Describe Polymerase Chain Reaction (PCR): Principle, Types		**CI3.7** variants of PCR (Touch -Down PCR, Hot start PCR, Inverse PCR, RT-PCR,	**SL3.5** Diagrammatically explain inverse PCR. RT-PCR
	SO3.8 Analyze the advantages of multiplex PCR, nested PCR), Real time PCR		**CI3.8** multiplex PCR, nested PCR), Real time PCR.	
	SO3.9 Revision and assessment		**CI3.9** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe principles and types of DNA sequencing
	SW3.2 Mini Project	Describe the significance, mechanism and applications of PCR
	SW3.3 Other Activities (Specify)	Prepare a draft on blotting techniques and its applications

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)**
CO1-56MB206.4: Describes the genome mapping and sequencing and methods and DNA fingerprinting	**SO4.1** Understand the basic of Molecular typing: RFLP	LI 4.1 Preapre reagent for the RFLP	**Unit-IV** **CI4.1** Molecular typing: RFLP (Ribotyping, IS based),	**SL4.1** Learn about techniques of molecular typing
	SO4.2 Illustrate RAPD, AFLP,		**CI4.2** RAPD, AFLP,	**SL4.2** Discuss applications of RAPD, AFLP
	SO4.3 Understand VNTR, SNP		**CI4.3** VNTR, SNP,	**SL4.3** Learn about VNTR, SNP
	SO4.4 Understand fluorescence Spectroscopy.		**CI4.4** Whole genome sequence:	**SL4.4** Studies related to Whole genome sequence:
	SO4.5 Evaluate the need of reporter genes,		**CI4.5** GIS Promoter characterization: promoter analysis through reporter genes,	
	SO4.6 Evaluate the need of ESR		**CI4.6** electrophoretic mobility, shift assay, DNA foot-printing &	**SL4.5** Evaluate the need and applications of DNA footprinting
	SO4.7 Analyze the advantages DNA fingerprinting	LI4.2 Demonstration of DNA fingerprinting	**CI4.7** DNA fingerprinting.	
	SO4.8 Analyze the applications of transgenic animals in current research.		**CI4.8** Transgenic animals: Strategies and methods. Construction of knockout mutants.	
	SO4.9 Revision and assessment		**CI4.9** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe principles and types of molecular typing
	SW4.2 Mini Project	Describe the whole genome sequencing in detail and its applications
	SW4.3 Other Activities (Specify)	Prepare list of transgenic animals and their applications

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)**
CO1-56MB206.5: Evaluate applications of recombinant technology in Medicine, agriculture and other filelds	**SO5.1** Understand the Applications of Recombinant DNA Technology in Medicine	LI5.1 Prepare a recombinant DNA using suitable marker	**Unit-V** **CI5.1** Applications of Recombinant DNA Technology in Medicine.	**SL5.1** learn about Applications of Recombinant DNA Technology
	SO5.2 Illustrate Molecular diagnostics,		**CI5.2** Molecular diagnostics,	**SL5.2** learn about molecular diagnostics
	SO5.3 Understand recombinant vaccines and its examples	LI5.2 To prepare a transformed gene for the vaccine development	**CI5.3** recombinant vaccines and.	**SL5.3** Give role of recombinant vaccines
	SO5.4 Understand technique of DNA vaccine and its applications		**CI5.4** DNA vaccines	**SL5.4** Learn about DNA vaccines
	SO5.5 Analyze the advantages and limitations of gene therapy		**CI5.5** Gene therapy:	
	SO5.6 Describe somatic and germ line gene therapy		**CI5.6** somatic and germ line gene therapy	

	SO5.7 Describe Applications of Recombinant DNA Technology in Agriculture		**CI5.7** Applications of Recombinant DNA Technology in Agriculture	
	SO5.8 Evaluate the applications of R DNA in industry		**CI5.8** Industry.	**SL5.5** Learn industrial recombinant products
	SO5.9 Revision and assessment		**CL5.9** revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Describe applications of R DNA technology
	SW5.2 Mini Project	Describe the gene therapy in detail
	SW5.3 Other Activities (Specify)	Prepare list of commercialized recombinant products and their applications.

Course duration (in hours) to attain Course Outcomes:

Course Title: Genetic Engineering and Genomics **Course Code:** 56MB206

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-56MB206.1: Understanding the basic steps of gene cloning and the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering.	9	4	5	1	19
CO1-56MB206.2: Getting detailed knowledge of identifying suitable hosts for cloning and learning gene libraries	9	4	5	1	19
CO1-56MB206.3: Acquiring theoretical knowledge in the techniques, tools, application of genetic engineering	9	4	5	1	19
CO1-56MB206.4: Describes the genome mapping and sequencing and methods and DNA fingerprinting	9	4	5	1	19
CO1-56MB206.5: Evaluate applications of recombinant technology in Medicine, agriculture and other filelds	9	4	5	1	19
Total Hours	45	20	25	05	95

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

Course Title: Genetic Engineering and Genomics **Course Code:** 56MB206

Course Outcomes				
	A	An	E	Total Marks
CO1-56MB206.1: Understanding the basic steps of gene cloning and the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering.	02	02	01	05
CO1-56MB206.2: Getting detailed knowledge of identifying suitable hosts for cloning and learning gene libraries	03	05	02	10
CO1-56MB206.3: Acquiring theoretical knowledge in the techniques, tools, application of genetic engineering	05	05	05	15
CO1-56MB206.4: Describes the genome mapping and sequencing and methods and DNA fingerprinting	04	03	03	10
CO1-56MB206.5: Evaluate applications of recombinant technology in Medicine, agriculture and other filelds	05	04	01	10
Total Marks	19	19	12	50

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

Suggested learning Resources:

(a) Books:

(b)

S. No.	Title
1	1. Molecular Biotechnology. Glick BR, Pasternak JJ. ASM Press Washington D.C. Principles of Gene Manipulation. Old and Primrose. Blackwell Scientific Publication.
2	Gene Cloning. T. A. Brown, Blackwell Publishing.
3	Molecular cloning- A laboratory manual, Sambrook, Fritsch and Miniatis, Cold Spring Harber Laboratory Press
4	Molecular Biotechnology 2nd Edition by S.B. Primrose. Blackwell Scientific Publishers, Oxford.
5	Genetic Engineering and Introduction to Gene Analysis and Exploitation in Eukaryotes by S.M. Kingsman and A.J. Kingsman, Blackwell Scientific Publications, Oxford.
6	PCR Technology - Principles and Applications for DNA Amplification by Henry A. Erlich (Ed.), Stockton Press.
7	Genes and Genomes: A Changing Perspective; Maxine Singer and Paul Berg. University Science Books, Mill Valley, CA, 1991

(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. Sc. Microbiology
Semester: I
Course Code: 56MB206
Course Title: Genetic Engineering and Genomics

Course Outcome	Program Outcomes (POs)					Program Specific Outcomes (PSOs)		
COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3
56MB206.1	2	2	-	1	2	3	3	3
56MB206.2	3	-	-	-	-	1	-	2
56MB206.3	2	1	-	1	-	1	1	2

56MB206.4	**-**	**1**	**-**	**2**	**2**	**1**	**2**	**3**
56MB206.5	**1**	**1**	**-**	**2**	**3**	**1**	**-**	**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	**CO1-56MB206.1:** 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	**CO1-56MB206.2:** Getting detailed knowledge of identifying suitable hosts for cloning and learning gene libraries	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	LI1, LI2	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	**CO1-56MB206.3:** Acquiring theoretical knowledge in the techniques, tools, application of genetic engineering	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, 4.8, 4.9	3SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO1-56MB206.4:** Describes the genome mapping and sequencing and methods and DNA fingerprinting	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, 4.8, 4.9	4SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO1-56MB206.5:** Evaluate applications of recombinant technology in Medicine, agriculture and other filelds	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9		5.1,5.2,5.3,5.4,5.5, 5.6, 5.7, 5.8, 5.9	5SL-1,2,3,4,5

Curriculum Development Team

Prof. Kamlesh Choure

Prof Ashwini A. Waoo

Prof. Deepak Mishra

Er. Arpit Srivastava

Piyush Kant Rai

Semester III

Program Name	**M.Sc. Microbiology**	
Semester	**Ist**	
Course Code:	**56MB301**	
Course title:	**Medical Microbiology**	**Curriculum Developer**: Mr. Piyush Kant Rai, Assistant professor
Pre-requisite:	A foundational understanding of general microbiology, basic biology, and biochemistry, along with knowledge of human anatomy and physiology, is essential for studying medical microbiology effectively.	
Rationale:	Medical Microbiology is a critical discipline within the field of healthcare and biomedical sciences, focusing on the study of microorganisms that cause diseases in humans. It encompasses various aspects, including the identification, characterization, and management of pathogenic microbes.	
Course Outcomes (COs):	**CO1-56MB301.1: Understand the classification of medically significant microorganisms and the relevance of the normal microbial flora.** **CO2-56MB301.2: Recognize the methods of disease transmission.** **CO3-56MB301.3: Be familiar with the principles underlying various serological techniques for identifying and quantifying illnesses.** **CO4-56MB301.4: Learn about virology, mycology, and medical microbiology.** **CO5-56MB301.5: Understand dermatophytes, Histoplasma, Cryptococcus, Candida, opportunistic mycoses, and mycotoxins.**	

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)	
PCC	**56MB105**	**Medical Microbiology**	3	1	1	1	6	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)		
PCC	**56MB105**	**Medical Microbiology**	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)		
PCC	56MB351	Medical Microbiology Lab	35	5	5	5	50	50	50

Course-Curriculum:

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

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	9	04	01	02	16

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

CO1-56MB301.1: Understand the classification of medically significant microorganisms and the relevance of the normal microbial flora.	**SO1.1** Overview of Infectious Diseases and Medically Important Microbes	**LI1.1** isolates the medically important from water samples	**CI1.1** Overview of Infectious Diseases and Medically Important Microbes	**SL1.1** Explain the basic principles of medical microbiology
	SO1.2 Sources and Routes of Transmission of Microbial Diseases	**LI1.2** to do the gram staining of the bacteria	**CI1.2** Sources and Routes of Transmission of Microbial Diseases	**SL1.2** Remember the microbial infection and virulence factor
	SO1.3 Pathogenesis of Microbial Infections		**CI1.3** Pathogenesis of Microbial Infections	
	SO1.4 Microbial Virulence and Virulence Factors		**CI1.4** Microbial Virulence and Virulence Factors	
	SO1.5 Treatment, Prevention, and Control of Microbial Infections		**CI1.5** Treatment, Prevention, and Control of Microbial Infections	
	SO1.6 Immunity to Microbial Diseases		**CI1.6** Immunity to Microbial Diseases	
	SO1.7 Diagnostic Methods for Microbial Infections		**CI1.7** Diagnostic Methods for Microbial Infections	

	SO1.8 Antibiotic Resistance and Mechanisms		**CI1.8** Antibiotic Resistance and Mechanisms	
	SO1.9 Emerging and Re-emerging Infectious Diseases		**CI1.9** Emerging and Re-emerging Infectious Diseases	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Summarizes microbial diseases.
	SW1.2 Mini Project	Understand the controlling of microbial infection
	SW1.3 Other Activities (Specify)	correlate the pathogenesis of the microbial infections and viral infection

Item	Cl	LI	SW	SL	Total
Approx. Hrs	9	4	1	3	**17**

Course Outcome (CO)	**Session Outcomes (SOs)**	**LaboratoryInstruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-56MB301.2: Recognize the methods of disease transmission.	**SO2.1** Collection and Transport of Clinical Specimens	**LI2.1** LI 2.1: Practice a clinical diagnosis of a typhoid test	**CI2.1** Collection and Transport of Clinical Specimens	**SL2.1** Practice sequence alignment algorithms
	SO2.2 Preliminary Processing of Clinical Specimens	LI 2.2: Perform preliminary processing of clinical specimens	**CI2.2** CI 2.2: Preliminary Processing of Clinical Specimens	**SL2.2** Recall types of disease-causing microbes

	SO2.3 Clinical Diagnosis of Microbial Diseases		**CI2.3** Clinical Diagnosis of Microbial Diseases	**SL 2.3** Review methods for clinical diagnosis of microbial diseases
	SO2.4 Microbiological Diagnosis of Microbial Diseases		**CI2.4** Microbiological Diagnosis of Microbial Diseases	
	SO2.5 Immunological Diagnosis of Microbial Diseases		**CI2.5** Immunological Diagnosis of Microbial Diseases	
	SO2.6 Molecular Diagnosis of Microbial Diseases		**CI2.6** Molecular Diagnosis of Microbial Diseases	
	SO2.7 Interpretation of Diagnostic Test Results		**CI2.7** Interpretation of Diagnostic Test Results	
	SO2.8 Quality Control in Diagnostic Testing		**CI2.8** Quality Control in Diagnostic Testing	
	SO2.9 Advanced Techniques in Diagnostic Microbiology		**CI2.9** CI 2.9: Advanced Techniques in Diagnostic Microbiology	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Justify the role of molecular diagnosis.
	SW2.2 Mini Project	Differentiate between diagnosis and treatment.
	SW2.3 Other Activities (Specify)	Incorporate some YouTube videos based on features of molecular diagnosis.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	9	4	1	2	**16**

