Curriculum Book

and

Assessment and Evaluation Scheme

based on

Outcome Based Education (OBE)

and

Choice-Based Credit System (CBCS)

in

Bachelor of Science (Hons.) in Biotechnology

B. Sc. Hons. (Biotechnology)

4 Year Degree Program

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

AKS University

Satna 485001, Madhya Pradesh, India

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Curriculum & Syllabus of B.Sc. (Hons.) Biotechnology Program

(Revised as of 2023)

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AKS University

Faculty of Life Sciences and Technology

Department of Biotechnology

Curriculum of B.Sc. (Hons.) Biotechnology Program

(Revised as on 2023)

Foreword

I am delighted to see that the Biotechnology Department's redesigned curriculum for the B.Sc. (Hons.) (Biotechnology) Programme smoothly incorporates the newest technological developments while adhering to NEP -2020 and 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 B.Sc. (Hons.)- Biotechnology program for implementation in the upcoming session.

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

01 August 2023

AKS University, ***Faculty of Life Sciences and Technology***

Department of Biotechnology

Curriculum of B.Sc. (Hons.) Biotechnology Program

(Revised as on 2023)

From the Desk of the Vice-Chancellor

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

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

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

I am confident that the updated curriculum for B.Sc. (Hons.) Biotechnology will not only enhance students' technical skills but also contribute significantly to their employability. During the process of revising the curriculum, I am pleased to observe that the Biotechnology department has diligently adhered to the guidelines provided by the 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
01 August 2023

Professor B. A. Chopade
Vice-Chancellor

Preface

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

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

This curriculum closely adheres to the NEP model syllabus distributed in 2020. 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 B. Sc.(Hons.) Biotechnology program is capped at 13 credits.

This curriculum is enriched with course components in alignment with UGC guidelines, encompassing various disciplines such as Major Courses, Minor Course, Generic Electives, Skill Enhancement Course, Ability Enhancement Core Courses, and Discipline Specific Courses.

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

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

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

OVERVIEW OF THE DEPARTMENT

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

VISION

The vision of the department is to dedicate research for Human and Environmental welfare. To become a 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. Our aim is to address global challenges, improve human well-being, and contribute to sustainable development through the application of biotechnological solutions by following aspects:

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

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

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

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

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

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

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

PROGRAM OUTCOMES (POs)

PO1: Capable of demonstrating comprehensive knowledge and understanding of major concepts, theoretical principles and experimental findings of the laws of nature that govern all natural processes, develop a sense of inquisitiveness that would lead them to explore the reasons and logic behind scientific phenomena/principles through established methods of observation, modelling, experimentation and calculations.

PO2: Demonstrate knowledge for in-depth scientific, analytical and critical thinking to identify, formulate and solve the issues related to Biotechnology Industry, Pharma industry, Medical or hospital related organizations, Regulatory Agencies, & Academia.

PO3:Perceive things and the events that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) in the light of scientific principles.

PO4: Develop state-of-the-art laboratory skills like proper handling of scientific instruments, knowledge of SOPs on laboratory protocols, planning and executionin the areas of life sciences and biotechnology.

PO5: Apply the scientific research method to design, execute and analyze an experiment and also demonstrate the scientific procedures, experimental observation and inferences derived from collected practical data.

PO6: Inculcate critical thinking abilities, problem-solving through accuracy and validity of practical knowledge, and to validate their assumptions and ideas based on accurate results from careful research and observations

PO7: Elevate the student's awareness about the issues of environmental deterioration, pollution and sustainable development. Developing critical problem-solving approach for these societal concerns via bioremediation and integrated management.

PO8: Design solutions for complex scientific problemsand design system components or processes that meet the specified needs with appropriateconsideration for the public health and safety, and the cultural, societal, and environmentalconsiderations.

PO9: Recognize the need for, and have the preparation and ability toengage in independent and life-long learning in the broadest context of technological change aimed at personal development and for improving knowledge/skill development and reskilling.

PO10: Development of effective professional communication skills for speak, read and write up in scientific literature and other social media platform related to biotechnology by connecting people, ideas, books, media and technology.

PO11: Expand their learning avenues through use of multiple learning resources to keep themselves abreast of the scientific developments worldwide; take up advanced studies in the fields of 1Life sciences and Applied Sciences.

PO12: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them.

GRADUATE ATTRIBUTES (GA)

The Graduate Attributes are the knowledge skills and attitudes which the students have at the time of graduation. These attributes are generic and are common to all programs.

1. Technical Knowledge: Apply the knowledge of mathematics, science, and a specialization to identify the solutions of complex life science-based challenges.
2. Problem Findings: Identify, formulate, review and analyze complex biotechnology problems reaching substantiated conclusions using multidisciplinary approach.
3. Skill Development: Design solutions for complex problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations with core and soft skills.
4. Research Oriented Learning: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. Technical Development: Create, select, and apply appropriate techniques, resources, and modern IT tools including prediction and modeling to complex activities with an understanding of the limitations.
6. Contribution in Society Development: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional practice.
7. Environment and Sustainability: Understand the impact of the professional technical solutions in societal and environmental contexts, and demonstrate the knowledge of, and needfor sustainable development.
8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities andnorms of the biotechnical procedures.
9. 3Ts: Function effectively as a member or a leader in diverse teams, and in multidisciplinary work styles empowering Time, Team and Task management
10. Project and Practical Skills: Demonstrate knowledge and understanding of the biotechnology principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
11. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Recognized as technologists and leaders, who would help solve industry's scientific problems

PEO2: Demonstrate professional integrity and ethical attitude with awareness of global and national competencies and think about the social entailment of their work, especially its impact on safety, health and environment for sustainable development.

PEO3: Create new opportunities through innovations in startup sector and pursue higher education in multidisciplinary domains of biotechnology

PEO4: Apply the acquired practical skills and broad biotechnological training in product, process and inculcate leadership qualities for innovative entrepreneurship to meet the societal demands.
PEO5: Develop leadership qualities and propose techno-economic and social considerations, and aptitude for life-long learning, and get introduced to professional ethics and ethos.

PROGRAM SPECIFIC OBJECTIVES (PSOs)

PSO1: To impart an ability to apply biotechnology skills (including molecular & micro biology, immunology & genetic engineering, bioprocess & fermentation, enzyme & food technology and bioinformatics) and its applications in core and allied fields.
PSO2: To provide students with the concepts and research approaches with professional ethics in analytical, scientific and technical domains for their higher career in the field of biotechnology and develop their scientific interest.
PSO3: To impart in-depth practical oriented knowledge and transferable skills to students in various thrust areas of biotechnology, so as to meet the demands of industry and academia for job trades and employment opportunities.

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 UG Degree Course in Biotechnology, the total number of credits proposed for the Four-year B. Sc. (Biotechnology) is kept as 160.

C. Structure of UG Program in Biotechnology:

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

S. No.	Category	Breakup of Credits
1	Major Course	48
2	Minor Course	32
3	Generic Elective Course	16
4	Ability Enhancement Course	08
5	Skill Enhancement Course	12
6	Discipline Specific Core Course	16

7	Field Project/ Internship/ Apprenticeship	28
	TOTAL	160

D. Course Code and Definition:

Course code	Definitions
L	Lecture
T	Tutorial
P	Practical
C	Credits

- **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.

E. Evaluation Scheme (Suggestive only):

F. Mapping of Marks to Grades

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

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

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B.Sc. (Hons.)in Biotechnology
Four-Year Full Time Degree Programme
B.Sc. – First Semester
(Undergraduate Certificate in Biotechnology)

The department provides a Four-year B.Sc. (Hons) programme in Biotechnology using a Choice Based Credit System (CBCS) that consists of Eight semesters. In which after completion of I and II Semester student get Undergraduate Certificate in Biotechnology, III and IV Semester student get Undergraduate Diploma in Biotechnology, V and VI Semester student get Undergraduate Degree in Biotechnology and after VII and VIII Semester completion he get B.Sc. (Hons.) in Biotechnology. The regulations for the B.Sc. (Hons.) in Biotechnology provided by AKS University under the Choice Based Credit System (CBCS) are shown here.

S.No.	Subject	Subject Code	Subject/Paper Title	Subject area	Periods			Credit	Marks Distribution		
					L	T	P		Internal	External	Total
Major Subject											
1.	Biotechnology	01BT101	Cell Structure & Introduction to Biotechnology	MJ 1	4	-	-	4	50	50	100
2.		01BT101-L	Cell Biology & Basic Instrumentation Lab	MJ 1 P	-	-	4	2	50	50	100
Minor Subject (Choose Any one)											
3.	Microbiology	02MB101	Basics of Microbiology	MI 1	4	-	-	4	50	50	100
4.		02MB101-L	Microbial Techniques Lab	MI 1 P	-	-	4	2	50	50	100
5.	Biochemistry	02BC101	General Biochemistry	MI 1	4	-	-	4	50	50	100
6.		02BC101-L	General Biochemistry Lab	MI 1 P	-	-	4	2	50	50	100
Generic Elective Course (Choose Any One) • *Student can opt second group of Minor Subject as a generic elective course but credit will be 3:1.*											
7.	Microbiology	03MB101	Basics of Microbiology	GEC 1	3	-	-	3	50	50	100
8.		03MB101-L	Microbial Techniques Lab	GEC 1 P	-	-	2	1	50	50	100
9.	Biochemistry	03BC101	General Biochemistry	GEC 1	3	-	-	3	50	50	100
10.		03BC101-L	General Biochemistry Lab	GEC 1 P	-	-	2	1	50	50	100
Ability Enhancement Course											
11.	English	0SSD101	English Language	AEC 1	2	-	-	2	50	50	100
12.	SDG	0SDG102	Sustainable Development Goals	AEC 2	2	-	-	2	50	50	100
				TOTAL	**15**	**-**	**10**	**20**	**400**	**400**	**800**

B.Sc. (Hons.)in Biotechnology
Four-Year Full Time Degree Programme
B.Sc. – Second Semester
(Undergraduate Certificate in Biotechnology)

S.No.	Subject	Subject Code	Subject/Paper Title	Subject area	Periods			Credit	Marks Distribution		
					L	T	P		Internal	External	Total
Major Subject											
1.	Biotechnology	01BT201	Molecular Biology & Diagnostic Techniques	MJ 2	4	-	-	4	50	50	100
2.		01BT201-L	Molecular Biology & Diagnostic Techniques Lab	MJ 2 P	-	-	4	2	50	50	100
Minor Subject (Choose Any one)											
3.	Microbiology	02MB201	Microbial Physiology	MI 2	4	-	-	4	50	50	100
4.		02MB201-L	Microbial Physiology Lab	MI 2 P	-	-	4	2	50	50	100
5.	Biochemistry	02BC201	Bioenergetics and Metabolism	MI 2	4	-	-	4	50	50	100
6.		02BC201-L	Advanced Biochemistry Lab	MI 2 P	-	-	4	2	50	50	100
Generic Elective Course (Choose Any One) • *Student can opt second group of Minor Subject as a generic elective course but credit will be 3:1.*											
7.	Microbiology	03MB201	Microbial Physiology	GEC 2	3	-	-	3	50	50	100
8.		03MB201-L	Microbial Physiology Lab	GEC 2 P	-	-	2	1	50	50	100
9.	Biochemistry	03BC201	Bioenergetics and Metabolism	GEC 2	3	-	-	3	50	50	100
10.		03BC201-L	Advanced Biochemistry Lab	GEC 2 P	-	-	2	1	50	50	100
Ability Enhancement Course											
11.	IKS	0IKS201	Indian Knowledge System	AEC 3	2	-	-	2	50	50	100
12.	Environment	0EVS202	Environmental Studies	AEC 4	2	-	-	2	50	50	100
				TOTAL	**15**	**-**	**10**	**20**	**400**	**400**	**800**

B.Sc. (Hons.)in Biotechnology
Four-Year Full Time Degree Programme
B.Sc. – Third Semester
(Undergraduate Diploma in Biotechnology)

S.No.	Subject	Subject Code	Subject/Paper Title	Subject area	Periods			Credit	Marks Distribution		
					L	T	P		Internal	External	Total
Major Subject											
1.	Biotechnology	01BT301	Bioanalytical Tools and Techniques	MJ 3	4	-	-	4	50	50	100
2.		01BT301-L	Bioanalytical Tools and Techniques Lab	MJ 3 P	-	-	4	2	50	50	100
Minor Subject (Choose Any one)											
3.	Microbiology	02MB301	Fermentation Technology	MI 3	4	-	-	4	50	50	100
4.		02MB301-L	Fermentation Technology Lab	MI 3 P	-	-	4	2	50	50	100
5.	Biochemistry	02BC301	Clinical Biochemistry	MI 3	4	-	-	4	50	50	100
6.		02BC301-L	Clinical Biochemistry Lab	MI 3 P	-	-	4	2	50	50	100
Generic Elective Course (Choose Any One) • *Student can opt second group of Minor Subject as a generic elective course but credit will be 3:1.*											
7.	Microbiology	03MB301	Fermentation Technology	GEC 3	3	-	-	3	50	50	100
8.		03MB301-L	Fermentation Technology Lab	GEC 3 P	-	-	2	1	50	50	100
9.	Biochemistry	03BC301	Clinical Biochemistry	GEC 3	3	-	-	3	50	50	100
10.		03BC301-L	Clinical Biochemistry Lab	GEC 3 P	-	-	2	1	50	50	100
Skill Enhancement Course											
11.	SEC	04BT301	Plant Tissue Culture Technology	SEC 1	3	-	-	3	50	50	100
12.	SEC	04BT301-L	Plant Tissue Culture Technology Lab	SEC 1 P	-	-	2	1	50	50	100
				TOTAL	**14**	**-**	**12**	**20**	**400**	**400**	**800**

B.Sc. (Hons.)in Biotechnology
Four-Year Full Time Degree Programme
B.Sc. – Fourth Semester
(Undergraduate Diploma in Biotechnology)

S.No.	Subject	Subject Code	Subject/Paper Title	Subject area	Periods			Credit	Marks Distribution		
					L	T	P		Internal	External	Total
Major Subject											
1.	Biotechnology	01BT401	Genetics	MJ 4	4	-	-	4	50	50	100
2.		01BT401-L	Genetics Lab	MJ 4 P	-	-	4	2	50	50	100
Minor Subject (Choose Any one)											
3.	Microbiology	02MB401	Medical Microbiology	MI 4	4	-	-	4	50	50	100
4.		02MB401-L	Medical Microbiology Lab	MI 4 P	-	-	4	2	50	50	100
5.	Biochemistry	02BC401	Enzymology	MI 4	4	-	-	4	50	50	100
6.		02BC401-L	Enzymology Lab	MI 4 P	-	-	4	2	50	50	100
Generic Elective Course (Choose Any One) • *Student can opt second group of Minor Subject as a generic elective course but credit will be 3:1.*											
7.	Microbiology	03MB401	Medical Microbiology	GEC 4	3	-	-	3	50	50	100
8.		03MB401-L	Medical Microbiology Lab	GEC 4 P	-	-	2	1	50	50	100
9.	Biochemistry	03BC401	Enzymology	GEC 4	3	-	-	3	50	50	100
10.		03BC401-L	Enzymology Lab	GEC 4 P	-	-	2	1	50	50	100
Skill Enhancement Course											
11.	SEC	04BT401	Entrepreneurship in Biotechnology	SEC 2	2	-	-	2	50	50	100
12.	SEC	04BT402	Basics of Forensic Science	SEC 3	2	-	-	2	50	50	100
				TOTAL	**15**	**-**	**10**	**20**	**400**	**400**	**800**

B.Sc. (Hons.) in Biotechnology
Four-Year Full Time Degree Programme
B.Sc. – Fifth Semester
(Undergraduate Degree in Biotechnology)

S.No.	Subject	Subject Code	Subject/Paper Title	Subject area	Periods			Credit	Marks Distribution		
					L	T	P		Internal	External	Total
Major Subject(Core)											
1.	Biotechnology	01BT501	Genetic Engineering & Technology	MJ 5	4	-	-	4	50	50	100
2.		01BT501-L	Genetic Engineering & Technology Lab	MJ 5 P	-	-	4	2	50	50	100
Major (DSC)											
3.	Any One	05BT501	Environmental Biotechnology	MJD1	3	-	-	3	50	50	100
4.		05BT501-L	Environmental Biotechnology Lab	MJD1P	-	-	2	1	50	50	100
5.		05BT502	Food Biotechnology	MJD1	3	-	-	3	50	50	100
6.		05BT502-L	Food Biotechnology Lab	MJD1P	-	-	2	1	50	50	100
Skill Enhancement Course											
7	SEC	04BT501	Biosafety, Bioethics IPRs and patenting	SEC 4	2	-	-	2	50	50	100
8		04BT501-L	Biosafety, Bioethics IPRs and patenting Lab	SEC 4 P	-		2	1	50	50	100
9		04BT502	Yoga Science	SEC 5 P	-	-	2	1	50	50	100
Field Project											
10	FP	06BT501-P	Field Project/ Internship/ Apprenticeship	FP1	-	-	12	6	50	50	100
				TOTAL	**9**	**-**	**22**	**20**	**400**	**400**	**800**

B.Sc. (Hons.) in Biotechnology
Four-Year Full Time Degree Programme
B.Sc. – Sixth Semester
(Undergraduate Degree in Biotechnology)

S.No.	Subject	Subject Code	Subject/Paper Title	Subject area	Periods			Credit	Marks Distribution		
					L	T	P		Internal	External	Total
Major Subject (Core)											
1.	Biotechnology	01BT601	Immunology and Immuno Technology	MJ 5	4	-	-	4	50	50	100
2.		01BT601-L	Immunology and Immuno Technology Lab	MJ 5 P	-	-	4	2	50	50	100
Major (DSC)											
3.	Any One	05BT601	Animal Biotechnology	MJD2	3	-	-	3	50	50	100
4.		05BT601-L	Animal Biotechnology Lab	MJD2P	-	-	2	1	50	50	100
5.		05BT602	Agriculture Biotechnology	MJD2	3	-	-	3	50	50	100
6.		05BT602-L	Agriculture Biotechnology Lab	MJD2P	-	-	2	1	50	50	100
7.	Any One	05BT603	Nano Biotechnology	MJD3	3	-	-	3	50	50	100
8.		05BT603-L	Nano Biotechnology Lab	MJD3P	-	-	2	1	50	50	100
9.		05BT604	Biostatistics	MJD3	3	-	-	3	50	50	100
10.		05BT504-L	Biostatistics Lab	MJD3P	-	-	2	1	50	50	100
Field Project											
11.	FP	06BT601-P	Field Project/ Internship/ Apprenticeship	FP2	-	-	12	6	50	50	100
				TOTAL	**10**	**-**	**20**	**20**	**350**	**350**	**700**

B.Sc. (Hons.) in Biotechnology
Four-Year Full Time Degree Programme
B.Sc. – Seventh Semester
(Honors in Biotechnology)

S.No.	Subject	Subject Code	Subject/Paper Title	Subject area	Periods			Credit	Marks Distribution		
					L	T	P		Internal	External	Total
Major Subject (Core)											
1.	Biotechnology	01BT701	Computational Biology and Bioinformatics	MJ 5	4	-	-	4	50	50	100
2.		01BT701-L	Computational Biology and Bioinformatics Lab	MJ 5 P	-	-	4	2	50	50	100
Major (DSC)											
3.	Any One	05BT701	Pharmaceutical Biotechnology	MJD2	3	-	-	3	50	50	100
4.		05BT701-L	Pharmaceutical Biotechnology Lab	MJD2P	-	-	2	1	50	50	100
5.		05BT702	Stem Cell and Tissue Engineering	MJD2	3	-	-	3	50	50	100
6.		05BT702-L	Stem Cell and Tissue Engineering Lab	MJD2P	-	-	2	1	50	50	100
Minor Subject											
7.	RM	02RM701	Research Methodology	MI5	3	-	-	3	50	50	100
8.	RM	02RM701-L	Research Methodology Lab	MI5	-	-	2	1	50	50	100
Skill Enhancement Course											
9	FP	06BT701-P	Field Project/ Internship/ Apprenticeship	FP3	-	-	12	6	50	50	100
				TOTAL	**10**	**-**	**20**	**20**	**350**	**350**	**700**

B.Sc. (Hons.) in Biotechnology
Four-Year Full Time Degree Programme
B.Sc. – Eighth Semester
(Honors in Biotechnology)

S.No.	Subject	Subject Code	Subject/Paper Title	Subject area	Periods			Credit	Marks Distribution		
					L	T	P		Internal	External	Total
Major Subject (Core)											
1.	Biotechnology	01BT801	Genomics and Proteomics	MJ 5	4	-	-	4	50	50	100
2.		01BT801-L	Genomics And Proteomics Lab	MJ 5 P	-	-	4	2	50	50	100
Minor Subject											
3.	Biochemistry	02BC801	Mammalian Physiology	MI 6	3	-	-	3	50	50	100
4.		02BC801-L	Mammalian Physiology Lab	MI6P	-	-	2	1	50	50	100
5.	Microbiology	02MB801	Bioprocess Engineering	MI 6	3	-	-	3	50	50	100
6.		02MB801-L	Bioprocess Engineering Lab	MI6P	-	-	2	1	50	50	100
Skill Enhancement Course											
7.	SEC	06BT801-P	Field Project/ Internship/ Apprenticeship	FP2		-	20	10	50	50	100
				TOTAL	**7**	**-**	**26**	**20**	**250**	**250**	**500**

Program Name	**Bachelor of Science (BSc) Honours- Biotechnology**	
Semester	I	
Course Code:	**01BT101**	
Course title:	**Cell Structure and Biotechnology**	**Curriculum Developer**: Paras Koshe, Assistant Professor
Pre-requisite:	Student should have basic knowledge of cell structure and organelles	
Rationale:	The B.Sc first-semester course in cell biology and genetics serves as a crucial introduction to the fundamental building blocks of life—cells and genetic mechanisms. By delving into cellular structures, processes, and genetic principles, students establish a foundational understanding of life at the molecular level. This course paves the way for comprehending intricate biological phenomena, ranging from cellular functions to inheritance patterns, and sets the stage for future explorations in biotechnology, RDT, and related fields.	
Course Outcomes (COs):	**CO1-01BT101 .1**: Students will demonstrate a thorough understanding of cell, cell theory, cell types, biological membranes and cytoskeleton. **CO2-01BT101. 2**: Students will exhibit proficiency in drawing and explaining ultra structure of Endoplasmic reticulum and Ribosome. **CO3-01BT101. 3**: Evaluate the roles cell division, cell cycle and cell signaling. **CO4-01BT101. 4**: Students will exhibit mastery of Biotechnology and know about the Applications of Biotechnology for human welfare **CO5-01BT101. 5**: Illustrate recombinant DNA technology, stem cell technology and characteristics and molecular basis of cancer	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=4:0:2)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
MAJOR	01BT101	Cell Structure and Biotechnology	4	4	1	5	14	4+2=6

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)		
MAJOR	01BT101	Cell Biology and Genetics	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)		
MAJOR	**01BT101-L**	Cell Biology and Genetics	35	5	5	5	50	50	100

Course-Curriculum:

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

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	10	01	06	29

Course outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction(CI)	Self-Learning(SL)
CO1-01BT101 .1: Students will demonstrate a thorough understanding of cell, cell theory, cell types, biological membranes and cytoskeleton	**SO1.1** Understand Cell as basic unit of living System	**LI1** Study and observation of Prokaryotic cell and eukaryotic under microscope	**Unit-1** **CI1.1** Cell as basic unit of living System	**SL1.1** Study of prokaryotic and eukaryotic cell
	SO1.2 Understand classification of organisms by cell structure	**LI 2** Demonstration of all equipment used in cell biology	**CI1.2** classification of organisms by cell structure	**SL1.2** Difference between unicellular and multicellular organisms
	SO1.3 Illustration of cell theory	**LI 3** To prepare a slide of onion cells to view under microscope	**CI1.3** cell theory	**SL1.3** Write postulates of cell theory
	SO1.4 Learn and draw PPLO cell	LI4 study of microscope	**CI1.4**ultra structure of cell types PPLOs,	
	SO1.5 Learn and draw Bacterial cell	Li5 preparation of slide	**CI1.5** Bacteria	**SL1.4** Draw and label ultra structure of bacteria
	SO1.6 Learn and draw Plant cell and draw animal cell		**CI1.6** Plant Cell and Animal Cell	
	SO1.7 Focus on principle and process of cell fractionation.		**CI1.7** cell fractionation	
	SO1.8 Illustrate Chemical components of biological membranes		**CI1.8** Cell Membrane and Permeability: Chemical components of biological membranes	**SL1.5** Learn about osmosis and diffusion
	SO1.9 Understand process and types membrane transport		**CI1.9** membrane transport	**SL1.6** Role of cytoskeleton in cell division and movement and muscle contraction
	SO1.10 Describe the component of Cytoskeleton		**CI1.10** Structure and function of microtubules	
	SO1.11 Learn Structure and function of microfilaments.		**CI1.11** microfilaments.	

	SO1.12 Learn Structure and function of Intermediate filaments.		**CI1.12** Intermediate filaments	

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

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	12	00	01	05	18

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-01BT101. **2**: Students will exhibit proficiency in drawing and explaining ultra structure of Endoplasmic reticulum and Ribosome	**SO2.1**Explore the structure of Endoplasmic reticulum		**Unit-II** **CI2.1** Ultra structure of Endoplasmic reticulum	**SL2.1** Learn structure and function of endomembrane system
	SO2.2 Describe structure and function of cell organelles, endoplasmic reticulum		**CI2.2** structure and function of cell organelles, endoplasmic reticulum,	**SL2.2** Write a note on Golgi complex
	SO2.3 Study function of endoplasmic reticulum		**CI2.3** function of ER including role in protein segregation	**SL2.3** Learn about contents of cytosol
	SO2.4 Explain structure and function of Golgi bodies		**CI2.4** Golgi complex: Structure and functions	**SL2.3** Discuss **r**ole of ribosome in protein synthesis
	SO2.5 Assessing the Role of Golgi complex in cell		**CI2.5** functions including role in protein secretion	
	SO2.6 Explaining the structure of Lysosomes.		**CI2.6** Lysosomes and its types	**SL2.5** Prepare diagram of ribosome
	SO2.7 Explaining functions of lysosomes		**CI2.7** functions and importance of lysosomes.,	

	SO2.8 Understand the structure and functions of Vacuoles		**CI2.8** structure and functions of Vacuoles	
	SO2.9 Explain structure and functions of micro bodies.		**CI2.9** micro bodies: Structure and functions	
	SO2.10 Describing the structure of ribosome's		**CI2.10** Ribosome: Structures and function	
	SO2.11 Explain types of ribosome		**CI2.11** Ribosome - types	
	SO2.12 Analyze function including role in protein synthesis**.**		**CI2.12** Ribosomes: Structures and function including role in protein synthesis.	

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

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	12	12	01	05	30

Course Outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Class room Instruction (CI)**	**Self-Learning(SL)**
CO3-01BT101. 3: Evaluate the roles cell division, cell cycle and cell signaling.	**SO3.1** Explain Structure and function of Mitochondria	**LI1** Study of mitosis with onion root tip	**Unit-III** **CI3.1** Mitochondria: Structure and function	**SL3.1** Read about cell division
	SO3.2 Assessing Structure and function of Mitochondria	**LI 2** Study of meiosis with onion bud	**CI3.2** Mitochondria: Structure and function	**SL3.2** Draw a diagram of Meiosis
	SO3.3 Understand Biogenesis of Mitochondria	**LI 3** To prepare temporary mount of a leaf peel in order to show the stomata of	**CI3.3** biogenesis	**SL3.3** Illustration about different stages of cell cycle and checkpoints

		leaf		
	SO3.4 Explain the structure and functions of chloroplasts	**LI 4** To examine chloroplast inside plant cell with the help of microscope	**CI3.4** Chloroplasts: Structure and function	
	SO3.5 Explain the structure and functions of chloroplasts	**LI1.5** Study of mitosis	**CI3.5** Chloroplasts: Structure and function	
	SO3.6 Describing the structure and functions of Nucleus	**LI 6** Study of meiosis	**CI3.6** Nucleus: Structure and function	**SL3.4** Write a note on cell signalling
	SO3.7 Describe chromosomes and their structure		**CI3.7** chromosomes and their structure	**SL3.5** Diagrammatically explain structure of abnormal chromosomes
	SO3.8 Study Composition of Extracellular Matrix:,		**CI3.8** Extracellular Matrix: Composition	
	SO3.9 Illustrate the mechanism of cell transduction		**CI3.9** Signal transduction	
	SO3.10		**CI3.10** Apoptosis	
	SO3.2 SO3.11 Illustrate Cell cycle and all stages		**CI3.11** Cell cycle	
	SO3.12 Describe cell division and its types		**CI3.12** Cell division.	

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

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	00	01	05	18

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction (CI)	Self-Learning(SL)
CO4-01BT101. 4: Students will exhibit mastery of Biotechnology and know about the Applications of Biotechnology for human welfare	**SO4.1** Understand Scopes and importance of Biotechnology		**Unit-IV** **CI4.1** Introduction to Biotechnology	**SL4.1** Learn about terms used in Biotechnology
	SO4.2 Assessing the various definitions of biotechnology		**CI4.2** Definitions	**SL4.2** Discuss top most biotechnology companies in india.
	SO4.3 Learn about the Historical perspectives of biotechnology.		**CI4.3** Historical perspectives	**SL4.3** Practice about Good laboratory practices in your institute
	SO4.4 Illustrate Scope and importance of Biotechnology		**CI4.4** Scope and importance	**SL4.4** Studies related to Red and Green Biotechnology
	SO4.5 Understand the rules and procedure of Good laboratory practices.		**CI4.5** Good laboratory practices	
	SO4.6 Analyze the Role of Biotechnology in India and Global trends		**CI4.6** Biotechnology in India and Global trends	**SL4.5** Evaluate the bio safety and bioethics in biotechnology
	SO4.7 Evaluate the need of Biotechnology in India and Global trends		**CI4.7** Biotechnology in India and Global trends.	
	SO4.8 Illustrate the Applications of Biotechnology for human welfare (agriculture)		**CI4.8** Applications of Biotechnology for human welfare(agriculture)	
	SO4.9 Explain Applications of Biotechnology for human welfare(medicine)		**CI4.9** Applications of Biotechnology for human welfare(medicine)	
	SO4.10 Focus on **1** Applications of Biotechnology for human welfare(Industries)		**CI4.10** Applications of Biotechnology for human welfare(Industries)	
	SO4.11 Explain principles and rules of bio safety and bioethics in biotechnology		**CI4.11** bio safety and bioethics in biotechnology	
	SO4.12 Describe bio safety and bioethics in biotechnology		**CI4.12** bio safety and bioethics in biotechnology	

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

	Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	08	01	06	27

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO5-01BT101. 5: Illustrate recombinant DNA technology, stem cell technology and characteristics and molecular basis of cancer	**SO5.1** Define Recombinant DNA Technology: its historical perspectives and scopes.	**LI 1** To perform transformation experiment	**Unit-V** **CI5.1** Recombinant DNA Technology: Introduction	**SL5.1** learn about in vivo and invitro gene cloning
	SO5.2 Illustrate Tools of rDNA Technology	**LI 2** Identify Barr Body in female buccal epithelium	**CI5.2** Tools of rDNA Technology	**SL5.2**learn about enzymes and vectors used in RDT
	SO5.3 Elaborate Steps of rDNA Technology,	**LI3** Demonstration of PCR	**CI5.3** Steps of rDNA Technology,	**SL5.3**Give role of RDT in quality enhancement
	SO5.4 Understand principle and requirement of PCR	**LI4** Isolation of DNA from human cheek cell	**CI5.4** Polymerase Chain Reaction (PCR) introduction	**SL5.4** Learn about diseases caused by abnormal chromosomes
	SO5.5 Understand the steps of Polymerase Chain Reaction (PCR) and cycles		**CI5.5** Polymerase Chain Reaction (PCR) steps and cycles	Give diagrammatic representation of types cancer and its types
	SO5.6 Describe applications of PCR		**CI5.6** Polymerase Chain Reaction (PCR) applications	
	SO5.7 Describe Variants of PCR		**CI5.7** Variants of PCR	
	SO5.8 Elaborate Transgenic Plants with Beneficial Traits		**CI5.8** Transgenic Plants with Beneficial Traits.	**SL5.5** Learn genetically modified organisms and their impacts.
	SO5.9 Elaborate Transgenic Animals with Beneficial Traits		**CI5.9** Transgenic animals with Beneficial Traits.	

	SO5.10 Explain principle and steps of Stem cell technology		**CI5.10** Stem Cell Technology	**SL5.6** Write about regenerative medicine**.**
	SO5.11 Learn about the characteristics and types of cancer		**CI5.11** Cancer: characteristics	
	SO5.12 Illustrate molecular basis of cancer.		**CI5.12** Cancer: molecular basis of cancer.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Describe principle steps , variants and applications of PCR.
	SW5.2 Mini Project	Write a detail note on Recombinant DNA Technology
	SW5.3 Other Activities (Specify)	Prepare a detail draft on stem cell technology.

Course duration (in hours) to attain Course Outcomes:

Course Title: Cell Structure and Biotechnology **Course Code: 01BT101**

Course Outcomes(COs)	**Class lecture (CI)**	**Laboratory Instruction(LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-01BT101.1: Students will demonstrate a thorough understanding of cell, cell theory, cell types, biological membranes and cytoskeleton	12	10	6	1	29
CO2-01BT101. 2: Students will exhibit proficiency in drawing and explaining ultra structure of Endoplasmic reticulum and Ribosome.	12	0	5	1	18
CO3-01BT101. 3: Evaluate the roles cell division, cell cycle and cell signalling.	12	12	5	1	30
CO4-01BT101. 4: Students will exhibit mastery of Biotechnology and know about the Applications of Biotechnology for human welfare .	12	0	5	1	18
CO5-01BT101. 5: Illustrate recombinant DNA technology, stem cell technology and characteristics and molecular basis of cancer	12	8	6	1	27
Total Hours	60	30	27	05	122

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

Course Title: Cell Structure and Biotechnology **Course Code: 98BT107**

Course Outcomes				
	A	**An**	**E**	**Total Marks**
CO1-01BT101.1: Students will demonstrate a thorough understanding of cell, cell theory, cell types, biological membranes and cytoskeleton	02	02	01	05
CO2-01BT101. 2: Students will exhibit proficiency in drawing and explaining ultra structure of Endoplasmic reticulum and Ribosome.	03	05	02	10
CO3-01BT101. 3: Evaluate the roles cell division, cell cycle and cell signaling.	05	05	05	15
CO4-01BT101. 4: CO4-01BT101. 4: Students will exhibit mastery of Biotechnology and know about the Applications of Biotechnology for human welfare.	04	03	03	10
CO5-01BT101. 5: Illustrate recombinant DNA technology, stem cell technology and characteristics and molecular basis of cancer	05	04	01	10
Total Marks	19	19	12	50

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

Suggested learning Resources:

(a) Books:

(b)

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

(c) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: Bachelor of Science (BSc) Honours- Biotechnology
Semester: I
Course Title: Cell Structure and Biotechnology **Course Code: 01BT101**

CO/PO Mapping															
Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-01BT101.1: Students will demonstrate a thorough understanding of cell, cell theory, cell types, biological membranes and cytoskeleton	-	-	1	2	2	2	2	-	1	2	2	3	3	-	-
CO2-01BT101. 2: Students will exhibit proficiency in drawing and explaining ultra structure of Endoplasmic reticulum and Ribosome.	-	-	-	-	-	-	-	-	2	2	3	3	2	-	1
CO3-01BT101. 3: Evaluate the roles cell division, cell cycle and cell signalling.	-	1	1	1	-	2	2	-	3	3	3	2	2	2	1
CO4-01BT101. 4: Students will exhibit mastery of Biotechnology and know about the Applications of Biotechnology for human welfare	-	1	1	2	2	2	2	3	-	1	2	2	2	2	2
CO5-01BT101. 5: Illustrate recombinant DNA technology, stem cell technology and characteristics and molecular basis of cancer	1	1	1	-	-	3	3	3	1	2	3	2	2	2	1

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2,3	**CO1-01BT101.1**: Students will demonstrate a thorough understanding of cell, cell theory, cell types, biological membranes and cytoskeleton	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10 SO1.11 SO1.12	LI1, LI2 LI3, LI4, LI5	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8,1.9, 1.10,1.11, 1.12	1SL-1,2,3,4,5,6
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2,3	**CO2-01BT101. 2**: Students will exhibit proficiency in drawing and explaining ultra structure of Endoplasmic reticulum and Ribosome.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9 SO2.10 SO2.11 SO2.12		2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9, 2.10, 2.11, 2.12	2SL-1,2,3,4,5
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2,3	**CO3-01BT101. 3**: Evaluate the roles cell division, cell cycle and cell signalling.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7SO3.8 SO3.9 SO3.10 SO3.11 SO3.12	LI1, LI2 LI3, LI4, LI5 LI6	3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12	3SL-1,2,3,4,5
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2,3	**CO4-01BT101**. 4: Students will exhibit mastery of Biotechnology and know about the Applications of Biotechnology for human welfare .	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10 SO4.11 SO4.12		4.1,4.2,4.3,4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10,4.11,4.12	4SL-1,2,3,4,5
PO 1,2,3,4,5,6,7,8,9,10,11,12 PSO 1,2,3	**CO5-01BT101. 5**: Illustrate recombinant DNA technology, stem cell technology and characteristics and molecular basis of cancer	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9 SO5.10 SO5.11 SO5.12	LI1, LI2, LI3, LI4	5.1,5.2,5.3,5.4,5.5, 5.6,5.7,5.8,5.9,5.10,5.11 5.12	5SL-1,2,3,4,5,6

Program Name	**Bachelor of Science (Hons.) Biotechnology**	
Semester	I	
CourseCode:	02BC101	
Coursetitle:	General Biochemistry	**Curriculum Developer**: Mrs. Pratima Mishra, Guest Faculty
Pre-requisite:	Students should have basic knowledge of Biology and Chemistry	
Rationale:	For a successful biotechnologist is it essential to learn about basic concepts of those molecules which governs the anatomical and physiological components of biological 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):	**CO1-02BC101.1:** Understanding of the components of biological systems, significant functional groups, pH and buffers, and proteins. **CO2-02BC101.2:** Learning in-depth information regarding the composition and characteristics of numerous categories of carbohydrates. **CO3-02BC101.3:** Recognize various concepts related the structure, characteristics, function and biological role of nucleic acids and central dogma. **CO4-02BC101.4:** Assess various concepts related the structure, characteristics, function and biological role of different types of lipids. **CO5-02BC101.5:** 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=4:0:2)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
Minor	02BC101	General Biochemistry	4	4	1	5	14	4+2=6

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)		
Minor	02BC101	General Biochemistry	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)		
Minor	02BC101-L	General Biochemistry	35	5	5	5	50	50	100

Course-Curriculum:

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

ApproximateHours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	05	24

Course outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction(CI)	Self-Learning(SL)
CO1-02BC101.1: 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,	**SL1.2** Check the properties of water and buffers
	SO1.3 Describe about water	**LI1.2** Identification of amino acids	**CI1.3** Water	**SL1.3** Learn about various categories of amino acids
	SO1.4 Explain about amino acids		**CI1.4** Amino Acids: Classification	**SL1.4** Enlist the structure and properties of different amino acids and their role
	SO1.5 Describe structure of amino acids		**CI1.5** structure	
	SO1.6 Describe Properties of amino acids		**CI1.6** properties	
	SO1.7 Study the different types of amino acids		**CI1.7** unusual and modifies amino acids,	**SL1.5** Enlist the structure and properties of different proteins and their role
	SO1.8 Study of peptides.		**CI1.8** peptides,	
	SO1.9 Describe concept of Zwitter ion		**CI1.9** Isoelectric point, Zwitter ion,	
	SO1.10 Assess the concept of proteins	**LI1.3** Identification of Proteins	**CI1.10** Proteins: Classification,	
	SO1.11 Describe structure of proteins		**CI1.11** structure	
	SO1.12 Describe function of proteins		**CI1.12** 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	12	06	01	05	24

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
CO2-02BC101.2: 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 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** Identification of Non reducing sugar	**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		**CI2.6** Starch,	
	SO2.7 Describe about glycogen, chitin		**CI2.7** Glycogen, Chitin,	
	SO2.8 Describe biological role of cellutose,		**CI2.8** Cellulose	
	SO2.9 Describe role of peptidoglycan, heparin		**CI2.9** Peptidoglycan, Heparin	
	SO2.10 Describe Optical activity		**CI2.10** Optical activity,	
	SO2.11 Describe properties of mutarotation		**CI2.11** mutarotation,	
	SO2.12 Assess concept of monoasccharides oxidation		**CI2.12** 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	12	06	01	05	24

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction (CI)	Self-Learning(SL)
CO3-02BC101.3: Recognize various concepts related the structure, characteristics, function and biological role of nucleic acids and central dogma.	**SO3.1** Explain the concept of Nucleic acid.	**SL3.1** Isolation of nucleic acid	**Unit-III** **CI3.1** Nucleic Acids:	**SL3.1** Read about various types of nucleic acids and its derivatives.
	SO3.2 Assessing the structure of nucleotides	**SL3.2** Isolation of DNA	**CI3.2** Structure of nucleotides.	**SL3.2** Illustrate structure of different types of DNA and RNA
	SO3.3 study structure of DNA		**CI3.3** Structure of DNA	
	SO3.4 Assessing structure of RNA		**CI3.4** Structure of RNA	
	SO3.4 Assessing properties of DNA and RNA		**CI3.5** properties,	
	SO3.6 Study variation from Watson and Crick Model	**SL3.3** Isolation of RNA	**CI3.6** Variation from Watson and Crick model	
	SO3.7 Assessing different structure present in DNA		**CI3.7** Special types of structures present in DNA	**SL3.3** Study the variation in DNA structure from Watson and Crick model.
	SO3.8 Describe about hybridization,		**CI3.8** Hybridization,	
	SO3.9 Describe about hypo and hyperchromic shift		**CI3.9** Hypo and hyperchromic shift,	
	SO3.10 Describe about Tm		**CI3.10** Tm	
	SO3.11 Assessing the role of central Dogma		**CI3.11** Concept of Central Dogma,	**SL3.4** Study the mechanism of central dogma
	SO3.12 Describe about gene and its regulation		**CI3.12** Concept of genes and their regulation.	**SL3.5** Study the impact of gene regulation

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

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	05	24

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO4- 02BC101.4: 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** Isolation of lipids from different sources	**Unit-IV** **CI4.1** Lipids: Classification,	**SL4.1** Learn about different classes of lipids
	SO4.2 Assessing structure of lipids	**LI4.2** Determination of solubility of lipids	**CI4.2** structure,	**SL4.2** Discuss types and structure of lipids
	SO4.3 Assessing types of lipids	**LI4.3** Determination of acid value of lipids	**CI4.3** Types,	**SL4.3** Learn about biological function of lipids
	SO4.4 Explaining the biological function of lipids		**CI4.4** biological functions	
	SO4.5 Explaining the role of oils, fats and waxes		**CI4.5** Oils, fats, waxes,	**SL4.4** Learn about biological function of fatty acids
	SO4.6 Evaluate role of fatty acids,		**CI4.6** fatty acids,	
	SO4.7 Evaluate role of phospholipids		**CI4.7** phospholipids,	**SL4.5** Learn about significance of lipids
	SO4.8 Describe the impact of Sphingolipids		**CI4.8** Sphingolipids,	
	SO4.9 Describe the impact of galactolipids		**CI4.9** galactolipids,	
	SO4.10 Describe the impact of Sulpholipids		**CI4.10** Sulpholipids,	
	SO4.11 Describe the impact of Steroids		**CI4.11** Steroids	
	SO4.12 Evaluate role of lipids in signal transduction		**CI4.12** Lipids in signal transduction	

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	12	06	01	05	24

Course Outcome (CO)	SessionOutcomes(SOs)	LaboratoryInstruction(LI)	ClassroomInstruction(CI)	Self-Learning(SL)
CO5-02BC101.5: 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	**LI5.1** Demonstration of membrane transport	**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	**LI5.2** Demonstration of Diffusion	**CI5.2** diffusion, Group translocation,	**SL5.2**Review concept of diffusion and group translocation
	SO5.3 Apply the role of ionophore and membrane protein	**LI5.2** Demonstration of Osmosis	**CI5.3** Ionophore.	**SL5.3**learn how to membrane proteins works.
	SO5.4 Evaluate the role of cell junctions.		**CI5.4** Membrane proteins,	
	SO5.5 Assess the molecular mechanism of signal transduction pathways		**CI5.5** Cell Junctions,	
	SO5.6 Apply the role of PKC,PLC, GPCR		**CI5.6** Molecular mechanism of signal transduction pathways	**SL5.4** Learn about signalling pathways
	SO5.7 Apply the role of PKC,		**CI5.7** PKC,	
	SO5.8 Apply the role of PLC,		**CI5.8** PLC	
	SO5.9 Apply the role of GPCR		**CI5.9** GPCR	
	SO5.10 Explore about Signalling pathways		**CI5.10** Insulin Glucagon signalling	
	SO5.11 Elaborate the role of endotoxins		**CI5.11** Endotoxins	
	SO5.12 Elaborate the role of exotoxins		**CI5.12** exotoxins.	**SL5.5** Learn about toxins

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: General Biochemistry **Course Code:**02BC101

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-02BC101.1: Understanding of the components of biological systems, significant functional groups, pH and buffers, and proteins.	12	6	5	1	24
CO2-02BC101.2: Learning in-depth information regarding the composition and characteristics of numerous categories of carbohydrates.	12	6	5	1	24
CO3-02BC101.3: Recognize various concepts related the structure, characteristics, function and biological role of nucleic acids and central dogma.	12	6	5	1	24
CO4-02BC101.4: Assess various concepts related the structure, characteristics, function and biological role of different types of lipids.	12	6	5	1	24
CO5-02BC101.5: Appraise the relationship between principles molecular transport, cell junction and cell signaling in Cell and Cellular components.	12	6	5	1	24
Total Hours	60	30	25	05	120

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

Course Title: General Biochemistry **Course Code:**02BC101

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-02BC101.1: Understanding of the components of biological systems, significant functional groups, pH and buffers, and proteins.	2	1	1	1	5
CO2-02BC101.2: Learning in-depth information regarding the composition and characteristics of numerous categories of carbohydrates.	2	4	2	2	10
CO3-02BC101.3: Recognize various concepts related the structure, characteristics, function and biological role of nucleic acids and central dogma.	3	5	5	2	15
CO4-02BC101.4: Assess various concepts related the structure, characteristics, function and biological role of different types of lipids.	2	3	3	2	10
CO5-02BC101.5: 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: B.Sc. Hons Biotechnology
Semester: I Semester
Course Title: General Biochemistry
Course Code: 02BC101

Course Outcome (Cos)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-02BC101.1: Understanding of the components of biological systems, significant functional groups, pH and buffers, and proteins.	1	1	2	2	3	1	2	3	2	1	2	3	2	2	2
CO2-02BC101.2: Learning in-depth information regarding the composition and characteristics of numerous categories of carbohydrates.	1	1	1	1	2	1	2	2	1	2	2	2	2	3	2
CO3-02BC101.3: Recognize various concepts related the structure, characteristics, function and biological role of nucleic acids and central dogma.	1	1	2	2	1	1	1	1	2	1	2	2	1	2	1
CO4-02BC101.4: Assess various concepts related the structure, characteristics, function and biological role of different types of lipids.	1	1	2	1	2	1	2	2	2	2	1	3	1	2	1
CO5-02BC101.5: Appraise the relationship between principles molecular transport, cell junction and cell signaling in Cell and Cellular components.	1	1	2	1	1	1	1	1	1	2	2	3	1	2	1

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO1-02BC101.1:** 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 SO1.10 SO1.11 SO1.12	1.1,1.2,1.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.12	1SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO2-02BC101.2:** 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 SO2.10 SO2.11 SO2.12	2.1, 2.2, 2.3,	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11, 2.12	2SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO3-02BC101.3:** 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 SO3.10 SO3.11 SO3.12	3.1,3.2,3.3	3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12	3SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO4-02BC101.4:** 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 SO4.10 SO4.11 SO4.12	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, 4.11, 4.12	4SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO5-02BC101.5:** 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 S05.9 SO5.10 SO5.11 SO5.12	5.1,5.2,5.3	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 5.10, 5.11, 5.12	5SL-1,2,3,4,5

Program Name	**B.Sc. (HONS.) BIOTECHNOLOGY -**	
Semester	**I**	
CourseCode:	02MB101	
Coursetitle:	**Basics of Microbiology**	**Curriculum Developer**: Mrs. Maahi Choure, Guest Faculty
Pre-requisite:	To understand and work effectively in microbiology, especially when preparing consortia as you described, it's important to have a strong foundation in the basics of microbiology.	
Rationale:	Understanding the basics of microbiology, including microbial classification, cell structure, metabolism, genetics, and laboratory techniques, is essential to effectively study and manipulate microorganisms. This foundation enables accurate identification, cultivation, and utilization of microbes for various applications, such as creating beneficial consortia, ensuring experimental accuracy, and maintaining laboratory safety.	
CourseOutcomes (COs):	**CO1-02MB101.1:** Understand the role and significance of normal microflora in the human body and recognize various nosocomial infections and their implications. **CO2-02MB101.2:** Describe the morphology, pathogenesis, and symptoms of major gram-positive bacterial infections such as those caused by S. aureus and M. tuberculosis**.** **CO3-02MB101.3:** Explain the morphology, pathogenesis, and symptoms of key gram-negative bacterial pathogens, including E. coli and N. gonorrhoeae. **CO4-02MB101.4:** Identify the major viral pathogens, including Picornaviruses and Retroviruses, and understand their disease mechanisms and symptoms. **CO5-02MB101.5:** Recognize the morphology and clinical manifestations of significant fungal and protozoan infections, such as Dermatophytoses and Malaria.	