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-56MB301.3: Be familiar with the principles underlying various serological techniques for identifying and quantifying illnesses.	**SO3.1** Introduction to Bacteriology and Staphylococci	**LI3.1** LI3.1 Collecting CFU count from microbial grown plates	**CI3.1** Introduction to Bacteriology and Staphylococci	**SL3.1** Learn how to do spread plating
	SO3.2 Learn about the characteristics, pathogenesis, and treatment of diseases caused by Streptococci and Bacillus species	**LI3.2** LI3.2 To do the antibiotic susceptibility test	**CI3.2** Learn about the characteristics, pathogenesis, and treatment of diseases caused by Streptococci and Bacillus species	**SL3.2** Applications of pathogenesis in drug discovery
	SO3.3 Clostridium and Corynebacterium		**CI3.3** Clostridium and Corynebacterium	
	SO3.4 Enteric Bacteria: Escherichia, Salmonella, and Shigella		**CI3.4** Enteric Bacteria: Escherichia, Salmonella, and Shigella	
	SO3.5 Vibrio and Pseudomonas		**CI3.5** Vibrio and Pseudomonas	
	SO3.6 Mycobacteria and Rickettsia		**CI3.6** Mycobacteria and Rickettsia	
	SO3.7 Bacterial Genetics and Mutagenesis		**CI3.7** Bacterial Genetics and Mutagenesis	
	SO3.8 Molecular Techniques in Bacteriology		**CI3.8** Molecular Techniques in Bacteriology	

	SO3.9 Antibiotic Resistance and Control Measures		**CI3.9** Antibiotic Resistance and Control Measures	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Write about pseudomonas.
	SW3.2 Mini Project	Make a flow chart of steps of pathogenesis checking
	SW3.3 Other Activities (Specify)	How many types of enteric bacteria are there make the chart of it

Item	Cl	LI	SW	SL	Total
Approx. Hrs	9	4	1	2	16

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO4-56MB301.4: Learn about virology, mycology, and medical microbiology.	**SO4.1** Understanding the structure, multiplication, and classification of DNA viruses	**LI4.1** Isolate and observe DNA viruses (Pox, Herpes, Hepatitis, Adeno) using microscopy	**CI4.1** Structure, multiplication, and classification of DNA viruses	**SL4.1** Study the basic principles of DNA virus structure and replication
	SO4.2 Poxvirus: Structure, multiplication, and medical importance	**LI4.2** Perform plaque assays to quantify Poxvirus	**CI4.2** Detailed study of Poxvirus characteristics and medical relevance	**SL4.2** Research historical and current outbreaks of Poxvirus
	SO4.3 Herpesvirus: Structure, multiplication, and medical importance		**CI4.3** Study the pathogenesis and treatment of Herpesvirus infections	
	SO4.4 Hepatitis viruses: Structure, multiplication, and medical importance		**CI4.4** Overview of Hepatitis viruses and their impact on liver diseases	

	SO4.5 Adenovirus: Structure, multiplication, and medical importance		**CI4.5** Examine the role of Adenovirus in respiratory and eye infections	
	SO4.6 Picornavirus: Structure, multiplication, and medical importance		**CI4.6** Study the diseases caused by Picornavirus (e.g., Poliovirus)	
	SO4.7 Orthomyxovirus: Structure, multiplication, and medical importance		**CI4.7** Understand the role of Orthomyxovirus in influenza outbreaks	
	SO4.8 Paramyxovirus: Structure, multiplication, and medical importance		**CI4.8** Study Paramyxovirus-related diseases (e.g., Measles, Mumps)	
	SO4.9 Rabies and HIV viruses: Structure, multiplication, and medical importance		**CI4.9** Detailed study of Rabies and HIV pathogenesis and treatments	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Write about Retroviruses.
	SW4.2 Mini Project	
	SW4.3 Other Activities (Specify)	Search and learn via YouTube abou t Virus pathogenesis.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	9	4	**1**	2	**16**

Course Outcome (CO)	**Session Outcomes (SOs)**	**LaboratoryInstruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO5-56MB301.5: Understand dermatophytes, Histoplasma, Cryptococcus, Candida, opportunistic mycoses, and mycotoxins.	**SO5.1** Understanding human mycotic infections caused by Dermatophytes	**LI5.1** Culture and identify Dermatophytes from clinical samples	**CI5.1** Study the characteristics and infections caused by Dermatophytes	**SL5.1** Review treatment options and prevention strategies for

				dermatophyte infections
	SO5.2 Understanding human mycotic infections caused by Histoplasma	**LI5.2** Perform fungal staining and culture of Histoplasma	**CI5.2** Overview of Histoplasmosis and its clinical manifestations	**SL5.2** Investigate epidemiology and management of Histoplasmosis
	SO5.3 Understanding human mycotic infections caused by Cryptococcus		**CI5.3** Study Cryptococcosis, its pathogenesis, and diagnostic methods	
	SO5.4 Understanding human mycotic infections caused by Candida		**CI5.4** Examine Candida infections, especially candidiasis and thrush	
	SO5.5 Understanding opportunistic mycoses		**CI5.5** Study various opportunistic mycoses and their clinical impact	
	SO5.6 Understanding mycotoxins and their effects		**CI5.6** Study the types of mycotoxins and their impact on human health	
	SO5.7 Understanding the medical importance of Entamoeba		**CI5.7** Study Entamoebiasis and its clinical manifestations	
	SO5.8 Understanding the medical importance of Giardia		**CI5.8** Examine Giardiasis, its symptoms, and diagnostic techniques	
	SO5.9 Understanding the medical importance of Plasmodium		**CI5.9** Study Malaria, its lifecycle, and treatment options	
	SO5.10 Understandin		**CI5.10** Study Taeniasis	

	g the medical importance of Taenia		and Cysticercosis, including lifecycle and treatments	
	SO5.11 Understandin g the medical importance of Ascaris		**CI5.11** Study Ascariasis, its lifecycle, and treatment approaches	
	SO5.12 Understandin g the medical importance of Wuchereria		**CI5.12** Study Lymphatic Filariasis, its pathogenesis, and treatments	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Write about helminths
	SW5.2 Mini Project	
	SW5.3 Other Activities (Specify)	Try to learn medical parasitology.

Course duration (in hours) to attain Course Outcomes:

Course Title: Medical Microbiology **Course Code: 56MB105**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-56MB301.1: Understand the classification of medically significant microorganisms and the relevance of the normal microbial flora.	9	4	2	1	16
CO2-56MB301.2: Recognize the methods of	9	4	3	1	17

disease transmission.					
CO3-56MB301.3: Be familiar with the principles underlying various serological techniques for identifying and quantifying illnesses.	9	4	2	1	16
CO4-56MB301.4: Learn about virology, mycology, and medical microbiology.	9	4	2	1	16
CO5-56MB301.5: Understand dermatophytes, Histoplasma, Cryptococcus, Candida, opportunistic mycoses, and mycotoxins.	9	4	2	1	16
Total Hours	45	20	11	5	81

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

Course Title: Medical Microbiology **Course Code: 56MB105**

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-56MB301.1: Understand the classification of medically significant microorganisms and the relevance of the normal microbial flora.	02	03	04	1	10
CO2-56MB301.2: Recognize the methods of disease transmission.	03	04	02	1	10
CO3-56MB301.3: Be familiar with the principles underlying various serological techniques for identifying and quantifying illnesses.	02	05	02	1	10
CO4-56MB301.4: Learn about virology, mycology, and medical microbiology.	02	05	02	1	10
CO5-56MB301.5: Understand dermatophytes, Histoplasma, Cryptococcus, Candida, opportunistic mycoses, and mycotoxins.	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	Chaechter M. Medoff G. and Eisenstein BC. (1993) Mechanism of Microbial Diseases 2nd edition. Williams and Wilkins, Baltimore.
2	Apurba S Sastry, Sandhya Bhat medical microbiology Jaypee Brothers Medical Publishers 2023
3	Ronald M. Atlas. (1989) Microbiology. Fundamentals and Applications. II edition, Maxwell Macmillan international editions.

(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.Sc. Microbiology
Semester: Ist Sem
Course Title: Bioinformatics and Biostatistics
Course Code: 56MB105

Course Outcome (Cos)	Program Specific Outcomes (PSOs)							
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-56MB301.1: Understand the classification of medically significant microorganisms and the relevance of the normal microbial flora.	1	2	3	2	1	**3**	**3**	**1**
CO2-56MB301.2: Recognize the methods of disease transmission.	1	1	2	1	1	**1**	**1**	**2**
CO3-56MB301.3: Be familiar with the principles underlying various serological techniques for identifying and quantifying illnesses.	1	1	1	2	1	**1**	**1**	**1**
CO4-56MB301.4: Learn about virology, mycology, and medical microbiology.	-	**1**	**1**	1	**2**	**1**	**2**	**3**
CO5-56MB301.5: Understand dermatophytes, Histoplasma, Cryptococcus, Candida, opportunistic mycoses, and mycotoxins.	**1**	**1**	**1**	-	1	**1**	-	**2**

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2, 3	**CO1-56MB301.1: Understand the classification of medically significant microorganisms and the relevance of the normal microbial flora.**	SO1.1 SO1.2 SO1.3 SO1.4, SO1.5, SO1.6, SO1.7, SO1.8 SO1.9	**IL 1** **IL 2**	1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8, 1.9	**1SL-1,2,3**

PO 1,2,3,4,5 PSO 1,2, 3	**CO2-56MB301.2: Recognize the methods of disease transmission.**	SO2.1 SO2.2 SO2.3 SO2.4, SO2.5, SO2.6 SO2.7, SO2.8 SO2.9	**IL 1** **IL 2**	2.1, 2.2, 2.3, 2.4,2.5,2.6,2.7,2.8, 2.9	**2SL-1,2**
PO 1,2,3,4,5 PSO 1,2, 3	**CO3-56MB301.3: Be familiar with the principles underlying various serological techniques for identifying and quantifying illnesses.**	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 2,3,4,5 PSO 1,2, 3	**CO4-56MB301.4: Learn about virology, mycology, and medical microbiology.**	SO4.1 SO4.2 SO4.3 SO4.4, SO4.5, SO4.6, SO4.6, SO4.7, SO4.8, SO4.9	**IL 1** **IL 2**	4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8,4.9	**4SL-1,2**
PO 1,2,3,5 PSO 1, 3	**CO5-56MB301.5: Understand dermatophytes, Histoplasma, Cryptococcus, Candida, opportunistic mycoses, and mycotoxins.**	SO5.1 SO5.2 SO5.3, SO5.4, SO5.5, SO5.6, SO5.7, SO5.8, SO5.9	**IL 1** **IL 2**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8, 5.9	**5SL-1,2**

Curriculum Development Team

Prof. Kamlesh Choure
Prof Ashwini A. Waoo
Prof. Deepak Mishra
Er. Arpit Srivastava
Mr. Piyush Kant Rai

Program Name	**Master of Science in Microbiology (M.Sc. (microbiology))**	
Semester	III	
Course Code:	56MB302	
Course title:	Food and Dairy Microbiology	**Curriculum Developer**: Chahana Desai, Teaching Associate
Pre-requisite:	Students should have general knowledge and understanding about food, dairy and related microorganisms.	
Rationale:	• The objectives of the Food and dairy microbiology course is to provide students with a comprehensive understanding of the principles and applications of microbiology in the field of food and dairy. • The course aims to equip students with the knowledge and skills necessary to study microbial strains that inhibit, create or contaminate food and dairy products. • Additionally, the course seeks to impart theoretical and practical knowledge on microbial aspects of fluid milk, milk products and other foods to take up research work projects.	
Course Outcomes (COs):	**CO1-** An overview of food microbiology **CO2-** Acquire knowledge regarding food spoilage and contamination. **CO3-** Gain an understanding of food preservation and food fermentations. **CO4-**Elucidate the detailed methods of food sanitation and water potability. **CO5-**Elaborate the production of genetically modified food, food laws and quality control.	

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)	
PCC	56MB302	Food and Dairy microbiology	3	1	1	1	6	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 act any one (CAT)	Class Attendance	Total Marks (CA+CT+CAT+SA+AT)		
PCC	56MB302	Food and Dairy microbiology	**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	56MB352	Food and Dairy Microbiology Lab	35	5	5	5	50	50	50

Course-Curriculum:

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

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	11	04	01	02	18

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1 An overview of food microbiology	**SO1.1** Understand the basic knowledge about the scope of food microbiology	LI1.1 To observe and identify the structure of bacteria, yeast, and moulds using microscopy	**Unit-1 Detailed overview of food microbiology** **CI1.1** Scope of food microbiology,	**SL1.1** Overview of food microbiology
	SO1.2 Elucidate the knowledge about structure of bacteria	LI1.2 To investigate the factors influencing microbial growth in food by conducting controlled experiments.	**CI1.2** Microorganisms important in food microbiology – structure of Bacteria	**SL1.2** Types of microorganisms used in food and dairy microbiology.
	SO1.3 types of bacteria		**CI1.3** Microorganisms important in	

			food microbiology – types of Bacteria	
	SO1.4 functions and importance of bacteria in food microbiology		**CI1.4** Microorganisms important in food microbiology – functions and importance of bacteria in food microbiology	
	SO1.5 Understanding the knowledge about structure of yeast		**CI1.5** Microorganisms important in food microbiology- structure of yeast Yeasts	
	SO1.6 types of yeast		**CI1.6** Microorganisms important in food microbiology- types of yeast	
	SO1.7 functions of yeasts and its importance in food microbiology		**CI1.7** Microorganisms important in food microbiology-functions of yeasts and its importance in food microbiology	
	SO1.8 To understand the knowledge about structure of moulds		**CI1.8** Microorganisms important in food microbiology-strucutre of moulds.	
	SO1.9 types of moulds		**CI1.9** Microorganisms important in food microbiology-types of moulds	
	SO1.10 functions of moulds and its importance in food microbiology		**CI1.10** Microorganisms important in food microbiology- functions of moulds and its importance in food microbiology	
	SO1.11 Elucidate the various factors which influencing microbial growth in food.		**CI1.** Factors influencing microbial growth in food.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	1. Explain scope of food microbiology. 2. Discuss factors influencing microbial growth in food.

	SW1.2 Mini Project	Types and mechanism of action of microorganisms involved in food microbiology
	SW1.3 Other Activities (Specify)	Find out the Visual aspects of how microorganisms involved in food and dairy industry?

Item	Cl	LI	SW	SL	Total
Approx. Hrs	14	06	01	02	23

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2 **Acquire knowledge regarding food spoilage and contamination**	**SO2.1** To Understand the general principles of food spoilage and contamination.	**LI1** Isolation of any pathogenic bacteria (*Staphylococcus* or *Salmonella)* from food products.	**Unit-2 Food spoilage:** **CI2.1** General principles underlying food spoilage and contamination.	**SL2.1** Overall understanding about microorganisms involved in food spoilage.
	SO2.2 To learn about the various aspects of food poisoning	**LI2** Isolation of spoilage microorganisms from bread.	**CI2.2** Food poisoning,	**SL2.2** Characteristics of various microorganisms involved in food contamination..
	SO2.3 Elaborate the Indicator food borne pathogens Bacterial food borne infections and intoxications by Brucella	**LI3** Isolation of spoilage microorganisms from spoiled vegetables/fruit	**CI2.3** Indicator food borne pathogens Bacterial food borne infections and intoxications-Brucella,	
	SO2.4 Elucidate the food borne infections and intoxications by Campylobacter.		**CI2.4** Campylobacter,	
	SO2.5 To learn about the food borne infections and intoxications by clostridium		**CI2.5** Clostridium,	
	SO2.6 Explain the food borne infections and intoxications by Escherichia (ETEC/EHEC/EPEC/EAEC)		**CI2.6** Escherichia (ETEC/EHEC/EPEC/EAEC).	

	SO2.7 Explanation about the food borne infections and intoxications by salmonella and shigella		**CI2.7** Salmonella, Shigella,	
	SO2.8 Elaborate the food borne infections and intoxications by Listeria, Vibrio, and Yersinia.		**CI2.8** Listeria, Vibrio, and Yersinia.	
	SO2.9 To understand the non-bacterial food borne infections and intoxications by Nematodes		**CI2.9** Non- bacterial food borne infections and intoxications-Nematodes,	
	SO2.10 To learn about the non-bacterial food borne infections and intoxication by protozoa, algae, fungi, and viruses.		**CI2.10** protozoa, algae, fungi, and viruses.	
	SO2.11 Explanation about the culture and non-culture based detection of food pathogens and viruses		**CI2.11** Culture and non-culture based detection of food pathogens and viruses,	
	SO2.12 Elaborate the General methods for diagnosis of infections		**CI2.12** General methods for diagnosis of infections,	
	SO2.13 Explanation about the mechanism of intoxications		**CI2.13** intoxications	
	SO2.14 Elucidate the preventive measures for various food borne pathogen		**CI2.14** preventive measures.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	1. Explain mechanism of intoxification. 2. Elucidate the general methods for diagnosis of infections.
	SW2.2 Mini Project	Detailed mechanism of bacteria involved in food spoilage
	SW2.3 Other Activities (Specify)	Show some visual content about how food contamination happens?

Item	Cl	LI	SW	SL	Total
Approx. Hrs	14	06	01	02	23

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3 Gain an understanding of food preservation and food fermentations.	**SO3.1** Elucidate the principles of food preservation.	**LI1** MBRT of milk samples and their standard plate count.	**Unit-3 food preservation and food fermentation** **CI3.1** Food preservation: Principles of food preservation	**SL3.1** Concept of food preservation
	SO3.2 Explanation about the mechanism of asepsis and removal of microorganisms	**LI2** Alkaline phosphatase test to check the efficiency of pasteurization of milk.	**CI3.2** Asepsis, removal of microorganisms,	**SL3.2** Basic concept of sterilization.
	SO3.3 Elucidate the various factors like aerobic condition, high and low temperatures for removal of microorganisms	**LI3** Preparation of yogurt/Dahi	**CI3.3** anaerobic conditions, high and low temperatures,	
	SO3.4 Elucidate the various factors like drying, irradiation for removal of microorganisms		**CI3.4** drying, irradiation.	
	SO3.5 To learn the mechanism of chemical and bio preservatives		**CI3.5** Chemical and bio preservatives	
	SO3.6 Elaborate the role and importance of food additives.		**CI3.6** food additives.	
	SO3.7 Elaborate the mechanism and importance of food packaging and labeling.		**CI3.7** Food packaging and labeling.	
	SO3.8 Explanation about the and mechanism of food fermentations and		**CI3.8** Food fermentations: Starter cultures their biochemical activities,	

	biochemical activities of starter cultures			
	SO3.9 To understand about the production and preservation of the fermented foods.		**CI3.9** production and preservation of the following fermented foods.	
	SO3.10 Elucidate the production and preservation of oriental fermented foods.		**CI3.10** Oriental fermented foods,	
	SO3.11 Elucidate the production and preservation of dairy fermented foods **(**Cheese, yogurt and Indigenous dairy products India),		**CI3.11** Dairy fermented foods (Cheese, yogurt and Indigenous dairy products India),	
	SO3.12 Elucidate the production and preservation of Fermented vegetables – Sauerkraut,		**CI3.12** Fermented vegetables – Sauerkraut,	
	SO3.13 Explanation about Production and application of Bakers Yeast,		**CI3.13** Production and application of Bakers Yeast,	
	SO3.14 Elaborate the application of microbial enzymes in food industry		**CI3.14** Application of microbial enzymes in food industry	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	1. Explain the role of food additives. 2. Elaborate the applications of microbial enzymes in food industry.
	SW3.2 Mini Project	Make a detailed note on asepsis.
	SW3.3 Other Activities (Specify)	Get the power point presentation about food preservation.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	02	01	02	11

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4 Elucidate the detailed methods of food sanitation and water potability	**SO4.1** Elucidate the Treatment of drinking (potable) water,	**LI1** Determination of potability and feacal contamination of water samples by presumptive test/MPN test, confirmed and completed tests.	**Unit-4 Food sanitation and water potability** **CI4.1**Treatment of drinking (potable) water,	**SL4.1** Concept of water potability.
	SO4.2 Elucidate the safety of potable water.		**CI4.2** Safety of potable water.	
	SO4.3 Elaborate the methods to detect potability of water samples: (a) standard qualitative procedure:		**CI4.3** methods to detect potability of water samples: (a) standard qualitative procedure:	**SL4.2** characteristics of drinking water.
	SO4.4 Understanding the procedure of presumptive test/MPN test		**CI4.4** The procedure of presumptive test/MPN test	
	SO4.5 Elucidate the importance of presumptive test/MPN test		**CI4.5** The importance of presumptive test/MPN test	
	SO4.6 Elaborate the confirmed and completed tests for fecal coliforms.		**CI4.6** confirmed and completed tests for fecal coliforms	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	1. Write the methods to detect potability of water.
	SW4.2 Mini Project	Explain safety of potable water.
	SW4.3 Other Activities (Specify)	1. Power point presentation on MPN test

Item	Cl	LI	SW	SL	Total
Approx. Hrs	15	02	01	02	20

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5 Elaborate the production of genetically modified food, food laws and quality control	**SO5.1** To understand the production of genetically modified food.	LI5.1 To analyze the effectiveness of HACCP (Hazard Analysis and Critical Control Points) in a food processing setting.	**Unit-5 Food laws and quality control** **CI5.1** Production of genetically modified foods.	**SL5.1** Basics of food standards.
	SO5.2 Elucidate the importance of genetically modified food		**CI5.2** Importance of genetically modified food.	
	SO5.3 Detailed knowledge about Biosensors in food.		**CI5.3** Biosensors in food.	**SL5.2** Basic knowledge about genetic engineering
	SO5.4 Elucidate the Food research organizations/institutes in India.		**CI5.4** Food research organizations/institutes in India	
	SO5.5 Explanation about Recent foodborne outbreaks		**CI5.5** Recent foodborne outbreaks,	
	SO5.6 Elaborate about Food laws		**CI5.6** Food laws	
	SO5.7 Elucidate about the quality control of HACCP,		**CI5.7** quality control – HACCP,	
	SO5.8 Elucidate the functioning of HACCP		**CI5.8** Functioning of HACCP	
	SO5.9 Elaborate about the functioning of Codex alimentarius.		**CI5.9** Codex alimentarius,	
	SO5.10 Elaborate about the functioning of PFA		**CI5.10** PFA,	
	SO5.11		**CI5.11**	

	Elucidate the role of FPO.		FPO,	
	SO5.12 Elaborate the role of MFPO		**CI5.12** MFPO,	
	SO5.13 Explanation about the Functioning of BIS		**CI5.13** BIS	
	SO5.14 Elucidate the types of AGMARK**.**		**CI5.14** Types of AGMARK.	
	SO5.15 Elaborate the functioning of AGMARK		**CI5.15** Functioning of AGMARK	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	1. Explanation about biosensors in food
	SW5.2 Mini Project	List out various criteria for quality control
	SW5.3 Other Activities (Specify)	Make a powerpoint presentation about food standards.

Course duration (in hours) to attain Course Outcomes:

Course Title: Food and Dairy microbiology **Course Code:** 56MB302

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1 An overview of food microbiology	11	4	2	1	18
CO2 Acquired the knowledge regarding food spoilage and contamination	14	6	2	1	23
CO3 Gain an understanding of food preservation and food fermentations.	14	6	2	1	23
CO4 Elucidate the detailed methods of food sanitization and water potability	6	2	2	1	11
CO5 Elaborate the production of genetically modified food, food laws and quality control.	15	2	2	1	20

Total Hours	60	20	10	05	95

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

Course Title: Food and Dairy microbiology **Course Code:** 56MB302

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1 An overview of food microbiology	2	1	1	1	5
CO2 Acquired the knowledge regarding food spoilage and contamination	2	4	5	1	12
CO3 Gain an understanding of food preservation and food fermentations.	3	5	5	1	14
CO4 Elucidate the detailed methods of food sanitization and water potability	2	3	5	1	11
CO5 Elaborate the production of genetically modified food, food laws and quality control.	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 Microbiology Frazier and Westnoff
2	Industrial Microbiology Prescott and Dunn.
3	Text Book of Biotechnology R.C.Dubey.
4	Applied Biotechnology Fr. Ignachimuthu.

(c) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: M.Sc. Microbiology

Semester: III Semester
Course Title: Food and Dairy microbiology
Course Code: 56MB302

CO/PO/PSO Mapping								
Course Outcome (COs)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1 An overview of food microbiology	1	2	-	1	2	2	2	1
CO2 Acquired the knowledge regarding food spoilage and contamination	-	1	1	-	-	1	1	2
CO3 Gain an understanding of food preservation and food fermentations.	1	1	2	1	-	3	1	1
CO4 Elucidate the detailed methods of food sanitization and water potability	1	1	1	-	2	1	1	3
CO5 Elaborate the production of genetically modified food, food laws and quality control.	2	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 1,2,4,5 PSO 1,2, 3	**CO1** An overview of food microbiology	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10 SO1.11	LI1.1 LI1.2	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11	**1SL-1,2**
PO 2,3, PSO 1,2, 3	**CO2** Acquired the knowledge regarding food spoilage and contamination	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9 SO2.10 SO2.11 SO2.12 SO2.13 SO2.14	LI2.1 LI2.2 LI2.3	2.1, 2.2, 2.3,2.4,2.5,2.6,2.7,2.8,2.9,2.10,2.11,2.12, 2.13, 2.14	**2SL-1,2**
PO 1,2,3,4 PSO 1,2, 3	**CO3** Gain an understanding of food preservation and food fermentations.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9 SO3.10 SO3.11 SO3.12 SO3.13 SO3.14	LI3.1 LI3.2 LI3.3	3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9,3.10, 3.11, 3.12, 3.13, 3.14	**3SL-1,2**

PO 1,2,3,5 PSO 1,2, 3	**CO4** Elucidate the detailed methods of food sanitization and water potability	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6	LI4.1 LI4.2	4.1,4.2,4.3,4.4, 4.5, 4.6	**4SL-1,2**
PO 1,2,3, PSO 1,2, 3	**CO5 E**laborate the production of genetically modified food, food laws and quality control.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9 SO5.10 SO5.11 SO4.12 SO4.13 SO4.14 SO4.15		5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9,5.10,5.11, 5.12, 5.13, 5.14, 5.15	**5SL-1,2**