Scheme of Studies:

Board of Study	**CourseCode**	**CourseTitle**	**Scheme ofstudies (Hours/Week)**					**Total Credits(C) (L:T:P=4:0:2)**
			Cl	LI	SW	SL	**Total Study Hours(CI+LI+SW+SL)**	
Minor	02MB101	Basics of microbiology	4	4	1	2	11	4+2=6

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)		
Minor	02MB101	Basics of Microbiology	15	20	5	5	5	50	50

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
Minor	02MB101-L	Basics of Microbiology	35	5	5	5	50	50	100

Course-Curriculum:

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

ApproximateHours

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

Course outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction(CI)	Self-Learning(SL)
CO1-02MB101.1: Understand the role and significance of normal microflora in the human body and recognize various nosocomial infections and their implications.	**SO1.1** Overview of microbiology, its history, and major milestones.	**LI1.1** Learn how to handle pathogens	**CI1.1** Overview of microbiology, its history, and major milestones.	**SL1.1** Remember Carriers in Disease Transmission
	SO1.2 Key contributions of historical figures.	**LI1.2**Learn about basic instrumentation	**CI1.2** Key contributions of historical figures.	**SL1.2** Explore micro flora of university
	SO1.3 Overview of microbial taxonomy	**LI1.3**learn sterilization	**CI1.3** Overview of microbial taxonomy	
	SO1.4 Introduction to molecular techniques in taxonomy.		**CI1.4** Introduction to molecular techniques in taxonomy.	
	SO1.5 Understanding evolutionary relationships.		**CI1.5** Understanding evolutionary relationships.	
	SO1.6 Study of modern classification systems.		**CI1.6** Study of modern classification systems.	
	SO1.7 Discussion on various classification criteria.		**CI1.7** Criteria in Microbial Taxonomy	
	SO1.8 Timeline of microbial evolution		**CI1.8** Evolutionary History	
	SO1.9 Exploration of microbial diversity through history**.**		**CI1.9** Microbial Diversity	
	SO1.10 Famous experiments and their impacts on microbiology		**CI1.10** Case Studies on microbiology	
	SO1.11 Review Session		**CI1.11** Summary and Q&A on key topics.	
	SO1.12 Interactive session to assess understanding and discuss future trends.		**CI1.12** Assessment and Discussion	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Summarizes theAnalysis on Septic Shock.
	SW1.2 Mini Project	DemonstrateTypes and Mechanisms of Toxins.
	SW1.3 Other Activities (Specify)	Documentation of instruments used in microbiology

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	6	1	2	21

Course Outcome (CO)	SessionOutcomes (SOs)	LaboratoryInstruction (LI)	ClassroomInstruction (CI)	Self Learning (SL)
CO2-02MB101.2: Describe the morphology, pathogenesis, and symptoms of major gram-positive bacterial infections such as those caused by S. aureus and M. tuberculosis**.**	**SO2.1** Overview of microbial diversity.	**LI2.1** Preparation of cotton plug	**CI2.1** Introduction to Microbial Diversity	**SL2.1** Research on M. tuberculosis
	SO2.2 Prokaryotic vs. Eukaryotic Cells: Key differences and characteristics.	**LI2.2** Preparation of NAM media	**CI2.2** Prokaryotic vs. Eukaryotic Cells	**SL2.2** Case Study on C. diphtheriae
	SO2.3 Bacterial Morphology: Structure and function.	**LI2.3**Preparation of NBM media	**CI2.3** Bacterial Morphology	
	SO2.4 Algae and Fungi: Characteristics and significance.		**CI2.4** Algae and Fungi	
	SO2.5 Protozoa: Morphology and role in ecosystems.		**CI2.5** Protozoa	
	SO2.6 Viruses: Unique features and life cycles.		**CI2.6** Viruses.	
	SO2.7 Microbial Distribution: Environmental factors influencing distribution		**CI2.7** Microbial Distribution	
	SO2.8 Characterization Techniques: Methods to study microbial diversity.		**CI2.8** Characterization Techniques.	
	SO2.9 Microbial Ecology: Role of microorganisms in ecosystems.		**CI2.9** Microbial Ecology	
	SO2.10 Case Studies: Unique microbial habitats and their inhabitants.		**CI2.10** Case Studies	
	SO2.11 Review Session: Summary and Q&A on key topics.		**CI2.11** Review Session: Summary and Q&A on key topics.	
	SO2.12 Assessment and Discussion: Interactive session to assess understanding and discuss future research.		**CI2.12** Assessment and Discussion: Interactive session to assess understanding and discuss future research.	

Suggested Sessional Work (SW):*anyone*	**SW2.1** Assignments	Justify the role ofPreventive Measures and Chemotherapy.
	SW2.2 Mini Project	Understand the pathogenesis of M. leprae.
	SW2.3 Other Activities (Specify)	Remember laboratory diagnosis technique.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	6	1	2	21

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction (CI)	Self-Learning(SL)
CO3-02MB101.3: Explain the morphology, pathogenesis, and symptoms of key gram-negative bacterial pathogens, including E. coli and N. gonorrhoeae	**SO3.1** Importance of cultivating microorganisms.	**LI3.1** Perform gram staining, spore staining	**CI3.1** Introduction to Cultivation	**SL3.1**Practice local alignment
	SO3.2 Different nutritional needs of microorganisms.	**LI3.2** Perform negative staining, hanging drop method	**CI3.2** Nutritional Categories	**SL3.2**Practice global alignment
	SO3.3 Methods for isolating microorganisms.		**CI3.3** Isolation Techniques	
	SO3.4 Techniques for purifying microbial cultures.	**LI3.3**enumeration of microorganism- total & viable count	**CI3.4** Purification Methods	
	SO3.5 Methods for long-term preservation.		**CI3.5** Preservation Techniques	
	SO3.6 Types of media used for microbial growth		**CI3.6** Cultivation Media	
	SO3.7 Factors affecting microbial cultivation.		**CI3.7** Growth Conditions	
	SO3.8 Safe handling and maintenance of cultures.		**CI3.8** Laboratory Practices	
	SO3.9 Understanding the growth curve.		**CI3.9** Microbial Growth Phases	
	SO3.10 Case Studies: Successful cultivation of challenging microorganisms.		**CI3.10** Case Studies: Successful cultivation of challenging microorganisms.	
	SO3.11 Review Session: Summary and Q&A on key topics.		**CI3.11** Review Session: Summary and Q&A on key topics.	
	SO3.12 Assessment and Discussion: Interactive session to assess understanding and discuss advanced techniques.		**CI3.12** Assessment and Discussion: Interactive session to assess understanding and discuss advanced techniques.	

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

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	6	1	2	21

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO4-02MB101.4: Identify the major viral pathogens, including Picornaviruses and Retroviruses, and understand their disease mechanisms and symptoms.	**SO4.1** Basic concepts and importance.	**LI4.1** Determination of bacterial cell size by micrometry	**CI4.1** Introduction to Microbial Growth	**SL4.1** Learn techniques of preventive measures
	SO4.2 Phases of microbial growth.	**LI4.2** Method of isolation of bacteria from soil	**CI4.2** Growth Curve Analysis	**SL4.2** Understand symptoms of various diseases
	SO4.3 Generation Time: Calculating and understanding its significance.	**LI4.3** Methods of isolation of bacteria from air	**CI4.3** Generation Time: Calculating and understanding its significance.	
	SO4.4 Batch and Continuous Culture: Methods and applications.		**CI4.4** Batch and Continuous Culture: Methods and applications.	
	SO4.5 Methods to measure microbial growth		**CI4.5** Measurement Techniques	
	SO4.6 Environmental and nutritional factors.		**CI4.6** Factors Affecting Growth	
	SO4.7 Overview of microbial metabolism.		**CI4.7** Metabolic Pathways	
	SO4.8 Integration of catabolic and biosynthetic pathways.		**CI4.8** Amphi-catabolic Pathways	
	SO4.9 Mechanisms and processes.		**CI4.9** Bacterial Reproduction	
	SO4.10 Endospores and Sporulation: Formation and significance		**CI4.10** Endospores and Sporulation: Formation and significance	
	SO4.11 Review Session: Summary and Q&A on key topics.		**CI4.11** Review Session: Summary and Q&A on key topics.	
	SO4.12 Assessment and Discussion: Interactive session to assess understanding and discuss advanced topics.		**CI4.12** Assessment and Discussion: Interactive session to assess understanding and discuss advanced topics.	

Suggested Sessional Work (SW): *anyone*		
	SW4.1 Assignments	Write about Morphology and Pathogenesis ofHerpes Virus.
	SW4.2 Mini Project	Documentation of characteristic of bacteria
	SW4.3 Other Activities (Specify)	Search and learn via YouTube how to take Preventive Measures and Chemotherapy for the Papova Virus.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	6	1	2	21

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO5-02MB101.5: Recognize the morphology and clinical manifestations of significant fungal and protozoan infections, such as Dermatophytoses and Malaria.	**SO5.1** Introduction to Microbial Control: Importance and methods.	**LI5.1** Isolation of bacteria	**CI5.1** Introduction to Microbial Control: Importance and methods.	**SL5.1**Learn how Chemotherapy for Systemic Infections
	SO5.2 Heat, radiation, and filtration.	**LI5.2** Biochemical characterization of bacteria	**CI5.2** Physical Control Methods	**SL5.2** Classify all Fungal and Protozoan Infections
	SO5.3 Disinfectants and antiseptics	**LI5.3** Identification characterization of bacteria	**CI5.3** Chemical Control Methods	
	SO5.4 Antibiotics and their mechanisms		**CI5.4** Chemotherapeutic Agents	
	SO5.5 Bacterial pollutants and indicators.		**CI5.5** Water Microbiology	
	SO5.6 Coliforms and Non-coliforms: Detection and significance.		**CI5.6** Coliforms and Non-coliforms: Detection and significance.	
	SO5.7 Sewage Composition and Disposal: Methods and importance.		**CI5.7** Sewage Composition and Disposal: Methods and importance.	
	SO5.8 Food Microbiology: Microorganisms in food production and spoilage.		**CI5.8** Food Microbiology: Microorganisms in food production and spoilage.	
	SO5.9 Foodborne Infections and Intoxications: Causes and prevention		**CI5.9** Foodborne Infections and Intoxications: Causes and prevention	
	SO5.10 Food Preservation Methods: Techniques and applications.		**CI5.10** Food Preservation Methods: Techniques and applications.	
	SO5.11 Microorganisms in fermentation and their benefits.		**CI5.11** Fermented Foods:	
	SO5.12 Assessment and Discussion: Interactive session to assess understanding and discuss control methods.		**CI5.12** Assessment and Discussion: Interactive session to assess understanding and discuss control methods.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Write aboutTreatment Strategies for Fungal and Protozoan Infections.
	SW5.2 Mini Project	
	SW5.3 Other Activities (Specify)	Try to learn and apply preventive Measures and Chemotherapy for Malaria.

Course duration (in hours)to attain Course Outcomes:

Course Title:Medical Microbiology **Course Code:**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-02MB101.1: Understand the role and significance of normal microflora in the human body and recognize various nosocomial infections and their implications.	12	6	2	1	21
CO2-02MB101.2: Describe the morphology, pathogenesis, and symptoms of major gram-positive bacterial infections such as those caused by S. aureus and M. tuberculosis**.**	12	6	2	1	21
CO3-02MB101.3: Explain the morphology, pathogenesis, and symptoms of key gram-negative bacterial pathogens, including E. coli and N. gonorrhoeae.	12	6	2	1	21
CO4-02MB101.4: Identify the major viral pathogens, including Picornaviruses and Retroviruses, and understand their disease mechanisms and symptoms.	12	6	2	1	21
CO5-02MB101.5: Recognize the morphology and clinical manifestations of significant fungal and protozoan infections, such as Dermatophytoses and Malaria.	12	6	2	1	21
Total Hours	60	30	10	05	105

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

Course Title: basics of microbiology **Course Code:**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-02MB101.1: Understand the role and significance of normal microflora in the human body and recognize various nosocomial infections and their implications.	02	03	04	1	10
CO2-02MB101.2: Describe the morphology, pathogenesis, and symptoms of major gram-positive bacterial infections such as those caused by S. aureus and M. tuberculosis**.**	03	04	02	1	10
CO3-02MB101.3: Explain the morphology, pathogenesis, and symptoms of key gram-negative bacterial pathogens, including E. coli and N. gonorrhoeae.	02	05	02	1	10
CO4-02MB101.4: Identify the major viral pathogens, including Picornaviruses and Retroviruses, and understand their disease mechanisms and symptoms.	02	05	02	1	10
CO5-02MB101.5: Recognize the morphology and clinical manifestations of significant fungal and protozoan infections, such as Dermatophytoses and Malaria.	03	04	03	1	11
Total Marks	12	21	13	05	51

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

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Essentials of Medical Microbiology Sastry Apurba S , Bhat SandhyaJaypee Brothers Medical Publishers 2020
2	Medical Microbiology RajanMJP Publishers 2021

(b) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B.Sc.(Hons) Biotechnology
Semester: I
Course Title: Basics of Microbiology
Course Code:

CO/PO/PSO Mapping															
Course Outcome (Cos)	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-02MB101.1: Understand the role and significance of normal microflora in the human body and recognize various nosocomial infections and their implications.	-	-	-	**1**	**2**	**2**	**1**	-	**1**	**2**	**2**	**3**	**3**	**3**	**1**
CO2-02MB101.2: Describe the morphology, pathogenesis, and symptoms of major gram-positive bacterial infections such as those caused by S. aureus and M. tuberculosis**.**	-	-	-	-	-	-	**3**	-	**2**	**2**	**3**	**3**	**1**	**1**	**2**
CO3-02MB101.3: Explain the morphology, pathogenesis, and symptoms of key gram-negative bacterial pathogens, including E. coli and N. gonorrhoeae.	-	**1**	**1**	**1**	-	-	**2**	-	**3**	**1**	**1**	**2**	**1**	**1**	**1**
CO4-02MB101.4: Identify the major viral pathogens, including Picornaviruses and Retroviruses, and understand their disease mechanisms and symptoms.	-	**1**	**1**	-	**2**	**2**	**2**	**3**	-	**1**	-	-	**1**	**2**	**3**
CO5-02MB101.5: Recognize the morphology and clinical manifestations of significant fungal and protozoan infections, such as Dermatophytoses and Malaria.	**1**	**1**	**1**	-	-	**2**	**3**	**3**	**1**	**2**	**2**	**2**	**1**	-	**2**

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 4,5,6 7,9,10,11,12 PSO 1,2, 3	**CO1-02MB101.1:** Understand the role and significance of normal microflora in the human body and recognize various nosocomial infections and their implications.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10 SO1.11 SO1.12	1.1,1.2,1.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.12	**1SL-1,2**
PO 7,9,10,11,12 PSO 1,2, 3	**CO2-02MB101.2:** Describe the morphology, pathogenesis, and symptoms of major gram-positive bacterial infections such as those caused by S. aureus and M. tuberculosis**.**	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9 SO2.10 SO2.11 SO2.12	2.1, 2.2, 2.3,	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11, 2.12	**2SL-1,2**
PO 2,3,4, 7,9,10,11,12 PSO 1,2, 3	**CO3-02MB101.3:** Explain the morphology, pathogenesis, and symptoms of key gram-negative bacterial pathogens, including E. coli and N. gonorrhoeae.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9 SO3.10 SO3.11 SO3.12	3.1,3.2,3.3	3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12	**3SL-1,2**
PO 2,3,5,6 7,8,10,11,12 PSO 1,2, 3	**CO4-02MB101.4:** Identify the major viral pathogens, including Picornaviruses and Retroviruses, and understand their disease mechanisms and symptoms.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10 SO4.11 SO4.12	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, 4.11, 4.12	**4SL-1,2**
PO 1,2,3,6 7,8,9,10,11,12 PSO 1, 2, 3	**CO5-02MB101.5:** Recognize the morphology and clinical manifestations of significant fungal and protozoan infections, such as Dermatophytoses and Malaria.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 S05.9 SO5.10 SO5.11 SO5.12	5.1,5.2,5.3	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 5.10, 5.11, 5.12	**5SL-1**

Program Name	**Bachelor of Science (Hons.) Biotechnology**	
Semester	I	
CourseCode:	03BC101	
Coursetitle:	General Biochemistry	**Curriculum Developer**: Mrs. Pratima Mishra, Guest Faculty
Pre-requisite:	Students should have basic knowledge of Biology and Chemistry	
Rationale:	For a successful biotechnologist is it essential to learn about basic concepts of those molecules which governs the anatomical and physiological components of biological 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):	**CO1-03BC101.1:** Understanding of the components of biological systems, significant functional groups, pH and buffers, and proteins. **CO2-03BC101.2:** Learning in-depth information regarding the composition and characteristics of numerous categories of carbohydrates. **CO3-03BC101.3:** Recognize various concepts related the structure, characteristics, function and biological role of nucleic acids and central dogma. **CO4-03BC101.4:** Assess various concepts related the structure, characteristics, function and biological role of different types of lipids. **CO5-03BC101.5:** 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)	
Generic Elective	03BC101	General Biochemistry	3	2	1	5	11	3+1=4

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

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
Generic Elective	03BC101	General Biochemistry	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)		
Generic Elective	03BC101-L	General Biochemistry	35	5	5	5	50	50	100

Course-Curriculum:

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

ApproximateHours

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)
CO1-03BC101.1: 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		**CI1.7** Isoelectric point, Zwitter ion,	
	SO1.8 Assess the concept of proteins		**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	04	01	05	19

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
CO2-03BC101.2: 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		**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		**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	02	01	05	17

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction (CI)	Self-Learning(SL)
CO3-03BC101.3: 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	**SL3.1** Isolation of 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,	
	SO3.6 Assessing hypo and hyperchromic shift		**CI3.6** Hypo and hyperchromic shift,	**SL3.4** Study the mechanism of central dogma
	SO3.7 Describe about concept of Tm		**CI3.7** Tm.	**SL3.5** Study the impact of gene regulation
	SO3.6 Assessing the role of central Dogma		**CI3.8** Concept of Central Dogma,	**SL3.6**
	SO3.7 Describe about concept of gene and its regulation		**CI3.9** Concept of genes and their regulation	**SL3.7**

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail structure and function of different types of nucleic acids.
	SW3.2 Mini Project	Describe the role of nucleic acids in biological system.
	SW3.3 Other Activities (Specify)	Prepare a model for explaining 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- 03BC101.4: 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		**Unit-IV** **CI4.1** Lipids: Classification,	**SL4.1** Learn about different classes of lipids
	SO4.2 Assessing role of lipids and its structure	**LI4.1** 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	**LI4.2** Determination of acid value 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		**CI4.7** Sulpholipids,	**SL4.5** Learn about significance of lipids
	SO4.8 Describe the impact of Steroids		**CI4.8** Steroids	
	SO4.9 Evaluate role of lipids in signal transduction		**CI4.9** Lipids in signal transduction	

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	01	01	05	16

Course Outcome (CO)	SessionOutcomes(SOs)	LaboratoryInstruction(LI)	ClassroomInstruction(CI)	Self-Learning(SL)
CO5-03BC101.5: 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	**LI5.1** Demonstration of membrane transport	**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		**CI5.8** Endotoxins	**SL5.5** Learn about endotoxins and exotoxins
	SO5.9 Elaborate the role of exotoxins		**CI5.9** exotoxins.	

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: General Biochemistry **Course Code:**03BC101

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-03BC101.1: Understanding of the components of biological systems, significant functional groups, pH and buffers, and proteins.	9	4	5	1	19
CO2-03BC101.2: Learning in-depth information regarding the composition and characteristics of numerous categories of carbohydrates.	9	4	5	1	19
CO3-03BC101.3: Recognize various concepts related the structure, characteristics, function and biological role of nucleic acids and central dogma.	9	2	5	1	17
CO4-03BC101.4: Assess various concepts related the structure, characteristics, function and biological role of different types of lipids.	9	4	5	1	19
CO5-03BC101.5: Appraise the relationship between principles molecular transport, cell junction and cell signaling in Cell and Cellular components.	9	1	5	1	16
Total Hours	45	15	25	05	90

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

Course Title: General Biochemistry **Course Code:**03BC101

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-03BC101.1: Understanding of the components of biological systems, significant functional groups, pH and buffers, and proteins.	2	1	1	1	5
CO2-03BC101.2: Learning in-depth information regarding the composition and characteristics of numerous categories of carbohydrates.	2	4	2	2	10
CO3-03BC101.3: Recognize various concepts related the structure, characteristics, function and biological role of nucleic acids and central dogma.	3	5	5	2	15
CO4-03BC101.4: Assess various concepts related the structure, characteristics, function and biological role of different types of lipids.	2	3	3	2	10
CO5-03BC101.5: 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: B.Sc. Hons Biotechnology
Semester: I Semester
Course Title: General Biochemistry
Course Code: 03BC101

Course Outcome (Cos)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-03BC101.1: Understanding of the components of biological systems, significant functional groups, pH and buffers, and proteins.	1	1	2	2	3	1	2	3	2	1	2	3	2	2	2
CO2-03BC101.2: Learning in-depth information regarding the composition and characteristics of numerous categories of carbohydrates.	1	1	1	1	2	1	2	2	1	2	2	2	2	3	2
CO3-03BC101.3: Recognize various concepts related the structure, characteristics, function and biological role of nucleic acids and central dogma.	1	1	2	2	1	1	1	1	2	1	2	2	1	2	1
CO4-03BC101.4: Assess various concepts related the structure, characteristics, function and biological role of different types of lipids.	1	1	2	1	2	1	2	2	2	2	1	3	1	2	1
CO5-03BC101.5: Appraise the relationship between principles molecular transport, cell junction and cell signaling in Cell and Cellular components.	1	1	2	1	1	1	1	1	1	2	2	3	1	2	1

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO1-03BC101.1:** 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,	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9,	1SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO2-03BC101.2:** 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,	2.1, 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, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO3-03BC101.3:** 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,	3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9,	3SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO4-03BC101.4:** 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	4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9,	4SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO5-03BC101.5:** 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 S05.9	5.1,	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9,	5SL-1,2,3,4,5

Program Name	**B.Sc. (HONS.) BIOTECHNOLOGY -**	
Semester	**I**	
CourseCode:	03MB101	
Coursetitle:	Basics of Microbiology	**Curriculum Developer**: Mrs. Maahi Choure, Guest Faculty
Pre-requisite:	To understand and work effectively in microbiology, especially when preparing consortia as you described, it's important to have a strong foundation in the basics of microbiology.	
Rationale:	Understanding the basics of microbiology, including microbial classification, cell structure, metabolism, genetics, and laboratory techniques, is essential to effectively study and manipulate microorganisms. This foundation enables accurate identification, cultivation, and utilization of microbes for various applications, such as creating beneficial consortia, ensuring experimental accuracy, and maintaining laboratory safety.	
CourseOutcomes (COs):	**CO1-03MB101.1:** Understand the role and significance of normal microflora in the human body and recognize various nosocomial infections and their implications. **CO2-03MB101.2:** Describe the morphology, pathogenesis, and symptoms of major gram-positive bacterial infections such as those caused by S. aureus and M. tuberculosis**.** **CO3-03MB101.3:** Explain the morphology, pathogenesis, and symptoms of key gram-negative bacterial pathogens, including E. coli and N. gonorrhoeae. **CO4-03MB101.4:** Identify the major viral pathogens, including Picornaviruses and Retroviruses, and understand their disease mechanisms and symptoms. **CO5-03MB101.5:** Recognize the morphology and clinical manifestations of significant fungal and protozoan infections, such as Dermatophytoses and Malaria.	

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)**	
Generic Elective	03MB101	Basics of Microbiology	3	2	1	2	8	3+1=4

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

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
Generic Elective	03MB101	Basics of Microbiology	15	20	5	5	5	50	50

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
Generic Elective	03MB101-L	Basics of Microbiology	35	5	5	5	50	50	100

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**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)**
CO1-03MB101.1: Understand the role and significance of normal microflora in the human body and recognize various nosocomial infections and their implications.	**SO1.1** Overview of microbiology, its history, and major milestones.	**LI1.1** Learn about Sterilization	**CI1.1** Overview of microbiology, its history, and major milestones.	**SL1.1** Remember Carriers in Disease Transmission
	SO1.2 Key contributions of historical figures.	**LI1.2**Learn about basic instrumentation	**CI1.2** Key contributions of historical figures.	**SL1.2** Explore micro flora of university
	SO1.3 Overview of microbial taxonomy		**CI1.3** Overview of microbial taxonomy	
	SO1.4 Introduction to molecular techniques in taxonomy.		**CI1.4** Introduction to molecular techniques in taxonomy.	
	SO1.5 Understanding evolutionary relationships.		**CI1.5** Understanding evolutionary relationships.	
	SO1.6 Study of modern classification systems.		**CI1.6** Study of modern classification systems.	
	SO1.7 Discussion on various classification criteria.		**CI1.7** Criteria in Microbial Taxonomy	
	SO1.8 Timeline of microbial evolution		**CI1.8** Evolutionary History	
	SO1.9 Exploration of microbial diversity through history**.**		**CI1.9** Microbial Diversity	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Summarizes theAnalysis on Septic Shock.
	SW1.2 Mini Project	DemonstrateTypes and Mechanisms of Toxins.
	SW1.3 Other Activities (Specify)	Documentation of instruments used in microbiology

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	2	1	2	14

Course Outcome (CO)	SessionOutcomes (SOs)	LaboratoryInstruction (LI)	ClassroomInstruction (CI)	Self Learning (SL)
CO2-03MB101.2: Describe the morphology, pathogenesis, and symptoms of major gram-positive bacterial infections such as those caused by S. aureus and M. tuberculosis**.**	**SO2.1** Overview of microbial diversity.		**CI2.1** Introduction to Microbial Diversity	**SL2.1** Research on M. tuberculosis
	SO2.2 Prokaryotic vs. Eukaryotic Cells: Key differences and characteristics.	**LI2.1** Preparation of NAM and NBM media	**CI2.2** Prokaryotic vs. Eukaryotic Cells	**SL2.2** Case Study on C. diphtheriae
	SO2.3 Bacterial Morphology: Structure and function.		**CI2.3** Bacterial Morphology	
	SO2.4 Algae and Fungi: Characteristics and significance.		**CI2.4** Algae and Fungi	
	SO2.5 Protozoa: Morphology and role in ecosystems.		**CI2.5** Protozoa	
	SO2.6 Viruses: Unique features and life cycles.		**CI2.6** Viruses.	
	SO2.7 Microbial Distribution: Environmental factors influencing distribution		**CI2.7** Microbial Distribution	
	SO2.8 Characterization Techniques: Methods to study microbial diversity.		**CI2.8** Characterization Techniques.	
	SO2.9 Microbial Ecology: Role of microorganisms in ecosystems.		**CI2.9** Microbial Ecology	

Suggested Sessional Work (SW):*anyone*	**SW2.1** Assignments	Justify the role ofPreventive Measures and Chemotherapy.
	SW2.2 Mini Project	Understand the pathogenesis of M. leprae.
	SW2.3 Other Activities (Specify)	Remember laboratory diagnosis technique.

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

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction (CI)	Self-Learning(SL)
CO3-03MB101.3: Explain the morphology, pathogenesis, and symptoms of key gram-negative bacterial pathogens, including E. coli and N. gonorrhoeae	**SO3.1** Importance of cultivating microorganisms.	**LI3.1** Perform gram staining, spore staining	**CI3.1** Introduction to Cultivation	**SL3.1**Practice local alignment
	SO3.2 Different nutritional needs of microorganisms.	**LI3.2** Perform negative staining, hanging drop method	**CI3.2** Nutritional Categories	**SL3.2**Practice global alignment
	SO3.3 Methods for isolating microorganisms.		**CI3.3** Isolation Techniques	
	SO3.4 Techniques for purifying microbial cultures.		**CI3.4** Purification Methods	
	SO3.5 Methods for long-term preservation.		**CI3.5** Preservation Techniques	
	SO3.6 Types of media used for microbial growth		**CI3.6** Cultivation Media	
	SO3.7 Factors affecting microbial cultivation.		**CI3.7** Growth Conditions	
	SO3.8 Safe handling and maintenance of cultures.		**CI3.8** Laboratory Practices	
	SO3.9 Understanding the growth curve.		**CI3.9** Microbial Growth Phases	

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

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	2	1	2	14

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO4-03MB101.4: Identify the major viral pathogens, including Picornaviruses and Retroviruses, and understand their disease mechanisms and symptoms.	**SO4.1** Basic concepts and importance.	**LI4.1** Determination of bacterial cell size by micrometry	**CI4.1** Introduction to Microbial Growth	**SL4.1** Learn techniques of preventive measures
	SO4.2 Phases of microbial growth.		**CI4.2** Growth Curve Analysis	**SL4.2** Understand symptoms of various diseases
	SO4.3 Generation Time: Calculating and understanding its significance.		**CI4.3** Generation Time: Calculating and understanding its significance.	
	SO4.4 Batch and Continuous Culture: Methods and applications.		**CI4.4** Batch and Continuous Culture: Methods and applications.	
	SO4.5 Methods to measure microbial growth		**CI4.5** Measurement Techniques	
	SO4.6 Environmental and nutritional factors.		**CI4.6** Factors Affecting Growth	
	SO4.7 Overview of microbial metabolism.		**CI4.7** Metabolic Pathways	
	SO4.8 Integration of catabolic and biosynthetic pathways.		**CI4.8** Amphi-catabolic Pathways	
	SO4.9 Mechanisms and processes.		**CI4.9** Bacterial Reproduction	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Write about Morphology and Pathogenesis ofHerpes Virus.
	SW4.2 Mini Project	Documentation of characteristic of bacteria
	SW4.3 Other Activities (Specify)	Search and learn via YouTube how to take Preventive Measures and Chemotherapy for the Papova Virus.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	3	1	2	15

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO5-03MB101.5: Recognize the morphology and clinical manifestations of significant fungal and protozoan infections, such as Dermatophytoses and Malaria.	**SO5.1** Introduction to Microbial Control: Importance and methods.	**LI5.1** Characterization of bacteria	**CI5.1** Introduction to Microbial Control: Importance and methods.	**SL5.1**Learn how Chemotherapy for Systemic Infections
	SO5.2 Heat, radiation, and filtration.		**CI5.2** Physical Control Methods	**SL5.2** Classify all Fungal and Protozoan Infections
	SO5.3 Disinfectants and antiseptics		**CI5.3** Chemical Control Methods	
	SO5.4 Antibiotics and their mechanisms		**CI5.4** Chemotherapeutic Agents	
	SO5.5 Bacterial pollutants and indicators.		**CI5.5** Water Microbiology	
	SO5.6 Coliforms and Non-coliforms: Detection and significance.		**CI5.6** Coliforms and Non-coliforms: Detection and significance.	
	SO5.7 Sewage Composition and Disposal: Methods and importance.		**CI5.7** Sewage Composition and Disposal: Methods and importance.	
	SO5.8 Food Microbiology: Microorganisms in food production and spoilage.		**CI5.8** Food Microbiology: Microorganisms in food production and spoilage.	
	SO5.9 Foodborne Infections and Intoxications: Causes and prevention		**CI5.9** Foodborne Infections and Intoxications: Causes and prevention	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Write aboutTreatment Strategies for Fungal and Protozoan Infections.
	SW5.2 Mini Project	
	SW5.3 Other Activities (Specify)	Try to learn and apply preventive Measures and Chemotherapy for Malaria.

Course duration (in hours)to attain Course Outcomes:

Course Title:Medical Microbiology **Course Code:**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-03MB101.1: Understand the role and significance of normal microflora in the human body and recognize various nosocomial infections and their implications.	9	4	2	1	16
CO2-03MB101.2: Describe the morphology, pathogenesis, and symptoms of major gram-positive bacterial infections such as those caused by S. aureus and M. tuberculosis**.**	9	2	2	1	14
CO3-03MB101.3: Explain the morphology, pathogenesis, and symptoms of key gram-negative bacterial pathogens, including E. coli and N. gonorrhoeae.	9	4	2	1	16
CO4-03MB101.4: Identify the major viral pathogens, including Picornaviruses and Retroviruses, and understand their disease mechanisms and symptoms.	9	2	2	1	14
CO5-03MB101.5: Recognize the morphology and clinical manifestations of significant fungal and protozoan infections, such as Dermatophytoses and Malaria.	9	3	2	1	15
Total Hours	45	15	10	05	75

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

Course Title: basics of microbiology **Course Code:**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-03MB101.1: Understand the role and significance of normal microflora in the human body and recognize various nosocomial infections and their implications.	02	03	04	1	10
CO2-03MB101.2: Describe the morphology, pathogenesis, and symptoms of major gram-positive bacterial infections such as those caused by S. aureus and M. tuberculosis**.**	03	04	02	1	10
CO3-03MB101.3: Explain the morphology, pathogenesis, and symptoms of key gram-negative bacterial pathogens, including E. coli and N. gonorrhoeae.	02	05	02	1	10
CO4-03MB101.4: Identify the major viral pathogens, including Picornaviruses and Retroviruses, and understand their disease mechanisms and symptoms.	02	05	02	1	10
CO5-03MB101.5: Recognize the morphology and clinical manifestations of significant fungal and protozoan infections, such as Dermatophytoses and Malaria.	03	04	03	1	11
Total Marks	12	21	13	05	51

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

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Essentials of Medical Microbiology Sastry Apurba S , Bhat SandhyaJaypee Brothers Medical Publishers 2020
2	Medical Microbiology RajanMJP Publishers 2021

(b) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B.Sc.(Hons) Biotechnology
Semester: I
Course Title: Basics of Microbiology
Course Code:

CO/PO/PSO Mapping															
Course Outcome (Cos)	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-03MB101.1: Understand the role and significance of normal microflora in the human body and recognize various nosocomial infections and their implications.	-	-	-	**1**	**2**	**2**	**1**	-	**1**	**2**	**2**	**3**	**3**	**3**	**1**
CO2-03MB101.2: Describe the morphology, pathogenesis, and symptoms of major gram-positive bacterial infections such as those caused by S. aureus and M. tuberculosis**.**	-	-	-	-	-	-	**3**	-	**2**	**2**	**3**	**3**	**1**	**1**	**2**
CO3-03MB101.3: Explain the morphology, pathogenesis, and symptoms of key gram-negative bacterial pathogens, including E. coli and N. gonorrhoeae.	-	**1**	**1**	**1**	-	-	**2**	-	**3**	**1**	**1**	**2**	**1**	**1**	**1**
CO4-03MB101.4: Identify the major viral pathogens, including Picornaviruses and Retroviruses, and understand their disease mechanisms and symptoms.	-	**1**	**1**	-	**2**	**2**	**2**	**3**	-	**1**	-	-	**1**	**2**	**3**
CO5-03MB101.5: Recognize the morphology and clinical manifestations of significant fungal and protozoan infections, such as Dermatophytoses and Malaria.	**1**	**1**	**1**	-	-	**2**	**3**	**3**	**1**	**2**	**2**	**2**	**1**	-	**2**

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 4,5,6 7,9,10,11,12 PSO 1,2, 3	**CO1-03MB101.1:** Understand the role and significance of normal microflora in the human body and recognize various nosocomial infections and their implications.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	1.1,1.2,	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9,	**1SL-1,2**
PO 7,9,10,11,12 PSO 1,2, 3	**CO2-03MB101.2:** Describe the morphology, pathogenesis, and symptoms of major gram-positive bacterial infections such as those caused by S. aureus and M. tuberculosis**.**	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	2.1, ,	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9,	**2SL-1,2**
PO 2,3,4, 7,9,10,11,12 PSO 1,2, 3	**CO3-03MB101.3:** Explain the morphology, pathogenesis, and symptoms of key gram-negative bacterial pathogens, including E. coli and N. gonorrhoeae.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	3.1,3.2	3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9,	**3SL-1,2**
PO 2,3,5,6 7,8,10,11,12 PSO 1,2, 3	**CO4-03MB101.4:** Identify the major viral pathogens, including Picornaviruses and Retroviruses, and understand their disease mechanisms and symptoms.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	4.1,	4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9,	**4SL-1,2**
PO 1,2,3,6 7,8,9,10,11,12 PSO 1, 2, 3	**CO5-03MB101.5:** Recognize the morphology and clinical manifestations of significant fungal and protozoan infections, such as Dermatophytoses and Malaria.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 S05.9	5.1,	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9,	**5SL-1**

ABILITY ENHANCEMENT COURSE ON SUSTAINABLE DEVELOPMENT GOALS (SDGs)
FOR B.Sc. (HONS) BIOTECHNOLOGY

Course Code: 0SDG102

Course Title : **Sustainable Development Goals (SDGs)**

Pre-requisite: Student should have basic knowledge of Environment, Natural resources, Climate change and sustainability.

Rationale: To inculcate the knowledge base on sustainable development with a view to balance our economic, environmental and social needs, allowing prosperity for now and future generations. To train students to undertake major initiatives in the efficient management of natural resources and the prevention of environmental pollution with focus on Sustainable Development.
To use environmental management tools that help to improve the quality of environment, to assess local vulnerabilities with respect to climate, natural disasters and to achieve sustainable developmental needs.

Course Outcomes:

0SDG102.1: Examine critically the 17 newly minted UN Sustainable Development Goals and understand the historical evolution, key theories, and concepts of sustainable development.

0SDG102.2: Identify and apply methods for assessing the achievement of sustainable development and discover the science, technology, economics, and politics underlying the concepts of sustainability.

0SDG102.3: Understand the implications of overuse of resources, population growth and economic growth and sustainability and explore the challenges the society faces in making transition to renewable resource use.

0SDG102.4: Develop skills to understand attitudes on individuals, society and their role regarding causes and solutions in the field of sustainable development and apply critical thinking skills to evaluate the quality, credibility and limitations of an argument for solution.

0SDG102.5: Describe the steps of the design thinking methodology and how design thinking can accelerate effective SDG implementation. Deepen knowledge and pedagogical tools to incorporate values-based education for sustainable development in educational programmes and processes.

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies(Hours/Week)					Total Credits (C)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
AEC	0SDG102	Sustainable Development Goal	2	0	1	1	4	2

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

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

Scheme of Assessment:

Theory

Board of Study	Cous e Code	Course Title	**Scheme of Assessment (Marks)**							
			Progressive Assessment (PRA)						**End Semester Assessment**	**Total Marks**
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+ SA+CAT +AT)	**(ESA)**	(PRA+ ESA)
AEC	0SDG 102	Sustainable Development Goal	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

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

0SDG102.1: Examine critically the 17 newly minted UN Sustainable Development Goals and understand the historical evolution, key theories, and concepts of sustainable development.

Approximate Hours

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

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

SW-1 Suggested Sessional Work (SW):

a. Assignments:
Overview of SDGs, Sustainable Consumption and Production, Details of 17 SDGs

b. Other Activities (Specify):
Note down the different challenges in our state and district to achieve SDG

0SDG102.2: Identify and apply methods for assessing the achievement of sustainable development and discover the science, technology, economics, and politics underlying the concepts of sustainability and measuring.

Approximate Hours

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

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

SW-1 Suggested Sessional Work (SW):

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

d. Other Activities (Specify): Seminar and group discussion on ESD and measuring sustainability Millennium Development Goals (MDGs)

0SDG102.3: Understand the implications of overuse of resources, population growth and economic growth and sustainability and explore the challenges the society faces in making transition to renewable resource use.

Approximate Hours

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

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

SW-1 Suggested Sessional Work (SW):

Smart cities

e. Assignments:

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

Other Activities (Specify):

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

0SDG102.4: Develop skills to understand attitudes on individuals, society and their role regarding causes and solutions in the field of sustainable development and apply critical thinking skills to evaluate the quality, credibility and limitations of an argument for solution.

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Approximate Hours

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

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

	(LI)		
SO4.1 Understand environmental sustainability is crucial in reducing the impacts of climate change **SO4.2** Discuss causes of emission of GHGs and its consequences **SO4.3** Explain how climate change and sustainable development both play a role in shaping the human and environmental factors of the world. **SO4.4** Explain the importance of sustainable production and consumption **SO4.**5 Climate change is disrupting national economies and affecting lives and livelihoods, especially for the most vulnerable and its mitigation.		**Unit-4.0 Climate Change, Energy and Sustainable Development** 4.1 The greenhouse effect: Causes and Consequences 4.2 Climate Change: A Threat to Sustainable Development 4.3 Adaptation to Current and Future Climate Regimes 4.4 The consequences: crop failure 4.5 Solutions technology and lifestyle changes 4.6 Mitigating Climate Change	**1** Agreement on Climate Change, Trade, and Sustainability Carbon Credit, carbon trading Kyoto Protocol

SW-1 Suggested Sessional Work (SW):

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

Other Activities (Specify):

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0SDG102.5 Describe the steps of the design thinking methodology and how design thinking can accelerate effective SDG implementation. Deepen knowledge and pedagogical tools to incorporate values-based education for sustainable development in educational programmes and processes.