Curriculum Development Team

Prof. Kamlesh Choure

Prof Ashwini A. Waoo

Prof. Deepak Mishra

Er. Arpit Srivastava

Mr. Piyush Kant Rai

Program Name	**Masters of Science (M.Sc.)- Microbiology**	
Semester	III	
Course Code:	56MB303	
Course title:	Industrial Microbiology and Fermentation	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of microbiology and fermentation	
Rationale:	Industrial microbiology and fermentation study and solve problems related to industrial production processes. They may examine microbial growth found in the pipes of a chemical factory, monitor the impact industrial waste has on the local ecosystem, or oversee the microbial activities used in cheese production to ensure quality. Fermentation is frequently used for the cultivation of biomass and in the production of enzymes, pharmaceuticals, energy, food and feedstock, bioactive compounds, biopolymers, etc., in which different microorganisms, and including filamentous fungi, are involved.	
Course Outcomes (COs):	**CO1-56MB303.1.** Describe the fundamentals of Industrial Microbiology and Fermentation Technology **CO2-56MB303.2.** Define the role of microbiology for the production of desired bioproducts **CO3-56MB303.3.** Derive the working mechanism of upstream and downstream processing **CO4-56MB303.4.** Interpretate the mechanism of fermentation process in industry **CO5-56MB303.5.** Examine the mechanism of biological product development using microbes	

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)	
PCC	56MB303	Industrial Microbiology and Fermentation	3	1	1	1	6	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 (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
PCC	56MB303	Industrial Microbiology and Fermentation	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
PCC	56MB353	Industrial Microbiology and Fermentation Technology Lab	35	5	5	5	50	50	50

Course-Curriculum:

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

Approximate Hours

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

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-56MB303.1. Describe the fundamentals of Industrial Microbiology and Fermentation	SO1.1 Understand the brief history and developments in industrial microbiology	LI1.1 Observe historical advancements in industrial microbiology	CI1.1 Introduction to the history of industrial microbiology	SL1.1 Research key milestones and

Technology		through case studies		developments in industrial microbiology
	SO1.2 Learn about solid-state and liquid-state fermentations	LI1.2 Set up and compare solid-state vs. liquid-state fermentation experiments	CI1.2 Overview of solid-state and liquid-state fermentations	SL1.2 Compare the advantages and disadvantages of solid-state vs. liquid-state fermentations
	SO1.3 Understand batch, fed-batch, and continuous fermentations		CI1.3 Introduction to batch, fed-batch, and continuous fermentation processes	
	SO1.4 Identify components of a typical bioreactor		CI1.4 Overview of bioreactor components and their functions	
	SO1.5 Learn about laboratory, pilot-scale, and production fermenters		CI1.5 Introduction to laboratory, pilot-scale, and production fermenters	
	SO1.6 Understand constantly stirred tank fermenter (CSTF)		CI1.6 Overview of CSTF and its operational principles	
	SO1.7 Learn about tower fermenters		CI1.7 Introduction to tower fermenters and their applications	

	SO1.8 Understand fixed bed and fluidized bed bioreactors		CI1.8 Overview of fixed bed and fluidized bed bioreactors	
	SO1.9 Learn about air-lift fermenters		CI1.9 Introduction to air-lift fermenters and their advantages	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail "Applications of Microorganisms in various Sectors"
	SW1.2 Mini Project	Draw various types of Fermenters with specifications
	SW1.3 Other Activities (Specify)	List down the tables of different domains of microorganisms which are industrially important

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

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-56MB303.2. Define the role of microbiology for the production of desired bioproducts	SO2.1 Measurement of fermentation parameters: pH, temperature, dissolved oxygen, foaming, and aeration	LI2.1 Measure pH, temperature, and dissolved oxygen in fermentation processes	CI2.1 Introduction to measurement techniques for fermentation parameters	SL2.1 Review methods for measuring pH, temperature, and dissolved oxygen in fermentation

	SO2.2 Isolation of strains and media preparation: crude and synthetic media	LI2.2 Prepare and analyze different media types including molasses, corn-steep liquor, and whey	CI2.2 Overview of media types: crude vs. synthetic, including ingredients like molasses and yeast extract	SL2.2 Investigate various types of fermentation media and their applications
	SO2.3 Primary and secondary screening of strains	LI2.3 Perform primary and secondary screening of microbial strains	CI2.3 Introduction to strain screening methods and their importance	
	SO2.4 Strain development, preservation, and maintenance		CI2.4 Overview of strain development, preservation, and maintenance	
	SO2.5 Crude and synthetic media ingredients: molasses, corn-steep liquor, sulphite waste liquor, whey, yeast extract		CI2.5 Detailed analysis of crude and synthetic media components and their roles	
	SO2.6 Downstream processing techniques: filtration, centrifugation, cell disruption		CI2.6 Introduction to downstream processing techniques and their applications	
	SO2.7 Solvent extraction, precipitation, and ultrafiltration		CI2.7 Overview of solvent extraction, precipitation, and ultrafiltration techniques	
	SO2.8 Lyophilization and spray drying		CI2.8 Introduction to lyophilization and spray drying techniques	

	SO2.9 Integration of measurement, screening, media preparation, and downstream processing		CI2.9 Comprehensive review of industrial fermentation processes and integration of techniques	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Write down any 5 kinds of Unit Operations used in Downstream Processing
	SW1.2 Mini Project	Draw a well labelled diagram of Bacterial Cell Wall showing gram+/- staining
	SW1.3 Other Activities (Specify)	Watch animation related to working of different kinds of bioreactor used in various industries

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

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-56MB303.3 Derive the working mechanism of upstream and downstream processing	SO3.1 Understanding metabolic pathways and control mechanisms in microbial fermentations	LI3.1 Analyze metabolic pathways in microbial cultures	CI3.1 Overview of metabolic pathways and control mechanisms in microorganisms	SL3.1 Study the principles of metabolic control mechanisms in fermentation

	SO3.2 Industrial production of citric acid	LI3.2 Perform fermentation to produce citric acid	CI3.2 Introduction to citric acid production processes and their industrial relevance	SL3.2 Research the industrial applications of citric acid and production methods
	SO3.3 Industrial production of lactic acid		CI3.3 Overview of lactic acid production, its industrial applications and processes	
	SO3.4 Production of enzymes: alpha-amylase, lipase, xylase, pectinases, proteases		CI3.4 Introduction to enzyme production techniques and applications	
	SO3.5 Industrial production of acetone-butanol		CI3.5 Overview of acetone-butanol production and its industrial applications	
	SO3.6 Industrial production of lysine		CI3.6 Introduction to lysine production and its industrial importance	
	SO3.7 Industrial production of glutamic acid		CI3.7 Overview of glutamic acid production processes and applications	

	SO3.8 Metabolic control mechanisms in enzyme production		CI3.8 Introduction to metabolic control in enzyme production and its impact	
	SO3.9 Integration of metabolic pathways and industrial production processes		CI3.9 Review of metabolic pathways and their integration in industrial fermentations	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail cultivation of microorganisms
	SW3.2 Mini Project	Prepare a flowchart showing industrial production of biological products using fermentation
	SW3.3 Other Activities (Specify)	Make a Power Point Presentation on "Different Types of Microbial Culture Media"

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

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-56MB303.4 Interpretate the mechanism of fermentation process in industry	SO4.1 Understanding microbial production of β-lactams	LI4.1 Conduct fermentation to produce β-lactams and analyze yield	CI4.1 Overview of β-lactam antibiotics and their microbial production processes	SL4.1 Study the industrial applications and production methods of β-lactams
	SO4.2 Microbial production of aminoglycosides	LI4.2 Perform fermentation to produce aminoglycosides	CI4.2 Introduction to aminoglycoside production and its industrial importance	SL4.2 Research the production processes and applications of aminoglycosides

		and evaluate effectiveness		
	SO4.3 Production of Ansamycins (Rifamycin)		CI4.3 Overview of Ansamycins (Rifamycin) production and their therapeutic uses	
	SO4.4 Production of peptide antibiotics		CI4.4 Introduction to peptide antibiotics and their microbial production	
	SO4.5 Production of Quinolinones		CI4.5 Overview of Quinolinones production processes and their medical relevance	
	SO4.6 Biotransformation of steroids		CI4.6 Introduction to steroid biotransformation and its industrial applications	
	SO4.7 Production of Vitamin B12		CI4.7 Overview of Vitamin B12 production and its significance in nutrition	
	SO4.8 Production of riboflavin		CI4.8 Introduction to riboflavin production and its applications in health	
	SO4.9 Integration of therapeutic compound production processes		CI4.9 Review of microbial production processes for therapeutic compounds	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain the role of Antibiotics and its disadvantages
	SW4.2 Mini Project	Describe how therapeutics being produced in biotech-based industries
	SW4.3 Other Activities (Specify)	Make a list of "Biogas producing centres in India"

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

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-56MB303.5 Examine the mechanism of biological product development using microbes	SO5.1 Production of bioplastics (PHB, PHA)	LI5.1 Conduct fermentation to produce PHB and PHA and analyze yield	CI5.1 Overview of bioplastics production (PHB and PHA) and their environmental benefits	SL5.1 Study the latest advancements in bioplastics production and applications
	SO5.2 Production of bioinsecticides (e.g., thuricide)	LI5.2 Set up experiments to produce and test bioinsecticides	CI5.2 Introduction to bioinsecticides, focusing on thuricide and its applications	SL5.2 Research the use and production methods of bioinsecticides
	SO5.3 Production of biopolymers (dextran, alginate, xanthan, pullulan)		CI5.3 Overview of biopolymers production and their industrial applications	
	SO5.4 Production of biofertilizers (e.g., nitrogen-fixer Azotobacter, phosphate-solubilizing microorganisms)		CI5.4 Introduction to biofertilizers and their role in agriculture	
	SO5.5 Production of Single Cell Protein (SCP)		CI5.5 Overview of SCP production and its significance in food security	
	SO5.6 Production and safety considerations of biological weapons (e.g., anthrax)		CI5.6 Introduction to the production of biological weapons, focusing on anthrax	
	SO5.7 Review of modern		CI5.7 Summary of	

	trends in microbial production		modern trends in microbial production and their impact on industry	
	SO5.8 Future directions in microbial production		CI5.8 Exploration of emerging technologies and their potential impacts	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general characteristics of Biopolymers & their applications
	SW5.2 Mini Project	Describe the production process of Single Cell Production
	SW5.3 Other Activities (Specify)	Prepare one article on Applications of Biofertilizers

Course duration (in hours) to attain Course Outcomes:

Course Title: Industrial Microbiology and Fermentation **Course Code:** 56MB303

Course Outcomes (COs)	**Class lecture (CI)**	**Laboratory Instruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-56MB303.1: Describe the fundamentals of Industrial Microbiology and Fermentation Technology	9	4	2	1	16
CO2-56MB303.2: Define the role of microbiology for the production of desired bioproducts	9	4	2	1	16
CO3-56MB303.3: Elaborate the working mechanism of upstream and downstream processing	9	4	2	1	16
CO4-56MB303.4: Interpretate the mechanism of fermentation process in industry	9	4	2	1	16
CO5-56MB303.5: Examine the mechanism of biological product development using microbes	9	4	2	1	16
Total Hours	45	20	10	05	80

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

Course Title: Industrial Microbiology and Fermentation **Course Code:** 56MB303

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-56MB303.1: Describe the fundamentals of Industrial Microbiology and Fermentation Technology	2	1	1	1	5
CO2-56MB303.2: Define the role of microbiology for the production of desired bioproducts	2	4	2	2	10
CO3-56MB303.3: Elaborate the working mechanism of upstream and downstream processing	3	5	5	2	15
CO4-56MB303.4: Interpretate the mechanism of fermentation process in industry	2	3	3	2	10
CO5-56MB303.5: Examine the mechanism of biological product development using microbes	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

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

Suggested learning Resources:

(a) Books:

(b)

S.No.	Title/Author/Publisher details

1	Textbook of Microbiology by Ananthnarayanan and Paniker's, eighth edition, Universities Press
2	Microbiology; Lansing M Prescott, John P. Harley, Donald A Klein, Sixth edition, Mc Graw Hill Higher education.
3	J.E. Bailey and D.F. Ollis, Biochemical Engineer-ing Fundamentals, McGraw-Hill, New York
4	Industrial Microbiology and Biotechnology, Pradeep Verma, Springer, 2022
5	An Introduction to Industrial Microbiology, Sivakumar, K. Sukesh and Joe, S. Chand Publications, 2010

(c) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial
3. Case method
4. Group Discussion
5. Role play
6. Visit to Industrial plant of Biotech-based organizations
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: M. Sc. Microbiology
Semester: III Semester
Course Title: Industrial Microbiology and Fermentation Technology
Course Code: 56MB303

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-56MB303.1: Describe the fundamentals of Industrial Microbiology and Fermentation Technology	2	-	-	1	2	2	2	1
CO2-56MB303.2: Define the role of microbiology for the production of desired bioproducts	-	-	-	-	-	1	1	2
CO3-56MB303.3: Elaborate the working mechanism of upstream and downstream processing	-	1	1	1	-	1	1	1
CO4-56MB303.4: Interpretate the mechanism of fermentation process in industry	-	1	1	-	2	1	1	3
CO5-56MB303.5: Examine the mechanism of biological product development using microbes	1	1	1	-	-	1	3	2

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-56MB303.1:** Describe the fundamentals of Industrial Microbiology and Fermentation Technology	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**
PO 1,2,3,4,5 PSO 1,2,3	**CO2-56MB303.2:** Define the role of microbiology for the production of desired bioproducts	SO2.1 SO2.2 SO2.3 SO2.4, SO2.5, SO2.6 SO2.7, 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**
PO 1,2,3,4,5 PSO 1,2,3	**CO3-56MB303.3:** Elaborate the working mechanism of upstream and downstream processing	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**
PO 1,2,3,4,5 PSO 1,2,3	**CO4-56MB303.4:** Interpretate the mechanism of fermentation process in industry	SO4.1 SO4.2 SO4.3 SO4.4, SO4.5,	**LI 1** **LI 2**	4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8,4.9	**4SL-1,2**

		SO4.6, SO4.6, SO4.7, SO4.8, SO4.9			
PO 1,2,3,4,5 PSO 1,2,3	**CO5-56MB303.5:** Examine the mechanism of biological product development using microbes	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**

Curriculum Development Team

Prof. Kamlesh Choure
Prof Ashwini A. Waoo
Prof. Deepak Mishra
Er. Arpit Srivastava
Mr. Piyush Kant Rai

Program Name	**Masters of Science (M.Sc.)- Microbiology**	
Semester	III	
Course Code:	56MB304	
Course title:	Pharmaceutical microbiology	**Curriculum Developer**: Mrs. Sonal Gupta, Assistant Professor
Pre-requisite:	Students should have knowledge of general microbiology, industrial microbiology, and pharmaceutical science	
Rationale:	Microbiology is the study of microorganisms, e.g., bacteria, fungus and viruses. When microbiological concepts, processes and techniques are applied to pharmaceutical operations, the subject is then called 'pharmaceutical microbiology'. It can be defined as the study of microorganisms that are pertinent to the production of antibiotics, enzymes, vitamins, vaccines, and other pharmaceutical products; it also incorporates the study of microorganisms that cause pharmaceutical contaminations, and degradation, deterioration and spoil of pharmaceutical raw materials and finished products. The role of pharmaceutical microbiology has become even more significant and relevant to quality healthcare provisions, and must be taught in great lengths, especially in healthcare and medicine related curricula world-wide.	
Course Outcomes (COs):	**CO1-56MB304.1**: To study the various classes of antimicrobial agents with special reference to their introduction, chemical structure MOA, etc. **CO2-56MB304.2**: To understand the microbial pathogenicity and also study the modern concept of drug targeting. **CO3-56MB304.3**: To learn the microbial production of Pharmaceutics along with spoilage of pharmaceutics and various methods to protect them against spoilage. **CO4-56MB304.4**: To elaborate the modern trends in pharmaceutical microbiology like drug carriers, Immobilization techniques, Vaccines, Biosensors etc. **CO5-56MB304.5**: To study various standards and principles to assure quality of the pharmaceutical 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)	
PCC	56MB304	Pharmaceutical Microbiology	3	1	1	1	6	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	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
PC	56MB304	Pharmaceutical Microbiology	**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)		
PCC	56MB354	Pharmaceutical Microbiology Lab	35	5	5	5	50	50	50

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx. Hrs** | 11 | 04 | 01 | 05 | 21

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO1-56MB304.1: To study the various classes of antimicrobial agents with special reference to their introduction, chemical structure MOA, etc.	**SO1.1** An overview on antimicrobial agents.	**LI1.1** To perform antibiotic sensitivity test.	**CI1.1** Brief outline on antimicrobial agents.	**SL1.1** Make a comparative chart of various antibiotics
	SO1.2 Explain various types of antibiotics like beta lactam,	**LI1.2** Make a list of various antiseptic and disinfectants used in microbiology lab.	**CI1.2** Beta lactam antibiotics.	**SL1.2** Describe antifungal agents and their types
	SO1.3 Aminoglycosides		**CI1.3** Aminoglycosides.	**SL1.3** Write an overview on antimicrobial agents
	SO1.4 Tetracycline.		**CI1.4** Tetracycline.	**SL1.4** Explain various types of antitumor agents.
	SO1.5 Chloramphenicol.		**CI1.5** Chloramphenicol.	

	SO1.6 Peptide antibiotics.		**CI1.6** Peptide antibiotics.	**SL1.5** Classify antiseptics and disinfectants on the basis of their mechanism of actions
	SO1.7 Sulphonamide.		**CI1.7** Sulphonamide.	
	SO1.8 Quinolone		**CI1.8** Quinolone.	
	SO1.9 Antifungal agents		**CI1.9** Antifungal agents.	
	SO1.10 Antitumor agents.		**CI1.10** Antitumor agents.	
	SO1.11 Antiseptic and Disinfectants.		**CI1.11** Antiseptic and Disinfectants.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe different classes of antibiotics on the basis of mechanisms of action.
	SW1.2 Mini Project	Make a list of various antitumor agents and their mechanism.
	SW1.3 Other Activities (Specify)	Describe various antiseptics and disinfectants used in daily life.

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

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO2-56MB304.2: To understand the microbial pathogenicity and also study the modern concept of drug targeting.	**SO2.1** To study the resistance mechanism of pathogens against antibiotics	**LI2.1** Compare sensitivity of *E. coli* against streptomycin, tetracycline and chloramphenicol. .	**CI2.1** Describe the various types of antibiotic resistance mechanism	**SL2.1** Read the resistance against antibiotics
	SO2.2 Describe various approaches of targeted drug delivery.	**LI2.2** Isolation of streptomycin resistant bacteria from given sample**.**	**CI2.2** Detail overview on targeted drug delivery system.	**SL2.2** Role of various microbial structural and molecular components in pathogenesis.
	SO2.3 Explain concept of gene therapy.		**CI2.3** Explain gene therapy in detail.	**SL2.3** Learn the molecular principle of targeted drug delivery.
	SO2.4 To describe various carriers used in Gene therapy.		**CI2.4** Describe various drug carriers used in gene therapy.	SL2.4 Read about various carriers used in gene therapy.
	SO2.5 To explain various mechanisms of membrane transport.		**CI2.5** Elaborate membrane transportation in detail.	
	SO2.6		**CI2.6**	

	To elaborate the detail mechanism of microbial pathogenesis. SO2.7 Barrier of microbial pathogenesis.		Understand microbial pathogenesis.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Detail account on membrane transport mechanisms.
	SW2.2 Mini Project	Various approaches of targeted drug delivery.
	SW2.3 Other Activities (Specify)	How microbial pathogens penetrate the host defense.

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

Course Outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO3-56MB304.3: To learn the microbial production of Pharmaceutics along with spoilage of pharmaceutics and various methods to protect them against spoilage**.**	**SO3.1** An overview on spoilage of a pharmaceutical product.	**LI3.1** Isolation and characterization of microorganisms from spoiled food sample.	**CI3.1** Spoilage: its types, and effects. . .	**SL3.1** What is spoilage, describe its types and factors affecting the rate of spoilage of a product
	SO3.2 Learn different methods of sterilization used to protect a product from spoilage.	**LI3.2** Demonstrate various instruments used in microbiology laboratory.	**CI3.2** Sterilization methods and their types.	**SL3.2** Discuss various types physical and chemical sterilization methods
	SO3.3		**CI3.3**	**SL3.3**

	Differentiate D-value and Z-value.		Parameters to check thermal sterilization: D-value, Z-value.	Read the chemical and biological indicators.
	SO3.4 Explain the survival curve to check the radiation sterilization.		**CI3.4** Survival curve and its significance.	**SL3.4** How to design a microbiology lab.
	SO3.5 Define chemical and biological indicators used in sterilization.		**CI3.5** Sterilization indicators.	
	SO3.6 Design a microbiology lab.		**CI3.6** Layout and designing of microbiology laboratory.	
	SO3.7 Describe various safety level in microbiology labs.		**CI3.7** General idea on biosafety levels in microbiology lab.	
	SO3.8 Explain the microbial process of production of pharmaceutical products		**CI3.8** Detailed method of microbial production of pharmaceuticals.	
	SO3.9 Explain microbial production of streptokinase and streptodornase		**CI3.9** Detailed manufacturing process of streptokinase and streptodornase.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe the safety parameters in microbiology laboratory.
	SW3.2 Mini Project	Describe the various methods of sterilization used in pharmaceutical industry.
	SW3.3 Other Activities (Specify)	Prepare a flow diagram of fermentative production of streptokinase and streptodornase.

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)
CO4-56MB304.4: To elaborate the modern trends in pharmaceutical microbiology like drug carriers, Immobilization techniques, Vaccines, Biosensors etc.	**SO4.1** Describe the vaccine technology	**LI4.1** Demonstrate the immobilization process by using calcium alginate method.	**CI4.1** Vaccine technology	**SL4.1** Learn various immobilization methods.
	SO4.2 Explain various types of vaccines.	**LI4.2** Make a laboratory chart on clinical trial.	**CI4.2** Describe various types of vaccines.	**SL4.2** Describe vaccine and its types.
	SO4.3 How to design clinical trials.		**CI4.3** Vaccine clinical trials	**SL4.3** Understand the working mechanism of biosensor.
	SO4.4 Explain various immobilization methods.		**CI4.4** Immobilization: its types and significance.	SL4.4 Explain clinical trials.
	SO4.5 Elaborate molecular carriers.		**CI4.5** Explain different types of molecular carriers	SL4.5 Study various types of drug carriers.
	SO4.6 Explain Cellular carriers		**CI4.6** Brief account on various cellular drug carriers.	

	SO4.7 Understand about biosensors		**CI4.7** Biosensors: construction and working mechanism	
	SO4.8 Types of Biosensors.		**CI4.8** Classify biosensors	
	SO4.9 Describe various enzymes used in pharmaceutical industry.		**CI4.9** Pharmaceutically important enzymes.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain immobilization methods and their significance
	SW4.2 Mini Project	Describe the various types of vaccines
	SW4.3 Other Activities (Specify)	Prepare a list of enzymes used as pharmaceutical agent

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)**
CO5-56MB304.5: To study various standards and principles to assure quality of the pharmaceutical products.	**SO5.1** Explain guidelines and significance of GMP	**LI5.1** Make a chart of guidelines of good laboratory practices.	**CI5.1** Good manufacturing practice (GMP)	**SL5.1** read pharmacopoeias available in library.
	SO5.2	**LI5.2** Perform different	**CI5.2**	**SL5.2**

	GLP and its importance in pharmaceutical industry	sterilization methods.	Good laboratory practice (GLP)	Explore various guidelines of GMP
	SO5.3 Understand the regulatory aspects of quality control in pharmaceutical production		**CI5.3** Regulatory aspects of quality control.	**SL5.3** Read guideline of GLP
	SO5.4 How to assure and manage quality parameters in pharmaceutical industry.		**CI5.4** Quality assurance and quality management in pharmaceutical science.	**SL5.4** study the reimbursements of biologics.
	SO5.5 Learn various standardization used in pharmaceutical industry.		**CI5.5** Various certifications used in pharmaceuticals.	SL5.5 Explain rational drug design.
	SO5.6 Learn the financing capital in R&D and market outlook in pharmaceutical sector		**CI5.6** Financing R&D and market outlook of pharmaceutical industry.	
	SO5.7 Study the government regulatory practices and policies regulate pharmaceutical production		**CI5.7** Government regulatory practices and policies	

	SO5.8 Understand reimbursement of biologics		**CI5.8** Reimbursement of biologics	
	SO5.9 How to design rational drugs		**CI5.9** Rational drug design	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain quality assurance and management in pharmaceuticals.
	SW5.2 Mini Project	Describe various government regulatory practices in pharmaceutical science
	SW5.3 Other Activities (Specify)	Prepare a flow diagram on rational drug design

Course duration (in hours) to attain Course Outcomes:

Course Title: Pharmaceutical Microbiology **Course Code:** 56MB101

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Sessional work (SW)	Self-Learning (SL)	Total Hours (Li+CI+SL+SW)
CO1-56MB304.1: To study the various classes of antimicrobial agents with special reference to their introduction, chemical structure MOA, etc.	09	04	01	05	**19**
CO2-56MB304.2: To understand the microbial pathogenicity and also study the modern concept of drug targeting.	09	04	01	03	**17**
CO3-56MB304.3: To learn the microbial production of Pharmaceutics along with spoilage of pharmaceutics and various methods to protect them against spoilage.	09	04	01	05	**19**

CO4-56MB304.4: To elaborate the modern trends in pharmaceutical microbiology like drug carriers, Immobilization techniques, Vaccines, Biosensors etc.	09	04	01	03	**17**
CO5-56MB304.5: To study various standards and principles to assure quality of the pharmaceutical products.	09	04	01	04	**18**
Total Hours	**45**	**20**	**05**	**20**	**90**

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

Course Title: Pharmaceutical Microbiology **Course Code:** 56MB101

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-56MB304.1: To study the various classes of antimicrobial agents with special reference to their introduction, chemical structure MOA, etc.	2	1	1	1	**5**
CO2-56MB304.2: To understand the microbial pathogenicity and also study the modern concept of drug targeting.	2	4	2	2	**10**
CO3-56MB304.3: To learn the microbial production of Pharmaceutics along with spoilage of pharmaceutics and various methods to protect them against spoilage.	3	5	5	2	**15**
CO4-56MB304.4: To elaborate the modern trends in pharmaceutical microbiology like drug carriers, Immobilization techniques, Vaccines, Biosensors etc.	2	3	3	2	**10**
CO5-56MB304.5: To study various standards and principles to assure quality of the pharmaceutical products.	5	4	1	0	**10**
Total Marks	**14**	**17**	**12**	**07**	**50**

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

Suggested learning Resources:

A. Books:

S.No.	Title/Author/Publisher details
1	Pharmaceutical Microbiology – Edt. by W.B. Hugo & A.D. Russell Sixth edition. Blackwell scientific Publications.
2	Quinolinone antimicrobial agents – Edt. by David C. Hooper, John S. Wolfson. ASM Washington DC.
3	Pharmaceutical Biotechnology by S.P. Vyas & V.K. Dixit. CBS Publishers & Distributors, New Delhi.
4	Good Manufacturing Practices for Pharmaceuticals Second Edition, by Sydney H. Willig, Murray M. Tuckerman, William S. Hitchings IV. Mercel Dekker NC New York.
5	Quality control in the Pharmaceutical Industry - Edt. by Murray S. Cooper Vol.2. Academic Press New York.