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Approximate Hours

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

Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
SO4.1 Understand the relevance and the concept of sustainability and the global initiatives in this direction **SO4.2** Understand role of Corporations and Ecological Sustainability**.** **SO4.3** Explain role of CSR in Sustainability. **SO4.4** Understand the SD challenge for companies, their responsibility and their potentials for action **SO4.5** Discuss the role of world government for world justice and peace		**Unit-5.0 Sustainable Business Practices:** 5.1 Corporate Social Responsibility 5.2 Sustainable products and services 5.3 Business and Environment 5.4 Corporations and Ecological Sustainability 5.5 Life Cycle Assessment: • LCA Overview and Application 5.6 World peace and justice: • United nations goals for peace and justice • World Government for peace	Local to the Global: Can Sustainable Development Work

SW-1 Suggested Sessional Work (SW):

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

Other Activities (Specify):
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Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
0SDG102.1: Examine critically the 17 newly minted UN Sustainable Development Goals and understand the historical evolution, key theories, and concepts of sustainable development.	6	1	1	8
0SDG102.2: Identify and apply methods for assessing the achievement of sustainable development and discover the science, technology, economics, and politics underlying the concepts of sustainability.	6	1	1	8
0SDG102.3: Understand the implications of overuse of resources, population growth and economic growth and sustainability and explore the challenges the society faces in making transition to renewable resource use.	6	1	1	8
0SDG102.4 Develop skills to understand attitudes on individuals, society and their role regarding causes and solutions in the field of sustainable development and apply critical thinking skills to evaluate the quality, credibility and limitations of an argument for solution.	6	1	1	8

0SDG102.5: Describe the steps of the design thinking methodology and how design thinking can accelerate effective SDG implementation. Deepen knowledge and pedagogical tools to incorporate values-based education for sustainable development in educational programmes and processes.	6	1	1	8
Total Hours	30	5	5	40

Suggestion for End Semester Assessment

Suggested Specification Table(For ESA)

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

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

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

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

Suggested Instructional/Implementation Strategies:

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

Suggested Learning Resources:

(a) Books:

S. No.	Title	Author	Publisher	Edition & Year
1	The Economics of Sustainable Development: The Case of India (Natural Resource Management and Policy)"	Surender Kumar and Shunsuke Managi	Springer Switzerland	2009
2	Corporate Social Responsibility in Developing and Emerging Markets	Onyeka Osuji	Cambridge	New Edition June 2022
3	Smart Cities for Sustainable Development	Ram Kumar Mishra, Ch Lakshmi Kumari, Sandeep Chachra, P.S. Janaki Krishna	Springer Switzerland	March 2022
4	Sustainable Development: Linking Economy, Society, Environment	Tracey Strange and Anne Bayley		
5	Management Of Resources For Sustainable Devpt	Sushma Goyal	The Orient Blackswan	2016
6	Energy, Environment and Sustainable Development: Issues and Policies	S. Ramaswamy Sathis G. Kumar	Regal Publications	2009
7	The New Map: Energy, Climate, and the Clash of Nations	Daniel Yergin	Penguin Press	September 2015
8	Contributions of Education for Sustainable Development (ESD) to Quality Education:	Laurie, R., Nonoyama-Tarumi, Y., Mckeown, R., & Hopkins, C.	A Synthesis of Research. Journal of Education for Sustainable Development, 10(2), 226–242.	2016
9	Sustainable Results in Development: Using the SDGs for Shared Results and Impact	OECD	OECD Publishing, Paris	2019
10	Development Discourse and Global History from colonialism to the sustainable development goals	Ziai, Aram	Routledge, London & New York	2016
11	Sustainable Development Goals An Indian Perspective,	Hazra, Somnath., Bhukta, Anindya	Springer Switzerland	2020
12	Environmental Ecology, Biodiversity and Climate Change	HM Saxena	Rawat Publication	January 2021
13	https://www.un.org/sustainabledevelopment/			
14	https://www.aiu.ac.in/documents/AIU_Publications/UN-SDG goals			
15	https://www.unesco.org/en/education-sustainable-development			

16	https://onlinecourses.nptel.ac.in/noc23_hs57/preview
17	ttps://www.iau-hesd.net/news/5180-berlin-declaration-education-sustainable development-adopted-unesco-esd-conference-17-19

Curriculum Development Team

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COs, POs and PSOs Mapping

Course Code : 0SDG102

Course Title: Sustainable Development Goals (SDGs)

Course Outcomes	Program Outcomes												Program Specific Outcome			
	PO1	PO 2	PO 3	PO4	PO5	PO 6	PO7	PO8	PO9	PO1 0	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
	knowledge	Problem analysis	Design/ development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability:	Ethics	Individual and team work:	Communication:	Project management and finance:	Life-long learning	The ability to apply technical & engineering knowledge to mitigate the consequences of global warming	Ability to understand the Different SD Goals and their significance	Ability to understand the latest Technology to achieve SD	Ability to use the research based innovative knowledge for SDGs
CO1: Examine critically the 17 newly minted UN Sustainable Development Goals and understand the historical evolution, key theories, and concepts of sustainable development.	1	1	1	2	3	2	3	2	2	1	3	2	2	3	3	1

CO2: Identify and apply methods for assessing the achievement of sustainable development and discover the science, technology, economics, and politics underlying the concepts of sustainability.	**1**	**1**	**2**	**2**	**1**	**2**	**3**	**2**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**1**
CO3: Understand the implications of overuse of resources, population growth and economic growth and sustainability and explore the challenges the society faces in making transition to renewable resource use.	**2**	**2**	**1**	**1**	**1**	**2**	**2**	**2**	**1**	**2**	**1**	**2**	**1**	**1**	**2**	**2**
CO4: Develop skills to understand attitudes on individuals, society and their role	**3**	**2**	**2**	**2**	**3**	**2**	**3**	**2**	**2**	**1**	**2**	**3**	**3**	**3**	**3**	**2**

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

Legend:1–Low,2–Medium, 3–High

Course Curriculum Map:

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

PO1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4, 5	**CO4:** Develop skills to understand attitudes on individuals, society and their role regarding causes and solutions in the field of sustainable development and apply critical thinking skills to evaluate the quality, credibility and limitations of an argument for solution.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5		Unit-4 : Climate Change, Energy and Sustainable Development 4.1, 4.2,4.3,4.4,4.5,4.6,4.7	
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4, 5	**CO5:** Describe the steps of the design thinking methodology and how design thinking can accelerate effective SDG implementation. Deepen knowledge and pedagogical tools to incorporate values-based education for sustainable development in educational programmes and processes	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5		Unit 5: Sustainable Business Practices, LCA and World peace and justice 5.1,5.2,5.3,5.4,5.5,5.6	

Program Name	**Bachelor of Science B.Sc. (Biotechnology)**	
Semester	I	
Course Code:	0SSD101	
Course title:	Communication Skills	**Curriculum Developer**: Mr. Dhirendra Mishra, Teaching Associate
Pre-requisite:	Students should have basic knowledge of Communication Skills	
Rationale:	Communication today is very important both in the business world and in private life. Successful communication helps us better understand people and situations. It helps us overcome diversities, build trust and respect, and create conditions for sharing creative ideas and solving problems.	
Course Outcomes (COs):	**CO1-0SSD101.1:** To enhance the Speaking Skills of the students in such a way where they will be able to communicate effectively with immense self confidence in themselves **CO2-0SSD101.2:** To develop the leadership skills, public speaking skills and social skills in students along with the basic knowledge of how to make an impressive Resume. **CO3-0SSD101.3:** To improve the presentation skills of the students that plays a pivotal role in building and shaping the career of the students **CO4-0SSD101.4:** To focus on improving the fundamental grammar of the students in order to bring accuracy while speaking and writing. **CO5-0SSD101.5:** To make them aware of the Indian Culture and English Language by imbibing the dramas and poetry of some famous Indian English Writers	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme ofstudies (Hours/Week)					Total Credits(C) (L:T:P=2:0:0)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
AEC	0SSD101	Communication Skills	2	0	1	3	6	2

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

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
AEC	0SSD101	Communication Skills	15	20	10	5	50	50	100

Course-Curriculum:

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

Approximate Hours

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

Course outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Class room Instruction(CI)**	**Self-Learning(SL)**
CO1-0SSD101.1: To enhance the Speaking Skills of the students in such a way where they will be able to communicate effectively with immense self confidence in themselves	**SO1.1** Anytime we're trying to get people to think of us a certain way, it's an act of self presentation. Generally speaking, we work to present ourselves		**Unit 1 Self Grooming, Basic Etiquettes and Presentation Skills** **CI1.1** Self Introduction	**SL1.1** The Role of Education in Life, The Importance of English in Today's World
	SO1.2 Generally, oral presentation is public speaking, either individually or as a group, the aim of which is to providing information entertain, persuade the audience, or educate		**CI 1.2** Oral Presentation	**SL1.2** Dressing and Grooming Etiquettes (Male and Female)
	SO1.3 Understands the role of education in life by oral presentation		**CI 1.3** The Role of Education in Life,	
	SO1.4 Understands the importance of English in today's life by oral presentation		**CI 1.4** The Importance of English in Today's World and Necessity of Uniform in a College	
	SO1.5 Be a professionally refined person. Project a confident image by being well groomed. Building up a good self-image.		**CI 1.5** Dressing and Grooming Etiquettes	**SL1.3** Importance of Body Language **(**Gesture, Posture, Facial Expressions & Sign Language, etc.)
	SO1.6 The most effective communication occurs when the importance of body language in teaching is acknowledged. When these nonverbal cues are in sync with our verbal ones, it creates communication synergy.		**CI1.6** Importance of Body Language	**SL1.4** Role Plays (Hospital Scene, Interaction in the Classroom and Travelling by Train).
	SO1.7 Role play has helped 'enhance active listening skills, social problem solving skills and demonstration of emotional empathy'"		**CI1.7** Role Plays.	**SL1.5** Students will self practice to improve their Interviews skills.
	SO1.8 Getting insight into the candidate's rational knowledge, quick thinking, communication skills and creativity. Verifying if a candidate is a right fit for the company culture and work ethic		**CI1.8** Interviews and their Kinds	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Make practice on self introduction
	SW1.2 Mini Project	Write some role play to improve speaking skills and developing self confidence
	SW1.3 Other Activities (Specify)	Attend some publics and socials activities or program to improve self onfidence

Item	Cl	LI	SW	SL	Total
Approx.Hrs	06	00	01	03	10

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
CO2-0SSD101.2: To develop the leadership skills, public speaking skills and social skills in students along with the basic knowledge of how to make an impressive Resume.	**SO2.1** Skill development: It helps individuals develop important skills such as communication, critical thinking, problem-solving, and collaboration.		**Unit-II** **Confidence Building Skills and Interview Skills**. **CI2.1** Group Discussion. Impact of Covid-19 on mental health,	**SL2.1** Read the Group Discussion steps and process(Impact of Covid-19 on mental health
	SO2.2 Understand The Impact of Social Media on Our Lives.		**CI2.2** The Impact of Social Media on Our Lives and The Pros and Cons of Technology	
	SO2.3 Know the process and kinds of interviews.		**CI2.3** Interviews and their Kinds	**SL2.2** Read the question which mostly asks during an interview?
	SO2.4 Understand about Debate and their importance.		**CI2.4** Debate (Should the Use of Plastic Be Banned?,	.**SL2.3** Debate students will self practice to improve their skills.
	SO2.5 Know the importance of career.		**CI2.5** Should Parents Decide Which Career Their Children Will Pursue?	
	SO2.6 Understand about Artificial Intelligence Useful or Dangerous?		**CI2.6** Is Artificial Intelligence Useful or Dangerous?	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Write steps of interview.
	SW2.2 Mini Project	Write the steppes of Group Discussion
	SW2.3 Other Activities (Specify)	Some class activities for improvement of team work.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	07	00	01	03	11

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction (CI)	Self-Learning(SL)
CO3-0SSD101.3: To improve the presentation skills of the students that plays a pivotal role in building and shaping the career of the students	**SO3.1** Speech/ Anchoring (Occasional Speech, Valedictory Speech, Patriotic Speech),.		**Unit-III** **Public Speaking Skills and Conversational Skills.** **CI 3.1** Speech/ Anchoring	**SL3.1** Take chance for Speech and Anchoring to improve public speaking skills.
	SO3.2 The students will identify words and/or phrases related to the topic. The students will draw inferences relying on the context. The students will express themselves fluently. The students will express themselves with acceptable accuracy		**CI 3.2** Occasional Speech	**SL3.2** Pros and Cons of Online teaching
	SO3.3 The students will identify words and/or phrases related to the topic. The students will draw inferences relying on the context. The students will express themselves fluently. The students will express themselves with acceptable accuracy		**CI 3.3** Valedictory Speech	**SL3.3** Conversational Topics (Inquiry at bank, Airport, Station and Hospitals).
	SO3.4 The students will identify words and/or phrases related to the topic. The students will draw inferences relying on the context. The students will express themselves fluently. The students will express themselves with acceptable accuracy		**CI 3.4** Patriotic Speech	
	SO3.5 Extemporaneous speech has many benefits for both the speaker and the audience For The Speaker.		**CI 3.5** Extempore	
	SO3.6 Understands the pros and cons of online teaching.		**CI 3.6** Pros and Cons of Online teaching,	
	SO3.7 Understands the Environment Conservation and Education of a Girl Child		**CI3.7** Environment Conservation and Education of a Girl Child	

Suggested Sessional Work (SW): *anyone*		
	SW3.1 Assignments	Write key features of Anchoring
	SW3.2 Mini Project	Inquiry at bank.
	SW3.3 Other Activities (Specify)	Occasional Speech

Item	Cl	LI	SW	SL	Total
Approx.Hrs	08	00	01	03	9

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
0SSD101CO4: To focus on improving the fundamental grammar of the students in order to bring accuracy while speaking and writing.	**SO4.1** **Prepositions (**Place, Time and Direction),		**Unit-IV** **Functional Grammar and Vocabulary Building:** **CI4.1** 1Prepositions	**SL4.1** Learn about appropriate use of preposition
	SO4.2 Understand the uses of present tense.		**CI4.2** Tenses (Present tense)	**SL4.2** Learn tenses and their use
	SO4.3 Understand the uses of present tense.		**CI4.13** Tenses (Past tense)	
	SO4.4 Understand the uses of present tense.		**CI4.4** Tenses (Future tense)	
	SO4.5 Know the uses of active voice		**CI4.5** Voice (Active - Passive voice)	
	SO4.6 Know the uses of Passive voice.		**CI4.6** Modals	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Write structure of Tense.
	SW4.2 Mini Project	Write the uses of Prepositions **(**Place, Time and Direction),
	SW1.3 Other Activities (Specify)	Uses of tense

Item	Cl	LI	SW	SL	Total
Approx.Hrs	03	00	01	03	7

Course Outcome (CO)	SessionOutcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO5-0SSD101.5: To make them aware of the Indian Culture and English Language by imbibing the dramas and poetry of some famous Indian English Writers	**SO5.1** The Axe- R.K. Narayan to know the importance and values of trees.		**Unit-V Indian Writing in English & Hindi** **CI5.1** The Axe- R.K. Narayan	**SL5.1** Read the story Axe
	SO5.2 By reading The Night of the Scorpion- Nissim Ezekiel,the student will understand the Indian culture and English language.		**CI5.2** The Night of the Scorpion- Nissim Ezekiel	**SL5.2** Read the lession the night of the scorpion.
	SO5.3 The Portrait of a Lady - Khushwant Singh.		**CI5.3** The Portrait of a Lady - Khushwant Singh	**SL5.3** Learn about khushwant singh.

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Write about R.K.Narayan
	SW5.2 Mini Project	Make a list of Indian Dramas.
	SW5.3 Other Activities (Specify)	Find out some you tube videos based on Indian poet.

Course duration (in hours) to attain Course Outcomes:

Course Title: Communication Skills **Course Code: 0SSD101**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-0SSD101.1: To enhance the Speaking Skills of the students in such a way where they will be able to communicate effectively with immense self confidence in themselves	8	0	5	1	14
CO2-0SSD101.2: To develop the leadership skills, public speaking skills and social skills in students along with the basic knowledge of how to make an impressive Resume.	6	0	3	1	10
CO3-0SSD101.3: To improve the presentation skills of the students that plays a pivotal role in building and shaping the career of the students	7	0	3	1	11
CO4-0SSD101.4: To focus on improving the fundamental grammar of the students in order to bring accuracy while speaking and writing.	6	0	2	1	9
CO5-0SSD101.5: To make them aware of the Indian Culture and English Language by imbibing the dramas and poetry of some famous Indian English Writers	3	0	3	1	7
Total Hours	30	00	16	05	51

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

Course Title: Communication Skills **Course Code: 0SSD101**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-0SSD101.1: To enhance the Speaking Skills of the students in such a way where they will be able to communicate effectively with immense self confidence in themselves	2	1	1	1	5
CO2-0SSD101.2: To develop the leadership skills, public speaking skills and social skills in students along with the basic knowledge of how to make an impressive Resume.	2	4	2	2	10
CO3-0SSD101.3: To improve the presentation skills of the students that plays a pivotal role in building and shaping the career of the students	3	5	5	2	15
CO4-0SSD101.4: To focus on improving the fundamental grammar of the students in order to bring accuracy while speaking and writing.	2	3	3	2	10
CO5-0SSD101.5: To make them aware of the Indian Culture and English Language by imbibing the dramas and poetry of some famous Indian English Writers	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	Dr. Meenu Pandey: Communication Skills, NiraliPraksahan.
2	Dr. Neeta Sharma: Communication Skills, Satya Prakashan.
3	A. J. Thomson & A. V. Martinet: A Practical English Grammar, Oxford University Press..
4	K.P. Thakur: A Practical Guide to English Grammar, Bharti Bhawan Publishers & Distributors
5	Wilfred Funk: Six Weeks to Words of Power, W.R. Goyal Publishers and Distributors.
6	Grant Taylor: English Conversation Practise, Tata McGraw Hill Education Private Limited.

(b) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B. Sc.Biotechnology
Semester:I Semester
Course Title: Communication Skills
Course Code: 0SSD101

CO/PO/PSO Mapping								
Course Outcome (Cos)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-0SSD101.1: To enhance the Speaking Skills of the students in such a way where they will be able to communicate effectively with immense self confidence in themselves	2	-	-	1	2	2	2	1
CO2-0SSD101.2: To develop the leadership skills, public speaking skills and social skills in students along with the basic knowledge of how to make an impressive Resume.	-	-	-	-	-	1	1	2
CO3-0SSD101.3: To improve the presentation skills of the students that plays a pivotal role in building and shaping the career of the students	-	1	1	1	-	1	1	1
CO4-0SSD101.4: To focus on improving the fundamental grammar of the students in order to bring accuracy while speaking and writing.	-	1	1	-	2	1	1	3
CO5-0SSD101.5: To make them aware of the Indian Culture and English Language by imbibing the dramas and poetry of some famous Indian English Writers	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	**CO1-0SSD101.1:** To enhance the Speaking Skills of the students in such a way where they will be able to communicate effectively with immense self confidence in themselves	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8		1.1,1.2,1.3,1.4,1.5 1.6,1.7,1.8	**1SL-1,2,3**
PO 1,2,3,4,5 PSO 1,2,3	**CO2-0SSD101.2:** To develop the leadership skills, public speaking skills and social skills in students along with the basic knowledge of how to make an impressive Resume.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6		2.1, 2.2, 2.3, 2.4, 2.5, 2.6,	**2SL-1,2,3**
PO 1,2,3,4,5 PSO 1,2,3	**CO3-0SSD101.3:** To improve the presentation skills of the students that plays a pivotal role in building and shaping the career of the students	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7		3.1,3.2,3.3,3.4,3.5 3.6,3.7	**3SL-1,2,3**
PO 1,2,3,4,5 PSO 1,2,3	**CO4-0SSD101.4:** To focus on improving the fundamental grammar of the students in order to bring accuracy while speaking and writing.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6		4.1,4.2,4.3,4.4,4.5 4.6,	**4SL-1,2**
PO 1,2,3,4,5 PSO 1,2,3	**CO5-0SSD101.5:** To make them aware of the Indian Culture and English Language by imbibing the dramas and poetry of some famous Indian English Writers	SO5.1 SO5.2 SO5.3		5.1,5.2,5.3,	**5SL-1,2,3**

Program Name	**Bachelor of Science (B.Sc.)- Biotechnology**	
Semester	II	
Course Code:	01BT201	
Course title:	Molecular biology and diagnostic techniques	**Curriculum Developer**: Shaily Mishra, Assistant Professor
Pre-requisite:	Students should have basic knowledge of biology, biochemistry of nucleic acids, immune system related biological processes.	
Rationale:	The paper on Molecular biology and diagnostic techniques in a B.Sc. Biotechnology program provides students with an understanding of the basic principles and clinical significance of laboratory testing in the field of molecular diagnostics. Students will gain insights about the basic principles of DNA replication and how to perform basic molecular diagnostic techniques and their applications in the identification of genetic diseases and diseases caused by microorganisms.	
Course Outcomes (COs):	**CO1-01BT201.1:** Understand the basic structure of DNA and RNA, modes of DNA replication and its damage and repair mechanism. **CO2-01BT201.2:** Students are able to understand the chemical and molecular processes that occur in and between cells. **CO3-01BT201.3:** Gain knowledge about the protein synthesis mechanism and regulation of gene expression in prokaryotes. **CO4-01BT201.4:** Demonstrate an understanding of basic molecular diagnostic techniques. **CO5-01BT201.5:** Apply molecular diagnostic techniques to the identification and diagnosis of diseases.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme ofstudies (Hours/Week)					Total Credits(C) (L:T:P=4:0:2)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
Major	01BT201	Molecular Biology and Diagnostic Techniques	4	4	1	3	12	4+2=6

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)	Class Activity (CAT)	Seminar (SA)	Class Attendance (AT)	Total Marks (CA+CT+CAT+SA+AT)		
Major	01BT201	Molecular biology and diagnostic techniques	15	20	05	05	05	50	50	100

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
Major	01BT201-L	Molecular biology and diagnostic techniques	35	5	5	5	50	50	100

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx.Hrs** | 12 | 06 | 01 | 03 | 22

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-01BT201.1: Understand the basic structure of DNA and RNA, modes of DNA replication and its damage and repair mechanism.	**SO1.1** Learn about DNA as genetic material	**LI1.1** Preparation of solutions for Molecular biology experiments.	**Unit-1 DNA structure and replication** **CI1.1** DNA as genetic material,	**SL1.1** Study experiments that proves DNA as genetic material
	SO1.2 Understand the structure of DNA		**CI1.2** Structure of DNA	
	SO1.3 Study about different forms of DNA		**CI1.3** Types of DNA	
	SO1.4 Understand the experimental proof of semi conservative DNA replication.	**LI1.2** DNA isolation from different sources	**CI1.4** Semi conservative nature of DNA replication	**SL1.2** Understand the role of proteins and enzymes in DNA replication
	SO1.5 Role of replicon and polymerases in prokaryotes	**LI1.2** RNA isolation from different sources	**CI1.5** Replicon and DNA polymerases in prokaryotes	
	SO1.6 Role of replicon and polymerases in eukaryotes		**CI1.6** Replicon and DNA polymerases in eukaryotes	
	SO1.7 Study the process of replication in prokaryotes		**CI1.**7Replication of DNA in prokaryotes	
	SO1.8 Role of telomere in termination of replication		**CI1.8** Telomere and end replication problem	
	SO1.8 Study the process of replication in eukaryotes		**CI1.8** Replication of DNA in eukaryotes	
	SO1.10 Understand the rolling circle replication		**CI1.10** Rolling circle replication	
	SO1.11 Study the causes and types of DNA damage		**CI1.11** DNA damage	**SL1.3** Study about various factors responsible for DNA Damage
	SO1.12 DNA repair mechanism		**CI1.12** DNA repair	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Describe in detail the function of machinery involved in DNA replication.
	SW1.2 Mini Project	Diagrammatic representation of repair mechanism of damaged DNA.
	SW1.3 Other Activities (Specify)	Search research papers related to DNA damage.

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** | 12 | 06 | 01 | 03 | 22

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-01BT201.2: Students are able to understand the chemical and molecular processes that occur in and between cells.	**SO2.1** Understand the structure of RNA	**LI2.1** Isolation of bacterial plasmid and their separation to confirm the coiling.	**Unit-2 Transcription** **CI2.1** RNA structure	**SL2.1** Function of different types of RNA.
	SO2.2 Types of RNA		**CI2.2** Types of RNA	
	SO2.3 Study the role of RNA polymerase enzyme in transcription	**LI2.2** Agarose gel electrophoresis	**CI2.3** Transcription in prokaryotes: Prokaryotic RNA polymerase	**SL2.2** Study the interaction of DNA and proteins.
	SO2.4 Learn about importance of different promoters	**LI2.3** DNA electrophoresis	**CI2.4** Role of sigma factor and promoter	
	SO2.5 Understand the mechanism of transcription in prokaryotes		**CI2.5** Initiation, elongation and termination of RNA chains in prokaryotes	
	SO2.6 Study the role of RNA polymerase enzyme in eukaryotes		**CI2.6** Transcription in eukaryotes: Eukaryotic RNA polymerases,	**SL2.3** Understand the role of regulatory proteins.
	SO2.7 Study the role of transcription factors, promoters and enhancers		**CI2.7** Transcription factors, promoters, enhancers	
	SO2.8 Understand the mechanism of DNA replication in prokaryotes		**CI2.8** Mechanism of transcription in eukaryotes	
	SO2.9 Learn about RNA processing		**Cl2.9** RNA splicing and processing	
	SO2.10 Understand about post-transcriptional changes in precursor RNA		**CI2.10** Post-transcriptional modifications in different types of precursor RNA	
	SO2.11 Types of RNA processing		**CI2.11** Types of RNA splicing of precursor RNA	
	SO2.12 Learn about the mechanism of RNA splicing		**CI2.12** RNA Splicing mechanism	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Differentiate between structure of RNA polymerase in prokaryotes and eukaryotes.
	SW1.2 Mini Project	Diagrammatic representation of mechanism of different types of RNA splicing.
	SW1.3 Other Activities (Specify)	Make a PowerPoint presentation on mechanism of transcription in prokaryotes.

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	12	06	01	04	23

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-01BT201.3: Gain knowledge about the protein synthesis mechanism and regulation of gene expression in prokaryotes.	**SO3.1** Study about genetic code	**LI3.1**Demonstration of AMES test	**Unit-3 Translation & Gene Expression** **CI3.1**Genetic code and its characteristics	**SL4.1** Structure of protein (primary, secondary and tertiary)
	SO3.2 Study the role of ribosome in translation.	**LI3.2**Kirby-Bauyer method (disc-diffusion method) to study antibiotic sensitivity of a bacterial culture	**CI3.2**Prokaryotic translation: ribosome structure and assembly,	**SL4.2**Role of protein in biological activities.
	SO3.3 Role of charging of aminoacyl tRNA in translation	**LI3.3** Demonstration of reverse mutation for carcinogenicity	**CI3.3**Charging of tRNA, aminoacyl tRNA synthetases	
	SO3.4 Structure and function of mRNA		**CI3.4** Polycistronic and monocistronic mRNA	
	SO3.5 Steps involved in process of protein synthesis in prokaryotes		**CI3.5** Mechanism of initiation, elongation and termination of polypeptides	**SL4.3**Understand the role of molecular chaperones
	SO3.6 Steps involved in process of protein synthesis in eukaryotes		**CI3.6** Mechanism of initiation, elongation and termination of polypeptides	**SL4.3**Understand the role of molecular chaperones
	SO3.7 Post-translational modifications		**CI3.7**Post-translational modifications of proteins	**SL4.4** Study the role of regulatory proteins in gene regulation.
	SO3.8 Learn about types of post-translational modifications		**CI3.8** Types of Post-translational modifications of proteins	
	SO3.9 Understand the mechanism of protein modifications		**CI3.9** Mechanism of protein modifications	
	SO3.10 Understand the gene regulation mechanism in bacteria		**CI3.10** Regulation of gene expression in prokaryotes.	
	SO3.11 Learn about operon concept		**CI3.11** Operon concept in prokaryotes	
	SO3.12 Understand the regulation of different operon in prokaryotes		**CI3.12** *Lac* and *Trp* operon in prokaryotes	

Suggested Sessional Work (SW):*anyone*	**SW3.1** Assignments	Describe the importance of post translation modification of proteins.
	SW3.2 Mini Project	Diagrammatic representation of *lac* and *trp* operon.
	SW3.3 Other Activities (Specify)	Draw a chart of genetic code and watch you tube videos of models of protein structures.

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**ApproximateHours** **Item** | Cl | LI | SW | SL | Total **Approx.Hrs** | 12 | 06 | 01 | 04 | 23

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-01BT201.4: Demonstrate an understanding of basic molecular diagnostic techniques.	**SO4.1** Understand about molecular diagnostic techniques.	**LI4.1** A kit-based detection of a microbial infection (Widal test).	**Unit-4 Molecular Diagnostics Techniques-I** **CI4.1** Introduction to molecular Diagnostics	**SL4.1** Study different molecular techniques
	SO4.2 Explain PCR and DNA sequencing	**LI4.2** Demonstration of PCR	**CI4.2** PCR and its applications	**SL4.2** Gain insights of DNA replication mechanism
	SO4.3 Learn about the function of different types of PCR	**LI4.2** Demonstration of Gel Doc	**CI4.3** Types of PCR	
	SO4.4 Application of DNA sequencing		**CI4.4** DNA sequencing and its method	
	SO4.5 Different types of DNA sequencing methods		**CI4.5** Types of DNA sequencing	
	SO4.6 Understand difference among different blotting technique		**CI4.6** Blotting Techniques-Southern Blotting	**SL4.3** Learn about DNA,RNA and protein
	SO4.7 Concept of Blotting Techniques		**CI4.7** Northern Blotting	
	SO4.8 Applications of blotting techniques		**CI4.8** Southern Blotting	
	SO4.9 Demonstrate about the diagnosis of genetic diseases.		**CI4.9** Diagnosis of genetic diseases,	**SL4.4** Study about molecular basis of genetic diseases.
	SO4.10 Methods of detection of mutations in DNA		**CI4.10** Detection of mutation in DNA.	
	SO4.11 Illustration of Flow cytometry		**CI4.11** Flow cytometry and its applications	
	SO4.12 Illustration of cell sorting		**CI4.12** Cell sorting and its applications	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Differentiate between different blotting techniques used in molecular biology.
	SW4.2 Mini Project	Diagrammatic representation of PCR and DNA sequencing methods.
	SW4.3 Other Activities (Specify)	Find out some you tube videos related to detection of genetic diseases and mutation in DNA.

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**ApproximateHours** **Item** | Cl | LI | SW | SL | Total **Approx.Hrs** | 12 | 06 | 01 | 03 | 22

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-01BT201.5: Apply molecular diagnostic techniques to the identification and diagnosis of diseases.	**SO5.1** Describe the techniques for testing microbial susceptibility	**LI5.1** Perform immune-diagnostic test (Typhoid, Malaria).	**Unit-5 Molecular Diagnostics Techniques-II** **CI5.1** Susceptibility tests-Micro-dilution and macro-dilution broth procedures	**SL5.1** Study about effect of different antibiotics on microbial cell
	SO5.2 Learn about types and applications of susceptibility test		**CI5.2** Diffusion test procedures.	
	SO5.2 Study the tests for bactericidal activity.	**LI5.2** Demonstration of ELISA	**CI5.3** Tests for bactericidal activity	**SL5.2** List out antibiotics that have bactericidal effect
	SO5.2 Understand the application of bactericidal activity	**LI5.3** Perform immune-diagnostic test (Dengue).	**CI5.4** Application of bactericidal activity	
	SO5.3 Elucidate enzyme immuno assay technique		**CI5.5** Enzyme Immuno assay	**SL5.3** Learn about role of enzyme-substrate complex in immunological diagnostics.
	SO5.2 Recognize the application of enzyme in immunodiagnostic tests		**CI5.6** Applications of enzyme immunoassays in diagnostic microbiology	
	SO5.2 Learn about Immunodiagnostic tests		**CI5.7** Immunodiagnostic tests	
	SO5.2 Understand the application of immunodiagnostic tests		**CI5.8** Application of immunodiagnostic tests	
	SO5.4 Explain different immune assays techniques		**CI5.9** Immuno florescence	
	SO5.10 Applications of Immuno florescence		**CI5.10** Applications of Immuno florescence	
	SO5.11 Learn about Radioimmunoassay		**CI5.11** Radioimmunoassay	
	SO5.12 Understand the applications of Radioimmunoassay		**CI5.12** Applications of Radioimmunoassay	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Draw a ray diagram to show different immuno assay methods used in molecular diagnostics.
	SW5.2 Mini Project	Make a power point presentation on immune fluorescence.
	SW5.3 Other Activities (Specify)	Search research paper on microbial susceptibility test.

Course duration (in hours)to attain Course Outcomes:

Course Title: Molecular biology and diagnostic techniques

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-01BT201.1: Understand the basic structure of DNA and RNA, modes of DNA replication and its damage and repair mechanism.	12	6	01	03	22
CO2-01BT201.2: Students are able to understand the chemical and molecular processes that occur in and between cells.	12	6	01	03	22
CO3-01BT201.3: Gain knowledge about the protein synthesis mechanism and regulation of gene expression in prokaryotes.	12	6	01	04	23
CO4-01BT201.4: Demonstrate an understanding of basic molecular diagnostic techniques.	12	6	01	04	23
CO5-01BT201.5: Apply molecular diagnostic techniques to the identification and diagnosis of diseases.	12	6	01	03	22
Total Hours	60	30	05	17	112

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

Course Title: Molecular biology and diagnostic techniques

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-01BT201.1: Understand the basic structure of DNA and RNA, modes of DNA replication and its damage and repair mechanism.	2	1	1	0	4
CO2-01BT201.2: Students are able to understand the chemical and molecular processes that occur in and between cells.	2	4	2	0	08
CO3-01BT201.3: Gain knowledge about the protein synthesis mechanism and regulation of gene expression in prokaryotes.	3	5	4	1	13
CO4-01BT201.4: Demonstrate an understanding of basic molecular diagnostic techniques.	2	3	3	2	10
CO5-01BT201.5: Apply molecular diagnostic techniques to the identification and diagnosis of diseases.	4	4	2	2	12
Total Marks	**13**	**17**	**12**	**05**	**47**

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

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Genes V by Benjamin Lewin, Oxford University Press, New York, 1994.
2	Gene IX, Benjamin Lewin Oxford University Press, New York, 2006.
3	Principles of Genetics, Snustad and Simmons, Seventh Edition, John Wiley and Sons, Inc.,2015.
4	Molecular Cell Biology, Lodish et.al., W. H. Freeman and Company,Eighth Edition,2016.
5	Genomes 5 by T.A. Brown, John Wiley and sons (Asia)PTE LTD, New York, Fifth Edition2023
6	Genes V by Benjamin Lewin, Oxford University Press, New York, 1994.

(b) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B. Sc. Biotechnology
Semester: II Semester
Course Title: Molecular biology and diagnostic techniques

CO/PO Mapping															
Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-01BT201.1: Understand the basic structure of DNA and RNA, modes of DNA replication and its damage and repair mechanism.	-	-	-	-	2	2	3	-	3	3	3	3	2	2	1
CO2-01BT201.2: Students are able to understand the chemical and molecular processes that occur in and between cells.	-	-	-	-	-	-	3	-	3	2	3	3	2	1	2
CO3-01BT201.3: Gain knowledge about the protein synthesis mechanism and regulation of gene expression in prokaryotes.	-	-	-	-	-	-	3	-	3	1	3	3	1	1	3
CO4-01BT201.4: Demonstrate an understanding of basic molecular diagnostic techniques.	-	-	-	-	2	2	3	3	-	1	3	3	1	1	3
CO5-01BT201.5: Apply molecular diagnostic techniques to the identification and diagnosis of diseases.	-	-	-	-	-	2	3	3	-	2	3	3	1	3	2

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO1-01BT201.1:** Understand the basic structure of DNA and RNA, modes of DNA replication and its damage and repair mechanism.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1,8 SO1.9 SO1.10 SO1.11 SO1.12	1.1,1.2,1.3	1.1,1.2,1.3,1.4,1.5, 1.6,1.7,1.8,1.9,1.10, 1.11,1.12	**1SL-1,2,3**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO2-01BT201.2:** Students are able to understand the chemical and molecular processes that occur in and between cells.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9 SO2.10 SO2.11 SO2.12	2.1, 2.2, 2.3,	2.1,2.2,2.3,2.4,2.5,2.6, 2.7,2.8,2.9,2.10,2.11, 2.12	**2SL-1,2,3**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO3-01BT201.3:** Gain knowledge about the protein synthesis mechanism and regulation of gene expression in prokaryotes.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9 SO3.10 SO3.11 SO3.12	3.1,3.2,3.3	3.1,3.2,3.3,3.4,3.5, 3.6,3.7,3.8,3.9,3.10, 3.11,3.12	**3SL-1,2,3,4**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO4-01BT201.4:** Demonstrate an understanding of basic molecular diagnostic techniques.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10 SO4.11 SO4.12	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, 4.11,4.12	**4SL-1,2,3**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO5-01BT201.5:** Apply molecular diagnostic techniques to the identification and diagnosis of diseases.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9 SO5.10 SO5.11 SO5.12	5.1,5.2,5.3	5.1,5.2,5.3,5.4,5.5, 5.6,5.7,5.8,5.9,5.10, 5.11,5.12	**5SL-1,2,3**

Program Name	**Bachelor of Science (Hons.) Biotechnology**	
Semester	II	
CourseCode:	02BC201	
Coursetitle:	Bioenergetics and Metabolism	**Curriculum Developer**: Mrs. Pratima Mishra, Guest Faculty
Pre-requisite:	Students should have basic knowledge of Biomolecules, Biochemistry and Chemistry	
Rationale:	The Bioenergetics and Metabolism course in a B.Sc. (Hons.) Biotechnology program is essential for understanding how organisms acquire, transform, and utilize energy at the molecular level. It provides foundational knowledge crucial for optimizing biotechnological processes like fermentation and metabolic engineering. Understanding metabolic pathways and energy transformations is vital in developing biotechnological solutions for healthcare, such as metabolic disorders and drug metabolism studies. The course's interdisciplinary approach integrates biology, chemistry, and physics, fostering critical thinking and preparing graduates for diverse careers in biotechnology, research, and innovation in a rapidly evolving field.Top of Form	
Course Outcomes (COs):	**CO1-02BC201.1:** Understanding of the components of biological systems i.e. enzymes, vitamins and minerals **CO2-02BC201.2:** Learning in-depth information regarding the Key elements of Bioenergetics and metabolism **CO3-02BC201.3:** Recognize various concepts related the carbohydrate metabolism and biological significance. **CO4- 02BC201.4:** Assess various concepts related the lipid, fatty acid and amino acid metabolism and its significance **CO5-02BC201.5:** Appraise the relationship between purine and pyrimidine metabolism and its biological significance.	

Scheme of Studies:

Board of Study	**Course Code**	**CourseTitle**	**Scheme of studies (Hours/Week)**					**Total Credits(C) (L:T:P=4:0:2)**
			Cl	LI	SW	SL	**Total Study Hours(CI+LI+SW+SL)**	
Minor	02BC201	Bioenergetics and Metabolism	4	4	1	5	14	4+2=6

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)		
Minor	02BC201	Bioenergetics and Metabolism	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)		
Minor	02BC201-L	Bioenergetics and Metabolism	35	5	5	5	50	50	100

Course-Curriculum:

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

ApproximateHours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	15	10	01	05	31

Course outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction(CI)	Self-Learning(SL)
CO1-02BC201.1: Understanding of the components of biological systems i.e. enzymes, vitamins and minerals	**SO1.1** Define and Describe concept and Nomenclature of Enzymes	**LI1.1** Determination of enzyme activity	**Unit 1** **CI1.1** Enzymes: Nomenclature	**SL1.1** Search various reference books and study material to start the learning
	SO1.2 Describe about classification of enzyme	**LI1.2** Identification of enzyme	**CI1.2** Enzyme Classification	**SL1.2** Check the properties of enzymes
	SO1.3 Explain about characteristics of enzyme		**CI1.3** Characteristics	**SL1.3** Learn about various categories of enzymes
	SO1.4 Describe factors affecting enzyme activity	**LI1.3** To study the effect of temp. of enzyme activity	**CI1.4** Factors affecting enzyme activity	**SL1.4** Enlist the structure and properties of different vitamins
	SO1.5 Study the mechanism of enzyme	**LI1.4** To study the effect of $[S_0]$ of enzyme activity	**CI1.5** Mechanism of enzyme action	
	SO1.6 Study MM equation		**CI1.6** MM Equation	
	SO1.7 Describe enzyme specificity	**LI1.5** To study the effect of pH of enzyme activity	**CI1.7** Enzyme specificity	
	SO1.8 Assess application of enzyme		**CI1.8** Application of Enzyme	**SL1.5** Enlist the structure and properties of different minerals
	SO1.9 Describe concept and types of vitamins		**CI1.9** Vitamins: Introduction, types	
	SO1.10 Describe structure and sources of vitamins		**CI1.10** Structure, Sources,	
	SO1.11 Describe function and deficiency of vitamins		**CI1.11** Function and deficiencies of water soluble vitamins.	
	SO1.12 Describe function and deficiency of vitamins		**CI1.12** Function and deficiencies of fat-soluble vitamins	
	SO1.13 Assess the concept and types of minerals		**CI1.13** Minerals: Introduction, types,	
	SO1.14 Assess Function and deficiencies of nutrients		**CI1.14** Function and deficiencies of macro nutrients	
	SO1.15 Assess Function and deficiencies of nutrients		**CI1.15** Function and deficiencies of micro nutrients	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Describe in detail classification, characteristics and biological significance of enzyme.
	SW1.2 Mini Project	Prepare a chart on vitamins and minerals.
	SW1.3 Other Activities (Specify)	Collect the data about biological role of vitamins/minerals and their deficiencies.