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.Sc. Microbiology
Semester: III Semester
Course Title: Pharmaceutical Microbiology
Course Code: 56MB101

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-56MB304.1: To study the various classes of antimicrobial agents with special reference to their introduction, chemical structure MOA, etc.	2	-	-	1	2	2	1	1
CO2-56MB304.2: To understand the microbial pathogenicity and also study the modern concept of drug targeting.	-	-	-	-	-	1	2	-
CO3-56MB304.3: To learn the microbial production of Pharmaceutics along with spoilage of pharmaceutics and various methods to protect them against spoilage.	-	1	1	1	-	1	1	1
CO4-56MB304.4: To elaborate the modern trends in pharmaceutical microbiology like drug carriers, Immobilization techniques, Vaccines, Biosensors etc.	-	1	1	-	2	2	1	3
CO5-56MB304.5: To study various standards and principles to assure quality of the pharmaceutical products.	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	**CO1-56MB304.1**: To study the various classes of antimicrobial agents with special reference to their introduction, chemical structure MOA, etc.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10 SO1.11	**LI 1** **LI 2**	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9 1.10, 1.11	**1SL-1, 2, 3, 4, 5**
PO 1,2,3,4,5 PSO 1,2,3	**CO2-56MB304.2**: To understand the microbial pathogenicity and also study the modern concept of drug targeting.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7	**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	**CO3-56MB304.3**: To learn the microbial production of Pharmaceutics along with spoilage of pharmaceutics and various methods to protect them against spoilage.	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,**
PO 1,2,3,4,5 PSO 1,2,3	**CO4-56MB304.4**: To elaborate the modern trends in pharmaceutical microbiology like drug carriers, Immobilization techniques, Vaccines, Biosensors etc.	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**
PO 1,2,3,4,5 PSO 1,2,3	**CO5-56MB304.5**: To study various standards and principles to assure quality of the pharmaceutical products.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8	**LI 1** **LI 2**	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9	**5SL-1, 2, 3, 4,5**

		SO5.9			

Curriculum Development Team
Prof. Kamlesh Choure
Prof Ashwini A. Waoo
Prof. Deepak Mishra
Er. Arpit Srivastava
Mr. Piyush Kant Rai

Program Name	**M.Sc. Microbiology**	
Semester	lll	
CourseCode:	**56MB305**	
Coursetitle:	Clinical Diagnosis of Microorganisms	**Curriculum Developer**: Shaily Mishra, Assistant Professor
Pre-requisite:	Students should have basic knowledge of biology and biochemistry of microbial world and their interactions with environment.	
Rationale:	The paper on Clinical Diagnosis of Microorganisms in M.Sc. Microbiology program seeks to understand oneself with methods for microbiological isolation from various clinical samples. The students will acquire basic knowledge and learn about disease-related diagnostic procedures. The students will be able to learn how to measure the effectiveness of antibiotics using multiple established techniques.	
CourseOutcomes (COs):	**CO56MB305.1:** Importance of diagnosis of diseases and associated clinical samples for diagnosis. **CO56MB305.2:** Clinical samples and Master pure culture practices. **CO56MB305.3:** Learnt the fundamentals of diagnostic procedures and use disease diagnosis kits. **CO56MB305.4:** Understand Serological and Molecular Methods. **CO56MB305.5:** Understand Rapid Detection of Pathogens such as Typhoid, Dengue & Blood group.	

Scheme of Studies:

Board ofStudy	CourseCode	CourseTitle	Scheme ofstudies (Hours/Week)					Total Credits(C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
PCC	**56MB305**	Clinical Diagnosis of Microorganisms	3	1	1	2	7	4

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

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

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

SL: Self Learning;

C: Credits.

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

Scheme of Assessment:Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 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	**56MB305**	Clinical Diagnosis of Microorganisms	**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	56MB355	Clinical Diagnosis of Microorganisms Lab	35	5	5	5	50	50	50

Course-Curriculum:

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

ApproximateHours

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

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO56MB305.1: Importance of diagnosis of diseases and associated clinical samples for diagnosis.	**SO1.1** Understand the bacterial diseases of human body system	**LI1.1** Making of differential media for pathogenic microorganisms	**Unit-1** **Importance of Diagnosis of Diseases** **CI1.1** Bacterial diseases of various human body systems	**SL1.1** Study the morphology and structure of bacteria.
	SO1.2 Study about fungal diseases of human body system	**LI1.2** prepare PDA media using potato	**CI1.2** Fungal diseases of various human body systems	**SL1.2** Learn the different types of disease caused by microorganisms in humans.

	SO1.3 Explain Viral diseases of human body systems		**CI1.3** Viral diseases of various human body systems	
	SO1.4 Understand protozoan diseases of human body systems		**CI1.4** Protozoan diseases of various human body systems	
	SO1.5 Illustrate disease associated clinical samples for diagnosis		**CI1.5** Disease associated clinical samples for diagnosis.	
	SO1.6 Explain Diagnosis types and tests		**CI1.6** Diagnosis types and tests	
	SO1.7 Learn about significance of diagnostic tests		**CI1.7** Significance of diagnostic tests in fighting infectious diseases	
	SO1.8 Understand application of diagnosis		**CI1.8** Importance of diagnosis in health care	
	SO1.9 Revision and assessment		**CI1.9** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Diagrammatic representation of different disease of human body system caused by microorganisms.
	SW1.2 Mini Project	Explain the types of diagnostic tests used for humans against infection by microorganisms.
	SW1.3 Other Activities (Specify)	Find out some research paper on recent research on diagnostic tests against bacteria.

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

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO56MB305.2: Clinical samples and Master pure culture practices.	**SO2.1** Understand about collection of clinical samples	**LI2.1** Isolation & identification of microorganisms from skin, throat and nasal swab.	**Unit-2** **Collection of Clinical Samples** **CI2.1** How to collect clinical samples	**SL2.1** Learn about different types of clinical samples
	SO2.2 Learn about collection of clinical sample from oral cavity	**LI2.2** to collect the clinical sample septically	**CI2.2** Collection of clinical sample from oral cavity	**SL2.2** Understand about importance of clinical samples in diagnosis of diseases.
	SO2.3		**CI2.3**	

	Learn about collection of clinical sample from throat		Collection of clinical sample from throat	
	SO2.4 Learn about collection of clinical sample from skin		**CI2.4** Collection of clinical sample from skin	
	SO2.5 Learn about collection of clinical sample from urine and faeces		**CI2.5** Collection of clinical sample from CSF, urine and faeces	
	SO2.6 Explain precautions required for collection of clinical samples		**CI2.6** Precautions required for collection of clinical samples	
	SO2.7 Illustrate method of transport of clinical samples to laboratory		**CI2.7** Method of transport of clinical samples to laboratory	
	SO2.8 Study method of storage of clinical samples		**CI2.8** Method of storage of clinical samples	
	SO2.9 Revision and assessment		**CI2.9** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Write short notes on methods of storage and transport of clinical samples.
	SW1.2 Mini Project	List all the methods for collection of different clinical samples.
	SW1.3 Other Activities (Specify)	Find out some you tube videos related to collection of clinical samples.

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

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO56MB305.3: Learnt the fundamentals of diagnostic procedures and use disease diagnosis kits.	**SO3.1** Illustrate the examination of sample by staining	**LI3.1** Making of differential media for pathogenic microorganisms	**Unit-3** **Direct Microscopic Examination and Culture** **CI3.1** Examination of sample by staining - Gram stain,	**SL3.1** Study different types of staining methods.
	SO3.2 Study about Gram's stain and Giemsa stain	**Li 3.1** to perform the gram staining of the bacteria	**CI3.2** Examination of sample by staining -Giemsa stained thin blood film for malaria	**SL3.2** Elucidate importance of culture. media in clinical diagnosis
	SO3.3 Explain different types of culture media		**CI3.3** Preparation and use of culture media-Blood agar	
	SO3.4 Learn about preparation and use of chocolate agar		**CI3.4** Preparation and use of culture media- Chocolate agar	
	SO3.5 Learn about preparation and use of - Lowenstein-Jensen medium		**CI3.5** Preparation and use of culture media- Lowenstein-Jensen medium .	
	SO3.6 Learn about preparation and use of Mac Conkey agar		**CI3.6** Preparation and use of culture media- Mac Conkey agar	
	SO3.7 Study distinct colony properties of various bacterial pathogens		**CI3.7** Distinct colony properties of various bacterial pathogens	
	SO3.8 Understand microscopic examination of bacterial culture		**CI3.8** Microscopic examination of bacterial culture	
	SO3.9 Revision and assessment		**CI3.9** Revision and assessment	

Suggested Sessional Work	**SW1.1** Assignments	Write down the distinct colony properties of various bacterial pathogens.

(SW):*anyone*	**SW1.2**Mini Project	Differentiate between chocolate agar and Mac Conkey agar media and their usefulness in clinical diagnosis.
	SW1.3 Other Activities (Specify)	Make a chart showing different types of culture media used for the growth of different microorganisms.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	4	01	02	16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO56MB305.4: Understand Serological and Molecular Methods.	**SO4.1** Understand the concept of serological and molecular methods in clinical diagnosis of diseases.	LI4.1 to perform the enzyme linking using ELISA	**Unit-4 Serological and Molecular Methods** **CI4.1** Serological Methods - Agglutination	**SL4.1** Learn the structure of DNA and RNA
	SO4.2 Study agglutination and ELISA	LI4.2 to extract the nucleic acid from the genome	**CI4.2** Serological Methods - ELISA	**SL4.2** Study the application of various molecular techniques.
	SO4.3 Explain the method of immunofluorescence		**CI4.3** Serological Methods- Immunofluorescence	
	SO4.4 Understand the significance and application of serological methods.		**CI4.4** Application of serological methods	
	SO4.5 Illustrate the concept of nucleic acid based methods		**CI4.5** Nucleic acid based methods -PCR	
	SO4.6 Explain the role of nucleic acid probes		**CI4.6** Nucleic acid probes	
	SO4.7 Learn application of molecular methods		**CI4.7** Application of molecular methods	
	SO4.8 Understand the applications of serological and molecular methods in heailthcare.		**CI4.8** Significance of serological and molecular methods in healthcare	
	SO4.9 Revision and assessment		**CI4.9** Revision and assessment	

Suggested Sessional Work	**SW1.1** Assignments	Write the applications of serological and molecular methods used in clinical diagnosis of diseases.
	SW1.2 Mini Project	Make a list of various molecular based methods used in research and diagnosis.

(SW):*anyone*	**SW1.3** Other Activities (Specify)	Find out some you tube videos based on the serological methods used in clinical diagnostics.

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

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO56MB305.5: Understand Rapid Detection of Pathogens such as Typhoid, Dengue & Blood group.	**SO5.1** Illustrate the kit based Rapid Detection of Typhoid	**LI5.1** Determination of resistance/sensitivity of bacteria using disc diffusion method.	**Unit-5** **Kits for Rapid Detection of Pathogens** **CI5.1** Kits for Rapid Detection of Typhoid	**SL5.1** Study the effect of antibiotics on microorganisms.
	SO5.2 Understand the kits based Rapid Detection of Dengue	**LI5.2** Determination of minimal inhibitory concentration (MIC) of an antibiotic by serial double dilution method.	**CI5.2** Kits for Rapid Detection of Dengue.	**SL5.2** Learn various methods used for selection of antibiotic sensitive/resistance microorganisms.
	SO5.3 Understand the kits based Rapid Detection of blood group		**CI5.3** Kits for Rapid Detection of Blood group	
	SO5.4 Study disc diffusion method for sensitivity of bacteria		**CI5.4** Disc diffusion method for sensitivity of bacteria	
	SO5.5 Determination of resistance/sensitivity of bacteria using disc diffusion method		**CI5.5** Determination of resistance/sensitivity of bacteria using disc diffusion method	
	SO5.6 Explain the application of disc diffusion method for bacterial sensitivity		**CI5.6** Application of disc diffusion method for bacterial sensitivity	
	SO5.7 Learn application of kits for rapid detection of pathogens		**CI5.7** Application of kits for rapid detection of pathogens	
	SO5.8 Detection of bacterial diseases		**CI5.8** Detection of bacterial diseases	
	SO5.9 Revision and assessment		**CI5.9** Revision and assessment	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Diagrammatic representation of disc diffusion method for detection of bacteria.
	SW1.2 Mini Project	Illustrate the applications of detection of bacterial pathogens
	SW1.3 Other Activities (Specify)	Find out some research papers related to kits based detection of pathogens.