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)
CO2-02BC201.2: Learning in-depth information regarding the Key elements of Bioenergetics and metabolism	**SO2.1** Assess the concept of bioenergetics and metabolism		**Unit-II** **CI2.1** Bioenergetics and metabolism: Basic concepts	**SL2.1** Enlist the different components of bioenergetics
	SO2.2 Explain about first law of thermodynamics		**CI2.2** First law of thermodynamics	**SL2.2** Assess biological role of thermodynamics
	SO2.3 Explain about second law of thermodynamics		**CI2.3** second law of thermodynamics	**SL2.3** Learn about role of thermodynamics in metabolism
	SO2.4 Explain about high energy phosphor compounds		**CI2.4** High energy phosphate compounds	**SL2.4** Learn structure and function of NTPs
	SO2.5 Describe the role of ATP		**CI2.5** role of ATP	**SL2.5** collection of data about intermediary metabolism
	SO2.6 Describe role of ATP hydrolysis pathway		**CI2.6** structural basis of free energy change during hydrolysis of ATP	
	SO2.7 Describe biological role of ATP		**CI2.7** ATP and its role in biological system.	
	SO2.8 Explain hydrolysis of ATP		**CI2.8** hydrolysis of ATP	
	SO2.9 Explain ATP and energy		**CI2.9** ATP and Energy	

Suggested Sessional Work (SW) : *anyone*	**SW2.1** Assignments	Describe in detail bioenergetics and their biological role.
	SW2.2 Mini Project	Explain the mechanism of energy transfer in biological system.
	SW2.3 Other Activities (Specify)	Write an article on error of metabolism.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	04	01	05	22

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-02BC201.3: Recognize various concepts related the carbohydrate metabolism and biological significance.	**SO3.1** Explain the concept and components of carbohydrate metabolism	**SL3.1** Quantitative estimation of carbohydrate	**Unit-III** **CI3.1** Carbohydrate metabolism	**SL3.1** Read about various pathways of carbohydrate metabolism
	SO3.2 Assessing the structure and mechanism of gycolysis	**SL3.2** Qualitative estimation of carbohydrate	**CI3.2** Glycolysis	**SL3.2** Collect the information about various enzymes involved in carbohydrate metabolism
	SO3.3 Assessing the structure and mechanism of pyruvate activation		**CI3.3** activation of pyruvate	**SL3.3** Collect the information about various energy balances of carbohydrate metabolism.
	SO3.4 Assessing mechanism of Glycogenesis		**CI3.4** Glycogenesis	
	SO3.5 Describe about mechanism of Glycogenolysis		**CI3.5** Glycogenolysis	
	SO3.6 Assessing the role of Gluconeogenesis		**CI3.6** Gluconeogenesis	**SL3.4** Collect information about inborn errors of carbohydrate metabolism
	SO3.7 Describe about role of Pentose Phosphate Pathway		**CI3.7** Pentose phosphate pathway	**SL3.5** Study about regulation of carbohydrate metabolism
	SO3.8 Assessing mechanism of Kreb's cycle		**CI3.8** Kreb's cycle	
	SO3.9 Assessing mechanism of Electron transport Chain		**CI3.9** Electron transport Chain	
	SO3.10 Assessing mechanism of ATP synthesis		**CI3.10** ATP synthesis	
	SO3.11 Assessing mechanism of oxidative phosphorylation		**CI3.11** Oxidative phosphorylation	
	SO3.12 Assessing mechanism of ATP generation		**CI3.12** ATP Generation	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail about carbohydrate catabolism
	SW3.2 Mini Project	Describe the role of carbohydrate metabolism in biological system.
	SW3.3 Other Activities (Specify)	Prepare a model for explaining the carbohydrate metabolism.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	08	01	05	26

Course Outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Classroom Instruction(CI)**	**Self-Learning(SL)**
CO4- 02BC201.4: Assess various concepts related the lipid, fatty acid and amino acid metabolism and its significance	**SO4.1** Exploring the concept of lipids biosynthesis		**Unit-IV** **CI4.1** Lipids biosynthesis	**SL4.1** Read about various pathways of lipid metabolism
	SO4.2 Assessing role of lipid and fatty acid biosynthesis	**LI4.1** Quantitative estimation of amino acid	**CI4.2** Biosynthesis of lipids and fatty acids	**SL4.2** Collect the information about various enzymes involved in lipid metabolism
	SO4.3 Explaining the triglycerol biosynthesis		**CI4.3** Biosynthesis of triglycerol	
	SO4.4 Explaining the role of phosphor-lipid biosynthesis	**LI4.2** Perform Folin Lowry method of protein estimation	**CI4.4** Biosynthesis of phospholipids	
	SO4.5 Evaluate role of lipid catabolism	**LI4.3** Qualitative estimation of amino acid	**CI4.5** Lipid catabolism	
	SO4.6 Describe the impact of lipid degradation		**CI4.6** Degradation of Lipids	**SL4.3** Collect information about inborn errors of lipid metabolism
	SO4.7 Describe the impact of fatty acid oxidation	**LI4.4** Calcium Sulphate method of protein estimation	**CI4.7** oxidation of unsaturated, saturated fatty acids	
	SO4.8 Describe the impact of fatty acid oxidation		**CI4.8** oxidation of even and odd chain fatty acids	
	SO4.9 Elaborate the concept of amino acid metabolism		**CI4.9** Amino acid metabolism:	**SL4.4** Read various pathways of amino acid metabolism
	SO4.10 Explain the mechanism of amino acid biosynthesis		**CI4.10** Biosynthetic families of amino acids: Outlines	**SL4.5** Collect information of inborn errors of amino acid metabolism
	SO4.11 Explain the mechanism of amino acid catabolism		**CI4.11** Catabolism of amino acids	
	SO4.12 Assessing the urea cycle		**CI4.12** urea cycle	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe in detail about lipid and fatty acid metabolism
	SW4.2 Mini Project	Describe the role of amino acid metabolism in biological system.
	SW4.3 Other Activities (Specify)	Prepare a model for explaining the lipid and amino acid metabolism.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	08	01	05	26

Course Outcome (CO)	SessionOutcomes(SOs)	LaboratoryInstruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO5-02BC201.5: Appraise the relationship between purine and pyrimidine metabolism and its biological significance.	**SO5.1** Define the concept of nucleotide metabolism	**LI5.1** Quantitative estimation of DNA	**Unit-V** **CI5.1** Nucleotide metabolism	**SL4.1** Read about various pathways of nucleotide metabolism
	SO5.2 Able to execute role of purine biosynthesis	**LI5.2** Qualitative estimation of DNA	**CI5.2** Biosynthesis of purines nucleotides by denovo pathway	**SL4.2** Collect the information about various enzymes involved in nucleotide metabolism
	SO5.3 Apply the role of pyrimidine biosynthesis	**LI5.3** Quantitative estimation of RNA	**CI5.3** Biosynthesis of pyrimidine nucleotides by denovo pathway	**SL4.3** Collect information about inborn errors of nucleotide metabolism
	SO5.4 Evaluate the role of purine biosynthesis	**LI5.4** Qualitative estimation of RNA	**CI5.4** Biosynthesis of purines nucleotides by salvage pathway	
	SO5.5 Assess the role of pyrimidine biosynthesis		**CI5.5** Biosynthesis of pyrimidine nucleotides by salvage pathway	**SL4.4** Study about regulation of nucleotide metabolism
	SO5.6 Apply the role of purine nucleotide degradation		**CI5.6** Degradation of purine nucleotides	**SL4.5** Compare denovo and salvage pathways
	SO5.7 Explore about pyrimidine nucleotide degradation		**CI5.7** Degradation of pyrimidine nucleotides	
	SO5.8 Explore about Errors of metabolism		**CI5.8** Errors of metabolism	
	SO5.9 Revision Class		**CI5.9** Revision Class	
	SO5.10 Revision Class		**CI5.10** Revision Class	
	SO5.11 Revision Class		**CI5.11** Revision Class	
	SO5.12 Revision Class		**CI5.12** Revision Class	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general mechanism of denovo and salvage pathways.
	SW5.2 Mini Project	Describe the various components nucleotide metabolism
	SW5.3 Other Activities (Specify)	Prepare one model for showing nucleotide metabolism

Course duration (in hours) to attain Course Outcomes:

Course Title: Bioenergetics and Metabolism **Course Code:**02BC201

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-02BC201.1: Understanding of the components of biological systems i.e. enzymes, vitamins and minerals	15	10	5	1	31
CO2-02BC201.2: Learning in-depth information regarding the Key elements of Bioenergetics and metabolism.	9	0	5	1	15
CO3-02BC201.3: Recognize various concepts related the carbohydrate metabolism and biological significance.	12	4	5	1	22
CO4- 02BC201.4: Assess various concepts related the lipid, fatty acid and amino acid metabolism and its significance	12	8	5	1	26
CO5-02BC201.5: Appraise the relationship between purine and pyrimidine metabolism and its biological significance.	12	8	5	1	26
Total Hours	60	30	25	05	120

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

Course Title: Bioenergetics and Metabolism **Course Code:**02BC201

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-02BC201.1: Understanding of the components of biological systems i.e. enzymes, vitamins and minerals	2	1	1	1	5
CO2-02BC201.2: Learning in-depth information regarding the Key elements of Bioenergetics and metabolism.	2	4	2	2	10
CO3-02BC201.3: Recognize various concepts related the carbohydrate metabolism and biological significance.	3	5	5	2	15
CO4- 02BC201.4: Assess various concepts related the lipid, fatty acid and amino acid metabolism and its significance	2	3	3	2	10
CO5-02BC201.5: Appraise the relationship between purine and pyrimidine metabolism and its biological significance.	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: B.Sc. Hons Biotechnology
Semester: I Semester
Course Title: Bioenergetics and Metabolism
Course Code: 02BC201

Course Outcome (Cos)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-02BC201.1: Understanding of the components of biological systems i.e. enzymes, vitamins and minerals	1	2	2	2	3	3	2	3	3	1	2	3	2	2	3
CO2-02BC201.2: Learning in-depth information regarding the Key elements of Bioenergetics and metabolism.	1	2	1	1	2	2	2	2	2	2	2	2	2	3	2
CO3-02BC201.3: Recognize various concepts related the carbohydrate metabolism and biological significance.	1	2	2	2	1	2	1	1	2	1	2	2	1	2	2
CO4- 02BC201.4: Assess various concepts related the lipid, fatty acid and amino acid metabolism and its significance	1	1	2	1	2	3	2	2	3	2	1	3	1	2	3
CO5-02BC201.5: Appraise the relationship between purine and pyrimidine metabolism and its biological significance.	1	2	2	1	1	3	1	1	3	2	2	3	1	2	3

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO1-02BC201.1:** Understanding of the components of biological systems i.e. enzymes, vitamins and minerals	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	1.1,1.2,1.3,1.4,1.5,	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-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO2-02BC201.2:** Learning in-depth information regarding the Key elements of Bioenergetics and metabolism.	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, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO3-02BC201.3:** Recognize various concepts related the carbohydrate metabolism and biological significance.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9 SO3.10 SO3.11 SO3.12	3.1,3.2	3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12	3SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO4- 02BC201.4:** Assess various concepts related the lipid, fatty acid and amino acid metabolism and its significance	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10 SO4.11 SO4.12	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, 4.10, 4.11, 4.12	4SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO5-02BC201.5:** Appraise the relationship between purine and pyrimidine metabolism and its biological significance.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9 SO5.10 SO5.11 SO5.12	5.1,5.2,5.3, 5.4	5.1,5.2,5.3,5.4,5.5, 5.6, 5.7, 5.8, 5.9, 5.10, 5.11, 5.12	5SL-1,2,3,4,5

Program Name	**B.Sc. (HONOURS) BIOTECHNOLOGY**	
Semester	**IInd**	
CourseCode:	**02MB201**	
Coursetitle:	**MICROBIAL PHYSIOLOGY**	**Curriculum Developer**: Mr. Vivek Kumar Agnihotri, Assistant Professor
Pre-requisite:	Prerequisites for studying microbial physiology include a strong foundation in microbiology, biochemistry, molecular biology, and laboratory skills, encompassing an understanding of microbial growth, metabolism, genetics, and cellular processes.	
Rationale:	The study of microbial physiology provides insights into the fundamental processes governing microorganisms' growth, metabolism, and behavior, which is essential for various applications in biotechnology, medicine, and environmental science.	
CourseOutcomes (COs):	**CO1-02MB201.1:** Understand the nutritional requirements of microorganisms and classify them based on carbon, energy, and electron sources. **CO2-02MB201.2:** Analyze growth curves and interpret mathematical expressions of microbial growth. **CO3-02MB201.3:** explores microbial growth temperature ranges, classification, and adaptations, pH ranges, and adaptations, oxygen concentration effects**.** **CO4-02MB201.4:** Understand the diversity of photosynthetic pigments and their roles in phototrophic metabolism. **CO55-02MB201.5:** Understand the various pathways involved in microbial energetics and their significance in energy metabolism.	

Scheme of Studies:

Board ofStudy	**CourseCode**	**CourseTitle**	**Scheme ofstudies (Hours/Week)**					**Total Credits(C) (L:T:P=4:0:2)**
			Cl	LI	SW	SL	**Total Study Hours(CI+LI+SW+SL)**	
Minor	02MB201	Microbial Physiology	4	4	1	2	11	4+2=6

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)		
Minor	02MB201	Microbial Physiology	15	20	5	5	5	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)		
Minor	02MB201-L	Microbial Physiology	35	5	5	5	50	50	100

Course-Curriculum:

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

ApproximateHours

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

Course outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-02MB201.1: Understand the nutritional requirements of microorganisms and classify them based on carbon, energy, and electron sources.	**SO1.1** Explain the importance of nutritional classification in understanding microbial metabolism and ecology.	**LI1.1** Basics of media	**CI1.1** Introduction to Microbial Nutritional Classification	**SL1.1** Remember taxonomical classification of archaea and bacteria
	CI1.2 Classify microorganisms based on their carbon source preferences	**LI1.2** Perform Sterilization Technique	**CI1.3** Carbon Sources in Microbial Nutrition	**SL1.2** Learn classification of microorganism
	SO1.2 Know about Energy Sources in Microbial Nutrition	**LI1.3** preparation of different carbons sources	**CI1.4** Energy Sources in Microbial Nutrition	
	SO1.3 Know about Electron Sources in Microbial Nutrition		**CI1.5** Electron Sources in Microbial Nutrition	
	SO1.4 Know about Chemo lithotrophic Metabolism		**CI1.6** Chemo lithotrophic Metabolism	
	SO1.5 Understand the Physiological Groups of Aerobic Chemolithotrophs		**CI1.7** Physiological Groups of Aerobic Chemolithotrophs	
	SO1.6 Understand the Physiological Groups of Anaerobic Chemolithotrophs		**CI1.8** Physiological Groups of Anaerobic Chemolithotrophs	
	SO1.7 Know about Hydrogen-Oxidizing Bacteria		**CI1.9** Hydrogen-Oxidizing Bacteria	
	SO1.8 Know about Methanogens		**CI1.10** Methanogens	
	SO1.9 Understand Classification of Microorganisms Based on Nutritional Preferences		**CI1.11** Classification of Microorganisms Based on Nutritional Preferences	
	SO1.10 Know about Adaptations of Microorganisms to Different Environmental Conditions		**CI1.12** Adaptations of Microorganisms to Different Environmental Conditions	
	SO1.11 Understand Integration and Application of Concepts		**CI1.13** Integration and Application of Concepts	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Summarizes the Environmental Adaptations of Hydrogen-Oxidizing Bacteria
	SW1.2 Mini Project	To demonstrate chemo lithotrophic metabolism in microbial cultures.
	SW1.3 Other Activities (Specify)	Students will conduct a research project on nitrogen metabolism in microorganisms and its ecological implications.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	4	1	2	19

Course Outcome (CO)	SessionOutcomes (SOs)	LaboratoryInstruction (LI)	ClassroomInstruction (CI)	Self-Learning (SL)
CO2-02MB201.2Analyze growth curves and interpret mathematical expressions of microbial growth.	**SO2.1** Understand the fundamental concepts and definitions related to the growth and development of microorganisms.	**LI2.1** Discuss how to analyze growth rate of microbial population.	**CI2.1** Fundamental concepts and definitions related to the growth and development of microorganisms.	**SL2.1** Contrast the preparation of growth media
	SO2.2 Analyze the phases of microbial growth and their significance in microbial physiology and ecology.	**LI2.2** analyze growth rate of microbial population.	**CI2.2** Phases of microbial growth and their significance in microbial physiology and ecology.	**SL2.2** Recall mathematical expression of growth kinetics
	SO2.3 Interpret growth curves and mathematical expressions of microbial growth to assess growth kinetics.		**CI2.3** Growth curves and mathematical expressions of microbial growth to assess growth kinetics.	
	SO2.4 Evaluate the influence of environmental factors on microbial growth and development.		**CI2.4** Influence of environmental factors on microbial growth and development.	
	SO2.5 Explain the mechanisms of group translocation, including the phosphotransferase system, and its role in microbial metabolism.		**CI2.5** Mechanisms of group translocation, including the phosphotransferase system, and its role in microbial metabolism.	
	SO2.6 Differentiate between various types of membrane transport processes, such as symport, antiport, and uniport.		**CI2.6** Various types of membrane transport processes, such as symport, antiport, and uniport.	
	SO2.7 Define and compare electrogenic and electro-neutral transport mechanisms in microorganisms.		**CI2.7** Electrogenic and electro-neutral transport mechanisms in microorganisms.	
	SO2.8 Apply knowledge of microbial growth and transport processes to solve practical problems in microbiology and biotechnology.		**CI2.8** Microbial growth and transport processes to solve practical problems in microbiology and biotechnology.	
	SO2.9 Understand the mechanism of group translocation and its significance in microbial metabolism.		**CI2.9** Mechanism of group translocation and its significance in microbial metabolism.	

	SO2.10 Describe the components and regulation of the phosphotransferase system in bacteria.		**CI2.10** The components and regulation of the phosphotransferase system in bacteria.	
	SO2.11 Students will differentiate between symport, antiport, and uniport mechanisms of membrane transport.		**CI2.11** Symport, antiport, and uniport mechanisms of membrane transport.	
	SO2.12 Students will analyze the physiological roles of membrane transport processes in nutrient uptake, osmoregulation, and signal transduction in microorganisms.		**CI2.12** Physiological roles of membrane transport processes in nutrient uptake, osmoregulation, and signal transduction in microorganisms.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe the phases of microbial growth, including lag phase, exponential phase, stationary phase, and death phase.
	SW2.2 Mini Project	calculate growth parameters such as growth rate, generation time, and doubling time based on experimental data.
	SW2.3 Other Activities (Specify)	

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	**8**	1	2	24

Course Outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Class room Instruction (CI)**	**Self-Learning(SL)**
CO3-02MB201.3explores microbial growth temperature ranges, classification, and adaptations, pH ranges, and adaptations, oxygen concentration effects. and apply problem-solving skills in biological analyses.	**SO3.1** Know about Temperature and Microbial Growth	**LI3.1** Determination of pH of Microbial Media.	**CI3.1** Temperature and Microbial Growth	**SL3.1** Practice Transport Mechanism
	SO3.2 Know about pH and Microbial Adaptation	**LI3.2** Effect of Temperature of microbial growth.	**CI3.2** pH and Microbial Adaptation	**SL3.2** Learn Radiation and Pressure effect on Microorganisms
	SO3.3 Know about Oxygen Concentration and Microbial Metabolism	**LI3.3** Effect of nutrients of microbial growth.	**CI3.3** Oxygen Concentration and Microbial Metabolism	
	SO3.4 Learn Metabolite Transport Across Membranes	**LI3.4** Calculation of TDP	**CI3.4** Metabolite Transport Across Membranes	
	SO3.5 Describe Active Transport Mechanisms		**CI3.5** Active Transport Mechanisms	
	SO3.6 Know about Radiation and Pressure Effects on Microorganisms		**CI3.6** Radiation and Pressure Effects on Microorganisms	
	SO3.7 Explain the mechanisms of metabolite transport across microbial cell membranes, including passive diffusion and facilitated diffusion.		**CI3.7** Mechanisms of metabolite transport across microbial cell membranes, including passive diffusion and facilitated diffusion.	

	SO3.8 Know about the factors influencing the rate of metabolite transport and predict the transport mechanisms under different conditions.		**CI3.8** The factors influencing the rate of metabolite transport and predict the transport mechanisms under different conditions.	
	SO3.9 Differentiate between primary active and secondary active transport mechanisms and describe their molecular mechanisms.		**CI3.9** Primary active and secondary active transport mechanisms and describe their molecular mechanisms.	
	SO3.10 Know the effects of radiation and pressure on microbial growth, survival, and DNA damage.		**CI3.10** Effects of radiation and pressure on microbial growth, survival, and DNA damage.	
	SO3.11 Learn microbial adaptations to extreme environmental conditions, including mechanisms of radiation resistance and barophilic adaptations.		**CI3.11** Microbial adaptations to extreme environmental conditions, including mechanisms of radiation resistance and barophilic adaptations.	
	SO3.12 Learn adaptations of microorganisms to varying oxygen levels, including aerotolerance mechanisms and anaerobic metabolism pathways		**CI3.12** Adaptations of microorganisms to varying oxygen levels, including aerotolerance mechanisms and anaerobic metabolism pathways	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Write about microorganism adaptation.
	SW3.2 Mini Project	
	SW3.3 Other Activities (Specify)	Search and find the effects of radiation and pressure on microbial growth.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	**6**	**1**	2	21

Course Outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Classroom Instruction(CI)**	**Self-Learning(SL)**
CO4- 02MB201.4: Understand the diversity of photosynthetic pigments	**SO4.1** Know about Photosynthesis	**LI4.1** To isolate and analyze photosynthetic pigments from plant leaves using chromatography.	**CI4.1** Introduction to Photosynthesis	**SL4.1** Learn techniques of chromatography

and their roles in phototrophic metabolism**.**	**SO4.2** Learn anoxygenic and Oxygenic Photosynthesis	**LI4.2** To measure the rate of oxygen evolution during photosynthesis using an oxygen electrode.	**CI4.2** Anoxygenic and Oxygenic Photosynthesis	**SL4.2** Recall two phtosystem
	SO4.3 Know about Two Photosystems Concept	**LI4.3** To measure the rate of oxygen evolution.	**CI4.3** Two Photosystems Concept	
	SO4.4 Students will know about Photosynthetic Pigments and Photophosphorylation		**CI4.4** Photosynthetic Pigments and Photophosphorylation	
	SO4.5 Understand Physiology of Bacterial Photosynthesis		**CI4.5** Physiology of Bacterial Photosynthesis	
	SO4.6 Know about Carbon Dioxide Fixation and the Calvin Cycle		**CI4.6** Carbon Dioxide Fixation and the Calvin Cycle	
	SO4.7 Know about Crassulacean Acid Metabolism (CAM) Plants		**CI4.7** Crassulacean Acid Metabolism (CAM) Plants	
	SO4.8 Learn Photorespiration and Compensation Point		**CI4.8** Photorespiration and Compensation Point	
	SO4.9 Understand the Photosynthetic Efficiency and Environmental Factors		**CI4.9** Photosynthetic Efficiency and Environmental Factors	
	SO4.10 Know about Nitrogen Fixation and Photosynthesis		**CI4.10** Nitrogen Fixation and Photosynthesis	
	SO4.11 Understand the Biotechnological Applications of Photosynthesis		**CI4.11** Biotechnological Applications of Photosynthesis	
	SO4.12 Know about future Directions in Photosynthesis Research		**CI4.12** Future Directions in Photosynthesis Research	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Write about CAM
	SW4.2 Mini Project	
	SW4.3 Other Activities (Specify)	Search and learn via YouTube how to extract chlorophyll

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	6	1	2	21

Course Outcome (CO)	SessionOutcomes(SOs)	LaboratoryInstruction(LI)	ClassroomInstruction(CI)	Self-Learning(SL)
CO55-02MB201.5: To measure the rate of oxygen evolution during photosynthesis using an oxygen electrode.	**SO5.1** Introduction to Microbial Energetics	**LI5.1** measure nitrogen fixation activity in nitrogen-fixing bacteria using the acetylene reduction assay.	**CI5.1** Introduction to Microbial Energetics	**SL5.1**Learn fermentation pathway in microbes
	SO5.2 The Entner-Doudoroff (ED) Pathway		**CI5.2** The Entner-Doudoroff (ED) Pathway	**SL5.2** Classify electron transport
	SO5.3 The Glyoxylate Cycle		**CI5.3** The Glyoxylate Cycle	
	SO5.4 Mitochondrial and Bacterial Electron Transport	**LI5.2** To measure ATP production in microbial fermentation pathways using a luciferase-based assay.	**CI5.4** Mitochondrial and Bacterial Electron Transport	
	SO5.5 Fermentation Pathways in Microbes		**CI5.5** Fermentation Pathways in Microbes	
	SO5.6 Nitrogen-Fixing Microbes: Rhizobium	**LI5.3** Demonstrate fermentor	**CI5.6** Nitrogen-Fixing Microbes: Rhizobium	
	SO5.7 Nitrogen-Fixing Microbes: Azotobacter		**CI5.7** Nitrogen-Fixing Microbes: Azotobacter	
	SO5.8 Describe Properties of Nitrogenase and Hydrogenase		**CI5.8** Properties of Nitrogenase and Hydrogenase	
	SO5.9 Explain the Nif Gene and Regulation of Nitrogen Fixation		**CI5.9** The Nif Gene and Regulation of Nitrogen Fixation	
	SO5.10 Compare the mechanism Inorganic and Molecular Nitrogen Fixation		**CI5.10** Inorganic and Molecular Nitrogen Fixation	
	SO5.11 Describe the pathway of Nitrate Reduction and Ammonium Assimilation		**CI5.11** Nitrate Reduction and Ammonium Assimilation	
	SO5.12 Integration and Applications of Nitrogen Metabolism		**CI5.12** Integration and Applications of Nitrogen Metabolism	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Write about application of nitrogen metabolism
	SW5.2 Mini Project	
	SW5.3 Other Activities (Specify)	Try to learn Ed pathway

Course duration (in hours)to attain Course Outcomes:

Course Title: Microbial physiology **Course Code:02MB201**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-02MB201.1: Understand the nutritional requirements of microorganisms and classify them based on carbon, energy, and electron sources**.**	12	6	2	1	21
CO2-02MB201.2 Analyse growth curves and interpret mathematical expressions of microbial growth.	12	4	2	1	19
CO3-02MB201.3explores microbial growth temperature ranges, classification, and adaptations, pH ranges, and adaptations, oxygen concentration effects.	12	8	2	1	24
CO4-02MB201.4: Understand the diversity of photosynthetic pigments and their roles in phototrophic metabolism.	12	6	2	1	21
CO55-02MB201.5: Understand the various pathways involved in microbial energetics and their significance in energy metabolism.	12	6	2	1	21
Total Hours	60	30	10	05	105

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

Course Title: Microbial physiology **Course Code:02MB201**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-02MB201.1: Understand the nutritional requirements of microorganisms and classify them based on carbon, energy, and electron sources.	02	03	04	1	10
CO2-02MB201.2 Analyze growth curves and interpret mathematical expressions of microbial growth.	03	04	02	1	10
CO3-02MB201.3explores microbial growth temperature ranges, classification, and adaptations, pH ranges, and adaptations, oxygen concentration effects.	02	05	02	1	10
CO4-02MB201.4: Understand the diversity of photosynthetic pigments and their roles in phototrophic metabolism.	02	05	02	1	10
CO55-02MB201.5: Understand the various pathways involved in microbial energetics and their significance in energy metabolism.	03	04	03	1	11
Total Marks	12	21	13	05	51

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

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Microbial Physiology: Unity and Diversity (ASM Books) 1st Edition Ann M. Stevens (Author), Jayna L. Ditty (Author), Rebecca E. Parales (Author), Susan M. Merkel (Author) 2024
2	MICROBIAL PHYSIOLOGY WILL MORGAN Amazon 2024
3	Microbial Physiology S Meena Kumari MJP Publishers 2007

(b) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B.Sc. Biotechnology
Semester: II[nd] Sem
Course Title: Microbial physiology
Course Code: 02MB201

CO/PO/PSO Mapping															
Course Outcome (Cos)	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-02MB201.1: Understand the nutritional requirements of microorganisms and classify them based on carbon, energy, and electron sources.	-	-	-	**1**	**2**	**2**	**1**	-	**1**	**2**	**2**	**3**	**3**	**3**	**1**
CO2-02MB201.2 Analyze growth curves and interpret mathematical expressions of microbial growth.	-	-	-	-	-	-	**3**	-	**2**	**2**	**3**	**3**	**1**	**1**	**2**
CO3-02MB201.3explores microbial growth temperature ranges, classification, and adaptations, pH ranges, and adaptations, oxygen concentration effects.	-	**1**	**1**	**1**	-	-	**2**	-	**3**	**1**	**1**	**2**	**1**	**1**	**1**
CO4-02MB201.4: Understand the diversity of photosynthetic pigments and their roles in phototrophic metabolism.	-	**1**	**1**	-	**2**	**2**	**2**	**3**	-	**1**	-	-	**1**	**2**	**3**
CO55-02MB201.5: Understand the various pathways involved in microbial energetics and their significance in energy metabolism.	**1**	**1**	**1**	-	-	**2**	**3**	**3**	**1**	**2**	**2**	**2**	**1**	-	**2**

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO1-02MB201.1:** Understand the nutritional requirements of microorganisms and classify them based on carbon, energy, and electron sources.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10 SO1.11 SO1.12	**IL 1** **IL 2** **IL 3**	1.1,1.2,1.3,1.4,1.5,1.6.1.7,1.8,1.9,1.10,1.11,1.12	**1SL-1,2,3**
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO2-02MB201.2** Analyze growth curves and interpret mathematical expressions of microbial growth.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5,2.6,2.7,2.8,2.9,2.10, 2.11,2.12	**IL 1** **IL 2**	2.1, 2.2, 2.3, 2.4,2.5,2.6,2.7,2.8,2.9,2.10, 2.11,2.12	**2SL-1,2**
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO3-02MB201.3** explores microbial growth temperature ranges, classification, and adaptations, pH ranges, and adaptations, oxygen concentration effects.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6, .7,3.8,3.9,3.10,.311,3.12	**IL 1** **IL 2** **IL 3** **IL 4**	3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9, 3.10,3.11,3.12	**3SL-1,2**
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO4-02MB201.4:** Understand the diversity of photosynthetic pigments and their roles in phototrophic metabolism.	SO4.1 SO4.2 SO4.3 SO4.4,SO 4.5,SO4.6, SO4.7, SO4.8, SO 4.9, SO4.10 SO4.11 SO4.12	**IL 1** **IL 2** **IL 3**	4.1,4.2,4.3,4.4,4.5,4.6, 4.7, 4.8 ,4.9, 4.10,4.11, 4.12	**4SL-1,2**
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO55-02MB201.5:** Understand the various pathways involved in microbial energetics and their significance in energy metabolism.	SO5.1 SO5.2 SO5.3 SO5.4,SO5.5, SO5.6, SO5.7, SO5.8, SO5.9, SO5.10, SO5.11, SO5.12	**IL 1** **IL 2** **IL 3**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9,5.10,5.11,5.12	**5SL-1,2**

Program Name	**Bachelor of Science (Hons.) Biotechnology**	
Semester	II	
CourseCode:	03BC201	
Coursetitle:	Bioenergetics and Metabolism	**Curriculum Developer**: Mrs. Pratima Mishra, Guest Faculty
Pre-requisite:	Students should have basic knowledge of Biomolecules, Biochemistry and Chemistry	
Rationale:	The Bioenergetics and Metabolism course in a B.Sc. (Hons.) Biotechnology program is essential for understanding how organisms acquire, transform, and utilize energy at the molecular level. It provides foundational knowledge crucial for optimizing biotechnological processes like fermentation and metabolic engineering. Understanding metabolic pathways and energy transformations is vital in developing biotechnological solutions for healthcare, such as metabolic disorders and drug metabolism studies. The course's interdisciplinary approach integrates biology, chemistry, and physics, fostering critical thinking and preparing graduates for diverse careers in biotechnology, research, and innovation in a rapidly evolving field.Top of Form	
Course Outcomes (COs):	**CO1-03BC201.1:** Understanding of the components of biological systems i.e. enzymes, vitamins and minerals **CO2-03BC201.2:** Learning in-depth information regarding the Key elements of Bioenergetics and metabolism **CO3-03BC201.3:** Recognize various concepts related the carbohydrate metabolism and biological significance. **CO4- 03BC201.4:** Assess various concepts related the lipid, fatty acid and amino acid metabolism and its significance **CO5-03BC201.5:** Appraise the relationship between purine and pyrimidine metabolism and its biological significance.	

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)**	
Generic Elective	03BC201	Bioenergetics and Metabolism	3	2	1	5	11	3+1=4

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

Scheme of Assessment: Theory 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)		
Generic Elective	03BC201	Bioenergetics and Metabolism	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)		
Generic Elective	03BC201-L	Bioenergetics and Metabolism	35	5	5	5	50	50	100

Course-Curriculum:

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

ApproximateHours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	13	6	01	05	25

Course outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction(CI)	Self-Learning(SL)
CO1-03BC201.1: Understanding of the components of biological systems i.e. enzymes, vitamins and minerals	**SO1.1** Define and Describe concept and Nomenclature of Enzymes	**LI1.1** Determination of enzyme activity	**Unit 1** **CI1.1** Enzymes: Nomenclature	**SL1.1** Search various reference books and study material to start the learning
	SO1.2 Describe about classification of enzyme	**LI1.2** Identification of enzyme	**CI1.2** Enzyme Classification	**SL1.2** Check the properties of enzymes
	SO1.3 Explain about characteristics of enzyme	**LI1.3** To study the effect of [E_0] of enzyme activity	**CI1.3** Characteristics	**SL1.3** Learn about various categories of enzymes
	SO1.4 Describe factors affecting enzyme activity		**CI1.4** Factors affecting enzyme activity	**SL1.4** Enlist the structure and properties of different vitamins
	SO1.5 Study the mechanism of enzyme		**CI1.5** Mechanism of enzyme action	
	SO1.6 Study MM equation		**CI1.6** MM Equation	
	SO1.7 Describe enzyme specificity		**CI1.7** Enzyme specificity	
	SO1.8 Assess application of enzyme		**CI1.8** Application of Enzyme	**SL1.5** Enlist the structure and properties of different minerals
	SO1.9 Describe concept and types of vitamins		**CI1.9** Vitamins: Introduction, types	
	SO1.10 Describe structure and sources of vitamins		**CI1.10** Structure, Sources,	
	SO1.11 Describe function and deficiency of vitamins		**CI1.11** Function and deficiencies of water soluble vitamins.	
	SO1.12 Describe function and deficiency of vitamins		**CI1.12** Function and deficiencies of fat-soluble vitamins	
	SO1.13 Assess types Function and deficiencies of nutrients		**CI1.13** Minerals: Introduction, types, Function and deficiencies of micro and macro nutrients	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail classification, characteristics and biological significance of enzyme.
	SW1.2 Mini Project	Prepare a chart on vitamins and minerals.
	SW1.3 Other Activities (Specify)	Collect the data about biological role of vitamins/minerals and their deficiencies.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	06	00	01	05	12

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
CO2-03BC201.2: Learning in-depth information regarding the Key elements of Bioenergetics and metabolism	**SO2.1** Assess the concept of bioenergetics and metabolism		**Unit-II** **CI2.1** Bioenergetics and metabolism: Basic concepts	**SL2.1** Enlist the different components of bioenergetics
	SO2.2 Explain about first law of thermodynamics		**CI2.2** First law of thermodynamics	**SL2.2** Assess biological role of thermodynamics
	SO2.3 Explain about second law of thermodynamics		**CI2.3** second law of thermodynamics	**SL2.3** Learn about role of thermodynamics in metabolism
	SO2.4 Explain about high energy phosphor compounds		**CI2.4** High energy phosphate compounds	**SL2.4** Learn structure and function of NTPs
	SO2.5 Describe the role of ATP hydrolysis pathway		**CI2.5** structural basis of free energy change during hydrolysis of ATP role of ATP	**SL2.5** collection of data about intermediary metabolism
	SO2.6 Describe biological role of ATP		**CI2.6** ATP and its role in biological system.	

Suggested Sessional Work (SW) : *anyone*		
	SW2.1 Assignments	Describe in detail bioenergetics and their biological role.
	SW2.2 Mini Project	Explain the mechanism of energy transfer in biological system.
	SW2.3 Other Activities (Specify)	Write an article on error of metabolism.

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

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-03BC201.3: Recognize various concepts related the carbohydrate metabolism and biological significance.	**SO3.1** Explain the concept and components of carbohydrate metabolism	**SL3.1** Quantitative estimation of carbohydrate	**Unit-III** **CI3.1** Carbohydrate metabolism	**SL3.1** Read about various pathways of carbohydrate metabolism
	SO3.2 Assessing the structure and mechanism of gycolysis		**CI3.2** Glycolysis	**SL3.2** Collect the information about various enzymes involved in carbohydrate metabolism
	SO3.3 Assessing the structure and mechanism of pyruvate activation		**CI3.3** activation of pyruvate	**SL3.3** Collect the information about various energy balances of carbohydrate metabolism.
	SO3.4 Assessing mechanism of Glycogenesis		**CI3.4** Glycogenesis	
	SO3.5 Describe about mechanism of Glycogenolysis		**CI3.5** Glycogenolysis	
	SO3.6 Assessing the role of Gluconeogenesis		**CI3.6** Gluconeogenesis	**SL3.4** Collect information about inborn errors of carbohydrate metabolism
	SO3.7 Describe about role of Pentose Phosphate Pathway		**CI3.7** Pentose phosphate pathway	**SL3.5** Study about regulation of carbohydrate metabolism
	SO3.8 Assessing mechanism of Kreb's cycle		**CI3.8** Kreb's cycle	
	SO3.9 Assessing mechanism of Electron transport Chain		**CI3.9** Electron transport Chain	
	SO3.10 Assessing ATP synthesis oxidative phosphorylation		**CI3.10** ATP synthesis and Oxidative phosphorylation	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail about carbohydrate catabolism
	SW3.2 Mini Project	Describe the role of carbohydrate metabolism in biological system.
	SW3.3 Other Activities (Specify)	Prepare a model for explaining the carbohydrate metabolism.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	10	05	01	05	21

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO4- 03BC201.4: Assess various concepts related the lipid, fatty acid and amino acid metabolism and its significance	**SO4.1** Exploring the concept of lipids biosynthesis		**Unit-IV** **CI4.1** Lipids biosynthesis	**SL4.1** Read about various pathways of lipid metabolism
	SO4.2 Assessing role of lipid and fatty acid biosynthesis	**LI4.1** Quantitative estimation of a mino acid	**CI4.2** Biosynthesis of lipids and fatty acids	**SL4.2** Collect the information about various enzymes involved in lipid metabolism
	SO4.3 Explaining the triglycerol biosynthesis		**CI4.3** Biosynthesis of triglycerol	
	SO4.4 Explaining the role of phosphor-lipid biosynthesis	**LI4.2** Perform Folin Lowry method of protein estimation	**CI4.4** Biosynthesis of phospholipids	
	SO4.5 Evaluate role of lipid catabolism		**CI4.5** Lipid catabolism	
	SO4.6 Describe the impact of lipid degradation		**CI4.6** Degradation of Lipids	**SL4.3** Collect information about inborn errors of lipid metabolism
	SO4.7 Describe the impact of fatty acid oxidation		**CI4.7** oxidation of unsaturated, saturated fatty acids	
	SO4.8 Describe the impact of fatty acid oxidation		**CI4.8** oxidation of even and odd chain fatty acids	
	SO4.9 Elaborate the concept of amino acid metabolism		**CI4.9** Amino acid metabolism: Biosynthetic families of amino acids: Outlines	**SL4.4** Read various pathways of amino acid metabolism
	SO4.10 Explain the amino acid catabolism and Urea cycle		**CI4.10** Catabolism of amino acids, urea cycle	**SL4.5** Collect information of inborn errors of amino acid metabolism

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe in detail about lipid and fatty acid metabolism
	SW4.2 Mini Project	Describe the role of amino acid metabolism in biological system.
	SW4.3 Other Activities (Specify)	Prepare a model for explaining the lipid and amino acid metabolism.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	06	02	01	05	14

Course Outcome (CO)	SessionOutcomes(SOs)	LaboratoryInstruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO5-03BC201.5: Appraise the relationship between purine and pyrimidine metabolism and its biological significance.	**SO5.1** Define the concept of nucleotide metabolism	**LI5.1** Quantitative estimation of DNA	**Unit-V** **CI5.1** Nucleotide metabolism	**SL4.1** Read about various pathways of nucleotide metabolism
	SO5.2 Able to execute role of purine biosynthesis		**CI5.2** Biosynthesis of purines nucleotides by denovo pathway	**SL4.2** Collect the information about various enzymes involved in nucleotide metabolism
	SO5.3 Apply the role of pyrimidine biosynthesis		**CI5.3** Biosynthesis of pyrimidine nucleotides by denovo pathway	**SL4.3** Collect information about inborn errors of nucleotide metabolism
	SO5.4 Evaluate the role of purine biosynthesis		**CI5.4** Biosynthesis of purines nucleotides by salvage pathway	
	SO5.5 Assess the role of pyrimidine biosynthesis		**CI5.5** Biosynthesis of pyrimidine nucleotides by salvage pathway	**SL4.4** Study about regulation of nucleotide metabolism
	SO5.6 Apply the role of purine and pyrimidine nucleotide degradation		**CI5.6** Degradation of purine and pyrimidine nucleotides	**SL4.5** Compare denovo and salvage pathways

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general mechanism of denovo and salvage pathways.
	SW5.2 Mini Project	Describe the various components nucleotide metabolism
	SW5.3 Other Activities (Specify)	Prepare one model for showing nucleotide metabolism

Course duration (in hours) to attain Course Outcomes:

Course Title: Bioenergetics and Metabolism **Course Code:**03BC201

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-03BC201.1: Understanding of the components of biological systems i.e. enzymes, vitamins and minerals	13	6	5	1	25
CO2-03BC201.2: Learning in-depth information regarding the Key elements of Bioenergetics and metabolism.	6	0	5	1	12
CO3-03BC201.3: Recognize various concepts related the carbohydrate metabolism and biological significance.	10	2	5	1	18
CO4- 03BC201.4: Assess various concepts related the lipid, fatty acid and amino acid metabolism and its significance	10	5	5	1	21
CO5-03BC201.5: Appraise the relationship between purine and pyrimidine metabolism and its biological significance.	6	2	5	1	14
Total Hours	45	15	25	05	90

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

Course Title: Bioenergetics and Metabolism **Course Code:**03BC201

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-03BC201.1: Understanding of the components of biological systems i.e. enzymes, vitamins and minerals	2	1	1	1	5
CO2-03BC201.2: Learning in-depth information regarding the Key elements of Bioenergetics and metabolism.	2	4	2	2	10
CO3-03BC201.3: Recognize various concepts related the carbohydrate metabolism and biological significance.	3	5	5	2	15
CO4- 03BC201.4: Assess various concepts related the lipid, fatty acid and amino acid metabolism and its significance	2	3	3	2	10
CO5-03BC201.5: Appraise the relationship between purine and pyrimidine metabolism and its biological significance.	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: B.Sc. Hons Biotechnology
Semester: I Semester
Course Title: Bioenergetics and Metabolism
Course Code: 03BC201

Course Outcome (Cos)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-03BC201.1: Understanding of the components of biological systems i.e. enzymes, vitamins and minerals	1	2	2	2	3	3	2	3	3	1	2	3	2	2	3
CO2-03BC201.2: Learning in-depth information regarding the Key elements of Bioenergetics and metabolism.	1	2	1	1	2	2	2	2	2	2	2	2	2	3	2
CO3-03BC201.3: Recognize various concepts related the carbohydrate metabolism and biological significance.	1	2	2	2	1	2	1	1	2	1	2	2	1	2	2
CO4- 03BC201.4: Assess various concepts related the lipid, fatty acid and amino acid metabolism and its significance	1	1	2	1	2	3	2	2	3	2	1	3	1	2	3
CO5-03BC201.5: Appraise the relationship between purine and pyrimidine metabolism and its biological significance.	1	2	2	1	1	3	1	1	3	2	2	3	1	2	3

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO1-03BC201.1:** Understanding of the components of biological systems i.e. enzymes, vitamins and minerals	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	1.1,1.2,1.3,	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.12, 1.13,	1SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO2-03BC201.2:** Learning in-depth information regarding the Key elements of Bioenergetics and metabolism.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6		2.1, 2.2, 2.3, 2.4, 2.5, 2.6,	2SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO3-03BC201.3:** Recognize various concepts related the carbohydrate metabolism and biological significance.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9 SO3.10	3.1,	3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8, 3.9, 3.10,	3SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO4- 03BC201.4:** Assess various concepts related the lipid, fatty acid and amino acid metabolism and its significance	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10	4.1,4.2	4.1,4.2,4.3,4.4, 4.5, 4.6,4.7, 4.8, 4.9, 4.10,	4SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO5-03BC201.5:** Appraise the relationship between purine and pyrimidine metabolism and its biological significance.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6	5.1,	5.1,5.2,5.3,5.4,5.5, 5.6	5SL-1,2,3,4,5

Program Name	**B.Sc. (HONOURS) BIOTECHNOLOGY**	
Semester	**II**	
CourseCode:	**03MB201**	
Coursetitle:	MICROBIAL PHYSIOLOGY	**Curriculum Developer**: Mr. Vivek Kumar Agnihotri, Assistant Professor
Pre-requisite:	Prerequisites for studying microbial physiology include a strong foundation in microbiology, biochemistry, molecular biology, and laboratory skills, encompassing an understanding of microbial growth, metabolism, genetics, and cellular processes.	
Rationale:	The study of microbial physiology provides insights into the fundamental processes governing microorganisms' growth, metabolism, and behavior, which is essential for various applications in biotechnology, medicine, and environmental science.	
CourseOutcomes (COs):	**CO1-03MB201.1:** Understand the nutritional requirements of microorganisms and classify them based on carbon, energy, and electron sources. **CO2-03MB201.2:** Analyze growth curves and interpret mathematical expressions of microbial growth. **CO3-03MB201.3:** explores microbial growth temperature ranges, classification, and adaptations, pH ranges, and adaptations, oxygen concentration effects**.** **CO4-03MB201.4:** Understand the diversity of photosynthetic pigments and their roles in phototrophic metabolism. **CO55-03MB201.5:** Understand the various pathways involved in microbial energetics and their significance in energy metabolism.	

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)**	
Generic Elective	03MB201-L	Microbial Physiology	3	2	1	2	8	3+1=4

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

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
Generic Elective	03MB201-L	Microbial Physiology	15	20	5	5	5	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)		
Generic Elective	03MB201-L	Microbial Physiology	35	5	5	5	50	50	100

Course-Curriculum:

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

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)
CO1-03MB201.1: Understand the nutritional requirements of microorganisms and classify them based on carbon, energy, and electron sources.	**SO1.1** Explain the importance of nutritional classification in understanding microbial metabolism and ecology.	**LI1.1** Basics of media preparation of different carbons sources	**CI1.1** Introduction to Microbial Nutritional Classification	**SL1.1** Remember taxonomical classification of archaea and bacteria
	CI1.2 Classify microorganisms based on their carbon source preferences	**LI1.2** Perform Sterilization Technique	**CI1.3** Carbon Sources in Microbial Nutrition	**SL1.2** Learn classification of microorganism
	SO1.2 Know about Energy Sources in Microbial Nutrition		**CI1.4** Energy Sources in Microbial Nutrition	
	SO1.3 Understand the Physiological Groups of Aerobic Chemolithotrophs		**CI1.5** Physiological Groups of Aerobic Chemolithotrophs	
	SO1.4 Understand the Physiological Groups of Anaerobic Chemolithotrophs		**CI1.6** Physiological Groups of Anaerobic Chemolithotrophs	
	SO1.5 Understand Classification of Microorganisms Based on Nutritional Preferences		**CI1.7** Classification of Microorganisms Based on Nutritional Preferences	
	SO1.6 Know about Adaptations of Microorganisms to Different Environmental Conditions		**CI1.8** Adaptations of Microorganisms to Different Environmental Conditions	
	SO1.7 Understand Integration and Application of Concepts		**CI1.9** Integration and Application of Concepts	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Summarizes the Environmental Adaptations of Hydrogen-Oxidizing Bacteria
	SW1.2 Mini Project	To demonstrate chemo lithotrophic metabolism in microbial cultures.
	SW1.3 Other Activities (Specify)	Students will conduct a research project on nitrogen metabolism in microorganisms and its ecological implications.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	9	2	1	2	**14**

Course Outcome (CO)	SessionOutcomes (SOs)	LaboratoryInstruction (LI)	ClassroomInstruction (CI)	Self-Learning (SL)
CO2-03MB201.2Analyze growth curves and interpret mathematical expressions of microbial growth.	**SO2.1** Understand the fundamental concepts and definitions related to the growth and development of microorganisms.	**LI2.1** Discuss how to analyze growth rate of microbial population.	**CI2.1** Fundamental concepts and definitions related to the growth and development of microorganisms.	**SL2.1** Contrast the preparation of growth media
	SO2.2 Analyze the phases of microbial growth and their significance in microbial physiology and ecology.		**CI2.2** Phases of microbial growth and their significance in microbial physiology and ecology.	**SL2.2** Recall mathematical expression of growth kinetics
	SO2.3 Interpret growth curves and mathematical expressions of microbial growth to assess growth kinetics.		**CI2.3** Growth curves and mathematical expressions of microbial growth to assess growth kinetics.	
	SO2.4 Evaluate the influence of environmental factors on microbial growth and development.		**CI2.4** Influence of environmental factors on microbial growth and development.	
	SO2.5 Explain the mechanisms of group translocation, including the phosphotransferase system, and its role in microbial metabolism.		**CI2.5** Mechanisms of group translocation, including the phosphotransferase system, and its role in microbial metabolism.	
	SO2.6 Differentiate between various types of membrane transport processes, such as symport, antiport, and uniport.		**CI2.6** Various types of membrane transport processes, such as symport, antiport, and uniport.	
	SO2.7 Define and compare electrogenic and electro-neutral transport mechanisms in microorganisms.		**CI2.7** Electrogenic and electro-neutral transport mechanisms in microorganisms.	
	SO2.8 Apply knowledge of microbial growth and transport processes to solve practical problems in microbiology and biotechnology.		**CI2.8** Microbial growth and transport processes to solve practical problems in microbiology and biotechnology.	
	SO2.9 Understand the mechanism of group translocation and its significance in microbial metabolism.		**CI2.9** Mechanism of group translocation and its significance in microbial metabolism.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe the phases of microbial growth, including lag phase, exponential phase, stationary phase, and death phase.
	SW2.2 Mini Project	calculate growth parameters such as growth rate, generation time, and doubling time based on experimental data.
	SW2.3 Other Activities (Specify)	

Item	Cl	LI	SW	SL	Total
Approx.Hrs	9	2	1	2	14

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction (CI)	Self-Learning(SL)
CO3-03MB201.3explores microbial growth temperature ranges, classification, and adaptations, pH ranges, and adaptations, oxygen concentration effects. and apply problem-solving skills in biological analyses.	**SO3.1** Know about Temperature and Microbial Growth	**LI3.1** Determination of pH of Microbial Media.	**CI3.1** Temperature and Microbial Growth	**SL3.1** Practice Transport Mechanism
	SO3.2 Know about pH and Microbial Adaptation		**CI3.2** pH and Microbial Adaptation	**SL3.2** Learn Radiation and Pressure effect on Microorganisms
	SO3.3 Know about Oxygen Concentration and Microbial Metabolism		**CI3.3** Oxygen Concentration and Microbial Metabolism	
	SO3.4 Learn Metabolite Transport Across Membranes		**CI3.4** Metabolite Transport Across Membranes	
	SO3.5 Describe Active Transport Mechanisms		**CI3.5** Active Transport Mechanisms	
	SO3.6 Know about Radiation and Pressure Effects on Microorganisms		**CI3.6** Radiation and Pressure Effects on Microorganisms	
	SO3.7 Explain the mechanisms of metabolite transport across microbial cell membranes, including passive diffusion and facilitated diffusion.		**CI3.7** Mechanisms of metabolite transport across microbial cell membranes, including passive diffusion and facilitated diffusion.	
	SO3.8 Know about the factors influencing the rate of metabolite transport and predict the transport mechanisms under different conditions.		**CI3.8** The factors influencing the rate of metabolite transport and predict the transport mechanisms under different conditions.	
	SO3.9 Differentiate between primary active and secondary active transport mechanisms and describe their molecular mechanisms.		**CI3.9** Primary active and secondary active transport mechanisms and describe their molecular mechanisms.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Write about microorganism adaptation.
	SW3.2 Mini Project	
	SW3.3 Other Activities (Specify)	Search and find the effects of radiation and pressure on microbial growth.

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- 03MB201.4: Understand the diversity of photosynthetic pigments and their roles in phototrophic metabolism**.**	**SO4.1** Know about Photosynthesis	**LI4.1** To isolate and analyze photosynthetic pigments from plant leaves using chromatography.	**CI4.1** Introduction to Photosynthesis	**SL4.1** Learn techniques of chromatography
	SO4.2 Learn anoxygenic and Oxygenic Photosynthesis	**LI4.2** To measure the rate of oxygen evolution during photosynthesis using an oxygen electrode.	**CI4.2** Anoxygenic and Oxygenic Photosynthesis	**SL4.2** Recall two phtosystem
	SO4.3 Know about Two Photosystems Concept		**CI4.3** Two Photosystems Concept	
	SO4.4 Students will know about Photosynthetic Pigments and Photophosphorylation		**CI4.4** Photosynthetic Pigments and Photophosphorylation	
	SO4.5 Understand Physiology of Bacterial Photosynthesis		**CI4.5** Physiology of Bacterial Photosynthesis	
	SO4.6 Know about Carbon Dioxide Fixation and the Calvin Cycle		**CI4.6** Carbon Dioxide Fixation and the Calvin Cycle	
	SO4.7 Know about Crassulacean Acid Metabolism (CAM) Plants		**CI4.7** Crassulacean Acid Metabolism (CAM) Plants	
	SO4.8 Learn Photorespiration and Compensation Point		**CI4.8** Photorespiration and Compensation Point	
	SO4.9 Understand the Photosynthetic Efficiency and Environmental Factors		**CI4.9** Photosynthetic Efficiency and Environmental Factors	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Write about CAM
	SW4.2 Mini Project	
	SW4.3 Other Activities (Specify)	Search and learn via YouTube how to extract chlorophyll

Item	Cl	LI	SW	SL	Total
Approx.Hrs	9	**3**	1	2	15

Course Outcome (CO)	SessionOutcomes(SOs)	LaboratoryInstruction(LI)	ClassroomInstruction(CI)	Self-Learning(SL)
CO55-03MB201.5: To measure the rate of oxygen evolution during photosynthesis using an oxygen electrode.	**SO5.1** Introduction to Microbial Energetics	**LI5.1** o measure nitrogen fixation activity in nitrogen-fixing bacteria using the acetylene reduction assay.	**CI5.1** Introduction to Microbial Energetics	**SL5.1**Learn fermentation pathway in microbes
	SO5.2 The Entner-Doudoroff (ED) Pathway		**CI5.2** The Entner-Doudoroff (ED) Pathway	**SL5.2** Classify electron transport
	SO5.3 The Glyoxylate Cycle		**CI5.3** The Glyoxylate Cycle	
	SO5.4 Mitochondrial and Bacterial Electron Transport	**LI5.2** To measure ATP production in microbial fermentation pathways using a luciferase-based assay.	**CI5.4** Mitochondrial and Bacterial Electron Transport	
	SO5.5 Fermentation Pathways in Microbes		**CI5.5** Fermentation Pathways in Microbes	
	SO5.6 Nitrogen-Fixing Microbes: Rhizobium		**CI5.6** Nitrogen-Fixing Microbes: Rhizobium	
	SO5.7 Nitrogen-Fixing Microbes: Azotobacter		**CI5.7** Nitrogen-Fixing Microbes: Azotobacter	
	SO5.8 Describe Properties of Nitrogenase and Hydrogenase		**CI5.8** Properties of Nitrogenase and Hydrogenase	
	SO5.9 Explain the Nif Gene and Regulation of Nitrogen Fixation		**CI5.9** The Nif Gene and Regulation of Nitrogen Fixation	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Write about application of nitrogen metabolism
	SW5.2 Mini Project	
	SW5.3 Other Activities (Specify)	Try to learn Ed pathway

Course duration (in hours)to attain Course Outcomes:

Course Title: Microbial physiology **Course Code:03MB201**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-03MB201.1: Understand the nutritional requirements of microorganisms and classify them based on carbon, energy, and electron sources**.**	9	4	2	1	16
CO2-03MB201.2 Analyse growth curves and interpret mathematical expressions of microbial growth.	9	2	2	1	14
CO3-03MB201.3explores microbial growth temperature ranges, classification, and adaptations, pH ranges, and adaptations, oxygen concentration effects.	9	2	2	1	14
CO4-03MB201.4: Understand the diversity of photosynthetic pigments and their roles in phototrophic metabolism.	9	4	2	1	16
CO55-03MB201.5: Understand the various pathways involved in microbial energetics and their significance in energy metabolism.	9	3	2	1	15
Total Hours	45	15	10	05	75

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

Course Title: Microbial physiology **Course Code:03MB201**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-03MB201.1: Understand the nutritional requirements of microorganisms and classify them based on carbon, energy, and electron sources.	02	03	04	1	10
CO2-03MB201.2 Analyze growth curves and interprets mathematical expressions of microbial growth.	03	04	02	1	10
CO3-03MB201.3explores microbial growth temperature ranges, classification, and adaptations, pH ranges, and adaptations, oxygen concentration effects.	02	05	02	1	10
CO4-03MB201.4: Understand the diversity of photosynthetic pigments and their roles in phototrophic metabolism.	02	05	02	1	10
CO55-03MB201.5: Understand the various pathways involved in microbial energetics and their significance in energy metabolism.	03	04	03	1	11
Total Marks	12	21	13	05	51

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

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Microbial Physiology: Unity and Diversity (ASM Books) 1st Edition Ann M. Stevens (Author), Jayna L. Ditty (Author), Rebecca E. Parales (Author), Susan M. Merkel (Author) 2024
2	MICROBIAL PHYSIOLOGY WILL MORGAN Amazon 2024
3	Microbial Physiology S Meena Kumari MJP Publishers 2007

(b) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B.Sc. Biotechnology
Semester: II Semester
Course Title: Microbial physiology
Course Code: 03MB201

CO/PO/PSO Mapping															
Course Outcome (Cos)	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-03MB201.1: Understand the nutritional requirements of microorganisms and classify them based on carbon, energy, and electron sources.	-	-	-	**1**	**2**	**2**	**1**	-	**1**	**2**	**2**	**3**	**3**	**3**	**1**
CO2-03MB201.2 Analyze growth curves and interpret mathematical expressions of microbial growth.	-	-	-	-	-	-	**3**	-	**2**	**2**	**3**	**3**	**1**	**1**	**2**
CO3-03MB201.3explores microbial growth temperature ranges, classification, and adaptations, pH ranges, and adaptations, oxygen concentration effects.	-	**1**	**1**	**1**	-	-	**2**	-	**3**	**1**	**1**	**2**	**1**	**1**	**1**
CO4-03MB201.4: Understand the diversity of photosynthetic pigments and their roles in phototrophic metabolism.	-	**1**	**1**	-	**2**	**2**	**2**	**3**	-	**1**	-	-	**1**	**2**	**3**
CO55-03MB201.5: Understand the various pathways involved in microbial energetics and their significance in energy metabolism.	**1**	**1**	**1**	-	-	**2**	**3**	**3**	**1**	**2**	**2**	**2**	**1**	-	**2**

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO1-03MB201.1:** Understand the nutritional requirements of microorganisms and classify them based on carbon, energy, and electron sources.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	1.1,1.2,	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9,	**1SL-1,2,3**
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO2-03MB201.2** Analyze growth curves and interpret mathematical expressions of microbial growth.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	2.1,	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	**CO3-03MB201.3** explores microbial growth temperature ranges, classification, and adaptations, pH ranges, and adaptations, oxygen concentration effects.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	3.1	3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9,	**3SL-1,2**
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO4-03MB201.4:** Understand the diversity of photosynthetic pigments and their roles in phototrophic metabolism.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	4.1,4.2	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	**CO55-03MB201.5:** Understand the various pathways involved in microbial energetics and their significance in energy metabolism.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 S05.9	5.1,5.2	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9,	**5SL-1,2**

Course Code: **0IKS201**

Course Title: Indian Knowledge System

Pre- requisite: Creating awareness among the youths about the true history and past rich culture of India.

Rationale: India has very rich and versatile knowledge system and cultural heritage since antiquity. The Indian Knowledge systems was developed on life science, medical science, literature, drama, art, music, dance, astronomy, mathematics, architecture (Sthapatyaveda), chemistry, aeronautics etc, during ancient period. In this basic course, a special attention is given to the ancient and historical perspective of ideas occurrence in the ancient society, and implication to the concept of material world and religious, social and cultural beliefs. On the closer examination, religion, culture and science have appeared epistemological very rigidly connected in the Indian Knowledge System. This land of Bharat Bhumi has provided invaluable knowledge stuff to the society and the world in all sphere of life.

Course Outcomes:

CO- 0IKS201. 1: To understand the ancient civilization, Indian Knowledge Systems, Concept of Panch Mahabhuta, Origin of name Bharat Varsha, Ancient Rivers, Ancient Universities and ancient agriculture.

CO- 0IKS201.II: Students will have the ability to learn about ancient books, Religious places, basic concept of Indian dance, music and arts, and fundamental aspects of Sangeeta and Natyashashtra etc.

CO- 0IKS201.III: Student will be able to gain knowledge on Vedic Science, Astronomy, Astrovastu, Vedic Mathematics, Aeronautics, Metallurgy, Nakhatras, Panchang, Concept of Zero, Pi and point etc.

CO- I0IKS201. IV: Understanding on ancient Engineering, Science and Technology, Town Planning, Temple architecture, Chemistry and Metallurgy, Metal manufacturing etc.

CO- I0IKS201. V: Student will able to understand about the Life, Nature and Health through basic concept of Ayurveda andYoga, Traditional Medicinal Systems, Ethnomedicine, Nature conservation, World Heritage Sites etc.

Scheme of Studies:

Category of Course	Course Code	Course Title	Scheme of studies(Hours/Week)					Total Credits (C)
			CI	LI	SW	SL	Total Study Hours CI+LI+SW+SL	
AEC	**0IKS201**	Indian Knowledge System	2		1	1	4	2

Legend:

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

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

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

SL: Self Learning,

C: Credits.

Proposed examination scheme (Marking) as per the recommendation of University Grant Commission (UGC) for Under Graduate Courses in Fundamentals of Indian Knowledge Systems 2022-23 onwards

S. No.	Category of Course/Subject	Components of Marks				Total
		Semester End Examination (External	Mid Term exam (Internal)	Assignment (Internal)	Practical Exam (Internal)	
1	Only Theory Subject Course					
2	Subject/ Course with theory and Practical					
3	Subject/ Course only Practical					

Course-Curriculum Detailing:

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

0IKS201. 1. To understand Indian Civilization and Indian Knowledge Systems

Approximate Hours

Item	Approximate Hours
CI	**6**
LI	
SW	**2**
SL	**1**
Total	**9**

Session Outcomes (SOs)	Laboratory	Class room Instruction (CI)	Self Learning

	Instruction (LI)		(SL)
SO 1.1. Understand Overview of Indian Knowledge Systems (IKS) SO 1.2. Understand Classification of Ancient IKS texts SO 1.3. Understand Introduction to Panch Mahabhutas (Earth, Water, Fire, Sky and Air) SO 1.4. Understand Origin of the name Bharatvarsha: the Land of Natural Endowments SO 1.5. Understand Rivers of ancient India (The Ganga, Yamuna, Godawari, Saraswati, Narmada, Sindhu and Kaveri) SO 1.6. Understand Ancient Agriculture and ancient Universities: Takshashila and Nalanda, Gurukul system		**Unit-1. Indian Civilization and Indian Knowledge Systems** 1.1. Overview of Indian Knowledge Systems (IKS) 1.2 Classification of Ancient IKS texts 1.3 Introduction to Panch Mahabhutas (Earth, Water, Fire, Sky and Air) 1.4 Origin of the name Bharatvarsha: the Land of Natural Endowments 1.5 Rivers of ancient India (The Ganga, Yamuna, Godawari, Saraswati, Narmada, Sindhu and Kaveri) 1.6 Agriculture system in ancient India, Ancient Universities: Takshashila and Nalanda, Gurukul system	Golden era of ancient India

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Concepts of Panch Mahabhuta, Classification of ancient texts, origin of ancient rivers

b. Mini Project:

i. Ancient Universities: Takshashila and Nalanda,

c. Other Activities (Specify):

0IKS201.2: Students will have the ability to apply the knowledge gained about Indian Art, Literature and Religious Places

Approximate Hours

Item	Approximate Hours
CI	**6**
LI	
SW	**2**
SL	**1**
Total	**9**

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO 2.1. Understand the Ancient Indian Books: Vedas, Puranas, Shastras, Upanishads, Mahakavyas (Ramayana & Mahabharata), Smrities, Samhitas SO 2.2. Understand the Religious places: Puries, Dhams, Jyotiralinga, Shaktipeeths, Kumbha Mela SO 2.3. Understand the Legendary places of Madhya Pradesh: Ujjain, Chitrakoot, Omkareshwar, Bharhut, Maihar SO 2.4. Understand the Basic concept of Indian Art, Music and Dance, Indian Musical Instruments SO 2.5. Understand the Fundamental aspects of Sangeeta and Natya shastra SO 2.6. Understand the different schools of music, dance and painting in different regions of India		**Unit-2. Indian Art, Literature and Religious Places** 2.1. Ancient Indian Books: Vedas, Puranas, Shastras, Upanishads, Mahakavyas (Ramayana & Mahabharata), Smrities, Samhitas 2.2. Religious places: Puries, Dhams, Jyotiralinga, Shaktipeeths, Kumbha Mela 2.3. Legendary places of Madhya Pradesh: Ujjain, Chitrakoot, Omkareshwar, Bharhut, Maihar 2.4. Basic concept of Indian Art, Music and Dance, Indian Musical Instruments 2.5. Fundamental aspects of Sangeeta and Natya shastra 2.6. Different schools of music, dance and painting in different regions of India	**1.** Indian Art, Music and Dance

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Visit of Chitrakoot, Maihar and Bharhuta

b. Mini Project:

ii. Kumbhmela, Story of Ramayana and Mahabharata

c. Other Activities (Specify):

0IKS201. 3: Student will be able to understand Ancient Science, Astronomy and Vedic Mathematics

Approximate Hours

Item	Approximate Hours
CI	**6**
LI	
SW	**2**
SL	**1**
Total	**9**

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO 3.1. Understand Vedic Cosmology SO 3.2. Understand the Astronomy, Astrovastu, Vedang Jyotish, Nakshatras, Navagraha, Rashis, Vastushastra and their related plants SO 3.3. Understand the Time and Calendar, Panchang SO 3.4. Understand the Concept of Zero, Point, Pi -number system, Pythagoras SO 3.5. Understand the Vedic Mathematics, Vimana-Aeronautics, Basic idea of planetary model of Aryabhatta SO 3.6. Understand the Varanamala of Hindi language based on classification of sounds on		**Unit-3. Ancient Science, Astronomy, Mathematics** 3.1. Vedic Cosmology 3.2. Astronomy, Astrovastu, Vedang Jyotish, Nakshatras, Navagraha, Rashis, Vastushastra and their related plants 3.3. Time and Calendar, Panchang 3.4. Concept of Zero, Point, Pi -number system, Pythagoras 3.5. Vedic Mathematics, Vimana-Aeronautics, Basic idea of planetary model of Aryabhatta 3.6. Varanamala of Hindi language based on classification of sounds on the basis of their origin, Basic purpose of	1. Ancient Science, Astronomy and Vedic Mathematics

the basis of their origin, Basic purpose of science of Vyakarana		science of Vyakarana.	

SW-2 Suggested Sessional Work (SW):

a. Assignments:

1. Varanamala of Hindi language based on classification of sounds on the basis of their origin

b. Mini Project:

1. Nakshatras, Navagraha and their related plants

c. Other Activities (Specify):

0IKS201. 4: Understand the Engineering, Technology and Architecture

Approximate Hours

Item	Approximate Hours
CI	**6**
LI	
SW	**2**
SL	**1**
Total	**9**

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO 4.1. Understand the Engineering Science and Technology in Vedic and Post Vedic Era SO 4.2. Understand the Town and Home planning, Sthapatyaveda SO 4.3. Understand the Chemistry and Metallurgy as gleaned from archeological artifacts SO 4.4. Understand the Chemistry of Dyes, Pigments used in Paintings, Fabrics, Potteries and Glass SO 4.5. Understand the Temple Architecture: Khajuraho,		**Unit-4. Engineering, Technology and Architecture** 4.1.Engineering Science and Technology in Vedic and Post Vedic Era 4.2.Town and Home planning, Sthapatyaveda 4.3.Chemistry and Metallurgy as gleaned from archeological artifacts 4.4 Chemistry of Dyes, Pigments used in Paintings, Fabrics, Potteries and Glass 4.5.Temple Architecture:	2. Ancient Science, Astronomy and Vedic Mathematics

Sanchi Stupa, Chonsath Yogini temple SO 4.6. Understand the Mining and manufacture in India of Iron, Copper, Gold from ancient times		Khajuraho, Sanchi Stupa, Chonsath Yogini temple 4.6.Mining and manufacture in India of Iron, Copper, Gold from ancient times	

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Varanamala of Hindi language based on classification of sounds on the basis of their origin

b. Mini Project:

i. Nakshatras, Navagraha and their related plants

c. Other Activities (Specify):

0IKS201. 5: Understand about the Life, Nature and Health

Approximate Hours

Item	Approximate Hours
CI	**6**
LI	
SW	**2**
SL	**1**
Total	**9**

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO 5.1. Understand the Fundamentals of Ayurveda (Charaka & Shushruta) and Yogic Science (Patanjali), Ritucharya and Dinacharya SO 5.2. Understand the Traditional system of Indian medicines (Ayurveda, Siddha, Unani and Homoeopathy) SO 5.3. Understand Fundamentals of Ethnobotany and Ethnomedicines of India		**Unit-5. Life, Nature and Health** 5.1.Fundamentals of Ayurveda (Charaka & Shushruta) and Yogic Science (Patanjali), Ritucharya and Dinacharya 5.2. Traditional system of Indian medicines (Ayurveda, Siddha, Unani and Homoeopathy) 5.3.Fundamentals of Ethnobotany and	1. Concept of Ayurveda and Yoga 2. Traditional system of Indian medicines 3. Ethnobotany and Ethnomedicines of India 4. World Heritage

SO 5.4. Understand the Nature Conservation in Indian ancient texts SO 5.5. Understand the Introduction to Plant Science in Vrikshayurveda SO 5.6. Understand the World Heritage Sites of Madhya Pradesh: Bhimbetka, Sanchi, Khajuraho		Ethnomedicines of India 5.4.Nature Conservation in Indian ancient texts 5.5 Introduction to Plant Science in Vrikshayurveda 5.6.World Heritage Sites of Madhya Pradesh: Bhimbetka, Sanchi, Khajuraho	Sites

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Visit to world Heritage Site Khajuraho

b. Mini Project:

i. Ritucharya and Dincharya, Ethnomedicinal plants

c. Other Activities (Specify):

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
0IKS201. 1: To understand Indian Civilization and Indian Knowledge Systems	**6**	**2**	**1**	**9**
0IKS201. 2: Students will have the ability to apply the knowledge gained about Indian Art, Literature and Religious Places	**6**	**2**	**1**	**9**
0IKS201. 3: Student will be able to understand the Ancient Science, Astronomy and Vedic Mathematics	**6**	**2**	**1**	**9**
0IKS201. 4: Understand the Engineering, Technology and Architecture	**6**	**2**	**1**	**9**
0IKS201. 5: Understand about the Life, Nature and Health	**6**	**2**	**1**	**9**
Total	**30**	**10**	**5**	**45**

Suggestion for End Semester Assessment

Suggested Specification Table (For ESA)

CO	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
CO 1	Indian Civilization and Indian Knowledge Systems	**2**	**5**	**1**	**8**

CO 2	Indian Art, Literature and Religious Places	**2**	**6**	**2**	**8**
CO 3	Ancient Science, Astronomy and Vedic Mathematics	**2**	**6**	**5**	**13**
CO 4	Engineering, Technology and Architecture	**2**	**4**	**4**	**10**
CO 5	Life, Nature and Health	**2**	**5**	**2**	**9**
Total		**10**	**26**	**14**	**50**

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

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

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

Suggested Instructional/Implementation Strategies:

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

Suggested Learning Resources:

(a) Books:

S. No.	Title	Author	Publisher	Edition & Year
1	*An Introduction of Indian Knowledge Systems: Concept and Applications*	Mahadevan, B.; Bhat V. R. and Pavana, Nagendra R. N.	Prentice Hall of India.	2022
2	*Indian Knowledge Systems*: Vol. I and II.	Kapoor, Kapil and Singh, A. K.	D.K. Print World Ltd	2005
3	*Science of Ancient Hindus: Unlocking Nature in Pursuit of Salvation*	Kumar, Alok	Create pace Independent Publishing	2014
4	*A History of Agriculture in India*	Randhava, M.S.	ICAR, New Delhi	1980
5	*Panch Mahabhuta,*	Yogcharya, Jnan	Yog Satsang Ashram	2021

		Dev		
6	*The Indian Rivers*	Singh, Dhruv Sen	Springer	2018
7	*The Wonder That Was India*	Basam, Arthue Llewllyn	Sidgwick & Jackson	1954
8	*Ancient Cities, Sacred Skies: Cosmic Geometries and City Planning in Ancient India*	Malville, J. MacKim & Gujaral, Lalit M.	IGNCA & Aryan Books International, New Delhi	2000
9	*The Natya Shastra of Bharat Muni*	Jha, Narendra	Innovative Imprint, Delhi	2023
10	*Astronomy in India: A Historical Perspective*	Padmanabhan, Thanu	Indian National Science Academy, New Delhi & Springer (India).	2010
11	*History of Astronomy in India* 2nd Ed.	Sen, S.N. and Shukla, K.S.	INSA New Delhi	2001
12	*History of Indian Astronomy A Handbook*	Ramasubramanian, K.; Sule, Aniket and Vahia, Mayank	Science and Heritage Initiative, I.I.T. Mumbai and Tata Institute of Fundamental Research, Mumbai	2016
13	*Indian Mathematics and Astronomy: Some Landmarks*	Rao, Balachandra S.	Jnana Deep Publications, Bangalore, 3rd Edition	. 2004
14	*Vedic Mathematics and Science in Vedas*	Rao, Balachandra S.	Navakarnataka Publications, Bengaluru	2019
15	*A History of Hindu Chemistry*	Ray, Acharya Prafulla Chandra	Repbl Shaibya Prakashan Bibhag, Centenary Edition, Kolkata	1902
16	*Early Indian Architecture: Cities and City Gates*	Coomeraswamy, Anand	Munciram Manoharlal Publishers	2002
17	*Theory and Practices of Temple Architecture in Medieval India: Bhojas samrangasutradhar and the Bhojpur Line Drawings*	Hardy, Adams	Dev Publishers & Distributors.	2015
18	*Indian Science and Technology in Eighteenth Century*	Dharmpal	Academy of Gandhian Studies, Hyderabad.	1971
19	*Science in India: A Historical Perspective*	Subbarayappa, B.V.	Rupa New Delhi	2013
20	*Fine Arts & Technical*	Mishra, Shiv	Krishnadas Academy,	1982

	Sciences in Ancient India with special reference to Someswvara's Manasollasa	Shankar	Varanasi	
21	*Fundamental Principles of Ayurveda*, Volume One	Lad, Vasant D.	The Ayurvedic Press, Alboquerque, New Mexico.	2002
22	*Charak Samhita*, Chaukhamba	Pandey, Kashinath and Chaturvedi Gorakhnath	Vidya Bhawan, Varanasi	
23	*Ayurveda: The Science of Self-Healing*	Lad, Vasant D.	Lotus Press: Santa Fe	1984
24	*Ayurveda: Life, Health and Longevit*	Svoboda, Robert E	Penguin: London	1992
25	*Plants in the Indian Puranas*	Sensarma, P.	Naya Prokash, Calcutta	1989
26	*Indian Cultural Heritage Perspective for Tourism*	Singh, L. K.	Gyan Publishing House, Delhi	2008
27	*Glimpses of Indian Ethnobotany*	Jain, S.K.	Oxford & IBH Publishing Company Private Limited, New Delhi	1981
28	Manual of Ethnobotany	Jain, S.K.	Scientific Publishers, Jodhpur	2010

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Cos,POs and PSOs Mapping

Programme Title: B.Sc. (Hons.) Biotechnology
Course Code: 0IKS201
Course Title: Indian Knowledge System

Course Outcomes	Program Outcomes												Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO-1: To understand the ancient civilization, Indian Knowledge Systems, Concept of Panch Mahabhuta, Origin of name Bharat Varsha, Ancient Rivers, Ancient Universities and ancient agriculture.	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO-2: Students will have the ability to learn about ancient books, Religious places, basic concept of Indian dance, music and arts, and fundamental aspects of Sangeeta and Natyashashtra etc.	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
CO-.3: Student will be able to gain knowledge on Vedic Science, Astronomy, Astrovastu, Vedic Mathematics, Aeronautics, Metallurgy, Nakhatras, Panchang, Concept of Zero, Pi and point etc.	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1
CO- 4: Understanding on ancient Engineering, Science and Technology, Town Planning, Temple architecture, Chemistry and Metallurgy, Metal manufacturing etc.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CO- 5: Student will able to understand about the Life, Nature and Health through basic concept of Ayurveda andYoga, Traditional Medicinal Systems, Ethnomedicine, Nature conservation, World Heritage Sites etc.	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2

Legend:1–Low,2–Medium, 3–High

Course Curriculum Map:

POs & PSOs No.	Cos No.& Titles	SOs No.	Laboratory Instruction (LI)	Classroom Instruction(CI)	Self Learning (SL)
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4, 5	**CO-1:** To understand the ancient civilization, Indian Knowledge Systems, Concept of Panch Mahabhuta, Origin of name Bharat Varsha, Ancient Rivers, Ancient Universities and ancient agriculture.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		**Unit-1**: Indian Civilization and Indian Knowledge Systems 1.1,1.2,1.3,1.4,1.5,1.6	As mentioned
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4, 5	**CO-2:** Students will have the ability to learn about ancient books, Religious places, basic concept of Indian dance, music and arts, and fundamental aspects of Sangeeta and Natyashashtra etc.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5		**Unit-2:** Indian Art, Literature and Religious Places 2.1,2.2,2.3,2.4,2.5,2.6	
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4, 5	**CO-.3:** Student will be able to gain knowledge on Vedic Science, Astronomy, Astrovastu, Vedic Mathematics, Aeronautics, Metallurgy, Nakhatras, Panchang, Concept of Zero, Pi and point etc.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5		**Unit-3**: Ancient Science, Astronomy and Vedic Mathematics 3.1, 3.2,3.3,3.4,3.5,3.6	
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4, 5	**CO- 4:** Understanding on ancient Engineering, Science and Technology, Town Planning, Temple architecture, Chemistry and Metallurgy, Metal manufacturing etc.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5		**Unit-4:** Engineering, Technology and Architecture 4.1, 4.2,4.3,4.4,4.5,4.6	
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4, 5	**CO- 5:** Student will able to understand about the Life, Nature and Health through basic concept of Ayurveda andYoga, Traditional Medicinal Systems, Ethnomedicine, Nature conservation, World Heritage Sites etc.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5		Unit 5: **Life, Nature and Health** 5.1,5.2,5.3,5.4,5.5,5.6	

Course Code: 0EVS202

Course Title: Environmental Education

Pre-requisite: To study this course, the student must have a knowledge about the environmental components, pollution, biodiversity, and ecosystem at senior secondary, **Class** 12'h level.

Rationale: The students studying Environmental Science should possess foundational understanding about environment and its components. They should also know the importance of ecosystems in our surroundings.

Course Outcomes:

0EVS202.1: To understand various aspects of life forms, ecological processes, and the impacts on them by the human during Anthropocene era.

0EVS202.2: To build capabilities to identify relevant environmental issues, analyze the various underlying causes, evaluate the practices and policies, and develop framework to make inform decisions.

0EVS202.3: To develop empathy for all life forms, awareness, and responsibility towards environmental protection and naturepreservation.

0EVS202.4: To develop the critical thinking for shaping strategies such as; scientific, social. economic. administrative & legal. environmental protection, conservation of biodiversity. environmental equity and sustainabledevelopment.

0EVS202.5: To prepare for the competitiveexams.

Scheme of Studies:

Board ofStudy	CourseCode	CourseTitle	Scheme of studies(Hours/Week)					TotalCredits (C)
			Cl	LI	SW	SL	Total StudyHours(CI+LI +SW+SL)	
AEC	0EVS202	Environmental Science	2	0	1	1	5	2

Legend: CI: ClassroomInstruction(Includesdifferentinstructionalstrategiesi.e.,Lecture(L)andTutorial (T)andothers),
LI: LaboratoryInstruction(IncludesPracticalperformancesinlaboratoryworkshop, field or other locations using different instructional strategies)
SW: Sessional Work(includesassignment, seminar, miniprojectetc.),
SL: SelfLearning,
C: Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback ofteacherto ensureoutcomeofLearning.

Scheme of Assessment:

Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						End Semester Assessment	Total Marks
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA+CAT+AT)	(ESA)	(PRA+ ESA)
AEC	OEVS202	Environmental Science	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

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

0EVS202.1: To understand various aspects of life forms, ecological

processes, and the impacts on them by the human during Anthropocene era.

Approximate Hours

Item	AppX Hrs.
Cl	08
LI	0
SW	1
SL	2
Total	11

Session Outcomes (SOs)	Laboratory Instruction (LI)	ClassroomInstruction (CI)	Self-Learning (SL)
SO1.1Know multidisciplinary nature of environmental science. SO1.2 Learn about the natural resources. SO1.3Know the problems associated with land resource. SO1.4Learn the conservation of resources. SO1.5 Know alternative energy resources.	.	**Unit-1 Environment and Natural Resources:** 1.1 The Multidisciplinary nature of environmental studies. 1.2 Scope and Importance of Environmental studies 1.3 Components of Environment: Atmosphere, Hydrosphere, Lithosphere, and Biosphere. 1.4 Brief account of Natural Resources and associated problems 1.5 Land Resource 1.6 Water Resource 1.7 Energy Resource 1.8 Concept of Sustainability and Sustainable Development	i. What is environmental Science? ii. What are resources?

SW-1 SuggestedSessionalWork(SW):

a. Assignments:

- **i.** Write thedefinition and causes of soil erosion.
- **ii.** Define desertification and write its causes.
- **iii.** Describe structure of atmosphere.
- **iv.** Explain lithosphere.

0EVS202.2: To build capabilities to identify relevant environmental issues, analyze the various underlying causes, evaluate the practices and policies, and develop framework to make inform decisions.

Approximate Hours

Item	AppXHrs
Cl	05
LI	0
SW	2
SL	2
Total	09

SessionOutcomes (SOs)	LaboratoryInstruction (LI)	ClassroomInstruction (CI)	Self-Learning (SL)
SO2.1 Understand the concept of ecosystem. **SO2.2**Learn the structure of ecosystem. **SO2.3**Know the function of ecosystem. **SO2.4**Describe the structure of forest ecosystem. **SO2.**5 Learn about biodiversity and its conservation.		Unit-2 Biomes, **Ecosystem and Biodiversity** 2.1 Major Biomes: Tropical, Temperate, Forest, Grassland, Desert, Tundra, Wetland, Estuarine and Marine 2.2 Ecosystem: Structure 2.3 Function and types 2.4 their Preservation & Restoration 2.5 Biodiversity and its conservation practices.	i.What is biotic and abiotic components of environment ? ii. What are interactions?

SW-2 SuggestedSessionalWork(SW):

a. Assignments:

i. What do you mean by ecosystem? Describe the structure of ecosystem.
ii. Give a brief classification of ecosystem.
iii. Write the function of an ecosystem.
iv. Define biodiversity write strategies of biodiversity conservation.

b. MiniProject:

Visit to various ecosystem and study biotic and abiotic ecosystem.

0EVS202.3: To develop empathy for all life forms, awareness, and responsibility towards environmental protection and nature preservation.

Approximate Hours

Item	AppXHrs
Cl	07
LI	0
SW	02
SL	2
Total	11

SessionOutcomes (SOs)	LaboratoryInstruction (LI)	ClassroomInstruction (CI)	Self-Learning (SL)
SO3.1. Learn about pollution and its sources. **SO3.2**Know the sources of different pollutant. **SO3.3**Understand the law & legislation related to environment. **SO3.4**Learn the control of pollution. 3.1 **SO3.**5 Describe the role of information technology in environment and human health.		**Unit-3:Environmental Pollution, Management and** Social **Issues:** 3.2 Pollution: Types, Control measures, Management and associated problems. 3.3 Environmental Law and Legislation: Protection and conservation Acts. 3.4 International Agreement &**Program** 3.5 Environmental Movements, communication and public awareness Program. 3.6 National and International organizations related to environment conservation and monitoring. 3.7 Role of information technology in environment and human health.	i. What is pollution basic introduction? ii. What is pollutant?

SW-3 Suggested Sessional Work (SW):

a. Assignments:

i. Write an essay on air pollution.
ii. What do you mean by acid rain write its causes and effects.
iii. Describe the effects of water pollution.
iv. How soil pollution can be control?
v. Describe the role of information technology in environment and human health.
vi. Mention some national and international organizations related to environment conservation and monitoring.

b. Other Activities (Specify):

Visit to different polluted sites and study the source of pollution and their effects.

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self-Learning (Sl)	Total hour (Cl+SW+Sl)
0EVS202.1: To understand various aspects of life forms, ecological processes, and the impacts on them by the human during Anthropocene era.	08	1	2	11
0EVS202.2: To build capabilities to identify relevant environmental issues, analyze the various underlying causes, evaluate the practices and policies, and develop framework to make inform decisions.	05	2	2	09
0EVS202.3: To develop empathy for all life forms, awareness, and responsibility towards environmental protection and nature preservation.	07	2	2	11
Total Hours	20	05	06	31

Suggestion for End Semester Assessment

SuggestedSpecificationTable(ForESA)

CO	UnitTitles	MarksDistribution			Total Marks
		R	U	A	
CO-1	**Environment and Natural Resources:**	03	01	01	05
CO-2	Biomes, **Ecosystem and Biodiversity**	02	06	02	10
CO-3	**Environmental Pollution, Management and** Social **Issues**	03	07	05	15
Total		11	26	13	50

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

Theendofsemesterassessmentfor Fundamental of Environmental Sciencewillbeheldwith written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wiseteachers for above tasks. Teachers can also design different tasks as per requirement, for endsemesterassessment.

Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. CaseMethod
4. GroupDiscussion
5. RolePlay
6. Visit to cement plant
7. Demonstration
8. ICT Based Teaching Learning (Video Demonstration/ Tutorials CBT, Blog, Face book, Twitter, Online sources)
9. Brainstorming

Suggested Learning Resources:

(a) Books:

S. No.	Title	Author	Publisher	Edition&Year
1	Ecology; Environment Science and Conservation	Singh; J.S., Singh S.P. and Gupta, S. R	S. Chand publishing, New Delhi.	2018
2	Perspectives in Environmental Studies	Kaushik, Anubha, Kaushik, C.P.	New age International Publishers	2018
3	A Textbook of Environmental Studies	Asthana, D. K Asthana Meera	S. C1iand.Publishing, New Delhi	2007
4	Environmental Law and Policy in India: Cases, Material & Status	Divan, S. and Rosenkranz, A	Oxford University Press, India	2002

Program name	**Bachelor of Science (B.Sc.)- Biotechnology**	
Semester	III	
Course Code:	01BT301	
Course title:	Bioanalytical Tools and Techniques	Developer: Mrs. Keerti Samdariya, Assistant Professor
Pre-requisite:	Students should have basic knowledge of biochemical and analytical techniques.	
Rationale:	The paper on "Bioanalytical Tools and Techniques" in the B.Sc. (Hons) Biotechnology program allow an understanding of the working principle and application of numerous tools like spectroscopy, chromatography, and gel electrophoresis. Techniques like DNA microarray will advance the knowledge of research related to molecular biology, gene regulation	
Course Outcomes (COs):	**CO1-01BT301.1:** Recognize the finer points of microscopy. **CO2-01BT301.2:** Recognize the differences between colorimetry, fluorescence, UV visible spectroscopy, and centrifugation. **CO3-01BT301.3:** Calculate the Rf value from a chromatogram to study paper, ion exchange, and affinity chromatography apart. **CO4-01BT301.4:** Understand the working principle and application of electrophoresis **CO5-01BT301.5:** Learn the essential ideas behind the isolation of DNA and nanotechnology.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme ofstudies (Hours/Week)					Total Credits(C) (L:T:P=4:0:2)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
MAJOR	01BT301	Bioanalytical Tools and Techniques	4	4	1	2	11	4+2=6

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	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)		
MAJOR	01BT301	Bioanalytical Tools and Techniques	15	20	10	5	50	50	100

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
MAJOR	**01BT301-L**	Bioanalytical Tools and Techniques	35	5	5	5	50	50	100

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

Approximate Hours

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

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO1-01BT301.1: Understand the concept of microscopy.	SO 1.1: Attain Good Laboratory Practice	LI1.1: Demonstration of working of the microscope in the lab	CI 1.1: Introduction to Analysis: Concept of Good Laboratory Practice and Quality Management	SL1.1: Difference among the various spectrophotometer
	SO 1.2: Discuss the Working principle of Simple microscopy	LI1.2: Demonstration of working of the Spectrometer	CI 1.2: Discuss the Working principle of Simple microscopy	SL1.3: Principle of different spectroscopy
	SO 1.3: Discuss the Working principle of phase contrast microscopy	LI1.3: Demonstration of working of the TEM and SEM	CI 1.3: Discuss the Working principle of phase contrast microscopy	
	SO 1.4: Discuss the Working principle of fluorescence microscopy		CI 1.4: Discuss the Working principle of fluorescence microscopy	
	SO 1.5: Discuss working principle Electron microscopy (TEM and SEM)		CI 1.5: Discuss working principle Electron microscopy (TEM and SEM)	
	SO 1.6: Understand the Spectroscopy:		CI 1.6: Spectroscopy: Lambert Beer's Law, principle, instrumentation	
	SO 1.7: Understand principle, of spectroscopy		CI 1.7: principle	
	SO 1.8: Understand instrume-ntation of spectroscopy		CI 1.8: instrumentation	
	SO 1.9: Application of UV, visible, Spectroscopy		CI 1.9: Application of UV, visible, Spectroscopy	
	SO 1.10: Application of IR Spectroscopy in research		CI 1.10: Application of IR Spectroscopy	
	SO 1.11: Application of NMR Spectroscopy		CI 1.11: Application of NMR Spectroscopy	
	SO 1.12: Application of Spectroscopy in research		CI 1.12: Application of Spectroscopy	

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Explain in details about good laboratory practices
	SW1.2 Mini Project	Ray diagram of all microscope you studied with neat labelling. And their applications
	SW1.3 Other Activities (Specify)	Find out the literature discussing about the advancement of spectrophotometer.

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 / 12 / 06 / 01 / 02 / 21

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-01BT301.2: -Recognize the differences between colorimetry, fluorescence, and UV visible spectroscopy	SO2.1: Learn about Principle of absorption	LI2.1: Demonstration of working of cholorimeter	CI 2.1: Principle of absorption	SL2.1: fluorimetry and colorimetry
	SO2.2: Learn about the law of absorption.	LI2.2: Demonstration of working of centrifuge	CI 2.2: law of absorption	SL2.2: cell fractionation techniques
	SO2.3: Learn about fluorimetry		CI 2.3: Principle of fluorimetry	
	SO2.4: Learn about colorimetry		CI 2.4: Principle of colorimetry	
	SO2.5: Learn about spectrophotometry		CI 2.5: spectrophotometry	
	SO2.6: Learn about visible spectrophotometry		CI 2.6: visible spectrophotometry.	
	SO2.7: Learn about, infrared spectrophotometry		CI 2.7: infrared spectrophotometry	
	SO2.8: Learn about, UV spectrophotometry		CI 2.8: UV spectrophotometry	
	SO2.9: Learn abou centrifugation		CI 2.9: Centrifugation	
	SO2.10: Learn about cell fractionation techniques.	LI2.3: isolation of sub-cellular organelles and particles	CI 2.10: cell fractionation techniques,	
	SO2.11: study the isolation of sub-cellular organelles		CI 2.11: isolation of sub-cellular organelles and particles	
	SO2.12: Learn application of centrifugation		CI 2.12: application of centrifugation	

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Important precautions while working with centrifugation
	SW1.2 Mini Project	Prepare the poster evaluating different spectrophotometry
	SW1.3 Other Activities (Specify)	Find out the videos discussing about the different spectrophotometry

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	12	06	01	02	21

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-01BT301.3: Calculate the Rf value from a chromatogram to study paper, ion exchange, and affinity chromatography apart	SO 3.1: Introduction and concept of chromatographic techniques	LI 3.1: Thin layer chromatography	CI 3.1: Introduction and concept of chromatographic techniques	3.1: Study the fundamentals of various chromatography
	SO 3.2:Read the principle behind the various chromatographic techniques	LI 3.2: Paper chromatography	CI 3.2: principle of chromatography	3.2: Boost your knowledge for application of chromatographic techniques
	SO 3.3: Apply practical application of Chromatography.	LI 3.3: Column chromatography	CI 3.3: absorption chromatography	
	SO 3.4: Explain paper chromatography.		CI 3.4: Paper chromatography,	
	SO 3.5: Explain thin layer chromatography.		CI 3.5: thin layer chromatography,	
	SO 3.6: Explain column chromatography		CI 3.6: column chromatography	
	SO 3.7: Explain, gel chromatography.		CI 3.7: silica gel	
	SO 3.8: Explain gel filtration chromatography.		CI 3.8: silica and gel filtration	
	SO 3.9: Explain affinity chromatography.		CI 3.9: affinity chromatography	
	SO 3.10: Explain ion exchange chromatography.		CI 3.10: Ion exchange chromatography	
	SO 3.11: Explain gas chromatography.		CI 3.11: gas chromatography	
	SO 3.12: Explain HPLC		CI 3.12: HPLC	

Suggested Sessional Work (SW): *anyone*	Assignments:	What are the materials used as bead in different chromatography machine; explain in details
	Mini Project:	Make a poster explaining the principle of separation of ion exchange chromatography
	Other Activities (Specify):	Watch animation on explaining the functionality of HPLC and Gas chromatography

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	12	06	01	02	21

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-01BT301.4: Understand the working principle and application of electrophoresis in real world	SO4.1 Understanding the basic concept ofelectrophoresis	LI 4.1: DNA gel electrophoresis and DNA separation	CI 4.1: Concept and basic principle of electrophoresis	4.1: Enhance your knowledge about the agar gel electrophoresis and polyacrylamide gel electrophoresis
	SO4.2 Explain key factors affecting mobility	LI 4.2: PAGE for the separation of protein	CI 4.2: Factors affecting electrophoretic mobility	4.2: Understand the basis of separation of protein in PAGE
	SO4.3 Study in detail about free electrophoresis		CI 4.3: Free electrophoresis,	
	SO4.4Study about moving boundary electrophoresis		CI 4.4: moving boundary electrophoresis,	
	SO4.5 explain in detail about zone electrophoresis	LI 4.2: perform zone electrophoresis	CI 4.5: zone electrophoresis,	
	SO4.6Study in detail about paper electrophoresis		CI 4.6: paper electrophoresis,	
	SO4.7Study In detail about capillary electrophoresis		CI 4.7:, capillary electrophoresis,	
	SO4.8describe about gel electrophoresis		CI 4.8: gel electrophoresis	
	SO4.8describe about immunoelectrophoresis		CI 4.9: immuno-electrophoresis,	
	SO4.8describe about isoelectric focusing		CI 4.10: isoelectric-focusing	
	SO4.8describe about PAGE		CI 4.11: PAGE	
	SO4.8describe application of electrophoresis		CI 4.12: Applications of electrophoresis	

Suggested Sessional Work (SW): *anyone*	Assignments:	Working principle of Gel electrophoresis
	Mini Project:	Application of DNA-Protein Interaction analysis
	Other Activities (Specify):	Find out the videos discussing about the various types of electrophoresis techniques.