Course duration (in hours)to attain Course Outcomes:

Course Title: Clinical Diagnosis of Microorganisms **Course Code: 56MB305**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-98BT401.1. Understand the composition, structure and characteristics of nucleic acids.	9	4	2	1	16
CO2-98BT401.1. Understand molecular phenomena of DNA copying and transmission of information, its damage and repair mechanism.	9	4	2	1	16
CO3-98BT401.3. Students are able to understand the chemical and molecular processes that occur in and between cells.	9	4	2	1	16
CO4-98BT401.4. Gain knowledge about the protein synthesis mechanism and its localization in and between the cells.	9	4	2	1	16
CO5-98BT401.5. The regulation of gene function, respond to environment and associated phenomena.	9	4	2	1	16
Total Hours	45	20	10	5	80

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

Course Title: Clinical Diagnosis of Microorganisms **Course Code: 56MB305**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO56MB305.1: Importance of diagnosis of diseases and associated clinical samples for diagnosis.	2	2	3	1	08
CO56MB305.2: Clinical samples and Master pure culture practices.	2	4	4	1	11
CO56MB305.3: Learnt the fundamentals of diagnostic procedures and use disease diagnosis kits.	3	4	5	1	13

CO56MB305.4: Understand Serological and Molecular Methods.	2	3	5	1	11
CO56MB305.5: Understand Rapid Detection of Pathogens such as Typhoid, Dengue & Blood group.	4	2	1	2	09
Total Marks	**13**	**15**	**18**	**06**	**52**

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

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Textbook of Microbiology, Ananthanarayan R and Paniker CKJ (2009) 8th Edition,Universities Press Private Ltd.
2	Medical Microbiology, Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's 26th Edition. McGraw Hill Publication
3	Essentials of clinical diagnosis, Sunil K.Sen, (2022)9th Edition, CBS publishers & distributors PVT. LTD.
4	Oxford Handbook of Clinical Diagnosis, Llewelyn., Ang., Lewis , Abdullah (2014) 3rd Edition, Oxford University Press.

(b) Online Resources:

Suggested instructions/Implementation strategies:

1. Improved lecture
2. Tutorial

3. Case method
4. Group Discussion
5. Role play
6. Visit to Waste water/Effluent Treatment plant and downstream pharmaceutical plants
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: M.Sc. Microbiology
Semester: lll

Course Title: Clinical Diagnosis of Microorganisms

Course Code: 56MB305

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO56MB305.1: Importance of diagnosis of diseases and associated clinical samples for diagnosis.	**2**	**2**	**3**	**2**	**1**	**2**	**2**	**1**
CO56MB305.2: Clinical samples and Master pure culture practices.	**2**	**2**	**2**	**3**	**1**	**2**	**1**	**2**
CO56MB305.3: Learnt the fundamentals of diagnostic procedures and use disease diagnosis kits.	**2**	**2**	**2**	**2**	**1**	**2**	**1**	**3**
CO56MB305.4: Understand Serological and Molecular Methods.	**3**	**2**	**3**	**2**	**2**	**3**	**1**	**3**
CO56MB305.5: Understand Rapid Detection of Pathogens such as Typhoid, Dengue & Blood group.	**2**	**2**	**2**	**2**	**1**	**2**	**3**	**2**

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO56MB305.1:** Importance of diagnosis of diseases and associated clinical samples for diagnosis.	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**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO56MB305.2:** Clinical samples and Master pure culture practices.	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**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO56MB305.3:** Learnt the fundamentals of diagnostic procedures and use disease diagnosis kits.	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**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO56MB305.4:** Understand Serological and Molecular Methods.	SO4.1 SO4.2 SO4.3 SO4.4, SO4.5, SO4.6, 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 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO56MB305.5:** Understand Rapid Detection of Pathogens such as Typhoid, Dengue & Blood group.	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**

Curriculum Development Team

Prof. Kamlesh Choure
Prof Ashwini A. Waoo
Prof. Deepak Mishra
Er. Arpit Srivastava
Mr. Piyush Kant Rai

Program Name	**Masters of Science (M.Sc.)- Microbiology**	
Semester	III	
Course Code:	56MB306	
Course title:	Scientific Writing and Patenting Process	**Curriculum Developer**: Dr. Deepak Mishra, Professor
Pre-requisite:	Student should have basic knowledge of Microbiology and practical as well as research skills.	
Rationale:	The paper on Scientific Writing and Patenting Process in an MSc Microbiology program explores the critical role of specialized research and scientific tools in analyzing microbiology research. 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 systematic research process helps us for doing any research in a systematic manner along with data publication. It also explores the knowledge of law and legislation, patenting and ethics in Microbiology.	
Course Outcomes (COs):	**CO1-56MB306.1:** Students are being knowledgeable with essentials of scientific writing and research methods through various tools available for scientific research. **CO2-56MB306.2:** Development of critical thinking skills for evaluating scientific literature and identifying research problems **CO3-56MB306.3:** Proficiency in communicating research findings through various written forms. **CO4-56MB306.4:** Recognize various issues related to RDT research and analyze the regulatory frameworks, law and legislations related to biotechnological research. **CO5-56MB306.5:** Understanding of patenting process, laws, and drafting patent applications.	

Scheme of Studies:

Board of Study	CourseCode	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=3:0:0)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
DSC	56MB306	Scientific Writing and Patenting Process	3	1	1	5	10	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)		
PCC	**56MB306**	Scientific Writing and Patenting Process	**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)		
PCC	56MB354	Pharmaceutical Microbiology Lab	35	5	5	5	50	50	50

Course-Curriculum:

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

Item	Cl	LI	SW	SL	Total
Approx. Hrs	9	04	01	05	19

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-56MB306.1: Students are being knowledge-able with essentials of scientific writing and research methods through various tools available for scientific research.	**SO1.1** Define and Describe concept of scientific writing and research, its types	**LI1.1** Prepare a brief scientific article on a given topic, focusing on different types of scientific writing.	**Unit-1** **CI1.1** Scientific Writing & Research- meaning, types,	**SL1.1** Search various reference books and study material to start the learning of research and scientific writing
	SO1.2 Describe about objectives and approaches of research	**LI1.2** Design a research proposal outlining objectives and approaches for a given research topic.	**CI1.2** objectives, and approaches	**SL1.2** Differentiation of research problems based on objective
	SO1.3 Explain about methods and sources of literature		**CI1.3** Literature collection: Different sources,	**SL1.3** Searching and literature on different online resources.
	SO1.4 Describe about biological online database		**CI1.4** Biological online databases,	
	SO1.5 Study of sampling techniques		**CI1.5** Determining sample design,	**SL1.4** Use of sampling methods for collection of scientific data related to different research problems
	SO1.6 Study of data collection methods		**CI1.6** collecting data	
	SO1.7 Describe concept of hypothesis testing		**CI1.7** analysis and hypothesis testing	**SL1.5** Setting up the Hypothesis and their application in research
	SO1.8 Study about generalization and		**CI1.8** Generalization and	

	interpretation of research findings		interpretation.	
	SO1.9 Revision and assessment			

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 databased available on internet and their application in research

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)**
CO2-56MB306.2: Development of critical thinking skills for evaluating scientific literature and identifying research problems	**SO2.1** Explore the concept and techniques of writing reviews	**LI2.1** Write a review paper based on a given research topic.	**Unit-II** **CI2.1** Writing review articles,	**SL2.1** Search various contents for writing a review article
	SO2.2 Describe the contents of research article	**LI2.2** Analyze and summarize the contents of a provided research article.	**CI2.2** Writing Journal articles, bibliography	**SL2.2** designing of a research article
	SO2.3 Reflecting about the concept and contents of books and monograph		**CI2.3** books, and monographs-	**SL2.3** Learn about contents of an ideal book
	SO2.4 Explain about contents of an ideal thesis		**CI2.4** Structure of thesis;	**SL2.3** Searching and literature on different online resources.
	SO2.5 Assessing the role of manuscript and proof correction in research		**CI2.5** Manuscript and proof correction,	
	SO2.6 Explaining the steps of research process		**CI2.6** Research Process: selection of problems:	**SL2.5** Use of research process to solve different research problems
	SO2.7 Explaining the stages of execution of research		**CI2.7** stages in the execution of research	

	SO2.8 explain about different types of research designs.		**CI2.8** Research Designs.	
	SO2.9 Revision and assessment		**CI2.9** Revision and assessment	

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)**
CO3-56MB306.3: Proficiency in communicating research findings through various written forms.	**SO3.1** Explain the role of different types of data in research.	LI3.1 Analyze various types of research data (quantitative, qualitative, and mixed) and their role in research projects. Prepare a summary report.	**Unit-III** **CI3.1** Data Collection: Secondary Data, Primary Data	**SL3.1** Read about various types of data and their applications in research
	SO3.2 Assessing different methods used in data collection	LI3.2 Perform hands-on exercises with different data collection methods (surveys, interviews, experiments).	**CI3.2** Methods of collection	**SL3.2** Collection of research data using different tools
	SO3.3 Explaining concept and types of scales		**CI3.3** Scaling Techniques Concepts and types,	**SL3.3** Illustration about different scaling techniques
	SO3.4 Assessing different scaling methods used in research		**CI3.4** Rating scales and Ranking scales, Scale Construction techniques	
	SO3.5 Describe about multi-dimensional scaling		**CI3.5** Multi-Dimensional Scaling.	
	SO3.6 Assessing the role of research journals in research		**CI3.6** Journals: Standard of research	**SL3.4** Collection of different research journals

	and their standards		Journals	
	SO3.7 Describe about concept of impact factor and		**CI3.7** Impact factor,	**SL3.5** Assess role of impact factor and citation index in research
	SO3.8 Describe citation index		**CI3.8** Describe the citation index	
	SO3.9 Revision and assessment		**CI3.9** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail different categories of data and its collection methods.
	SW3.2 Mini Project	Describe the role of scaling methods in research and their application for data validation
	SW3.3 Other Activities (Specify)	Prepare a list of research journal and checking their standard parameters.

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)**
CO4-56MB306.4: Recognize various issues related to RDT research and analyze the regulatory frameworks, law and legislations related to biotechnological research.	**SO4.1** Exploring the legal and socioeconomic issues related to biotechnology	**LI4.1** Analyze case studies of legal and socioeconomic issues in biotechnology.	**Unit-IV** **CI4.1** The legal and socioeconomic impacts of biotechnology	**SL4.1** Learn about legal and socioeconomic impact of biotechnology
	SO4.2 Assessing the ethical issues of RDT research and biotechnology	LI4.2 Conduct a debate or role-playing exercise on ethical dilemmas in RDT research and biotechnology.	**CI4.2** Ethical concerns of biotechnology research and innovation	**SL4.2** Discuss ethical concern of biotechnology and its impact on society.
	SO4.3 Explaining the concept and types of IPRs		**CI4.3** Intellectual property rights,	**SL4.3** Learn about various types of Intellectual Property
	SO4.4 Explaining the administrative framework of biotech and RDT research		**CI4.4** Regulatory framework in India governing GMOs	**SL4.4** Case studies related to RDT and biotech laws
	SO4.5 Evaluate impact of law on RDT research		**CI4.5** Recombinant DNA Guidelines (1990),	
	SO4.6 Describe the impact of law on research on transgenics.		**CI4.6** Revised Guidelines for Research in Transgenic Plants (1998),	

	SO4.7 Assessing the role of law on preventing food adulteration		**CI4.7** Prevention Food Adulteration Act (1955),	**SL4.5** Case studies related to Food laws
	SO4.8 Describe law and standards of food regulation and safety		**CI4.8** The Food Safety and Standards Bill (2005),	
	SO4.9 Define the role of environmental policy on solving environmental issues		**CI4.9** National Environment Policy (2006).	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain about regulation of RDT research through different law
	SW4.2 Mini Project	Describe the various issues related to biotechnology and RDT research.
	SW4.3 Other Activities (Specify)	Prepare one article on law and safety issues related to food and food ingradients

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

Course Outcome (CO)	**Session Outcomes (SOs)**	**LaboratoryInstruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO5-56MB306.5: Understanding of patenting process, laws, and drafting patent applications.	**SO5.1** Define the concept and objective of patenting.	**LI5.1** Conduct a case study analysis on various patent applications related to biotechnology. Document the objectives and outcomes of each case.	**Unit-V** **CI5.1** Objectives of the patent system: Basic principles	**SL5.1** learn about basic concept & requirement of patents
	SO5.2 Able to execute to perform role of patent law	**LI5.2** Simulate the patent application process by preparing a mock patent application for a biotechnological invention. Include drafting claims, descriptions, and illustrations.	**CI5.2** general requirements of patent law,	**SL5.2** Review different Indian patent laws
	SO5.3 Apply the role of patenting system in biotech research		**CI5.3** Biotechnological inventions and patent law, Legal development,	**SL5.3** learn how get legal protection for invention by patenting

	SO5.4 Apply the patents for protection of innovation		**CI5.4** Patentable subjects and protection in biotechnology,	
	SO5.5 Evaluate the patenting process for living organisms		**CI5.5** The patenting living organisms,	
	SO5.6 Describe international patent law and its impact on patenting		**CI5.6** International conve-ntions patents	**SL5.4** Learn about international patenting law and legislations.
	SO5.7 Describe process of patenting		**CI5.7** methods of application of patents	
	SO5.8 Elaborate the role of biodiversity and for plant protection		**CI5.8** Biodiversity and farmer right.	**SL5.5** Learn about biodiversity and former right acts
	SO5.9 Revision and assessment		**CI5.9** Revision and assessment	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general characteristics of patent and impact of patent law on research
	SW5.2 Mini Project	Describe the role of patent law for protection of biotechnological innovations
	SW5.3 Other Activities (Specify)	Prepare a detail document on patent law of different countries