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	12	06	01	02	21

Course outcome (COs)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO1-01BT301.5: Learn the essential ideas behind Isolation of DNA and RNA	SO5.1: Explain the Isolation of DNA	LI 5.1:Nucleic Acid isolation	CI 5.1 DNA isolation – Principle and Protocol	SL5.1: Understand the southern blotting, northern blotting and western blotting
	SO5.2: Explain Isolation of DNA		CI 5.2DNA isolation from Different sources	
	SO5.3Explain RNA isolation		CI 5.3 RNA isolation	
	SO5.4 Understand genomic DNA isolation	LI 5.2: Genomic DNA isolation	CI5.4 Genomic DNA isolation	
	SO5.5Understand Plasmid DNA isolation	LI 5.3: Plasmid DNA isolation	CI 5.5 Plasmid DNA isolation	
	SO5.6Understand blotting and their applications		CI 5.6 Blotting Techniques	SL5.2: Understand blotting and their applications
	SO5.7 study southern blotting		CI 5.7 Southern Blotting	
	SO5.8 study northern blotting		CI 5.8 Northern Blotting	
	SO5.9 study western blotting		CI5.9 Western Blotting	
	SO5.10 study about Biosensor		CI5.10 Introduction to Biosensor	
	SO5.11 study Application of Biosensor		CI5.11 Application of Biosensor	
	SO5.12 study Nanotechn-ology and its application		CI5.12 Nanotechnology and its application	

Suggested Sessional Work (SW): Anyone	Assignments:	Working principle of Centrifugation
	Mini Project:	Image development and application of x-rays
	Other Activities (Specify):	Ultracentrifugation: Application in isolation of different cell organelles

Course duration (in hours) to attain Course Outcomes (Course title: Bioanalytical Tools and Techniques**)**					
Course Outcomes(COs)	**Class lecture(CI)**	**LaboratoryInstruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-01BT301.1: Recognize the finer points of microscopy.	12	6	2	1	21
CO2-01BT301.2: Recognize the differences between colorimetry, fluorescence, UV visible spectroscopy, and centrifugation.	12	6	2	1	21
CO3-01BT301.3: Calculate the Rf value from a chromatogram to study paper, ion exchange, and affinity chromatography apart.	12	6	2	1	21
CO4-01BT301.4: Understand the working principle and application of electrophoresis	12	6	2	1	21
CO5-01BT301.5: Learn the essential ideas behind the isolation of DNA and nanotechnology.	12	6	2	1	21
Total Hours	60	30	10	05	95

Suggested learning Resources:

S. no.	Title
1	Principles and Techniques of Biochemistry and Molecular Biology, Keith Wilson and John Walker, Cambridge University Press, 3 & 2018
2	Principles of Physical Biochemistry, K.E. Van Holde, Prentice Hall, Pearson Prentice Hall, 2 & 2005
3	Principles and Practice of Bioanalysis, Richard F. Venn, CRC Press Inc, 2 & 2008

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

End-semester Assessment Scheme for setting up question papers and assessments to evaluate the Course Outcome: (Course title: Bioanalytical Tools and Techniques**)**					
Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-01BT301.1: Recognize the finer points of microscopy.	2	1	1	1	5
CO2-01BT301.2: Recognize the differences between colorimetry, fluorescence, UV visible spectroscopy, and centrifugation.	2	4	2	2	10
CO3-01BT301.3: Calculate the Rf value from a chromatogram to study paper, ion exchange, and affinity chromatography apart.	3	5	5	2	15
CO4-01BT301.4: Understand the working principle and application of electrophoresis	2	3	3	2	10
CO5-01BT301.5: Learn the essential ideas behind the isolation of DNA and nanotechnology.	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**
Legend: A-Apply, A- Analyze, E- Evaluate, C- Create					

CO, PO and PSO Mapping

Program Title: B. Sc. Biotechnology, 3rd Sem
Course Code: 01BT301
Course Title: Bioanalytical Tools and Techniques

CO/PO Mapping															
Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-01BT301.1: Recognize the finer points of microscopy.	-	-	-	1	2	2	2	-	1	2	2	3	3	2	1
CO2-01BT301.2: Recognize the differences between colorimetry, fluorescence, UV visible spectroscopy, and centrifugation.	-	-	-	-	-	-	3	-	2	2	3	3	2	1	2
CO3-01BT301.3: Calculate the Rf value from a chromatogram to study paper, ion exchange, and affinity chromatography apart.	-	1	1	1	-	-	2	-	3	1	1	2	1	2	1
CO4-01BT301.4: Understand the working principle and application of electrophoresis	-	1	1	-	2	2	2	3	-	1	-	-	2	2	3
CO5-01BT301.5: Learn the essential ideas behind the isolation of DNA and nanotechnology.	1	1	1	-	-	2	3	3	1	2	2	2	2	1	2

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-01BT301.1:** Recognize the finer points of microscopy.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10 SO1.11 SO1.12	LI1, LI2 LI3,	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8,1.9, 1.10,1.11, 1.12	**1SL-1,2,**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-01BT301.2:** Recognize the differences between colorimetry, fluorescence, UV visible spectroscopy, and centrifugation.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9 SO2.10 SO2.11 SO2.12	LI1, LI2 LI3,	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9, 2.10, 2.11, 2.12	**2SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3-01BT301.3:** Calculate the Rf value from a chromatogram to study paper, ion exchange, and affinity chromatography apart.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7SO3.8 SO3.9 SO3.10 SO3.11 SO3.12	LI1, LI2 LI3,	3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12	**3SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-01BT301.4:** Understand the working principle and application of electrophoresis	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10 SO4.11 SO4.12	LI1, LI2 LI3,	4.1,4.2,4.3,4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10,4.11,4.12	**4SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO5-01BT301.5:** Learn the essential ideas behind the isolation of DNA and nanotechnology.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9 SO5.10 SO5.11 SO5.12	LI1, LI2, LI3,	5.1,5.2,5.3,5.4,5.5, 5.6,5.7,5.8,5.9,5.10,5.11 5.12	**5SL-1,2**

Program Name	**Bachelor of Science (Hons.) Biotechnology**	
Semester	III	
CourseCode:	**02BC301**	
Coursetitle:	Clinical Biochemistry	**Curriculum Developer**: Mrs. Pratima Mishra, Guest Faculty
Pre-requisite:	Students should have basic knowledge of Biomolecules, Biochemistry, Clinical Biochemistry	
Rationale:	The Clinical Biochemistry course in a B.Sc. Hons Biotechnology program is essential for understanding biochemical mechanisms underlying human health and disease. It covers principles of biomolecules, enzymology, metabolism, and molecular diagnostics relevant to clinical settings. This knowledge is crucial for developing and interpreting diagnostic tests, monitoring treatment responses, and understanding biochemical basis of diseases. It prepares students for roles in clinical laboratories, pharmaceutical industries, and healthcare sectors, where they contribute to disease diagnosis, treatment development, and personalized medicine. The course integrates theoretical knowledge with practical skills in biochemical analysis, fostering analytical thinking and preparing graduates for careers in biomedical research, healthcare delivery, and biotechnological innovation.	
Course Outcomes (COs):	**CO1-02BC301.1:** Proficiency in assessing fluid and electrolyte balance disorders in disease states, conducting function tests with clinical relevance. **CO2-02BC301.2:** Learning in-depth information regarding the components of metabolic, endocrine, and nutritional disorders and their clinical implications **CO3-02BC301.3:** Recognize various concepts of disease diagnosis, CSF chemistry, detoxification, xenobiotic metabolism, metal toxicity, ageing, cancer, AIDS. **CO4- 02BC301.4:** Gain comprehensive assess of drug action mechanisms, apoptosis in cancer, and medical applications of radioisotopes. **CO5-02BC301.5:** Achieve proficiency in managing disorders of mineral metabolism, trace elements, amino acids, steroids, vitamins, erythrocyte metabolism.	

Scheme of Studies:

Board of Study	Course Code	CourseTitle	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=4:0:2)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
MINOR	02BT301	Clinical Biochemistry	4	4	1	5	14	4+2=6

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)		
MINOR	02BT301	Clinical Biochemistry	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)		
MINOR	**02BT301-L**	Clinical Biochemistry	35	5	5	5	50	50	100

Course-Curriculum:

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

ApproximateHours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	05	24

Course outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction(CI)	Self-Learning(SL)
CO1-02BC301.1: Proficiency in assessing fluid and electrolyte balance disorders in disease states, conducting function tests with clinical relevance.	**SO1.1** Define and Describe concept of Fluid & electrolyte balance	**LI1.1** Perform SGPT	**Unit 1** **CI1.1** Fluid & electrolyte balance and imbalance in various diseases.	**SL1.1** Search various reference books and study material to start the learning
	SO1.2 Describe function tests of pancreases,	Perform SGOT	**CI1.2** Function tests of pancreases,	**SL1.2** Check clinical significance of function test
	SO1.3 Explain function tests of gastric	**LI1.2** Perform Kidney function test	**CI1.3** Function tests of gastric,	**SL1.3** Learn about various categories of body function test
	SO1.4 Describe function tests of Thyroid,		**CI1.4** Function tests of Thyroid,	**SL1.4** Case study related to mall function of body fluid
	SO1.5 Describe function tests of Kidney		**CI1.5** Function tests of Kidney	
	SO1.6 Describe function tests of Liver		**CI1.6** Function tests of Liver	
	SO1.7 Describe direct wander wall's test		**CI1.7** Direct wander wall's test	
	SO1.8 Assess indirect wander wall's test		**CI1.8** Indirect wander wall's test	**SL1.5** case study related to mall function of body components.
	SO1.9 Describe clinical significance of wander wall's test		**CI1.9** clinical significance wander wall's test	
	SO1.10 Assess clinical significance of SGPT		**CI1.10** Clinical significance of SGPT	
	SO1.11 Assess Clinical Significance of SGOT		**CI1.11** Clinical Significance of SGOT	
	SO1.12 Discuss Clinical role of diagnostics		**CI1.12** Clinical role of diagnostics	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Describe in detail on different body function test
	SW1.2 Mini Project	Prepare a chart on body function test.
	SW1.3 Other Activities (Specify)	Collect the data about biological role of body functional components

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	05	24

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
CO2-02BC301.2: Learning in-depth information regarding the components of metabolic, endocrine, and nutritional disorders and their clinical implications	**SO2.1** Assess the concept of Fatty liver and Jaundice	**LI2.1** Determine Blood Cratinine	**Unit-II** **CI2.1** Fatty liver, Jaundice	**SL2.1** Enlist the different components of blood test
	SO2.2 Explain about the role of Blood sugars	**LI2.2** Blood Examination	**CI2.2** Blood sugars	**SL2.2** Assess biological role of fat in body
	SO2.3 Explain about the role of Ketone bodies	**LI2.3** Urea Examination	**CI2.3** Ketone bodies	**SL2.3** Learn about role of lipoproteins
	SO2.4 Explain about Diabetes mellitus		**CI2.4** Diabetes mellitus	**SL2.4** Learn sugar imbalance and diabetes.
	SO2.5 Describe the role of Arthritis		**CI2.5** Arthritis	**SL2.5** Learn about Thyroid imbalance and associated issues.
	SO2.6 Describe role of Fats in diseases		**CI2.6** Fats in diseases	
	SO2.7 Describe role of Lipoprotein disorders		**CI2.7** Lipoproteins disorders	
	SO2.8 Assess the role of Nutrition and Chronic disease		**CI2.8** Nutrition and Chronic disease	
	SO2.9 Discuss about disorder of Thyroid		**CI2.9** Disorders of Thyroid: Hyperthyroidism,	
	SO2.10 Discuss about disorder of Hypothyroidism		**CI2.10** Hypothyroidism	
	SO2.11 Explore the role of Thyroid function test		**CI2.11** Thyroid function Tests: T3, T4	
	SO2.12 Explore the role of Thyroid function test		**CI2.12** Thyroid function Tests: TSH, TRH	

Suggested Sessional Work (SW) : *anyone*	**SW2.1** Assignments	Describe in detail Diabetes mellitus its symptom, diagnosis and treatment
	SW2.2 Mini Project	Explain the role of Thyroid and problems occurred due to its imbalance.
	SW2.3 Other Activities (Specify)	Write an article on clinical role of blood sugar and fat.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	05	24

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-02BC301.3: Recognize various concepts of disease diagnosis, CSF chemistry, detoxification, xenobiotic metabolism, metal toxicity, ageing, cancer, AIDS.	**SO3.1** Explain the concept of enzymes in different diagnosis of diseases	**SL3.1** Perform ELISA	**Unit-III** **CI3.1** Enzymes in different diagnosis of diseases	**SL3.1** Read about various Enzymes used in different diagnosis
	SO3.2 Explain clinical significance of enzymes	**SL3.2** Perform WIDAL	**CI3.2** their clinical significance	**SL3.2** Collect the information about Biochemistry of detoxification
	SO3.3 Assessing Cerebrospinal fluid (CSF) chemistry	**SL3.3** Perform RIA	**CI3.3** Cerebrospinal fluid (CSF) chemistry	Collect the information about Xenobiotic metabolism
	SO3.4 Assessing clinical significance of Cerebrospinal fluid		**CI3.4** clinical significance	
	SO3.5 Assessing the Biochemistry of detoxification		**CI3.5** Biochemistry of detoxification	
	SO3.6 Assessing mechanism of Xenobiotic metabolism		**CI3.6** Xenobiotic metabolism	**SL3.3** Collect information about inborn impact of chelation therapy
	SO3.7 Describe about mechanism of Metal ion toxicity		**CI3.7** Metal ion toxicity	**SL3.4** Study about impact of antioxidant therapy
	SO3.8 Assessing the role of chelation therapy		**CI3.8** Chelation therapy	
	SO3.9 Describe about role of antioxidant therapy		**CI3.9** antioxidant therapy	
	SO3.10 Assessing mechanism of Ageing		**CI3.10** Biochemistry of Ageing	
	SO3.11 Assessing mechanism and impact of Cancer		**CI3.11** Cancer	
	SO3.12 Assessing mechanism and impact of AIDS		**CI3.12** AIDS	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail about Biochemistry of detoxification
	SW3.2 Mini Project	Describe the cause symptoms and treatment of Cancer.
	SW3.3 Other Activities (Specify)	Prepare a model for explaining Life cycle of Ageing / HIV virus

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	05	24

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO4- 02BC301.4: Gain comprehensive assess of drug action mechanisms, apoptosis in cancer, and medical applications of radioisotopes.	**SO4.1** Exploring mechanism of drug action- Penicillin	**LI4.1** Demonstration of apoptosis	**Unit-IV** **CI4.1** Mechanism of drug action- Penicillin	**SL4.1** Read about various drug action mechanism
	SO4.2 Assessing mechanism of drug action- Tetracycline	**LI4.2** Demonstration of chemotherapy	**CI4.2** Mechanism of drug action- Tetracycline	**SL4.2** Collect the information about causes of cancer
	SO4.3 Explaining mechanism of drug action- Streptomycin	**LI4.3** Demonstration of mechanism of drug action	**CI4.3** Mechanism of drug action- Streptomycin	
	SO4.4 Explaining mechanism of drug action- Chloramphenicol		**CI4.4** Mechanism of drug action- Chloramphenicol	
	SO4.5 Evaluate mechanism of drug action- Sulphonamides.		**CI4.5** Mechanism of drug action- Sulphonamides.	
	SO4.6 Evaluate clinical significance of drugs		**CI4.6** Clinical significance of drugs	**SL4.3** Collect information about side effect of drugs
	SO4.7 Describe the impact of apoptosis		**CI4.7** Apoptosis:	**SL4.4** Collect information about side effect of chemotherapy
	SO4.8 Describe carcinogens		**CI4.8** Carcinogens	**SL4.5** Collect information about side effect of radiation therapy
	SO4.9 Describe cancerous growth		**CI4.9** Cancerous growth	
	SO4.10 Describe the impact of chemotherapy		**CI4.10** Chemotherapy	
	SO4.11 Describe the impact of radioactivity		**CI4.11** radioactivity	
	SO4.12 Elaborate the concept of radioisotopes		**CI4.12** radioisotopes in medicine	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe in detail about mechanism of drug action
	SW4.2 Mini Project	Describe the impact of environmental consequences in cancer
	SW4.3 Other Activities (Specify)	Prepare a model for explaining mechanism and treatment of cancer.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	10	06	01	05	24

Course Outcome (CO)	SessionOutcomes(SOs)	LaboratoryInstruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO5-02BC301.5: Achieve proficiency in managing disorders of mineral metabolism, trace elements, amino acids, steroids, vitamins, erythrocyte metabolism.	**SO5.1** Explore about disorders of mineral metabolism and trace element	**LI5.1** Detection of anaemia	**Unit-V** **CI5.1** Disorders of mineral metabolism and trace elements	**SL4.1** Read about various disorders of mineral metabolism
	SO5.2 Able to execute role of hypocalcemia	**LI5.2** Perform Immunodiagnostic test	**CI5.2** Hypocalcemia	**SL4.2** Collect the information about different disorders
	SO5.3 Apply the role of Hypo Hypercalcemia	**LI5.3** Perform WIDAL	**CI5.3** Hypercalcemia	**SL4.3** Case studies about disorders
	SO5.4 Apply the role of Hypo-phosphatemia		**CI5.4** Hypophosphatemia	
	SO5.5 Apply the role of Hyperphosphatemia		**CI5.5** Hyperphosphatemia	**SL4.4** Case studies related to anemia's
	SO5.6 Evaluate the disorders of amino acid		**CI5.6** Disorders of amino acids	**SL4.5** Case studies thalassemias.
	SO5.7 Assess the disorders of steroids		**CI5.7** Disorders of steroids	
	SO5.8 Assess the disorders of vitamins		**CI5.8** Disorders of vitamins	
	SO5.9 Explore about disorders of erythrocyte metabolism		**CI5.9** Disorders of erythrocyte metabolism	
	SO5.10 Explore about hemoglobinopathis		**CI5.10** hemoglobinopathis	
	SO5.11 Explore about thalassemias		**CI5.11** thalassemias	
	SO5.12 explore about anemia's		**CI5.12** anemia's	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general mechanism of disorders occurred in body.
	SW5.2 Mini Project	Describe the various symptoms and treatments of vitamin disorders.
	SW5.3 Other Activities (Specify)	Prepare one model for showing mechanism of disorders.

Course duration (in hours) to attain Course Outcomes:

Course Title: Clinical Biochemistry **Course Code:02BC301**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-02BC301.1: Proficiency in assessing fluid and electrolyte balance disorders in disease states, conducting function tests with clinical relevance.	12	6	5	1	24
CO2-02BC301.2: Learning in-depth information regarding the components of metabolic, endocrine, and nutritional disorders and their clinical implications	12	6	5	1	24
CO3-02BC301.3: Recognize various concepts of disease diagnosis, CSF chemistry, detoxification, xenobiotic metabolism, metal toxicity, ageing, cancer, AIDS.	12	6	5	1	24
CO4- 02BC301.4: Gain comprehensive assess of drug action mechanisms, apoptosis in cancer, and medical applications of radioisotopes.	12	6	5	1	24
CO5-02BC301.5: Achieve proficiency in managing disorders of mineral metabolism, trace elements, amino acids, steroids, vitamins, erythrocyte metabolism.	12	6	5	1	24
Total Hours	60	30	25	05	120

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

Course Title: Clinical Biochemistry **Course Code:02BC301**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-02BC301.1: Proficiency in assessing fluid and electrolyte balance disorders in disease states, conducting function tests with clinical relevance.	2	1	1	1	5
CO2-02BC301.2: Learning in-depth information regarding the components of metabolic, endocrine, and nutritional disorders and their clinical implications	2	4	2	2	10
CO3-02BC301.3: Recognize various concepts of disease diagnosis, CSF chemistry, detoxification, xenobiotic metabolism, metal toxicity, ageing, cancer, AIDS.	3	5	5	2	15
CO4- 02BC301.4: Gain comprehensive assess of drug action mechanisms, apoptosis in cancer, and medical applications of radioisotopes.	2	3	3	2	10
CO5-02BC301.5: Achieve proficiency in managing disorders of mineral metabolism, trace elements, amino acids, steroids, vitamins, erythrocyte 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	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: B.Sc. (Hons.) Biotechnology
Semester: III Semester
Course Title: Clinical Biochemistry
Course Code: 02BC301

Course Outcome (Cos)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-02BC301.1: Proficiency in assessing fluid and electrolyte balance disorders in disease states, conducting function tests with clinical relevance.	1	2	2	2	3	3	2	3	3	1	2	3	2	2	3
CO2-02BC301.2: Learning in-depth information regarding the components of metabolic, endocrine, and nutritional disorders and their clinical implications	1	2	1	1	2	2	2	2	2	2	2	2	2	3	2
CO3-02BC301.3: Recognize various concepts of disease diagnosis, CSF chemistry, detoxification, xenobiotic metabolism, metal toxicity, ageing, cancer, AIDS.	1	2	2	2	1	2	1	1	2	1	2	2	1	2	2
CO4- 02BC301.4: Gain comprehensive assess of drug action mechanisms, apoptosis in cancer, and medical applications of radioisotopes.	1	1	2	1	2	3	2	2	3	2	1	3	1	2	3
CO5-02BC301.5: Achieve proficiency in managing disorders of mineral metabolism, trace elements, amino acids, steroids, vitamins, erythrocyte metabolism.	1	2	2	1	1	3	1	1	3	2	2	3	1	2	3

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO1-02BC301.1:** Proficiency in assessing fluid and electrolyte balance disorders in disease states, conducting function tests with clinical relevance.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10 SO1.11 SO1.12	**IL 1** **IL 2** **IL 3**	1.1,1.2,1.3,1.4,1.5,1.6.1.7,1.8,1.9,1.10,1.11,1.12	1SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO2-02BC301.2:** Learning in-depth information regarding the components of metabolic, endocrine, and nutritional disorders and their clinical implications	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5,2.6,2.7,2.8,2.9,2.10, 2.11,2.12	**IL 1** **IL 2** **IL 3**	2.1, 2.2, 2.3, 2.4,2.5,2.6,2.7,2.8,2.9,2.10, 2.11,2.12	2SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO3-02BC301.3:** Recognize various concepts of disease diagnosis, CSF chemistry, detoxification, xenobiotic metabolism, metal toxicity, ageing, cancer, AIDS.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6, .7,3.8,3.9,3.10,.311,3.12	**IL 1** **IL 2** **IL 3**	3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9, 3.10,3.11,3.12	3SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO4- 02BC301.4:** Gain comprehensive assess of drug action mechanisms, apoptosis in cancer, and medical applications of radioisotopes.	SO4.1 SO4.2 SO4.3 SO4.4,SO 4.5,SO4.6, SO4.7, SO4.8, SO 4.9, SO4.10 SO4.11 SO4.12	**IL 1** **IL 2** **IL 3**	4.1,4.2,4.3,4.4,4.5,4.6, 4.7, 4.8 ,4.9, 4.10,4.11, 4.12	4SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO5-02BC301.5:** Achieve proficiency in managing disorders of mineral metabolism, trace elements, amino acids, steroids, vitamins, erythrocyte metabolism.	SO5.1 SO5.2 SO5.3 SO5.4,SO5.5, SO5.6, SO5.7, SO5.8, SO5.9, SO5.10, SO5.11, SO5.12	**IL 1** **IL 2** **IL 3**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9,5.10,5.11,5.12	5SL-1,2,3,4,5

Program Name	**Bachelor of Science (B.Sc.)- Biotechnology**	
Semester	III	
Course Code:	**02MB301**	
Course title:	Fermentation Technology	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of microbiology	
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.	
CourseOutcomes (COs):	**CO1-02MB301.1.** Define various modes and techniques of fermentation **CO2-02MB301.2.** Differentiate and predict the suitability of the fermentation methods and vessels **CO3-02MB301.3.** Identify and develop the microbial inoculum for industrial processing **CO4-02MB301.4.** Interpretate the mechanism of fermentation process in industry **CO5-02MB301.5.** Examine the mechanism of biological product development using microbes	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme ofstudies (Hours/Week)					Total Credits(C) (L:T:P=4:0:2)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
MINOR	**02MB301**	Fermentation Technology	4	4	1	4	13	4+2=6

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)		
Minor	02MB301	Fermentation Technology	15	20	5	5	5	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)		
Minor	02MB301-L	Fermentation Technology	35	5	5	5	50	50	100

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx. Hrs** | 12 | 06 | 01 | 03 | 22

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-02MB301.1. Define various modes and techniques of fermentation	**SO1.1** Define and Describe concept of fermentation	**LI1.1** Perform Sterilization	**Unit 1** **CI1.1** Introduction to fermentation	**SL1.1** Search various reference books and study material to start the learning
	SO1.2 Describe history of fermentation		**CI1.2** History of fermentation	**SL1.2** List out major contributors of fermentation
	SO1.3 Explain principle of fermentation	**LI1.2** Media sterilization	**CI1.3** Principle of fermentation	**SL1.3** Learn about various categories of fermentation
	SO1.4 Describe fermentation industry	**LI1.3** Isolation of microbes	**CI1.4** Development of Fermentation Industry	
	SO1.5 Describe requirement of fermentation		**CI1.5** General Requirement for fermentation Process	
	SO1.6 Describe factors affecting fermentation		**CI1.6** Factors affecting fermentation	
	SO1.7 Describe isolation of microbes		**CI1.7** Isolation of industrially important microbes	
	SO1.8 Assess protocol for media preparation		**CI1.8** Media preparation	
	SO1.9 Describe process of strilization		**CI1.9** Sterilization	
	SO1.10 Assess concept of strain improvement		**CI1.10** Strain improvement	
	SO1.11 Assess role of condition optimization		**CI1.11** Condition optimization	
	SO1.12 Discuss about microbial growth		**CI1.12** Growth and incubation	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail "Applications of Microorganisms in various Sectors"
	SW1.2 Mini Project	Make a project on "Historical Process of Fermentation and Products produced in India"
	SW1.3 Other Activities (Specify)	List down the tables of different domains of microorganisms which are industrially important

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Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	06	01	05	24

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-02MB301.2. Differentiate and predict the suitability of the fermentation methods and vessels	**SO2.1** Define and Describe concept of inoculate	**LI2.1** To Demonstrate the working of Equipment's used in Sterilization	**Unit 1** **CI2.1** Development of inoculate for industrial fermentation	**SL2.1** Search various reference books and study material to start the learning
	SO2.2 Describe kinetics of microbial growth	**LI2.2** To perform the primary and secondary of microorganisms from different kinds of samples	**CI2.2** Kinetics of microbial growth	**SL2.2** List out major instruments used for sterilization
	SO2.3 Explain principle of sterilization	**LI2.3** To prepare the different kinds of nutrient media for microbial culture	**CI2.3** Sterilization	**SL2.3** Learn about various categories of fermentation
	SO2.4 Describe types of sterilization		**CI2.4** Types of sterilization	
	SO2.5 Describe physical method		**CI2.5** Physical method	
	SO2.6 Describe chemical method		**CI2.6** Chemical method	
	SO2.7 Describe radiation sterilization		**CI2.7** Radiation sterilization	
	SO2.8 Assess protocol for media preparation		**CI2.8** Media preparation	
	SO2.9 Describe process of media sterilization		**CI2.9** Media sterilization process	
	SO2.10 Assess concept of fermentation		**CI2.10** Mode of fermentation	
	SO2.11 Assess role of condition optimization		**CI2.11** Condition optimization	
	SO2.12 Discuss about microbial growth		**CI2.12** Operations performed	

Suggested Sessional Work (SW): *anyone*		
	SW1.1 Assignments	Write down any 5 kinds of Unit Operations used in Sterilization
	SW1.2 Mini Project	Make a project on showing how microbial colonies grow on different kinds of Culture Media
	SW1.3 Other Activities (Specify)	Derive equations and Numerical problems based on "Modes of Fermentation"

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Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	06	01	05	24

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-02MB301.3. Identify and develop the microbial inoculum for industrial processing	**SO3.1** Define and Describe concept of fermentor	**LI3.1** To Demonstrate the working of a pH electrode	**Unit 1** **CI3.1** Fermentor	**SL3.1** Search various reference books and study material to define various kinds of reactors used in industries
	SO3.2 Describe basic design of fernmentor	**LI3.2** To perform the primary and secondary of microorganisms from different kinds of samples	**CI3.2** Basic design	**SL3.2** Find out the literature showing production of acids and solvents in industries
	SO3.3 Explain construction of fermentor	**LI3.3** To prepare the different kinds of nutrient media for microbial culture	**CI3.3** Construction of fermentor	**SL3.3** Find out how Biogas can be produced
	SO3.4 Describe about ancillaries		**CI3.4** ancillaries	**SL3.4** Write about different bioproducts manufacture in laboratory
	SO3.5 Describe different types of fermentation		**CI3.5** Different types of fermentations	**SL3.5** Find out the applications of Solid-substrate fermentation in industries
	SO3.6 Describe about aerobic fermentation		**CI3.6** Over view of aerobic fermentation	
	SO3.7 Describe about anaerobic fermentation		**CI3.7** Over view of anaerobic fermentation	
	SO3.8 Access protocol for fermentation process		**CI3.8** Fermentation process	
	SO3.9 Describe application of fermentation p0rocess		**CI3.9** Their application in biotechnology industry	
	SO3.10 Assess concept of solid state fermentation		**CI3.10** Solid state fermentation	
	SO3.11 Assess principle and working of SSF		**CI3.11** Principle and working	
	SO3.12 Discuss about Applications of SSF		**CI3.12** Its Applications	

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

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

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	06	01	04	23

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-02MB301.4. Interpretate the mechanism of fermentation process in industry	**SO4.1** Define and Describe concept of submerged fermentor	**LI4.1** To perform the Wine production using fruit waste and yeast	**Unit 1** **CI4.1** Submerged Fermentor	**SL4.1** Find out more on Solvents and their production process
	SO4.2 Describe concept of product development	**LI4.2** To prepare the different kinds of Submerged Substrates for microbial culture	**CI4.2** Product development in fermentation	**SL4.2** List out the difference between Solid and Submerged State Fermentation
	SO4.3 Explain acetone	**LI4.3** To determine the distribution of nutrients through Mass Transfer in reactor	**CI4.3** Acetone	**SL4.3** Explore the role of Diffusion, distribution and Dispersion in Mass transfer
	SO4.4 Describe about butanol		**CI4.4** butanol	**SL4.4** Draw a well labelled diagram of different kinds of bioreactors and its parts
	SO4.5 Describe about ethanol		**CI4.5** ethanol	
	SO4.6 Describe about role of biomass		**CI4.6** Role of biomass in fermentation	
	SO4.7 Describe about fundamental numerical		**CI4.7** Fundamental numerical	
	SO4.8 Access about deviation on mass transfer		**CI4.8** Deviation on mass transfer	
	SO4.9 Describe designing of reactor		**CI4.9** Designing of typical reactor	
	SO4.10 Assess concept of reactor		**CI4.10** principle	
	SO4.11 Assess principle and working of reactor		**CI4.11** working	
	SO4.12 Discuss about Applications of reactor		**CI4.12** Its Applications	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain the role of Solid and Submerged State Fermentation
	SW4.2 Mini Project	Describe how therapeutics being produced in biotech-based industries
	SW4.3 Other Activities (Specify)	Make a list of different kinds of microorganisms which can produce fermented products

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	12	06	01	04	23

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO5-02MB301.5 Examine the mechanism of biological product development using microbes	**SO5.1** Define and Describe concept of downstream processing	**LI5.1** To perform the downstream processing using various unit operations like (filtration)	**Unit 1** **CI5.1** Basics of downstream processing	**SL5.1** Explore the various kinds of downstream processing
	SO5.2 Describe concept of downstream processing in fermentation technology	**LI5.1** To perform the downstream processing using various unit operations like (centrifugation)	**CI5.2** Role of Downstream processing in fermentation technology	**SL5.2** Read research on advancement in fermentration technology
	SO5.3 Explain unit operation	**LI5.3** To prepare the different kinds of Solid Substrates for microbial culture	**CI5.3** Various types of unit operations	**SL5.3** Explore various protocols for the microbial production of other vitamins
	SO5.4 Describe about production of citric acid		**CI5.4** Production of citric Acids	**SL5.4** Explore the various protocols of the microbial production of other amino acids
	SO5.5 Describe about citric acids		**CI5.5** Fermentation conditions of citric Acids	
	SO5.6 Describe about acetic acids fermentation		**CI5.6** Production of acetic acids	
	SO5.7 Describe about acetic acid production process		**CI5.7** Fermentation conditions of acetic Acids	
	SO5.8 Access about vitamin B12 fermentation		**CI5.8** Production of Vitamin B12	
	SO5.9 Describe about vitamin B12 fermentation		**CI5.9** Fermentation conditions of Vitamin B12	
	SO5.10 Assess concept of antibiotic production process		**CI5.10** Production of Antibiotics	
	SO5.11 Assess fermentation conditions of antibiotics		**CI5.11** Fermentation conditions of Antibiotics	
	SO5.12 Discuss about production process of amino acids		**CI5.12** Production of Amino acids	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general characteristics ofDownstream processing and its significance
	SW5.2 Mini Project	Describe the production process of acids and other biomolecules through fermentation
	SW5.3 Other Activities (Specify)	Make a power point presentation on “Downstream Processing and Unit Operations associated with it”

Course duration (in hours)to attain Course Outcomes:

Course Title: Fermentation technology **Course Code:02MB301**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-02MB301.1: Define various modes and techniques of fermentation	12	6	3	1	22
CO2-02MB301.2: Differentiate and predict the suitability of the fermentation methods and vessels	12	6	5	1	24
CO3-02MB301.3: Identify and develop the microbial inoculums for industrial processing	12	6	5	1	24
CO4-02MB301.4: Interpretate the mechanism of fermentation process in industry	12	6	4	1	23
CO5-02MB301.5: Examine the mechanism of biological product development using microbes	12	6	4	1	23
Total Hours	60	30	21	05	116

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

Course Title: Fermentation Technology **Course Code: 02MB301**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-02MB301.1: Define various modes and techniques of fermentation	2	1	1	0	5
CO2-02MB301.2: Differentiate and predict the suitability of the fermentation methods and vessels	2	4	3	0	10
CO3-02MB301.3: Identify and develop the microbial inoculum for industrial processing	3	5	4	1	15
CO4-02MB301.4: Interpretate the mechanism of fermentation process in industry	2	3	2	1	10
CO5-02MB301.5: Examine the mechanism of biological product development using microbes	5	4	2	2	10
Total Marks	**14**	**17**	**12**	**04**	**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
6	Principle of Fermentation Technology-P.F. Stanbury, A. Whitakerand S.J.Hall –Butterworth, 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 Industrial plant of fermentation industries
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Sc. Biotechnology
Semester: III Semester
Course Title: Fermentation Technology
Course Code: 02MB301

CO/PO Mapping															
Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-02MB301.1: Define various modes and techniques of fermentation	-	1	-	1	2	2	1	-	3	1	3	1	1	2	1
CO2-02MB301.2: Differentiate and predict the suitability of the fermentation methods and vessels	-	1	-	-	-	-	3	-	3	2	3	3	3	-	2
CO3-02MB301.3: Identify and develop the microbial inoculums for industrial processing	-	2	1	1	-	-	3	-	3	1	3	3	1	1	1
CO4-02MB301.4: Interpretate the mechanism of fermentation process in industry	1	-	1	-	2	2	2	3	-	1	3	3	2	2	3
CO5-02MB301.5: Examine the mechanism of biological product development using microbes	1	-	2	-	-	2	3	3	-	2	3	3	1	1	2

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO1-02MB301.1:** Define various modes and techniques of fermentation	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10 SO1.11 SO1.12	LI1, LI2 LI3,	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8,1.9, 1.10,1.11, 1.12	**1SL-1,2,3,**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO2-02MB301.2:** Differentiate and predict the suitability of the fermentation methods and vessels	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9 SO2.10 SO2.11 SO2.12	LI1, LI2, LI3,	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9, 2.10, 2.11, 2.12	**2SL-1,2,3,4,5**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO3-02MB301.3:** Identify and develop the microbial inoculum for industrial processing	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7SO3.8 SO3.9 SO3.10 SO3.11 SO3.12	LI1, LI2 LI3,	3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12	**3SL-1,2,3,4,5**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO4-02MB301.4:** Interpretate the mechanism of fermentation process in industry	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10 SO4.11 SO4.12	LI1, LI2, LI3,	4.1,4.2,4.3,4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10,4.11,4.12	**4SL-1,2,3,4**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO502MB301.5:** 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 SO5.10 SO5.11 SO5.12	LI1, LI2, LI3,	5.1,5.2,5.3,5.4,5.5, 5.6,5.7,5.8,5.9,5.10,5.11 5.12	**5SL-1,2,3,4**

Program Name	**Bachelor of Science (Hons.) Biotechnology**	
Semester	III	
CourseCode:	**03BC301**	
Coursetitle:	Clinical Biochemistry	**Curriculum Developer**: Mrs. Pratima Mishra, Guest Faculty
Pre-requisite:	Students should have basic knowledge of Biomolecules, Biochemistry, Clinical Biochemistry	
Rationale:	The Clinical Biochemistry course in a B.Sc. Hons Biotechnology program is essential for understanding biochemical mechanisms underlying human health and disease. It covers principles of biomolecules, enzymology, metabolism, and molecular diagnostics relevant to clinical settings. This knowledge is crucial for developing and interpreting diagnostic tests, monitoring treatment responses, and understanding biochemical basis of diseases. It prepares students for roles in clinical laboratories, pharmaceutical industries, and healthcare sectors, where they contribute to disease diagnosis, treatment development, and personalized medicine. The course integrates theoretical knowledge with practical skills in biochemical analysis, fostering analytical thinking and preparing graduates for careers in biomedical research, healthcare delivery, and biotechnological innovation.	
Course Outcomes (COs):	**CO1-03BC301.1:** Proficiency in assessing fluid and electrolyte balance disorders in disease states, conducting function tests with clinical relevance. **CO2-03BC301.2:** Learning in-depth information regarding the components of metabolic, endocrine, and nutritional disorders and their clinical implications **CO3-03BC301.3:** Recognize various concepts of disease diagnosis, CSF chemistry, detoxification, xenobiotic metabolism, metal toxicity, ageing, cancer, AIDS. **CO4- 03BC301.4:** Gain comprehensive assess of drug action mechanisms, apoptosis in cancer, and medical applications of radioisotopes. **CO5-03BC301.5:** Achieve proficiency in managing disorders of mineral metabolism, trace elements, amino acids, steroids, vitamins, erythrocyte metabolism.	

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)	
Generic Elective	03BT301	Clinical Biochemistry	3	2	1	5	11	3+1=4

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

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
Generic Elective	03BT301	Clinical Biochemistry	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)		
Generic Elective	**03BT301-L**	Clinical Biochemistry	35	5	5	5	50	50	100

Course-Curriculum:

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ApproximateHours

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)
CO1-03BC301.1: Proficiency in assessing fluid and electrolyte balance disorders in disease states, conducting function tests with clinical relevance.	**SO1.1** Define and Describe concept of Fluid & electrolyte balance	**LI1.1** Perform SGPT AND SGOT	**Unit 1** **CI1.1** Fluid & electrolyte balance and imbalance in various diseases.	**SL1.1** Search various reference books and study material to start the learning
	SO1.2 Describe function tests of pancreases,		**CI1.2** Function tests of pancreases,	**SL1.2** Check clinical significance of function test
	SO1.3 Explain function tests of gastric	**LI1.2** Perform Kidney function test	**CI1.3** Function tests of gastric,	**SL1.3** Learn about various categories of body function test
	SO1.4 Describe function tests of Thyroid,		**CI1.4** Function tests of Thyroid,	**SL1.4** Case study related to mall function of body fluid
	SO1.5 Describe function tests of Kidney		**CI1.5** Function tests of Kidney	
	SO1.6 Describe function tests of Liver		**CI1.6** Function tests of Liver	
	SO1.7 Describe direct wander wall's test		**CI1.7** Direct wander wall's test	
	SO1.8 Assess indirect wander wall's test		**CI1.8** Indirect wander wall's test	**SL1.5** case study related to mall function of body components.
	SO1.9 Describe clinical significance of wander wall's test		**CI1.9** clinical significance wander wall's test	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail on different body function test
	SW1.2 Mini Project	Prepare a chart on body function test.
	SW1.3 Other Activities (Specify)	Collect the data about biological role of body functional components

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)
CO2-03BC301.2: Learning in-depth information regarding the components of metabolic, endocrine, and nutritional disorders and their clinical implications	**SO2.1** Assess the concept of Fatty liver and Jaundice		**Unit-II** **CI2.1** Fatty liver, Jaundice	**SL2.1** Enlist the different components of blood test
	SO2.2 Explain about the role of Blood sugars	**LI2.1** Blood Examination	**CI2.2** Blood sugars	**SL2.2** Assess biological role of fat in body
	SO2.3 Explain about the role of Ketone bodies	**LI2.2** Urea Examination	**CI2.3** Ketone bodies	**SL2.3** Learn about role of lipoproteins
	SO2.4 Explain about Diabetes mellitus		**CI2.4** Diabetes mellitus	**SL2.4** Learn sugar imbalance and diabetes.
	SO2.5 Describe the role of Arthritis		**CI2.5** Arthritis	**SL2.5** Learn about Thyroid imbalance and associated issues.
	SO2.6 Describe role of Fats in diseases		**CI2.6** Fats in diseases	
	SO2.7 Discuss about disorder of Thyroid		**CI2.7** Disorders of Thyroid: Hyperthyroidism,	
	SO2.8 Discuss about disorder of Hypothyroidism		**CI2.8** Hypothyroidism	
	SO2.9 Explore the role of Thyroid function test		**CI2.9** Thyroid function Tests: T3, T4, TSH, TRH	

Suggested Sessional Work (SW) : *anyone*	**SW2.1** Assignments	Describe in detail Diabetes mellitus its symptom, diagnosis and treatment
	SW2.2 Mini Project	Explain the role of Thyroid and problems occurred due to its imbalance.
	SW2.3 Other Activities (Specify)	Write an article on clinical role of blood sugar and fat.

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)
CO3-03BC301.3: Recognize various concepts of disease diagnosis, CSF chemistry, detoxification, xenobiotic metabolism, metal toxicity, ageing, cancer, AIDS.	**SO3.1** Explain the concept of enzymes in different diagnosis of diseases & their clinical significance	**SL3.1** Perform ELISA	**Unit-III** **CI3.1** Enzymes in different diagnosis of diseases & their clinical significance	**SL3.1** Read about various Enzymes used in different diagnosis
	SO3.2 Assessing Cerebrospinal fluid (CSF) chemistry and its clinical significance	**SL3.2** Perform RIA	**CI3.2** Cerebrospinal fluid (CSF) chemistry and clinical significance	**SL3.2** Collect the information about Biochemistry of detoxification
	SO3.3 Assessing the Biochemistry of detoxification		**CI3.3** Biochemistry of detoxification	Collect the information about Xenobiotic metabolism
	SO3.4 Assessing mechanism of Xenobiotic metabolism		**CI3.4** Xenobiotic metabolism	
	SO3.5 Describe about mechanism of Metal ion toxicity		**CI3.5** Metal ion toxicity	
	SO3.6 Assessing the role of chelation therapy		**CI3.6** Chelation therapy	**SL3.3** Collect information about inborn impact of chelation therapy
	SO3.7 Describe about role of antioxidant therapy		**CI3.7** antioxidant therapy	**SL3.4** Study about impact of antioxidant therapy
	SO3.8 Assessing mechanism of Ageing		**CI3.8** Biochemistry of Ageing	
	SO3.9 Assessing mechanism and impact of Cancer		**CI3.9** Cancer, AIDS	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail about Biochemistry of detoxification
	SW3.2 Mini Project	Describe the cause symptoms and treatment of Cancer.
	SW3.3 Other Activities (Specify)	Prepare a model for explaining Life cycle of Ageing / HIV virus

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

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO4- 03BC301.4: Gain comprehensive assess of drug action mechanisms, apoptosis in cancer, and medical applications of radioisotopes.	**SO4.1** Exploring mechanism of drug action- Penicillin	**LI4.1** Demonstration of apoptosis	**Unit-IV** **CI4.1** Mechanism of drug action- Penicillin	**SL4.1** Read about various drug action mechanism
	SO4.2 Assessing mechanism of drug action- Tetracycline		**CI4.2** Mechanism of drug action- Tetracycline	**SL4.2** Collect the information about causes of cancer
	SO4.3 Explaining mechanism of drug action- Streptomycin		**CI4.3** Mechanism of drug action- Streptomycin	
	SO4.4 Explaining mechanism of drug action- Chloramphenicol		**CI4.4** Mechanism of drug action- Chloramphenicol	
	SO4.5 Evaluate mechanism of drug action- Sulphonamides.		**CI4.5** Mechanism of drug action- Sulphonamides.	
	SO4.6 Describe the impact of apoptosis		**CI4.6** Apoptosis: Carcinogens	**SL4.3** Collect information about side effect of drugs
	SO4.7 Describe the impact of chemotherapy		**CI4.7** Cancerous growth & Chemotherapy	**SL4.4** Collect information about side effect of chemotherapy
	SO4.8 Describe the impact of radioactivity		**CI4.8** radioactivity	**SL4.5** Collect information about side effect of radiation therapy
	SO4.9 Elaborate the concept of radioisotopes		**CI4.9** radioisotopes in medicine	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe in detail about mechanism of drug action
	SW4.2 Mini Project	Describe the impact of environmental consequences in cancer
	SW4.3 Other Activities (Specify)	Prepare a model for explaining mechanism and treatment of cancer.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	02	01	05	19

Course Outcome (CO)	SessionOutcomes(SOs)	LaboratoryInstruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO5-03BC301.5: Achieve proficiency in managing disorders of mineral metabolism, trace elements, amino acids, steroids, vitamins, erythrocyte metabolism.	**SO5.1** Explore about disorders of mineral metabolism and trace element		**Unit-V** **CI5.1** Disorders of mineral metabolism and trace elements	**SL4.1** Read about various disorders of mineral metabolism
	SO5.2 Able to execute role of hypo-hypercalcemia	**LI5.1** Perform Immunodiagnostic test	**CI5.2** Hypo-Hypercalcemia	**SL4.2** Collect the information about different disorders
	SO5.3 Apply the role of Hypo Hyperphosphatemia		**CI5.3** Hypo Hyperphosphatemia	**SL4.3** Case studies about disorders
	SO5.4 Evaluate the disorders of amino acid		**CI5.4** Disorders of amino acids	
	SO5.5 Assess the disorders of steroids		**CI5.5** Disorders of steroids	**SL4.4** Case studies related to anemia's
	SO5.6 Assess the disorders of vitamins		**CI5.6** Disorders of vitamins	**SL4.5** Case studies thalassemias.
	SO5.7 Explore about disorders of erythrocyte metabolism		**CI5.7** Disorders of erythrocyte metabolism	
	SO5.8 Explore about hemoglobinopathis		**CI5.8** hemoglobinopathis	
	SO5.9 Explore about thalassemias		**CI5.9** Thalassemias, anemia's	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general mechanism of disorders occurred in body.
	SW5.2 Mini Project	Describe the various symptoms and treatments of vitamin disorders.
	SW5.3 Other Activities (Specify)	Prepare one model for showing mechanism of disorders.

Course duration (in hours) to attain Course Outcomes:

Course Title: Clinical Biochemistry **Course Code:03BC301**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-03BC301.1: Proficiency in assessing fluid and electrolyte balance disorders in disease states, conducting function tests with clinical relevance.	9	4	5	1	19
CO2-03BC301.2: Learning in-depth information regarding the components of metabolic, endocrine, and nutritional disorders and their clinical implications	9	4	5	1	19
CO3-03BC301.3: Recognize various concepts of disease diagnosis, CSF chemistry, detoxification, xenobiotic metabolism, metal toxicity, ageing, cancer, AIDS.	9	4	5	1	19
CO4- 03BC301.4: Gain comprehensive assess of drug action mechanisms, apoptosis in cancer, and medical applications of radioisotopes.	9	1	5	1	19
CO5-03BC301.5: Achieve proficiency in managing disorders of mineral metabolism, trace elements, amino acids, steroids, vitamins, erythrocyte metabolism.	9	2	5	1	19
Total Hours	45	15	25	05	95

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

Course Title: Clinical Biochemistry **Course Code:03BC301**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-03BC301.1: Proficiency in assessing fluid and electrolyte balance disorders in disease states, conducting function tests with clinical relevance.	2	1	1	1	5
CO2-03BC301.2: Learning in-depth information regarding the components of metabolic, endocrine, and nutritional disorders and their clinical implications	2	4	2	2	10
CO3-03BC301.3: Recognize various concepts of disease diagnosis, CSF chemistry, detoxification, xenobiotic metabolism, metal toxicity, ageing, cancer, AIDS.	3	5	5	2	15
CO4- 03BC301.4: Gain comprehensive assess of drug action mechanisms, apoptosis in cancer, and medical applications of radioisotopes.	2	3	3	2	10
CO5-03BC301.5: Achieve proficiency in managing disorders of mineral metabolism, trace elements, amino acids, steroids, vitamins, erythrocyte 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	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: B.Sc. (Hons.) Biotechnology
Semester: III Semester
Course Title: Clinical Biochemistry
Course Code: 03BC301

Course Outcome (Cos)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-03BC301.1: Proficiency in assessing fluid and electrolyte balance disorders in disease states, conducting function tests with clinical relevance.	1	2	2	2	3	3	2	3	3	1	2	3	2	2	3
CO2-03BC301.2: Learning in-depth information regarding the components of metabolic, endocrine, and nutritional disorders and their clinical implications	1	2	1	1	2	2	2	2	2	2	2	2	2	3	2
CO3-03BC301.3: Recognize various concepts of disease diagnosis, CSF chemistry, detoxification, xenobiotic metabolism, metal toxicity, ageing, cancer, AIDS.	1	2	2	2	1	2	1	1	2	1	2	2	1	2	2
CO4- 03BC301.4: Gain comprehensive assess of drug action mechanisms, apoptosis in cancer, and medical applications of radioisotopes.	1	1	2	1	2	3	2	2	3	2	1	3	1	2	3
CO5-03BC301.5: Achieve proficiency in managing disorders of mineral metabolism, trace elements, amino acids, steroids, vitamins, erythrocyte metabolism.	1	2	2	1	1	3	1	1	3	2	2	3	1	2	3

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO1-03BC301.1:** Proficiency in assessing fluid and electrolyte balance disorders in disease states, conducting function tests with clinical relevance.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	1.1,1.2,	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8, 1.9,	1SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO2-03BC301.2:** Learning in-depth information regarding the components of metabolic, endocrine, and nutritional disorders and their clinical implications	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	2.1, 2.2,	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, ,	2SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO3-03BC301.3:** Recognize various concepts of disease diagnosis, CSF chemistry, detoxification, xenobiotic metabolism, metal toxicity, ageing, cancer, AIDS.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	3.1,3.2	3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8, 3.9,	3SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO4- 03BC301.4:** Gain comprehensive assess of drug action mechanisms, apoptosis in cancer, and medical applications of radioisotopes.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	4.1,	4.1,4.2,4.3,4.4, 4.5, 4.6,4.7, 4.8, 4.9,	4SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO5-03BC301.5:** Achieve proficiency in managing disorders of mineral metabolism, trace elements, amino acids, steroids, vitamins, erythrocyte metabolism.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 S05.8 SO5.9	5.1,	5.1,5.2,5.3,5.4,5.5, 5.6, 5.7, 5.8, 5.9,	5SL-1,2,3,4,5

Program Name	**Bachelor of Science (B.Sc.)- Biotechnology**	
Semester	III	
Course Code:	**03MB301**	
Course title:	Fermentation Technology	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of microbiology	
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):	**CO1-03MB301.1.** Define various modes and techniques of fermentation **CO2-03MB301.2.** Differentiate and predict the suitability of the fermentation methods and vessels **CO3-03MB301.3.** Identify and develop the microbial inoculum for industrial processing **CO4-03MB301.4.** Interpretate the mechanism of fermentation process in industry **CO5-03MB301.5.** Examine the mechanism of biological product development using microbes	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme ofstudies (Hours/Week)					Total Credits(C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
MINOR	**03MB301**	Fermentation Technology	3	2	1	4	10	3+1=4

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

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
Minor	03MB301	Fermentation Technology	15	20	5	5	5	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)		
Minor	03MB301-L	Fermentation Technology	35	5	5	5	50	50	100

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx. Hrs** | 09 | 04 | 01 | 03 | 17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-03MB301.1. Define various modes and techniques of fermentation	**SO1.1** Define and Describe concept of fermentation	**LI1.1** Media sterilization	**Unit 1** **CI1.1** Introduction to fermentation	**SL1.1** Search various reference books and study material to start the learning
	SO1.2 Describe history of fermentation	**LI1.2** Isolation of microbes	**CI1.2** History of fermentation	**SL1.2** List out major contributors of fermentation
	SO1.3 Explain principle of fermentation		**CI1.3** Principle of fermentation	**SL1.3** Learn about various categories of fermentation
	SO1.4 Describe fermentation industry		**CI1.4** Development of Fermentation Industry	
	SO1.5 Describe requirement of fermentation		**CI1.5** General Requirement for fermentation Process	
	SO1.6 Describe factors affecting fermentation		**CI1.6** Factors affecting fermentation	
	SO1.7 Describe isolation of microbes		**CI1.7** Isolation of industrially important microbes	
	SO1.8 Assess protocol for media preparation, strain improvement		**CI1.8** Media preparation, Strain improvement	
	SO1.9 Assess role of condition optimization, microbial growth		**CI1.9** Condition optimization, Growth and incubation	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail "Applications of Microorganisms in various Sectors"
	SW1.2 Mini Project	Make a project on "Historical Process of Fermentation and Products produced in India"
	SW1.3 Other Activities (Specify)	List down the tables of different domains of microorganisms which are industrially important

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

Approximate Hours

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

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-03MB301.2. Differentiate and predict the suitability of the fermentation methods and vessels	**SO2.1** Define and Describe concept of inoculate	**LI2.1** To perform the primary and secondary of microorganisms from different kinds of samples	**Unit 1** **CI2.1** Development of inoculate for industrial fermentation	**SL2.1** Search various reference books and study material to start the learning
	SO2.2 Describe kinetics of microbial growth	**LI2.2** To prepare the different kinds of nutrient media for microbial culture	**CI2.2** Kinetics of microbial growth	**SL2.2** List out major instruments used for sterilization
	SO2.3 Explain principle of sterilization		**CI2.3** Sterilization	**SL2.3** Learn about various categories of fermentation
	SO2.4 Describe types of sterilization		**CI2.4** Types of sterilization	
	SO2.5 Assess protocol for media preparation		**CI2.5** Media preparation	
	SO2.6 Describe process of media sterilization		**CI2.6** Media sterilization process	
	SO2.7 Assess concept of fermentation		**CI2.7** Mode of fermentation	
	SO2.8 Assess role of condition optimization		**CI2.8** Condition optimization	
	SO2.9 Discuss about microbial growth		**CI2.9** Operations performed	

Suggested Sessional Work (SW): *anyone*		
	SW1.1 Assignments	Write down any 5 kinds of Unit Operations used in Sterilization
	SW1.2 Mini Project	Make a project on showing how microbial colonies grow on different kinds of Culture Media
	SW1.3 Other Activities (Specify)	Derive equations and Numerical problems based on “Modes of Fermentation”

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)
CO1-03MB301.3. Identify and develop the microbial inoculum for industrial processing	**SO3.1** Define and Describe concept of fermentor	**LI3.1** To perform the primary and secondary of microorganisms from different kinds of samples	**Unit 1** **CI3.1** Fermentor	**SL3.1** Search various reference books and study material to define various kinds of reactors used in industries
	SO3.2 Describe basic design of fernmentor	**LI3.2** To prepare the different kinds of nutrient media for microbial culture	**CI3.2** Basic design	**SL3.2** Find out the literature showing production of acids and solvents in industries
	SO3.3 Explain construction of fermentor		**CI3.3** Construction of fermentor ancillaries	**SL3.3** Find out how Biogas can be produced
	SO3.4 Describe different types of fermentation		**CI3.4** Different types of fermentations	**SL3.4** Write about different bioproducts manufacture in laboratory
	SO3.5 Describe about aerobic fermentation		**CI3.5** Over view of aerobic and anaerobic fermentation	**SL3.5** Find out the applications of Solid-substrate fermentation in industries
	SO3.6 Access protocol for fermentation process		**CI3.6** Fermentation process	
	SO3.7 Describe application of fermentation p0rocess		**CI3.7** Their application in biotechnology industry	
	SO3.8 Assess concept of solid state fermentation		**CI3.8** Solid state fermentation	
	SO3.9 Discuss about Applications of SSF		**CI3.9** Its Applications	

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

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx. Hrs** | 09 | 03 | 01 | 04 | 17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-03MB301.4. Interpretate the mechanism of fermentation process in industry	**SO4.1** Define and Describe concept of submerged fermentor	**LI4.1** To perform the Wine production using fruit waste and yeast	**Unit 1** **CI4.1** Submerged Fermentor	**SL4.1** Find out more on Solvents and their production process
	SO4.2 Describe concept of product development	**LI4.2** To prepare the different kinds of Submerged Substrates for microbial culture	**CI4.2** Product development in fermentation	**SL4.2** List out the difference between Solid and Submerged State Fermentation
	SO4.3 Explain acetone		**CI4.3** Acetone	**SL4.3** Explore the role of Diffusion, distribution and Dispersion in Mass transfer
	SO4.4 Describe about butanol		**CI4.4** butanol	**SL4.4** Draw a well labelled diagram of different kinds of bioreactors and its parts
	SO4.5 Describe about ethanol		**CI4.5** ethanol	
	SO4.6 Describe about role of biomass		**CI4.6** Role of biomass in fermentation	
	SO4.7 Access about deviation on mass transfer		**CI4.7** Fundamental numerical Deviation on mass transfer	
	SO4.8 Describe designing of reactor		**CI4.8** Designing of typical reactor	
	SO4.9 Discuss about Applications of reactor		**CI4.9** Its Applications	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain the role of Solid and Submerged State Fermentation
	SW4.2 Mini Project	Describe how therapeutics being produced in biotech-based industries
	SW4.3 Other Activities (Specify)	Make a list of different kinds of microorganisms which can produce fermented products

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	04	14

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO5-03MB301.5 Examine the mechanism of biological product development using microbes	**SO5.1** Define and Describe concept of downstream processing		**Unit 1** **CI5.1** Basics of downstream processing	**SL5.1** Explore the various kinds of downstream processing
	SO5.2 Describe concept of downstream processing in fermentation technology		**CI5.2** Role of Downstream processing in fermentation technology	**SL5.2** Read research on advancement in fermentration technology
	SO5.3 Explain unit operation		**CI5.3** Various types of unit operations	**SL5.3** Explore various protocols for the microbial production of other vitamins
	SO5.4 Describe about production of citric acid		**CI5.4** Production of citric Acids	**SL5.4** Explore the various protocols of the microbial production of other amino acids
	SO5.5 Describe about citric acids		**CI5.5** Fermentation conditions of citric Acids	
	SO5.6 Describe about acetic acids fermentation		**CI5.6** Production of acetic acids	
	SO5.7 Access about vitamin B12 fermentation		**CI5.7** Production of Vitamin B12	
	SO5.8 Assess concept of antibiotic production process		**CI5.8** Production of Antibiotics	
	SO5.9 Discuss about production process of amino acids		**CI5.9** Production of Amino acids	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general characteristics ofDownstream processing and its significance
	SW5.2 Mini Project	Describe the production process of acids and other biomolecules through fermentation
	SW5.3 Other Activities (Specify)	Make a power point presentation on “Downstream Processing and Unit Operations associated with it”

Course duration (in hours)to attain Course Outcomes:

Course Title: Fermentation technology **Course Code:03MB301**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-03MB301.1: Define various modes and techniques of fermentation	09	4	3	1	17
CO2-03MB301.2: Differentiate and predict the suitability of the fermentation methods and vessels	09	4	3	1	17
CO3-03MB301.3: Identify and develop the microbial inoculums for industrial processing	09	4	5	1	19
CO4-03MB301.4: Interpretate the mechanism of fermentation process in industry	09	3	4	1	17
CO5-03MB301.5: Examine the mechanism of biological product development using microbes	09	0	4	1	14
Total Hours	45	15	19	05	84

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

Course Title: Fermentation Technology **Course Code: 03MB301**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-03MB301.1: Define various modes and techniques of fermentation	2	1	1	0	5
CO2-03MB301.2: Differentiate and predict the suitability of the fermentation methods and vessels	2	4	3	0	10
CO3-03MB301.3: Identify and develop the microbial inoculum for industrial processing	3	5	4	1	15
CO4-03MB301.4: Interpretate the mechanism of fermentation process in industry	2	3	2	1	10
CO5-03MB301.5: Examine the mechanism of biological product development using microbes	5	4	2	2	10
Total Marks	**14**	**17**	**12**	**04**	**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
6	Principle of Fermentation Technology-P.F. Stanbury, A. Whitakerand S.J.Hall –Butterworth, 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 Industrial plant of fermentation industries
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Sc. Biotechnology
Semester: III Semester
Course Title: Fermentation Technology
Course Code: 03MB301

CO/PO Mapping															
Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-03MB301.1: Define various modes and techniques of fermentation	-	1	-	1	2	2	1	-	3	1	3	1	1	2	1
CO2-03MB301.2: Differentiate and predict the suitability of the fermentation methods and vessels	-	1	-	-	-	-	3	-	3	2	3	3	3	-	2
CO3-03MB301.3: Identify and develop the microbial inoculums for industrial processing	-	2	1	1	-	-	3	-	3	1	3	3	1	1	1
CO4-03MB301.4: Interpretate the mechanism of fermentation process in industry	1	-	1	-	2	2	2	3	-	1	3	3	2	2	3
CO5-03MB301.5: Examine the mechanism of biological product development using microbes	1	-	2	-	-	2	3	3	-	2	3	3	1	1	2

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO1-03MB301.1:** Define various modes and techniques of fermentation	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,**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO2-03MB301.2:** Differentiate and predict the suitability of the fermentation methods and vessels	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,**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO3-03MB301.3:** Identify and develop the microbial inoculum for industrial processing	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7SO3.8 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, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO4-03MB301.4:** Interpretate the mechanism of fermentation process in industry	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**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO503MB301.5:** 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	,	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9,	**5SL-1,2,3,4**

Program Name	**Bachelor of Science (Hons.) Biotechnology**	
Semester	III	
CourseCode:	04BT301	
Coursetitle:	Plant Tissue Culture Technology	**Curriculum Developer**: Dr. Deepak Mishra, Professor
Pre-requisite:	Students should have basic knowledge of Botany, Biotechnology and Biochemistry	
Rationale:	The Plant Tissue Culture Technology course is integral to the B.Sc. (Hons.) Biotechnology program as it imparts essential skills in manipulating plant cells and tissues. Students learn sterile techniques, media formulation, culture methods for genetic engineering and crop improvement. This course fosters practical expertise in tissue culture methodologies, preparing students for careers in agricultural biotechnology, plant biotechnology, and biotech industries. Understanding plant tissue culture enhances students' ability to innovate in sustainable agriculture, bioprospecting, and conservation biology. It equips them with foundational knowledge to contribute to advancements in biotechnological research, addressing global challenges in food security and environmental sustainability.	
Course Outcomes (COs):	**CO1-04BT301.1:** Proficiency in assessing principles of plant tissue culture, lab organization, media preparation, sterilization techniques, culture initiation. **CO2-04BT301.2:** Learning in-depth information regarding plant tissue culture methods including callus culture, organogenesis, and embryo culture techniques. **CO3-04BT301.3:** Explore protoplast isolation, culture, somatic hybridization, selection of hybrids, cybrids, somaclonal variation, mechanisms, and applications. **CO4- 04BT301.4:** Gain comprehensive assesses of haploid plant production methods, including anther culture, microspore culture, androgenesis, and gynogenesis. **CO5-04BT301.5:** Achieve proficiency in virus-free plant production, germplasm conservation, artificial seed preparation, PGPR and acclimatization,	

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)	
SEC	04BT301	Plant Tissue Culture Technology	3	2	1	5	11	3+1=4

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

Scheme of Assessment: Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
SEC	04BT301	Plant Tissue Culture 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)		
SEC	**04BT301-L**	Plant Tissue Culture Technology	35	5	5	5	50	50	100

Course-Curriculum:

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

ApproximateHours

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)
CO1-04BT301.1: Proficiency in assessing principles of plant tissue culture, lab organization, media preparation, sterilization techniques, culture initiation.	**SO1.1** Define and Describe concept of plant tissue culture	**LI1.1** Study organization and instrumentation in PTC	**Unit 1** **CI1.1** Introduction to Plant Tissue Culture	**SL1.1** Search various reference books and study material to start the learning
	SO1.2 Describe historical prospective of PTC,		**CI1.2** Historical Prospective	**SL1.2** Collect information about organization of PTC Lab
	SO1.3 Explain about PTC Lab organization	**LI1.2** Media preparation and sterilization	**CI1.3** general organization of PTC Lab	**SL1.3** Learn about various categories of PTC
	SO1.4 Describe about PTC Media,		**CI1.4** Plant tissue Culture Media	**SL1.4** standardize the protocol for explants sterilization .
	SO1.5 Describe about stock solution		**CI1.5** Stock Solution Preparation	
	SO1.6 Describe about sterilization techniques		**CI1.6** Sterilization techniques	
	SO1.7 Describe about culture initiation		**CI1.7** Culture Initiation	
	SO1.8 Assess about totipotency		**CI1.8** Totipotency	**SL1.5** standardize the protocol for culture intiation
	SO1.9 Describe Cryo and organogenic differentiation		**CI1.9** Cryo and organogenic differentiation	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Describe in detail on plant tissue culture lab and PTC methods
	SW1.2 Mini Project	Prepare a chart on totipotency
	SW1.3 Other Activities (Specify)	Collect the data about biological role of plant tissue culture techniques.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	10	06	01	05	22

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
CO2-04BT301.2: Learning in-depth information regarding plant tissue culture methods including callus culture, organogenesis, and embryo culture techniques.	**SO2.1** Assess the concept of different Methods of Plant Tissue Culture	**LI2.1** Perform shoot tip culture	**Unit-II** **CI2.1** Different Methods of Plant Tissue Culture	**SL2.1** Enlist the different methods of plant tissue culture
	SO2.2 Explain about the role of Callus Culture		**CI2.2** Callus Culture	**SL2.2** Assess biological role of plant tissue culture
	SO2.3 Explain about the role of Cell Suspension Culture	**LI2.2** Perform callus culture	**CI2.3** Cell Suspension Culture	**SL2.3** Standardize the protocol for callus culture
	SO2.4 Explain about Single Cell Culture	**LI2.3** Perform root culture	**CI2.4** Single Cell Culture	**SL2.4** Standardize the protocol for cell suspension culture
	SO2.5 Describe the role of Organ Culture	.	**CI2.5** Organ Culture	**SL2.5** Standardize the protocol for Single cell culture .
	SO2.6 Describe role of Shoot Meristem Culture		**CI2.6** Shoot Meristem Culture	
	CI2.7 Describe Organogenesis		**CI2.8** Organogenesis	
	SO2.7 Assess the role of Somatic Embryogenesis		**CI2.9** Somatic Embryogenesis	
	SO2.8 Discuss about Embryo Culture and Embryo rescue		**CI2.10** Embryo Culture and Embryo rescue	

Suggested Sessional Work (SW) : *anyone*	**SW2.1** Assignments	Describe in detail callus culture and characterization of callus
	SW2.2 Mini Project	Explain the role of hormones in organogenesis.
	SW2.3 Other Activities (Specify)	Make a chart on plant tissue culture methods.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	10	04	01	05	20

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-04BT301.3: Explore protoplast isolation, culture, somatic hybridization, selection of hybrids, cybrids, somaclonal variation, mechanisms, and applications.	**SO3.1** Explain the concept of Protoplast Isolation and fusion	**SL3.1** Perform organogenesis	**Unit-III** **CI3.1** Protoplast Isolation and fusion	**SL3.1** Read about various components used in protoplast isolation and protoplast fusion
	SO3.2 Assessing Methods of protoplast isolation		**CI3.2** Methods of protoplast isolation	**SL3.2** Standardize protocol for protoplast isolation and protoplast culture
	SO3.3 Assessing the Protoplast culture	**SL3.2** Perform protoplast fusion	**CI3.3** Protoplast culture	
	SO3.4 Assessing mechanism of Somatic hybridization		**CI3.4** Somatic hybridization	**SL3.3** Standardize protocol for protoplast fusion
	SO3.5 Describe about identification and selection of hybrid cells		**CI3.5** identification and selection of hybrid cells	**SL3.4** Collect information about impact of protoplast fusion on hybrid production
	SO3.6 Assessing the role of Cybrids		**CI3.6** Cybrids	**SL3.5** Collect information about impact of somaclonal variation
	SO3.7 Describe about role of somatic hybridization		**CI3.7** Potential of somatic hybridization its limitations	
	SO3.8 Assessing mechanism of somaclonal variation		**CI3.8** Somaclonal variation-Mechanism	
	SO3.9 Assessing methods of somaclonal variation		**CI3.9** Somaclonal variation - Methods	
	SO3.10 Assessing application of somaclonal variation		**CI3.10** Somaclonal variation - Applications	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail about mechanism of protoplast fusion
	SW3.2 Mini Project	Describe the criteria used for identification of somaclones.
	SW3.3 Other Activities (Specify)	Prepare a model for representing process of protoplast isolation, culture and fusion.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	10	00	01	05	16

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO4- 04BT301.4: Gain comprehensive assesses of haploid plant production methods, including anther culture, microspore culture, androgenesis, and gynogenesis.	**SO4.1** Exploring mechanism of In vitro haploid production		**Unit-IV** **CI4.1** In vitro haploid production	**SL4.1** Read about various methods used for haploid plant production
	SO4.2 Assessing role of Anther culture		**CI4.2** Anther culture	**SL4.2** Standardize the protocol for anther culture
	SO4.3 Explaining the role of Androgenic methods		**CI4.3** Androgenic methods	
	SO4.4 Explaining the role of Microspore culture		**CI4.4** Microspore culture	**SL4.3** Standardize the protocol for Microspore culture
	SO4.5 Evaluate the role of androgenesis		**CI4.5** Androgenesis Significance and use of haploids	
	SO4.6 Describe the Ploidy level and chromosome doubling		**CI4.6** Ploidy level and chromosome doubling	
	SO4.7 Describe the impact of diplodization		**CI4.7** diplodization	**SL4.4** Collect information about impact of androgenesis
	SO4.8 Describe the impact of Gynogenic haploids		**CI4.8** Gynogenic haploids	**SL4.5** Collect information about impact of gynogenesis
	SO4.9 Elaborate the concept of Factors affecting gynogenesis		**CI4.9** Factors affecting gynogenesis	
	SO4.10 Elaborate Chromosome elimination techniques		**CI4.10** Chromosome elimination techniques for production of haploids in cereals.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe in detail about mechanism of haploid plant production
	SW4.2 Mini Project	Describe the impact of chromosome elimination on haploid production.
	SW4.3 Other Activities (Specify)	Prepare a model for explaining process of haploid plant production

Item	Cl	LI	SW	SL	Total
Approx.Hrs	06	02	01	05	14

Course Outcome (CO)	SessionOutcomes(SOs)	LaboratoryInstruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO5-04BT301.5: Achieve proficiency in virus-free plant production, germplasm conservation, artificial seed preparation, PGPR and acclimatization,	**SO5.1** Explore about production of virus free plants		**Unit-V** **CI5.1** Production of Virus Free Plants	**SL4.1** Read about various methods used for production of virus free plants.
	SO5.2 Able to execute role of germplasm conservation		**CI5.2** Germplasm Conservation	**SL4.2** Study impact of germplasm conservation
	SO5.3 Apply the role of artificial seed preparation	**LI5.1** Production of artificial seeds	**CI5.3** Artificial Seed Preparation	**SL4.3** Study impact of artificial seeds
	SO5.4 Evaluate the role of PGPR		**CI5.4** Plant Growth Promoting Bacteria	**SL4.4** Study impact of PGPR.
	SO5.5 Assess the role of acclimatization		**CI5.5** Concept and Methods of Acclimatization	**SL4.5** Standardize protocol for hardening
	SO5.6 Assess the application of plant tissue culture		**CI5.6** Application of Plant Tissue Culture	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general mechanism of germplasm conservation.
	SW5.2 Mini Project	Describe the various techniques of virus free plant production.
	SW5.3 Other Activities (Specify)	Prepare one model for showing process of acclimatization.

Course duration (in hours) to attain Course Outcomes:

Course Title: Plant Tissue Culture Technology **Course Code:**04BT301

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-04BT301.1: Proficiency in assessing principles of plant tissue culture, lab organization, media preparation, sterilization techniques, culture initiation.	09	4	5	1	19
CO2-04BT301.2: Learning in-depth information regarding plant tissue culture methods including callus culture, organogenesis, and embryo culture techniques.	10	6	5	1	22
CO3-04BT301.3: Explore protoplast isolation, culture, somatic hybridization, selection of hybrids, cybrids, somaclonal variation, mechanisms, and applications.	10	4	5	1	20
CO4- 04BT301.4: Gain comprehensive assesses of haploid plant production methods, including anther culture, microspore culture, androgenesis, and gynogenesis.	10	0	5	1	16
CO5-04BT301.5: Achieve proficiency in virus-free plant production, germplasm conservation, artificial seed preparation, PGPR and acclimatization,	06	2	5	1	14
Total Hours	45	16	25	05	91

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

Course Title: Plant Tissue Culture Technology **Course Code:** 04BT301

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-04BT301.1: Proficiency in assessing principles of plant tissue culture, lab organization, media preparation, sterilization techniques, culture initiation.	2	1	1	1	5
CO2-04BT301.2: Learning in-depth information regarding plant tissue culture methods including callus culture, organogenesis, and embryo culture techniques.	2	4	2	2	10
CO3-04BT301.3: Explore protoplast isolation, culture, somatic hybridization, selection of hybrids, cybrids, somaclonal variation, mechanisms, and applications.	3	5	5	2	15
CO4- 04BT301.4: Gain comprehensive assesses of haploid plant production methods, including anther culture, microspore culture, androgenesis, and gynogenesis.	2	3	3	2	10
CO5-04BT301.5: Achieve proficiency in virus-free plant production, germplasm conservation, artificial seed preparation, PGPR and acclimatization,	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	Bhojwani, S.S. and Razdan 2504 Plant Tissue Culture and Practice.
2	Brown, T. A. Gene cloning and DNA analysis: An Introduction. Blackwell Publication.
3	Gardner, E.J. Simmonns, M.J. Snustad, D.P. 2508 8th edition Principles of Genetics. Wiley India.
4	Raven, P.H., Johnson, GB., Losos, J.B. and Singer, S.R. 2505 Biology. Tata MC Graw Hill.
5	Reinert, J. and Bajaj, Y.P.S. 1997 Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture. Narosa Publishing House.
6	Russell, P.J. 2509 Genetics – A Molecular Approach. 3rdedition. Benjamin Co.
7	Sambrook & Russel. Molecular Cloning: A laboratory manual. (3rd edition)
8	Slater, A., Scott, N.W. & Fowler, M.R. 2508 Plant Biotechnology: The Genetic Manipulation of Plants, 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 virology lab (BSL-3)
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B.Sc. (Hons.) Biotechnology
Semester: III Semester
Course Title: Plant Tissue Culture Technology
Course Code: 04BT301

Course Outcome (Cos)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-04BT301.1: Proficiency in assessing principles of plant tissue culture, lab organization, media preparation, sterilization techniques, culture initiation.	1	2	2	2	1	2	2	3	3	1	2	3	2	2	3
CO2-04BT301.2: Learning in-depth information regarding plant tissue culture methods including callus culture, organogenesis, and embryo culture techniques.	2	2	1	1	2	2	2	2	2	2	2	2	2	2	2
CO3-04BT301.3: Explore protoplast isolation, culture, somatic hybridization, selection of hybrids, cybrids, somaclonal variation, mechanisms, and applications.	1	1	2	2	1	2	1	1	2	1	2	2	1	1	2
CO4- 04BT301.4: Gain comprehensive assesses of haploid plant production methods, including anther culture, microspore culture, androgenesis, and gynogenesis.	2	2	2	1	2	1	2	2	3	2	1	3	1	2	3
CO5-04BT301.5: Achieve proficiency in virus-free plant production, germplasm conservation, artificial seed preparation, PGPR and acclimatization,	2	1	2	1	2	2	1	1	3	2	2	3	1	1	3

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO1-04BT301.1:** Proficiency in assessing principles of plant tissue culture, lab organization, media preparation, sterilization techniques, culture initiation.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	1.1,1.2,	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9,	1SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO2-04BT301.2:** Learning in-depth information regarding plant tissue culture methods including callus culture, organogenesis, and embryo culture techniques.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9 SO2.10	2.1, 2.2, 2.3	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10,	2SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO3-04BT301.3:** Explore protoplast isolation, culture, somatic hybridization, selection of hybrids, cybrids, somaclonal variation, mechanisms, and applications.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9 SO3.10	3.1,3.2,	3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 3.10,	3SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO4- 04BT301.4:** Gain comprehensive assesses of haploid plant production methods, including anther culture, microspore culture, androgenesis, and gynogenesis.	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, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10	4SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO5-04BT301.5:** Achieve proficiency in virus-free plant production, germplasm conservation, artificial seed preparation, PGPR and acclimatization,	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6	5.1,	5.1, 5.2, 5.3, 5.4, 5.5, 5.6,	5SL-1,2,3,4,5

Program name	**Bachelor of Science (B.Sc.)- Biotechnology**	
Semester	IV	
CourseCode:	01BT401	
Coursetitle:	Genetics	Developer: Dr. Kamlesh Kumar Soni, Assistant Professor
Pre-requisite:	Student should have basic knowledge biology	
Rationale:	The study of genetics students is essential for understanding the fundamental principles of inheritance, variation, and evolution. It equips students with knowledge crucial for medical advancements, biotechnology, and research in biological sciences. Genetics also has significant applications in fields such as forensic science, agriculture, and environmental management. It prepares students to address ethical, legal, and social issues related to genetic technologies. Overall, genetics provides a strong foundation for diverse career opportunities in science and technology.	
CourseOutcomes (COs):	**01BT401CO1**Students will comprehend the introduction to the Genetics and essentiality of cell cycles and heredity **01BT401CO2**Students will understand non-allelic genetic interactions and the organization of the eukaryotic nuclear genomeand the functions of centromeres and telomeres. **01BT401CO3**Students will understand the genetic organization of prokaryotic and viral genomes, the structure and characteristics of bacterial and eukaryotic chromosomes, and the concepts of euchromatin, heterochromatin, gene structure, and genetic coding. **01BT401CO4**The outcome of this syllabus is a comprehensive understanding of genetic mutations, chromosomal structure variations, sex determination mechanisms, and their implications in inheritance and genetic disorders **01BT401CO5**A deep understanding of genetic linkage, crossing over, chromosome mapping, extra chromosomal inheritance mechanisms, and evolutionary principles in population genetics	

Scheme of Studies:

Board ofStudy	CourseCode	CourseTitle	Scheme ofstudies (Hours/Week)					Total Credits(C) (L:T:P=4:0:2)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
MAJOR	01BT401	Genetics	4	4	1	3	12	4+2=6

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	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)		
MAJOR	01BT401	Genetics	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)		
MAJOR	**01BT401-L**	Genetics	35	5	5	5	50	50	100

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

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	03	22

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
01BT401**CO 1:**Students will comprehend the introduction to the genetics and essentiality of cell cycles and heredity	SO 1.1: Will be understanding the basic of genetics	LI 1.1: Modern organics; display	CI 1.1:Introduction: Historical developments in the field of genetics; Organisms suitable for geneticexperimentation and their genetic significance	SL 1.1: Study about the basic of gene
	SO 1.2: know about the importance of cell cycles	LI1.2: Preparation of slides to see the cell cycle phases	CI1.2: Cell Cycle: Mitosis and Meiosis:,	SL1.2: Learn about fundamental of cell cycles
	SO 1.3: understand the control points in cell cycle	LI1.3: Preparation of slides to see the Meiosis	CI1.3: Control points in cell-cycle progression in yeast. Role of meiosis in life cycles of organisms.	SL1.3: Study the fundamentals of chromosome pairing.
	SO 1.4: learn about concept of medallion genetics		CI1.4: Mendelian genetics: Mendel's experimental design,	
	SO 1.5: learn about different types of crosses		CI1.5: monohybrid, di-hybrid and tri hybrid crosses,	
	SO 1.6: learn how characters segregate and assort		CI1.6: Law of segregation & Principle of independent assortment	
	SO 1.7: How alleles intact to govern a phenotypes		CI1.7: Verification of segregates by test and back crosses,	
	SO 1.8 Explain about chromosomal theory of inheritance		CI1.8: Chromosomal theory of inheritance	
	SO 1.9: How alleles intact to govern a phenotypes		CI1.9: Allelic interactions: Concept of dominance, recessiveness,	
	SO 1.10: illustrate about different types of dominance		CI1.10: incomplete dominance, co-dominance, semi-dominance,	
	SO 1.11: Explain about pleiotropy, multiple alleles		CI1.11: pleiotropy, multiple alleles	
	SO 1.12: know why some allele are important for survival		CI1.12:Pseudo-allele, essential and lethal genes	

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Brief the cell cycle
	SW1.2 Mini Project	Explain different laws of mendal's
	SW1.3 Other Activities (Specify)	Watch animation on alleles and their function

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

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

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
01BT401CO2 Students will understand non-allelic genetic interactions and the organization of the eukaryotic nuclear genomeand the functions of centromeres and telomeres	SO2.1: know the basics of non-allelic interaction	LI2.1: Photograph of chromosome organization	CI2.1:Non allelic interactions: Interaction producing new phenotype	SL2.1: Study about the alleles and allelomorph
	SO2.2: Assess about Complementary genes, epistasis (dominant & recessive),	LI2.2: Preparation of slides to see the Mitosis I	CI2.2: Complementary genes, epistasis (dominant & recessive),	SL2.2: Gain basic information chromosome and importance of their various location
	SO2.3 Assess about duplicate genes and inhibitory genes	LI2.3: Preparation of slides to see the Mitosis II	CI2.3: duplicate genes and inhibitory genes.	
	SO2.4: explain about chromosomal organization		CI2.4: Chromosome and genomic organization	
	SO2.5: how eukaryotic chromosomes are arranged in a cell		CI2.5: Eukaryotic nuclear genome nucleotide sequence composition	
	SO2.6: learn why repetitive DNA is important		CI2.6: Unique & repetitive DNA,	
	SO2.7: learn why satellite DNA is important		CI2.7: satellite DNA	
	SO2.7: learn why centromere and telomere are important		CI2.8: Centromere and telomere DNA sequences	
	SO2.9: know about multiple repetitive sequences		CI2.9: Middle repetitive sequences-	
	SO2.10: know the essentiality of VNTRs		CI2.10: VNTRs & dinucleotide repeats	
	SO2.11: know the essentiality of LINES and SINEs		CI2.11: Repetitive transposed sequences- SINEs & LINEs,	
	SO2.12: know the essentiality of repetitive DNA		CI2.12: middle repetitive multiple copy genes	

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Explain the intron and exon
	SW1.2 Mini Project	Prepare the poster explaining Genetic interaction with example of complementary gene
	SW1.3 Other Activities (Specify)	Explain how centromere and telomeres are important

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

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	05	24

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
01BT401CO3 Students will understand the genetic organization of prokaryotic and viral genomes, the structure and characteristics of bacterial and eukaryotic chromosomes, and the concepts of euchromatin, heterochromatin, gene structure, and genetic coding	SO3.1: Discuss about hoe viral ang bacterial genome are organised	LI3.1: Karyotyping	CI3.1: Genetic organization of prokaryotic and viral genome	SL3.1: Build-up the concept on the genome and gene
	SO3.2: will understand the packaging of chromosome	LI3.2: DNA isolation	CI3.2: Structure and characteristics of bacterial chromosome	SL3.2: Advance the knowledgeabout chromosome organization
	SO3.3: Will understand the chromosome structure		CI3.3: Structure and characteristics of eukaryotic chromosome	
	SO3.4: will understand about chromosomal morphology	LI3.3: PCR	CI3.4:. Chromosome morphology	SL3.3: Clear the basic concept of the transactional regulation at chromosome level
	SO3.5: Arrangement of Chromosomes and expression of genes present on them		CI3.5: Concept of euchromatin and heterochromatin	SL3.4: Boost your knowledge onhistone and non-histone protein , DNA-protein interaction
	SO3.6: Learn how such long DNA is packaged in small cell		CI3.6: Packaging of DNA molecule into chromosomes	SL3.5 Know about the arrangement of the chromosome based on their size
	SO3.7: Gain knowledge about chromosome morphology		CI3.7: Chromosome banding pattern, ,	
	SO3.8: know more about karyotype		CI3.8: karyotype,	
	SO3.9: Know more of giant chromosome		CI3.9: Giant chromosomes	
	SO3.10: how one gene produce one polypeptide and protein		CI3.10: One gene one polypeptide hypothesis	
	SO3.11: Know more of various components of gene		CI3.11: Concept of cistron, exons, introns,	
	SO3.12: Know more of genetic code		CI3.12: Concept of genetic code	

Suggested Sessional Work (SW): *anyone*	Assignments:	Describe the Giant chromosome
	Mini Project:	Draw chromosomes packaging in a poster
	Other Activities (Specify):	Prepare the Giant chromosome in a poster

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

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	04	23

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
01BT401CO4 The outcome of this syllabus is a comprehensive understanding of genetic mutations, chromosomal structure variations, sex determination mechanisms, and their implications in inheritance and genetic disorders	SO4.1: learning why mutation is important	LI4.1:Demonstration of - Barr Body -Rhoeo translocation	CI4.1: Chromosome and gene mutations: Definition and types of mutations, causes of mutations	SL4.1: learn how mutation is created
	SO4.2: Know the biology mutant microorganism	LI4.1:Demonstration of – Ame's Test	CI4.2: Ame's test for mutagenic agents, screening procedures for isolation of mutants and uses of mutants,	SL4.2: Read how mutants are screened
	SO4.3: How variation in whole chromosomes occurs	LI4.1:Demonstration of – Chromosome structure	CI4.3: Variations in chromosomes structure-deletion, duplication, inversion and translocation (reciprocal and Robertsonian), position effects of gene expression, chromosomal aberrations	SL4.3: Detailing on the chromosome structural variations
	SO4.4: Lean how variation occur in single chromosome		CI4.4:Chromosomal abnormalities– Aneuploidy and Euploidy	SL4.4: Learn the effect of chromosome abnormalities
	SO4.5: Will be able to understand the sex determination in organisms		CI4.5: Sex determination	
	SO4.6: Discuss sex linkage		CI4.5: sex linkage	
	SO4.7: Will be able to understand the sex determination in organisms		CI4.7: Mechanisms of sex determination	
	SO4.8: Know how various external factor affect the sex determination		CI4.8: Environmental factors and sex determination,	
	SO4.9: Will be able to understand the sex differentiation		CI4.9: sex differentiation	
	SO4.10: Discuss mechanism of Barr bodies		CI4.10: Barr bodies, dosage compensation,	
	SO4.11: Know about genetic balance theory		CI4.11: genetic balance theory,	
	SO4.12: understand about chromosome		CI4.12: Fragile-X-syndrome and chromosome	

Suggested Sessional Work (SW): *anyone*	Assignments:	Explain the mutation and their types
	Mini Project:	Explain in detail about chromosome aberrations
	Other Activities (Specify):	Prepare a poster explaining the sex determination

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

ApproximateHours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	05	24

Course outcome (COs)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
01BT401CO5A deep understanding of genetic linkage, crossing over, chromosome mapping, extra chromosomal inheritance mechanisms, and evolutionary principles in population genetics	SO5.1: Know linkage affect the phenotype.	LI 5.1: Demonstration of linkage	CI5.1: Genetic linkage, crossing over	SL5.1: Principle of linkage
	SO5.2: how tightly genes are linked	LI5.2:Study of polyploidy in onion root tip by colchicine treatment	CI5.2: Chromosome mapping	SL5.2: Study fundamental of recombination
	SO5.2: Learn how recombination produces new phenotype	LI5.3: Pedigree charts of some common characters like blood group, color blindness and PTC tasting	CI5.3: Linkage and Recombination of genes in a chromosome crossing over,	SL5.3: Study molecular mechanism of regulation
	SO5.3: Understand the cytological changes occur during the crossing over		CI5.4:Cytological basis of crossing over, Molecular mechanism of crossing over	SL5.4: read in details about the extra chromosomal factor that affect the phonotype
	SO5.4: Know the importance of multiple crossing over		CI5.5: Crossing over at four strand stage, Multiple crossing overs Genetic mapping	
	SO5.5: Learn about extra chromosomal inheritance		CI5.6: Extra chromosomal inheritance:	
	SO5.6: How maternal material affect the phenotypes		CI5.7: Rules of extra nuclear inheritance	
	SO5.8: discuss about maternal inheritance		CI5.8: Maternal effects, maternal inheritance,	SL5.5: Learn the population genetics
	SO5.8: explain about cytoplasmic inheritance		CI5.9: cytoplasmic inheritance, organelle heredity,	
	SO5.8: Explain genomic impriniting		CI5.10: genomic imprinting	
	SO5.8: discuss about population genetics		CI5.11: Evolution and population genetics: In breeding and out breeding	
	SO5.8: discuss about Hary Weinberg Law		CI5.12: Hardy Weinberg law (prediction, derivation).	

Suggested Sessional Work (SW): Anyone	Assignments:	In details explain the maternal effect
	Mini Project:	Explain the crossing over
	Other Activities (Specify):	Explain the linkage and recombination

Course duration (in hours) to attain Course Outcomes (Course title: Genetics **(Course code:)**					
Course Outcomes(COs)	**Class lecture(CI)**	**LaboratoryInstruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
01BT401CO 1 Students will comprehend the introduction to the genetics and essentiality of cell cycles and heredity	12	6	3	1	22
01BT401CO2 Students will understand non-allelic genetic interactions and the organization of the eukaryotic nuclear genomeand the functions of centromeres and telomeres	12	6	2	1	21
01BT401CO3 Students will understand the genetic organization of prokaryotic and viral genomes, the structure and characteristics of bacterial and eukaryotic chromosomes, and the concepts of euchromatin, heterochromatin, gene structure, and genetic coding	12	6	5	1	24
01BT401CO4 The outcome of this syllabus is a comprehensive understanding of genetic mutations, chromosomal structure variations, sex determination mechanisms, and their implications in inheritance and genetic disorders	12	6	4	1	23
01BT401CO5:A deep understanding of genetic linkage, crossing over, chromosome mapping, extra chromosomal inheritance mechanisms, and evolutionary principles in population genetics	12	6	5	1	24
Total Hours	60	30	19	05	114

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome: Course title: Genetic Engineering & Technology**) (Course code:)**					
Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
01BT401CO1 Students will comprehend the introduction to the genetics and essentiality of cell cycles and heredity	2	1	1	1	5
01BT401CO2 Students will understand non-allelic genetic interactions and the organization of the eukaryotic nuclear genomeand the functions of centromeres and telomeres	2	4	2	2	10
01BT401CO3 Students will understand the genetic organization of prokaryotic and viral genomes, the structure and characteristics of bacterial and eukaryotic chromosomes, and the concepts of euchromatin, heterochromatin, gene structure, and genetic coding	3	5	5	2	15
01BT401CO4 The outcome of this syllabus is a comprehensive understanding of genetic mutations, chromosomal structure variations, sex determination mechanisms, and their implications in inheritance and genetic disorders	2	3	3	2	10
01BT401CO5 A deep understanding of genetic linkage, crossing over, chromosome mapping, extra chromosomal inheritance mechanisms, and evolutionary principles in population genetics	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	Principles of Genetics	Gardner, E.J., Simmons, M.J., Snustad, D.P.	John Wiley & Sons	8& 2006
2	Principles of Genetics	Michael J. Simmons, D. Peter Snustad	Wiley	7& 2015
3	*i*Genetics- A Molecular Approach	Peter J. Russell	Benjamin Cummings, San Francisco	3& 2010

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 and PSO Mapping

Program Title: B. Sc. Biotechnology, 4thSem
Course Code: 01BT401
Course Title: Genetics

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**
01BT401CO1 Students will comprehend the introduction to the genetics and essentiality of cell cycles and heredity	**3**	**3**	**1**	**1**	**-**	**-**	**2**	**1**	**1**	**3**	**3**	**2**	**2**	**2**	**2**
01BT401CO2 Students will understand non-allelic genetic interactions and the organization of the eukaryotic nuclear genomeand the functions of centromeres and telomeres	**1**	**1**	**2**	**2**	**2**	**-**	**1**	**1**	**-**	**2**	**3**	**2**	**2**	**2**	**1**
01BT401CO3 Students will understand the genetic organization of prokaryotic and viral genomes, the structure and characteristics of bacterial and eukaryotic chromosomes, and the concepts of euchromatin, heterochromatin, gene structure, and genetic coding	**1**	**3**	**2**	**3**	**2**	**-**	**-**	**2**	**3**	**1**	**1**	**2**	**3**	**3**	**1**
01BT401CO4 The outcome of this syllabus is a comprehensive understanding of genetic mutations, chromosomal structure variations, sex determination mechanisms, and their implications in inheritance and genetic disorders	**2**	**3**	**3**	**2**	**2**	**2**	**-**	**1**	**1**	**2**	**1**	**-**	**1**	**1**	**3**
01BT401CO5 A deep understanding of genetic linkage, crossing over, chromosome mapping, extra chromosomal inheritance mechanisms, and evolutionary principles in population genetics	**2**	**-**	**2**	**-**	**1**	**3**	**2**	**2**	**1**	**3**	**2**	**2**	**3**	**2**	**3**
Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3															

Program Title: B. Sc. Biotechnology, 4th Sem
Course Code:01BT401
Course Title: Genetics

Course Curriculum Map:					
POs & PSOs No.	COs No	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	**01BT401CO1** Students will comprehend the introduction to the genetics and essentiality of cell cycles and heredity	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10 SO1.11 SO1.12	1.1,1.2,1.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.12	1 SL-1,2,3
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**01BT401CO2** Students will understand non-allelic genetic interactions and the organization of the eukaryotic nuclear genomeand the functions of centromeres and telomeres	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9 SO2.10 SO2.11 SO2.12	2.1, 2.2, 2.3,	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 SL-1,2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**01BT401CO3**Students will understand the genetic organization of prokaryotic and viral genomes, the structure and characteristics of bacterial and eukaryotic chromosomes, and the concepts of euchromatin, heterochromatin, gene structure, and genetic coding	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9 SO3.10 SO3.11 SO3.12	3.1,3.2,3.3	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 SL-1,2,3,4,5
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**01BT401CO4**The outcome of this syllabus is a comprehensive understanding of genetic mutations, chromosomal structure variations, sex determination mechanisms, and their implications in inheritance and genetic disorders	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10 SO4.11 SO4.12	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, 4.11, 4.12	4 SL-1,2,3,4
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**01BT401CO5** A deep understanding of genetic linkage, crossing over, chromosome mapping, extra chromosomal inheritance mechanisms, and evolutionary principles in population genetics	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 S05.9 SO5.10 SO5.11 SO5.12	5.1,5.2,5.3	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 SL-1,2,3,4,5

Program Name	**Bachelor of Science (Hons.) in Biotechnology**	
Semester	IV	
Course Code:	02BC401	
Course title:	Enzymology	**Curriculum Developer**: Dr. Deepak Mishra, Professor
Pre-requisite:	Student should have basic knowledge of Biotechnology, Biochemistry and Molecular Biology.	
Rationale:	The Enzymology course in a B.Sc. Hons. Biotechnology program serves a crucial role by providing students with comprehensive knowledge and practical skills in the study of enzymes. Enzymes are fundamental to understanding biological processes at the molecular level, pivotal in fields ranging from healthcare and pharmaceuticals to agriculture and environmental science. This course equips students with an understanding of enzyme structure, function, regulation, and kinetics, essential for designing and optimizing biotechnological processes. By exploring enzyme mechanisms and their applications in biotechnology, students develop the proficiency to innovate and solve complex biological problems, preparing them for careers in research, development, and industrial applications within the biotechnology sector.	
Course Outcomes (COs):	**CO1-02BC401.1:** Familiarization with the basic concepts, key principles and mechanism of actions of enzymes. **CO2-02BC401.2:** Acquired Skills to analyze mechanism of single substrate enzyme catalyzed reaction and enzyme inhibition kinetics **CO3-02BC401.3:** Equipped to comprehend the fundamentals of bi and multi substrate kinetics and enzyme catalysis **CO4-02BC401.4:** Recognize various methods related to Protein Ligand binding enzyme immobilization and Protein engineering. **CO5-02BC401.5:** Explore role of enzyme extraction and purification and diverse applications of enzymes in various fields.	