Course duration (in hours) to attain Course Outcomes:

Course Title: Scientific Writing and Patenting Process **Course Code:** 56MB306

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-56MB306.1: Students are being knowledgeable with essentials of scientific writing and research methods through various tools available for scientific research.	9	4	5	1	19
CO2-56MB306.2: Development of critical thinking skills for evaluating scientific literature and identifying research problems	9	4	5	1	19
CO3-56MB306.3: Proficiency in communicating research findings through various written forms.	9	4	5	1	19

CO4-56MB306.4: Recognize various issues related to RDT research and analyze the regulatory frameworks, law and legislations related to biotechnological research.	9	4	5	1	19
CO5-56MB306.5: Understanding of patenting process, laws, and drafting patent applications.	9	4	5	1	19
Total Hours	45	20	25	05	95

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

Course Title: Scientific Writing and Patenting Process **Course Code:** 56MB306

Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-56MB306.1: Students are being knowledgeable with essentials of scientific writing and research methods through various tools available for scientific research.	2	1	1	1	5
CO2-56MB306.2: Development of critical thinking skills for evaluating scientific literature and identifying research problems	2	4	2	2	10
CO3-56MB306.3: Proficiency in communicating research findings through various written forms.	2	3	3	2	10
CO4-56MB306.4: Recognize various issues related to RDT research and analyze the regulatory frameworks, law and legislations related to biotechnological research.	3	5	5	2	15
CO5-56MB306.5: Understanding of patenting process, laws, and drafting patent applications.	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

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

Suggested learning Resources:

(a) Books:

(b)

S.No.	**Title/Author/Publisher details**
1	Beier, F.K., Crespi, R.S. and Straus, T. Biotechnology and Patent protection-Oxford and IBH Publishing Co. New Delhi.
2	Singh K, Intellectual Property rights on Biotechnology, BCIL, New Delhi
3	Writing the doctoral dissertation. Barrons Educational series, 2nd edition, Davis, G.B. and C.A. Parker, 1997. pp 160.
4	Authoring a PhD, thesis: how to plan, draft, write and finish a doctoral dissertation, Duncary, P. 2003.
5	Beier, F.K., Crespi, R.S. and Straus, T. Biotechnology and Patent protection-Oxford and IBH Publishing Co. New Delhi.

(c) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: M. Sc. Microbiology
Semester: III Semester
Course Title: Scientific Writing and Patenting Process
Course Code: 56MB306

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**

CO1-56MB306.1: Students are being knowledgeable with essentials of scientific writing and research methods through various tools available for scientific research.	2	1	3	3	2	2	2	3
CO2-56MB306.2: Development of critical thinking skills for evaluating scientific literature and identifying research problems	2	1	3	2	3	1	3	3
CO3-56MB306.3: Proficiency in communicating research findings through various written forms.	1	2	3	2	3	1	2	2
CO4-56MB306.4: Recognize various issues related to RDT research and analyze the regulatory frameworks, law and legislations related to biotechnological research.	1	1	3	3	2	1	3	3
CO5-56MB306.5: Understanding of patenting process, laws, and drafting patent applications.	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	**CO1-56MB306.1:** 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 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	**CO2-56MB306.2:** Development of critical thinking skills for evaluating	SO2.1 SO2.2 SO2.3 SO2.4,	LI1 LI2	2.1, 2.2, 2.3, 2.4,2.5,2.6,2.7,2.8, 2.9	2SL-1,2,3,4,5

PSO 1,2,3	scientific literature and identifying research problems	SO2.5, SO2.6 SO2.7, SO2.8 SO2.9			
PO 1,2,3,4,5 PSO 1,2,3	**CO3-56MB306.3:** Proficiency in communicating research findings through various written forms.	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	**CO4-56MB306.4:** 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, SO4.6, SO4.7, SO4.8, SO4.9	LI1 LI2	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	**CO5-56MB306.5:** Understanding of patenting process, laws, and drafting patent applications.	SO5.1 SO5.2 SO5.3, SO5.4, SO5.5, SO5.6, SO7.7, SO5.8, SO5.9	LI1 LI2	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8, 5.9	5SL-1,2,3,4,5

Curriculum Development Team

Prof. Kamlesh Choure
Prof Ashwini A. Waoo
Prof. Deepak Mishra
Er. Arpit Srivastava
Mr. Piyush Kant Rai

Semester IV

Course Code:	56MB451
Course Title:	Project, Dissertation and Training
Course Outcomes:	
56MB451.1	Analyze microbial data and research studies to identify patterns and infer conclusions.
56MB451.2	Evaluate and critique scientific literature to enhance understanding of microbiological concepts.
56MB451.3	Design and execute experiments to investigate microbial processes and phenomena.
56MB451.4	Synthesize research findings to contribute original insights to the field of microbiology.
56MB451.5	Communicate complex microbiological research clearly through written and oral presentations.

AKS UNIVERSITY

DEPARTMENT OF BIOTECHNOLOGY

Guideline for Project/Dissertation/Industrial Internship

Guidelines and Format
for
M. Sc. Biotechnology
M. Sc. Microbiology
Thesis Preparation

AKS UNIVERSITY
SATNA (M.P.)

For internal use only

April 2022

TABLE OF CONTENT

S. No.	Content	Page
1	Part 1: Must – Know Issues	3
2	Thesis Content	6
3	Thesis Format	9
4	Thesis Defense	16
5	Format for Thesis Cover Page	17
6	Relevant Forms	18
7	Sample papers	28

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. Sc. Biotechnology/Microbiology 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 6 working months. Students are expected to devote regular time in preparing the research proposal, commencing the research project, writing the thesis and presenting it before an Evaluation Committee.

S. No.	Nomenclature for M. Sc. degree program	Duration
1	Dissertation (4^{th} Sem)	6 Months

Industrial training/Internship/Apprentice Program

Students who are getting opportunity to initiate their project/internship/apprentice/dissertation for 6-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 6-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 suitable student but criteria for selection should be publicized.

It is possible for students to propose and arrange these projects themselves, but the topic and scientific content must be endorsed by an Advisor of the Department of the University. For project that will be conducted outside the University and supervised by non-University employer, students are requested to provide evidence for such an arrangement by completing Form BT01 along with a CV of your supervisor.

6. Assessment

The thesis will be evaluated by an anonymous examiner assigned by the University. Students are allowed to present his/her thesis only if the examiner approved the same. 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 the 6-month 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 an example of this section.

Recommended structure of the section:

2.1 Research object and location (information about the object of your research and where it was conducted)

2.2 Experimental design: describe the experimental design, methods adopted 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 6 months dissertation 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 between 40-50 pages approx. for 6-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 80.
- 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

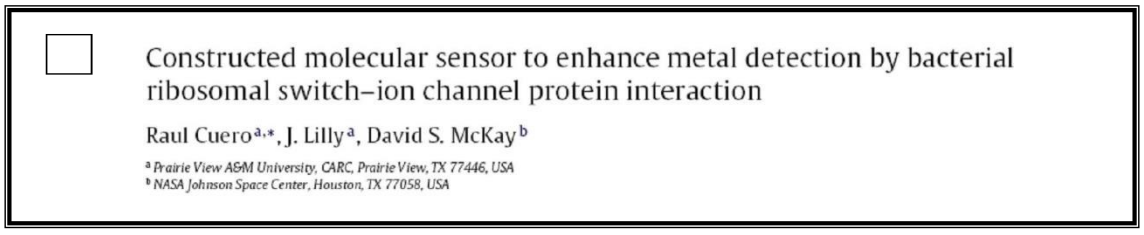
Author name(s) and affiliation

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

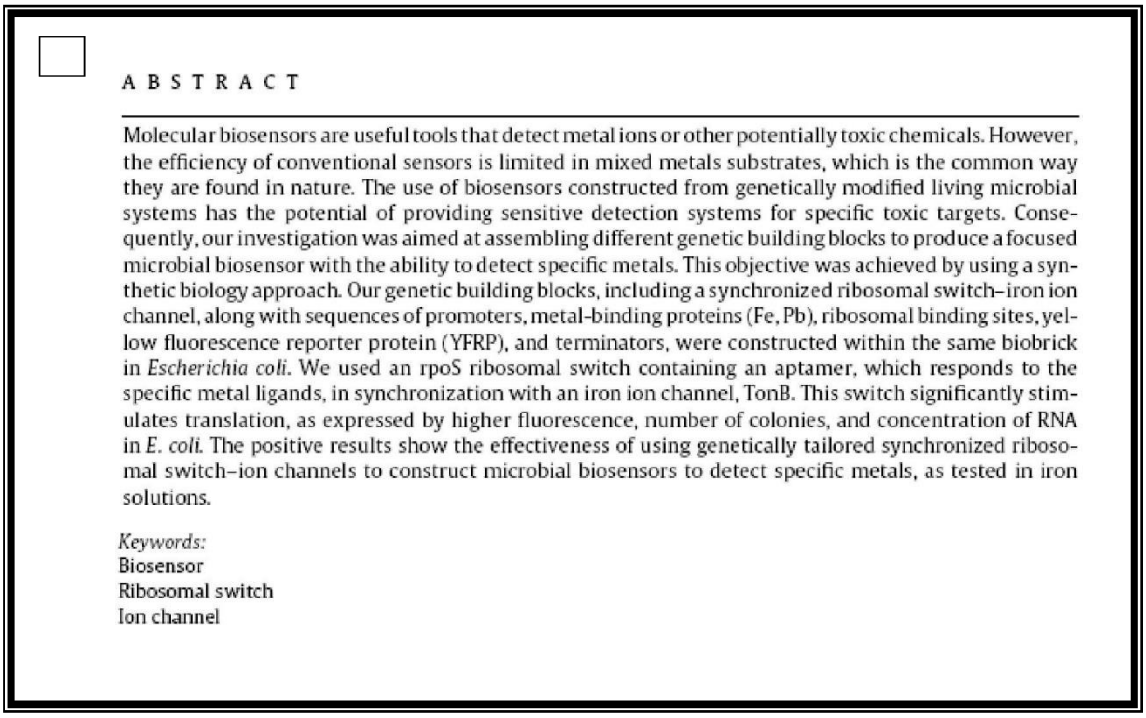
TITLE PAGE INFORMATION (see the example above)

- 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:

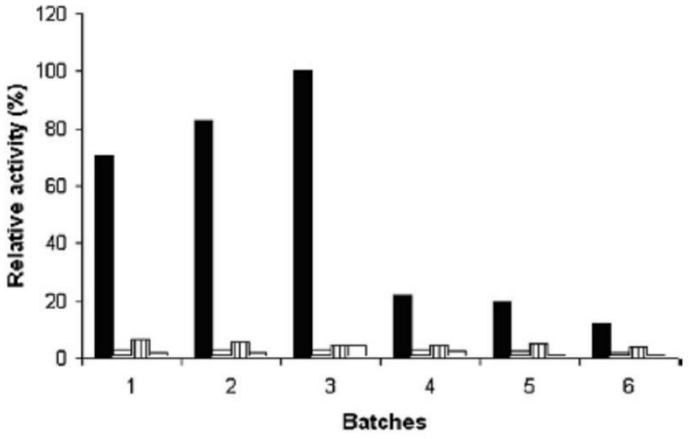


Fig. 5. Relative glucosyltransferase activity of the different low methoxyl pectin microcapsules containing glucosyltransferase after six batches of 30 min each of conversion of sucrose into isomaltulose. (■) Microcapsules with fat; (▣) microcapsules without fat; (◧) lyophilized microcapsules with fat;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

CITATION IN TEXT

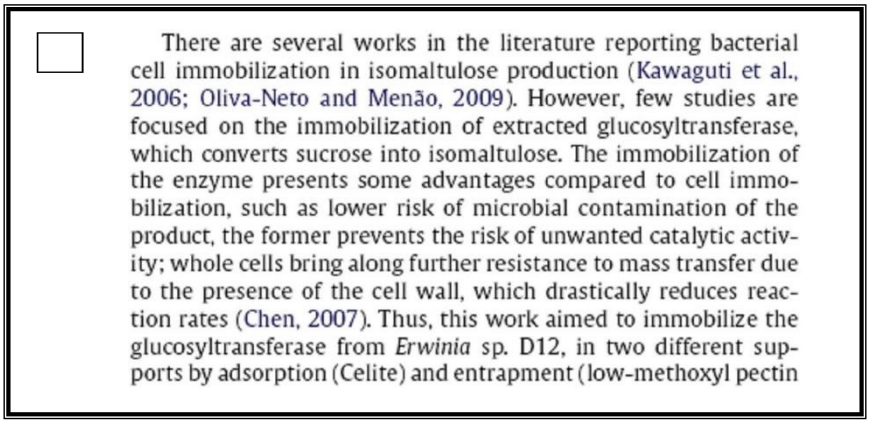
Please ensure that every reference cited in the text is also present in the reference list and vice versa. Any references cited in the abstract must be given in full. Unpublished results and personal communications are not recommended in the reference list, but may bementioned in the text. If these references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

.....

.....

.....

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,

.....

.....

.....

.....

.....

.....

.....

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

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

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)

.....

.....

.....

.....

.....

_____

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:

.....

.....

.....

.....

.....

.....

.....

_____

Name of Examiner

_____

Date Signed