Scheme of Studies:

Board of Study	**Course Code**	**Course Title**	**Scheme of studies (Hours/Week)**					**Total Credits(C) (L:T:P=4:0:2)**
			Cl	LI	SW	SL	**Total Study Hours(CI+LI+SW+SL)**	
MINOR	02BC401	Enzymology	4	4	1	5	13	4+2=6

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)		
MINOR	02BC401	Enzymology	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)		
MINOR	02BC401-L	Enzymology	35	5	5	5	50	50	100

Course-Curriculum:

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

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	06	01	05	24

Course outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Class room Instruction(CI)**	**Self-Learning(SL)**
CO1-02BC401.1: Familiarization with the basic concepts, key principles and mechanism of actions of enzymes.	**SO1.1** Define and Describe concept of enzyme	**LI1.1** Determination of enzyme activity	**Unit-1** **CI1.1** Enzymes: Introduction	**SL1.1** Search various reference books and study material to start the learning of enzymes
	SO1.2 Explain nomenclature of enzyme	**LI1.2** study the effect of pH on enzyme activity	**CI1.2** Nomenclature of Enzyme	**SL1.2** Examine role of enzymes in biological system
	SO1.3 Explain IUB Nomenclature System		**CI1.3** IUB Nomenclature System	**SL1.3** Examine the effect of different factors on enzyme
	SO1.4 Explain classification of enzyme	**LI1.3** study the effect of Temperature on enzyme activity	**CI1.4** Classification	**SL1.4** Enlist the enzymes.
	SO1.5 Explore Characteristics of enzyme		**CI1.5** characteristics of enzyme	**SL1.5** Examine the presence in enzyme in biological systems
	SO1.6 Study the factor affecting enzyme activity		**CI1.6** Factors affecting enzyme activity	
	SO1.7 Study about pH sensitivity		**CI1.7** pH Sentivity	
	SO1.8 Study about thermolability		**CI1.8** Thermolability	
	SO1.9 Study the enzyme specificity		**CI1.9** Enzyme Specificity	
	SO1.10 Study the theories of ES Complex formation		**CI1.10** Theories of enzyme substrate complex formation	
	SO1.11 Study the Lock and Key Model		**CI1.11** Lock and Key Model	
	SO1.12 Study the Induced Fit Hypothesis		**CI1.12** Induced Fit Hypothesis	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail biological significance of enzymes
	SW1.2 Mini Project	Prepare a list of enzymes used in biological reaction and biological systems
	SW1.3 Other Activities (Specify)	Preparation of laboratory manual for studying enzymes.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	06	01	05	24

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-02BC401.2: Acquired Skills to analyze mechanism of single substrate enzyme catalyzed reaction and enzyme inhibition kinetics	**SO2.1** Explore the concept Kinetics of single substrate reaction	**LI2.1** study the effect of Km	**Unit-II** **CI2.1** Enzyme Kinetics: Kinetics of single substrate reaction,	**SL2.1** Search various books and resources for study the enzyme kinetics
	SO2.2 Describe the Michaelis Menton equation	**LI2.2** study the effect of Vmax	**CI2.2** Michaelis Menton equation	**SL2.2** study about different kintic parameters
	SO2.3 Reflecting Briggs-Haldane modification	**LI2.3** study the effect of Substrate Concentration	**CI2.3** Briggs-Haldane modification	
	SO2.4 Explain Line Weaver Burk Plot		**CI2.4** Line Weaver Burk Plot	**SL2.3** to learn about plots of enzyme activity
	SO2.5 Assessing Eadie-Hofstee and hanes plot		**CI2.5** Eadie-Hofstee and hanes plot	**SL2.4** standardize the protocol for enzyme activity
	SO2.6 Explaining the concept of enzyme inhibition		**CI2.6** Enzyme Inhibition: Concept	**SL2.5** to learn models of enzyme kinetics
	SO2.7 Explaining the types of inhibition		**CI2.7** types of inhibition	
	SO2.8 Explaining the kinetics of inhibition		**CI2.8** Kinetics of Enzyme Inhibition	
	SO2.9 Explaining the kinetics of Competitive inhibition		**CI2.9** Kinetics of Competitive Inhibition	
	SO2.10 Explaining kinetics of Uncompetitive inhibition		**CI2.10** Kinetics of Un Competitive Inhibition	
	SO2.11 Explaining kinetics of Non Competitive inhibition		**CI2.11** Kinetics of Non Competitive Inhibition	
	SO2.12 Explaining the kinetics of Mixed inhibition		**CI2.12** Kinetics of Mixed Inhibition	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Assess the impact on enzyme kinetics in biological system
	SW2.2 Mini Project	Designing of poster for showing plots of enzyme kinetics
	SW2.3 Other Activities (Specify)	To analysed the impact of enzyme kinetics in living organisms

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	06	01	05	24

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction (CI)	Self-Learning(SL)
CO3-02BC401.3: Equipped to comprehend the fundamentals of bi and multi substrate kinetics and enzyme catalysis.	**SO3.1** Explain the concept Bi Bi reaction	**LI3.1** study the effect of enzyme inhibition	**Unit-III** **CI3.1** Classification of BiBi reaction	**SL3.1** Study about example of bi bi reaction
	SO3.2 Assessing the concept of Ping pong bibi mechanism		**CI3.2** Ping pong BiBi mechanism	**SL3.2** Study different types of mechanisms of bibi reaction
	SO3.3 Explaining Kinetics of Alberty equation	**LI3.2** study the effect of kinetic parameters	**CI3.3** Alberty Equation	**SL3.3** categorization of different kinetic parameters
	SO3.4 Assessing Kinetics of Dalziel Equation	**LI3.2** study the effect of Enzyme Concentration	**CI3.4** Dalziel Equation	
	SO3.5 Describe Mechanism of multi-substrate kinetics		**CI3.5** Multisubstrate Kinetics	**SL3.4** Study of role of multi substrate reaction
	SO3.6 Assessing the concept of Allosteric enzyme		**CI3.6** Allosteric Enzyme	**SL3.5** Assess models for studying allosteric enzymes
	SO3.7 Describe about MWC model		**CI3.7** MWC model.	
	SO3.8 Describe about KNF Model		**CI3.8** KNF model.	
	SO3.9 Describe concwept of enzyme catalysis		**CI3.9** Enzyme catalysis	
	O3.10 Describe mechanism of enzyme catalysis		**CI3.10** Mechanism of enzyme catalysis	
	SO3.11 Assessing the concept of Chymotripsin		**CI3.11** Chymotripsin	
	SO3.12 Describe about Ribonuclease		**CI3.12** Ribonuclease	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail about kinetics of enzyme inhibition
	SW3.2 Mini Project	Describe the role of factors on enzyme catalysis.
	SW3.3 Other Activities (Specify)	Prepare a an article on protein ligand binding and its impact.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	06	01	05	24

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO4-02BC401.4: Recognize various methods related to Protein Ligand binding enzyme immobilization and Protein engineering.	**SO4.1** Exploring the concept of Protein Ligand Binding	**LI4.1** to perform enzyme immobilization by gel entrapment methods	**Unit-IV** **CI4.1** Protein Ligand Binding	**SL4.1** Learn about different categories of Protein ligand binding
	SO4.2 Assessing role of cooperativity	**LI4.2** To perform enzyme immobilization by covalent binding	**CI4.2** Cooperativity	
	SO4.3 Explaining the hill equation	**LI4.3** To perform enzyme immobilization	**CI4.3** Hill Equation	**SL4.2** Compare application of enzyme immobilization
	SO4.4 Explaining the adhair equation.		**CI4.4** Adhair Equation	**SL4.3** Learn about various protein ligand complex
	SO4.5 Evaluate impact of immobilization		**CI4.5** Enzyme Immobilization: Basic concept	**SL4.4** optimization of protocol for enzymes immobilization
	SO4.6 evaluate the methods of immobilization		**CI4.6** Methods of immobilization	**SL4.5** optimization of protocol for enzyme extraction
	SO4.7 Discuss Benefits and Limitations of immobilization		**CI4.7** Benefits and Limitations of immobilization	
	SO4.8 Describe the application of enzyme immobilization		**CI4.8** Application of immobilized enzyme	
	SO4.9 Basic Concept of Protein Engineering		**CI4.9** Basic concept of Protein Engineering	
	SO4.10 Basic mechanism of Protein Engineering		**CI4.10** Basic mechanism of Protein Engineering	
	SO4.11 Describe site directed mutagenesis		**CI4.11** Site Directed Mutagenesis	
	SO4.12 Discuss its mechanism		**CI4.12** Mechanism of Site directed mutagensis	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain about different types of enzyme immobilization techniques and its impact.
	SW4.2 Mini Project	Standardize the protocol for enzyme immobilization.
	SW4.3 Other Activities (Specify)	Prepare one article on protein engineering

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	05	24

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO5-02BC401.5: Explore role of enzyme extraction and purification and diverse applications of enzymes in various fields.	**SO5.1** Elaborate the concept of Enzyme extraction	**LI5.1** To perform enzyme purification	**Unit-V** **CI5.1** Extraction of enzyme	**SL5.1** Learn about basic concept of enzyme engineering
	SO5.2 Elaborate the concept of Enzyme purification	**LI5.2** To perform enzyme Extraction	**CI5.2** Purification of Enzymes	**SL5.2** Learn about role purification of enzyme
	SO5.3 Elaborate the application of enzyme engineering	**LI5.3** To perform chromatography for enzyme	**CI5.3** Application of enzyme engineering	**SL5.3** Learn about biological function of enzyme
	SO5.4 Elaborate the role of enzyme in molecular biology		**CI5.4** enzyme engineering in molecular biology	**SL5.4** Learn about applications of enzyme in nutrition
	SO5.5 Elaborate the role of enzyme engineering		**CI5.5** Application of enzyme engineering in animal nutrition	**SL5.5** Learn about role & biosensors
	SO5.6 Elaborate concept of enzyme electrode		**CI5.6** enzyme electrodes-Concept	
	SO5.7 Explain types of enzyme electrode		**CI5.7** types of enzyme electrodes	
	SO5.8 Assess application of biosensor in industries		**CI5.8** their application as biosensors in industry	
	SO5.9 Explain concept of biosensor		**CI5.9** Concept of biosensors	
	SO5.10 Elaborate types of biosensor		**CI5.10** types of biosensor	
	SO5.11 Elaborate application of biosensor in Health care		**CI5.11** biosensors in health care	
	SO5.12 Elaborate application of biosensor in environment		**CI5.12** biosensors in environment.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general application of enzyme in industries and different areas
	SW5.2 Mini Project	Describe the role of enzyme engineering and site directed mutagenesis
	SW5.3 Other Activities (Specify)	Prepare a detail document on enzyme electrode and biosensors

Course duration (in hours) to attain Course Outcomes:

Course Title: Enzymology **Course Code:**02BC401

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-02BC401.1: Familiarization with the basic concepts, key principles and mechanism of actions of enzymes.	12	6	5	1	24
CO2-02BC401.2: Acquired Skills to analyze mechanism of single substrate enzyme catalyzed reaction and enzyme inhibition kinetics	12	6	5	1	24
CO3-02BC401.3: Equipped to comprehend the fundamentals of bi and multi substrate kinetics and enzyme catalysis	12	6	5	1	24
CO4-02BC401.4: Recognize various methods related to Protein Ligand binding enzyme immobilization and Protein engineering.	12	6	5	1	24
CO5-02BC401.5: Explore role of enzyme extraction and purification and diverse applications of enzymes in various fields.	12	6	5	1	24
Total Hours	60	30	25	05	120

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

Course Title: Enzymology **Course Code:** 02BC401

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-02BC401.1: Familiarization with the basic concepts, key principles and mechanism of actions of enzymes.	2	1	1	1	5
CO2-02BC401.2: Acquired Skills to analyze mechanism of single substrate enzyme catalyzed reaction and enzyme inhibition kinetics	2	4	2	2	10
CO3-02BC401.3: Equipped to comprehend the fundamentals of bi and multi substrate kinetics and enzyme catalysis	2	3	3	2	10
CO4-02BC401.4: Recognize various methods related to Protein Ligand binding enzyme immobilization and Protein engineering.	3	5	5	2	15
CO5-02BC401.5: Explore role of enzyme extraction and purification and diverse applications of enzymes in various fields.	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	Enzymes by Palmer (2001): Horwood Publishing Series.
2	Fundamentals of Enzymology by Price and Stevens (2002): Oxford University Press.
3	Enzyme Technology by Helmut uhling (1998): John Wiley
4	Introduction to Proteins Structure by Branden and Tooze (1998): Garland Publishing Group.
5	Lehninger's Principles of Biochemistry: Nelson & Cox

(b) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B Sc. (Hons.) Biotechnology
Semester: IV Semester
Course Title: Enzymology
Course Code: 02BC401

Course Outcome (Cos)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-02BC401.1: Familiarization with the basic concepts, key principles and mechanism of actions of enzymes.	2	2	3	2	3	3	2	2	2	1	3	2	3	2	3
CO2-02BC401.2: Acquired Skills to analyze mechanism of single substrate enzyme catalyzed reaction and enzyme inhibition kinetics	2	1	2	1	2	2	2	1	1	2	2	1	2	3	3
CO3-02BC401.3: Equipped to comprehend the fundamentals of bi and multi substrate kinetics and enzyme catalysis	2	2	2	2	2	2	3	2	2	1	2	2	1	1	3
CO4-02BC401.4: Recognize various methods related to Protein Ligand binding enzyme immobilization and Protein engineering.	1	1	3	1	3	3	3	1	2	2	3	1	2	2	3
CO5-02BC401.5: Explore role of enzyme extraction and purification and diverse applications of enzymes in various fields.	2	1	3	1	3	3	3	1	1	2	3	1	2	2	2

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO1-02BC401.1:** Familiarization with the basic concepts, key principles and mechanism of actions of enzymes.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10 SO1.11 SO1.12	1.1,1.2,1.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.12	1SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO2-02BC401.2:** Acquired Skills to analyze mechanism of single substrate enzyme catalyzed reaction and enzyme inhibition kinetics	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9 SO2.10 SO2.11 SO2.12	2.1, 2.2, 2.3,	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11, 2.12	2SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO3-02BC401.3:** Equipped to comprehend the fundamentals of bi and multi substrate kinetics and enzyme catalysis	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9 SO3.10 SO3.11 SO3.12	3.1,3.2,3.3	3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12	3SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO4-02BC401.4:** Recognize various methods related to Protein Ligand binding enzyme immobilization and Protein engineering.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10 SO4.11 SO4.12	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, 4.11, 4.12	4SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO5-02BC401.5:** Explore role of enzyme extraction and purification and diverse applications of enzymes in various fields.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 S05.9 SO5.10 SO5.11 SO5.12	5.1,5.2,5.3	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 5.10, 5.11, 5.12	5SL-1,2,3,4,5

Program Name	**B.Sc. (Hons.) Biotechnology**	
Semester	**IV**	
CourseCode:	**02MB401**	
Coursetitle:	**Medical Microbiology**	**Curriculum Developer**: Mrs. Maahi Choure, Guest Faculty
Pre-requisite:	Understanding fundamental concepts in biology, including cell biology, genetics, and basic microbiology.	
Rationale:	Medical microbiology is essential for understanding the role of microorganisms in human health and disease. This field provides critical insights into how pathogens cause disease, how the immune system responds, and the mechanisms of action for antibiotics and vaccines. Knowledge gained from medical microbiology is crucial for diagnosing, treating, and preventing infectious diseases, which remains a significant challenge in global health.	
CourseOutcomes (COs):	**CO1-02MB401.1:** Understand the fundamentals of microbial ecology and human microbiota **CO2-02MB401.2:** Analyze the morphology, pathogenesis, and laboratory diagnosis of gram-positive bacterial infections **CO3-02MB401.3:** Examine the characteristics and management of gram-negative bacterial infections **CO4-02MB401.4:** Analyze the etiology and characteristics of viral infections **CO5-02MB401.5:** Evaluate the clinical features and treatment of fungal and protozoan infections	

Scheme of Studies:

Board ofStudy	**CourseCode**	**CourseTitle**	**Scheme ofstudies (Hours/Week)**					**Total Credits(C) (L:T:P=4:0:2)**
			Cl	LI	SW	SL	**Total Study Hours(CI+LI+SW+SL)**	
MINOR	02MB401	Medical Microbiology	4	4	1	2	11	4+2=6

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)		
MINOR	02MB401	Medical 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)		
MINOR	02MB401-L	Medical Microbiology	35	5	5	5	50	50	100

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**ApproximateHours** **Item** | Cl | LI | SW | SL | Total **Approx.Hrs** | 12 | 06 | 01 | 02 | 21

Course outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction(CI)	Self-Learning(SL)
CO1-02MB401.1: : Understand the fundamentals of microbial ecology and human microbiota	**SO1.1** Introduction to Normal Microflora	**LI1.1** Learn how to handle pathogens	**CI1.1** Introduction to Normal Microflora	**SL1.1** Remember Carriers in Disease Transmission
	SO1.2 Role and Importance of Normal Microflora	**LI1.1** Perform sterilization	**CI1.2** Role and Importance of Normal Microflora	**SL1.2** Explore microflora of university
	SO1.3 Introduction to Nosocomial Infections	**LI1.1** identification of toxins	**CI1.3** Introduction to Nosocomial Infections	
	SO1.4 Carriers in Disease Transmission		**CI1.4** Carriers in Disease Transmission	
	SO1.5 Septic Shock and Septicemia		**CI1.5** Septic Shock and Septicemia	
	SO1.6 Concept of Pathogenicity		**CI1.6** Concept of Pathogenicity	
	SO1.7 Virulence Factors		**CI1.7** Virulence Factors	
	SO1.8 Types and Mechanisms of Toxins		**CI1.8** Types and Mechanisms of Toxins	
	SO1.9 Biosafety Levels		**CI1.9** Biosafety Levels	
	SO1.10 Normal Microflora		**CI1.10** Normal Microflora	
	SO1.11 Nosocomial Infections		**CI1.11** Nosocomial Infections	
	SO1.12 Analysis on Septic Shock		**CI1.12** Analysis on Septic Shock	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Summarizes theAnalysis on Septic Shock.
	SW1.2 Mini Project	DemonstrateTypes and Mechanisms of Toxins.
	SW1.3 Other Activities (Specify)	

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	6	1	2	21

Course Outcome (CO)	SessionOutcomes (SOs)	LaboratoryInstruction (LI)	ClassroomInstruction (CI)	Self Learning (SL)
CO2-02MB401.2: Analyze the morphology, pathogenesis, and laboratory diagnosis of gram-positive bacterial infections	**SO2.1** Introduction to Gram-Positive Bacteria	**LI2.1** Prepare morphology and Pathogenesis of *S. aureus* wet lab	**CI2.1** Introduction to Gram-Positive Bacteria	**SL2.1** Research on M. tuberculosis
	SO2.2 Morphology and Pathogenesis of *S. aureus*	**LI2.2** Perform diagnosis of S. pyogenes	**CI2.2** Morphology and Pathogenesis of *S. aureus*	**SL2.2** Case Study on C. diphtheriae
	SO2.3 Symptoms and Laboratory Diagnosis of *S. aureus*	**LI2.3** Perform diagnosis of B. anthracis	**CI2.3** Symptoms and Laboratory Diagnosis of *S. aureus*	
	SO2.4 Preventive Measures and Chemotherapy for *S. aureus*		**CI2.4** Preventive Measures and Chemotherapy for *S. aureus*	
	SO2.5 Morphology, Pathogenesis, and Symptoms of *S. pyogenes*		**CI2.5** Morphology, Pathogenesis, and Symptoms of *S. pyogenes*	
	SO2.6 Laboratory Diagnosis and Chemotherapy for *S. pyogenes*		**CI2.6** Laboratory Diagnosis and Chemotherapy for *S. pyogenes*	
	SO2.7 Pathogenesis and Symptoms of *B. anthracis*		**CI2.7** Pathogenesis and Symptoms of *B. anthracis*	
	SO2.8 Preventive Measures and Chemotherapy for *B. anthracis*		**CI2.8** Preventive Measures and Chemotherapy for *B. anthracis*	
	SO2.9 Clostridium Species (*C. perfringens, C. tetani, C. botulinum*)		**CI2.9** Clostridium Species (*C. perfringens, C. tetani, C. botulinum*)	
	SO2.10 Pathogenesis and Symptoms of*M.tuberculosis*		**CI2.10** Pathogenesis and Symptoms of *M. tuberculosis*	
	SO2.11 Pathogenesis and Symptoms of*M. leprae*		**CI2.11** Pathogenesis and Symptoms of *M. leprae*	
	SO2.12 Laboratory Diagnosis and Chemotherapy for *M. leprae*		**CI2.12** Laboratory Diagnosis and Chemotherapy for *M. leprae*	

Suggested Sessional Work (SW):*anyone*	**SW2.1** Assignments	Justify the role ofPreventive Measures and Chemotherapy.
	SW2.2 Mini Project	Understand the pathogenesis of M. leprae.
	SW2.3 Other Activities (Specify)	Remember laboratory diagnosis technique.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	**6**	**1**	2	**21**

Course Outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Class room Instruction (CI)**	**Self-Learning(SL)**
CO3-02MB401.3: Examine the characteristics and management of gram-negative bacterial infections	**SO3.1** Introduction to Gram-Negative Bacteria	**LI3.1** Identification of gram negative bacteria	**CI3.1** Introduction to Gram-Negative Bacteria	**SL3.1**Practice local alignment
	SO3.2 Morphology and Pathogenesis of *E. coli*	**LI3.2** Identification of gram positive bacteria	**CI3.2** Morphology and Pathogenesis of *E. coli*	**SL3.2**Practice global alignment
	SO3.3 Symptoms and Laboratory Diagnosis of *N. gonorrhoeae*	**LI3.3** Identification of pathogens	**CI3.3** Symptoms and Laboratory Diagnosis of *N. gonorrhoeae*	
	SO3.4 Preventive Measures and Chemotherapy for N. meningitidis		**CI3.4** Preventive Measures and Chemotherapy for *N. meningitidis*	
	SO3.5 Pathogenesis and Symptoms of *P. aeruginosa*		**CI3.5** Pathogenesis and Symptoms of *P. aeruginosa*	
	SO3.6 Laboratory Diagnosis and Chemotherapy for *S. typhi*		**CI3.6** Laboratory Diagnosis and Chemotherapy for *S. typhi*	
	SO3.7 Morphology and Pathogenesis of *S. dysenteriae*		**CI3.7** Morphology and Pathogenesis of *S. dysenteriae*	
	SO3.8 Preventive Measures and Chemotherapy for *Y. pestis*		**CI3.8** Preventive Measures and Chemotherapy for *Y. pestis*	
	SO3.9 Overview of *H. influenzae*		**CI3.9** Overview of *H. influenzae,*	
	SO3.10 Overview of *V. cholerae*		**CI3.10** Overview of *M. pneumoniae*	
	SO3.11 Overview of *M. pneumoniae*		**CI3.11** Overview of *M. pneumoniae*	
	SO3.12 Overview of *T. pallidum M. pneumoniae, Rickettsiaceae, Chlamydiae.*		**CI3.12** Overview of *T. pallidum M. pneumoniae, Rickettsiaceae, Chlamydiae.*	

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

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	**6**	**1**	2	**21**

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO4-02MB401.4: Analyze the etiology and characteristics of viral infections	**SO4.1** Introduction to Viral Diseases	**LI4.1** Compare and contrast the pathogenesis, symptoms, and treatment of different viral families	**CI4.1** Introduction to Viral Diseases	**SL4.1** Learn techniques of preventive measures
	SO4.2 Morphology and Pathogenesis of Picornaviruses	**LI4.2** How to identify the HIV/AIDS	**CI4.2** Morphology and Pathogenesis of Picornaviruses	**SL4.2** Understand symptoms of various diseases
	SO4.3 Symptoms and Laboratory Diagnosis of Orthomyxoviruses	**LI4.3** Diagnosis of viral infections	**CI4.3** Symptoms and Laboratory Diagnosis of Orthomyxoviruses	
	SO4.4 Preventive Measures and Chemotherapy for Paramyxoviruses		**CI4.4** Preventive Measures and Chemotherapy for Paramyxoviruses	
	SO4.5 Pathogenesis and Symptoms of Rhabdoviruses		**CI4.5** Pathogenesis and Symptoms of Rhabdoviruses	
	SO4.6 Laboratory Diagnosis and Chemotherapy for Reoviruses		**CI4.6** Laboratory Diagnosis and Chemotherapy for Reoviruses	
	SO4.7 Morphology and Pathogenesis of Pox Virus and Herpes Virus		**CI4.7** Morphology and Pathogenesis of Pox Virus and Herpes Virus	
	SO4.8 Preventive Measures and Chemotherapy for Papova Virus		**CI4.8** Preventive Measures and Chemotherapy for Papova Virus	
	SO4.9 Overview of Retroviruses (including HIV/AIDS) and Hepatitis Viruses		**CI4.9** Overview of Retroviruses (including HIV/AIDS) and Hepatitis Viruses	
	SO4.10 Types of Retroviruses (including HIV/AIDS) and Hepatitis Viruses		**CI4.10** Types of Retroviruses (including HIV/AIDS) and Hepatitis Viruses	
	SO4.11 Morphology and Pathogenesis ofHerpes Virus		**CI4.11** Morphology and Pathogenesis of Herpes Virus	
	SO4.12 Overview of Unit IV		**CI4.12** Overview of unit IV	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Write aboutMorphology and Pathogenesis ofHerpes Virus.
	SW4.2 Mini Project	
	SW4.3 Other Activities (Specify)	Search and learn via YouTube how to take Preventive Measures and Chemotherapy for the Papova Virus.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	6	1	2	21

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO5-02MB401.5: Evaluate the clinical features and treatment of fungal and protozoan infections	**SO5.1** Introduction to Fungal Infections	**LI5.1** Antibiotic sentivity test	**CI5.1** Fungal Infection	SL5.1Learn how Chemotherapy for Systemic Infections
	SO5.2 Introduction to Protozoan Infections	**LI5.2** How to perform pathogenesis test for fungus	**CI5.2** Protozoan Infection	
	SO5.3 Morphology and Pathogenesis of Dermatophytoses	**LI5.3** Prepare suitable media for the protozoans	**CI5.3** Morphology and Pathogenesis of Dermatophytoses	**SL5.2** Classify all Fungal and Protozoan Infections
	SO5.4 Symptoms and Laboratory Diagnosis of Subcutaneous Infection		**CI5.4** Symptoms and Laboratory Diagnosis of Subcutaneous Infection	
	SO5.5 Preventive Measures and Chemotherapy for Systemic Infections		**CI5.5** Preventive Measures and Chemotherapy for Systemic Infections	
	SO5.6 Pathogenesis and Symptoms of Opportunistic Fungal Infections		**CI5.6** Pathogenesis and Symptoms of Opportunistic Fungal Infections	
	SO5.7 Laboratory Diagnosis and Chemotherapy for Gastrointestinal Infections		**CI5.7** Laboratory Diagnosis and Chemotherapy for Gastrointestinal Infections	
	SO5.8 Morphology and Pathogenesis of Blood-borne Infections		**CI5.8** Morphology and Pathogenesis of Blood-borne Infections	
	SO5.9 Preventive Measures and Chemotherapy for Malaria		**CI5.9** Preventive Measures and Chemotherapy for Malaria	
	SO5.10 Overview of Treatment Strategies for Fungal and Protozoan Infections 1		**CI5.10** Overview of Treatment Strategies for Fungal and Protozoan Infections 1	
	SO5.11 Overview of Treatment Strategies for Fungal and Protozoan Infections 2		**CI5.11** Overview of Treatment Strategies for Fungal and Protozoan Infections 2	
	SO5.12 Overview of Treatment Strategies for Fungal and Protozoan Infections 3		**CI5.12** Overview of Treatment Strategies for Fungal and Protozoan Infections 3	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Write aboutTreatment Strategies for Fungal and Protozoan Infections.
	SW5.2 Mini Project	
	SW5.3 Other Activities (Specify)	Try to learn and apply preventive Measures and Chemotherapy for Malaria.

Course duration (in hours)to attain Course Outcomes:

Course Title: Medical Microbiology **Course Code:02MB401**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-02MB401.1: : Understand the fundamentals of microbial ecology and human microbiota	12	6	2	1	21
CO2-02MB401.2: Analyze the morphology, pathogenesis, and laboratory diagnosis of gram-positive bacterial infections	12	6	2	1	21
CO3-02MB401.3: Examine the characteristics and management of gram-negative bacterial infections	12	6	2	1	21
CO4-02MB401.4: Analyze the etiology and characteristics of viral infections	12	6	2	1	21
CO5-02MB401.5: Evaluate the clinical features and treatment of fungal and protozoan infections	12	6	2	1	21
Total Hours	60	30	10	05	105

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

Course Title: Medical Microbiology **Course Code:02MB401**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-02MB401.1: : Understand the fundamentals of microbial ecology and human microbiota	02	03	04	1	10
CO2-02MB401.2: Analyze the morphology, pathogenesis, and laboratory diagnosis of gram-positive bacterial infections	03	04	02	1	10
CO3-02MB401.3: Examine the characteristics and management of gram-negative bacterial infections	02	05	02	1	10
CO4-02MB401.4: Analyze the etiology and characteristics of viral infections	02	05	02	1	10
CO5-02MB401.5: Evaluate the clinical features and treatment of fungal and protozoan infections	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	Essentials of Medical Microbiology Sastry Apurba S , Bhat SandhyaJaypee Brothers Medical Publishers 2020
2	Medical Microbiology RajanMJP Publishers 2021

(c) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B.Sc. Biotechnology
Semester: IV
Course Title: Medical Microbiology
Course Code: 02MB401

CO/PO/PSO Mapping															
Course Outcome (Cos)	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-02MB401.1: : Understand the fundamentals of microbial ecology and human microbiota	-	-	-	**1**	**2**	**2**	**1**	-	**1**	**2**	**2**	**3**	**3**	**3**	**1**
CO2-02MB401.2: Analyze the morphology, pathogenesis, and laboratory diagnosis of gram-positive bacterial infections	-	-	-	-	-	-	**3**	-	**2**	**2**	**3**	**3**	**1**	**1**	**2**
CO3-02MB401.3: Examine the characteristics and management of gram-negative bacterial infections	-	**1**	**1**	**1**	-	-	**2**	-	**3**	**1**	**1**	**2**	**1**	**1**	**1**
CO4-02MB401.4: Analyze the etiology and characteristics of viral infections	-	**1**	**1**	-	**2**	**2**	**2**	**3**	-	**1**	-	-	**1**	**2**	**3**
CO5-02MB401.5: Evaluate the clinical features and treatment of fungal and protozoan infections	**1**	**1**	**1**	-	-	**2**	**3**	**3**	**1**	**2**	**2**	**2**	**1**	-	**2**

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-02MB401.1: :** Understand the fundamentals of microbial ecology and human microbiota	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10 SO1.11 SO1.12	1.1,1.2,1.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.12	**1SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-02MB401.2:** Analyze the morphology, pathogenesis, and laboratory diagnosis of gram-positive bacterial infections	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9 SO2.10 SO2.11 SO2.12	2.1, 2.2, 2.3,	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11, 2.12	**2SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3-02MB401.3:** Examine the characteristics and management of gram-negative bacterial infections	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9 SO3.10 SO3.11 SO3.12	3.1,3.2,3.3	3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12	**3SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-02MB401.4:** Analyze the etiology and characteristics of viral infections	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10 SO4.11 SO4.12	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, 4.11, 4.12	**4SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO5-02MB401.5**: Evaluate the clinical features and treatment of fungal and protozoan infections	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 S05.9 SO5.10 SO5.11 SO5.12	5.1,5.2,5.3	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 5.10, 5.11, 5.12	**5SL-1,2**

Program Name	**Bachelor of Science (Hons.) in Biotechnology**	
Semester	IV	
Course Code:	**03BC401**	
Course title:	Enzymology	**Curriculum Developer**: Dr. Deepak Mishra, Professor
Pre-requisite:	Student should have basic knowledge of Biotechnology, Biochemistry and Molecular Biology.	
Rationale:	The Enzymology course in a B.Sc. Hons. Biotechnology program serves a crucial role by providing students with comprehensive knowledge and practical skills in the study of enzymes. Enzymes are fundamental to understanding biological processes at the molecular level, pivotal in fields ranging from healthcare and pharmaceuticals to agriculture and environmental science. This course equips students with an understanding of enzyme structure, function, regulation, and kinetics, essential for designing and optimizing biotechnological processes. By exploring enzyme mechanisms and their applications in biotechnology, students develop the proficiency to innovate and solve complex biological problems, preparing them for careers in research, development, and industrial applications within the biotechnology sector.	
Course Outcomes (COs):	**CO1-03BC401.1:** Familiarization with the basic concepts, key principles and mechanism of actions of enzymes. **CO2-03BC401.2:** Acquired Skills to analyze mechanism of single substrate enzyme catalyzed reaction and enzyme inhibition kinetics **CO3-03BC401.3:** Equipped to comprehend the fundamentals of bi and multi substrate kinetics and enzyme catalysis **CO4-03BC401.4:** Recognize various methods related to Protein Ligand binding enzyme immobilization and Protein engineering. **CO5-03BC401.5:** Explore role of enzyme extraction and purification and diverse applications of enzymes in various fields.	

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)**	
Generic Elective	**03BC401**	Enzymology	3	2	1	5	11	3+1=4

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

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
Generic Elective	03BC401	Enzymology	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)		
Generic Elective	03BC401-L	Enzymology	35	5	5	5	50	50	100

Course-Curriculum:

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

Approximate Hours

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

Course outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Class room Instruction(CI)**	**Self-Learning(SL)**
CO1-03BC401.1: Familiarization with the basic concepts, key principles and mechanism of actions of enzymes.	**SO1.1** Define and Describe concept of enzyme	**LI1.1** Determination of enzyme activity	**Unit-1** **CI1.1** Enzymes: Introduction	**SL1.1** Search various reference books and study material to start the learning of enzymes
	SO1.2 Explain nomenclature of enzyme	**LI1.2** study the effect of pH on enzyme activity	**CI1.2** Nomenclature of Enzyme	
	SO1.3 Explain IUB Nomenclature System		**CI1.3** IUB Nomenclature System	
	SO1.4 Explain classification of enzyme	**LI1.3** study the effect of Temperature on enzyme activity	**CI1.4** Classification	**SL1.2** Examine role of enzymes in biological system
	SO1.5 Explore Characteristics of enzyme		**CI1.5** characteristics of enzyme	**SL1.3** Examine the effect of different factors on enzyme
	SO1.6 Study the factor affecting enzyme activity		**CI1.6** Factors affecting enzyme activity	
	SO1.7 Study the enzyme specificity		**CI1.7** Enzyme Specificity	**SL1.4** Enlist the enzymes.
	SO1.8 Study the theories of ES Complex formation		**CI1.8** Theories of enzyme substrate complex formation	**SL1.5** Examine the presence in enzyme in biological systems

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail biological significance of enzymes
	SW1.2 Mini Project	Prepare a list of enzymes used in biological reaction and biological systems
	SW1.3 Other Activities (Specify)	Preparation of laboratory manual for studying enzymes.

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

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-03BC401.2: Acquired Skills to analyze mechanism of single substrate enzyme catalyzed reaction and enzyme inhibition kinetics	**SO2.1** Explore the concept Kinetics of single substrate reaction	**LI2.1** study the effect of Km	**Unit-II** **CI2.1** Enzyme Kinetics: Kinetics of single substrate reaction,	**SL2.1** Search various books and resources for study the enzyme kinetics
	SO2.2 Describe the Michaelis Menton equation		**CI2.2** Michaelis Menton equation	**SL2.2** study about different kintic parameters
	SO2.3 Reflecting Briggs-Haldane modification		**CI2.3** Briggs-Haldane modification	
	SO2.4 Explain Line Weaver Burk Plot		**CI2.4** Line Weaver Burk Plot	**SL2.3** to learn about plots of enzyme activity
	SO2.5 Assessing Eadie-Hofstee and hanes plot		**CI2.5** Eadie-Hofstee and hanes plot	**SL2.4** standardize the protocol for enzyme activity
	SO2.6 Explaining the concept of enzyme inhibition		**CI2.6** Enzyme Inhibition: Concept	**SL2.5** to learn models of enzyme kinetics
	SO2.7 Explaining the types of inhibition		**CI2.7** types of inhibition	
	SO2.8 Explaining the kinetics of inhibition		**CI2.8** Kinetics of Enzyme Inhibition	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Assess the impact on enzyme kinetics in biological system
	SW2.2 Mini Project	Designing of poster for showing plots of enzyme kinetics
	SW2.3 Other Activities (Specify)	To analysed the impact of enzyme kinetics in living organisms

Item	Cl	LI	SW	SL	Total
Approx. Hrs	11	04	01	05	21

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction (CI)	Self-Learning(SL)
CO3-03BC401.3: Equipped to comprehend the fundamentals of bi and multi substrate kinetics and enzyme catalysis.	**SO3.1** Explain the concept Bi Bi reaction	**LI3.1** study the effect of enzyme inhibition	**Unit-III** **CI3.1** Classification of BiBi reaction	**SL3.1** Study about example of bi bi reaction
	SO3.2 Assessing the concept of Ping pong bibi mechanism		**CI3.2** Ping pong BiBi mechanism	**SL3.2** Study different types of mechanisms of bibi reaction
	SO3.3 Explaining Kinetics of Alberty equation	**LI3.2** study the effect of kinetic parameters	**CI3.3** Alberty Equation	**SL3.3** categorization of different kinetic parameters
	SO3.4 Assessing Kinetics of Dalziel Equation		**CI3.4** Dalziel Equation	
	SO3.5 Describe Mechanism of multi-substrate kinetics		**CI3.5** Multisubstrate Kinetics	**SL3.4** Study of role of multi substrate reaction
	SO3.6 Assessing the concept of Allosteric enzyme		**CI3.6** Allosteric Enzyme	**SL3.5** Assess models for studying allosteric enzymes
	SO3.7 Describe about MWC and KNF model		**CI3.7** MWC and KNF model.	
	SO3.8 Describe about enzyme catalysis		**CI3.8** Enzyme catalysis	
	SO3.9 Describe mechanism of enzyme catalysis		**CI3.9** Mechanism of enzyme catalysis	
	SO3.10 Assessing the concept of Chymotripsin		**CI3.10** Chymotripsin	
	SO3.11 Describe about Ribonuclease		**CI3.11** Ribonuclease	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail about kinetics of enzyme inhibition
	SW3.2 Mini Project	Describe the role of factors on enzyme catalysis.
	SW3.3 Other Activities (Specify)	Prepare a an article on protein ligand binding and its impact.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	04	01	05	22

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO4-03BC401.4: Recognize various methods related to Protein Ligand binding enzyme immobilization and Protein engineering.	**SO4.1** Exploring the concept of Protein Ligand Binding	**LI4.1** to perform enzyme immobilization by gel entrapment methods	**Unit-IV** **CI4.1** Protein Ligand Binding	**SL4.1** Learn about different categories of Protein ligand binding
	SO4.2 Assessing role of cooperativity	**LI4.2** To perform enzyme immobilization by covalent binding	**CI4.2** Cooperativity	
	SO4.3 Explaining the hill equation		**CI4.3** Hill Equation	**SL4.2** Compare application of enzyme immobilization
	SO4.4 Explaining the adhair equation.		**CI4.4** Adhair Equation	**SL4.3** Learn about various protein ligand complex
	SO4.5 Evaluate impact of immobilization		**CI4.5** Enzyme Immobilization: Basic concept	**SL4.4** optimization of protocol for enzymes immobilization
	SO4.6 evaluate the methods of immobilization		**CI4.6** Methods of immobilization	**SL4.5** optimization of protocol for enzyme extraction
	SO4.7 Describe the application of enzyme immobilization		**CI4.7** Application of immobilized enzyme	
	SO4.8 Describe the protein engineering		**CI4.8** Basic concept of Protein Engineering	
	SO4.9 Describe site directed mutagenesis		**CI4.9** Site Directed Mutagenesis	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain about different types of enzyme immobilization techniques and its impact.
	SW4.2 Mini Project	Standardize the protocol for enzyme immobilization.
	SW4.3 Other Activities (Specify)	Prepare one article on protein engineering

Item	Cl	LI	SW	SL	Total
Approx.Hrs	06	00	01	05	12

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO5-03BC401.5: Explore role of enzyme extraction and purification and diverse applications of enzymes in various fields.	**SO5.1** Elaborate the concept of Enzyme extraction		**Unit-V** **CI5.1** Extraction of enzyme	**SL5.1** Learn about basic concept of enzyme engineering
	SO5.2 Elaborate the concept of Enzyme purification		**CI5.2** Purification of Enzymes	**SL5.2** Learn about role purification of enzyme
	SO5.3 Elaborate the role of enzyme in molecular biology		**CI5.3** Application of enzyme engineering in molecular biology	**SL5.3** Learn about biological function of enzyme
	SO5.4 Elaborate the role of enzyme in animal nutrition		**CI5.4** Application of enzyme engineering in animal nutrition	**SL5.4** Learn about applications of enzyme in nutrition
	SO5.5 Elaborate the role of enzyme electrodes as biosensor		**CI5.5** enzyme electrodes and their application as biosensors in industry	**SL5.5** Learn about role & biosensors
	SO5.6 Elaborate the role of biosensors in health care		**CI5.6** biosensors in health care and environment.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general application of enzyme in industries and different areas
	SW5.2 Mini Project	Describe the role of enzyme engineering and site directed mutagenesis
	SW5.3 Other Activities (Specify)	Prepare a detail document on enzyme electrode and biosensors

Course duration (in hours) to attain Course Outcomes:

Course Title: Enzymology **Course Code: 03BC401**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-03BC401.1: Familiarization with the basic concepts, key principles and mechanism of actions of enzymes.	8	6	5	1	20
CO2-03BC401.2: Acquired Skills to analyze mechanism of single substrate enzyme catalyzed reaction and enzyme inhibition kinetics	8	1	5	1	15
CO3-03BC401.3: Equipped to comprehend the fundamentals of bi and multi substrate kinetics and enzyme catalysis	11	4	5	1	21
CO4-03BC401.4: Recognize various methods related to Protein Ligand binding enzyme immobilization and Protein engineering.	12	4	5	1	22
CO5-03BC401.5: Explore role of enzyme extraction and purification and diverse applications of enzymes in various fields.	6	0	5	1	12
Total Hours	45	15	25	05	90

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

Course Title: Enzymology **Course Code: 03BC401**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-03BC401.1: Familiarization with the basic concepts, key principles and mechanism of actions of enzymes.	2	1	1	1	5
CO2-03BC401.2: Acquired Skills to analyze mechanism of single substrate enzyme catalyzed reaction and enzyme inhibition kinetics	2	4	2	2	10
CO3-03BC401.3: Equipped to comprehend the fundamentals of bi and multi substrate kinetics and enzyme catalysis	2	3	3	2	10
CO4-03BC401.4: Recognize various methods related to Protein Ligand binding enzyme immobilization and Protein engineering.	3	5	5	2	15
CO5-03BC401.5: Explore role of enzyme extraction and purification and diverse applications of enzymes in various fields.	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	Enzymes by Palmer (2001): Horwood Publishing Series.
2	Fundamentals of Enzymology by Price and Stevens (2002): Oxford University Press.
3	Enzyme Technology by Helmut uhling (1998): John Wiley
4	Introduction to Proteins Structure by Branden and Tooze (1998): Garland Publishing Group.
5	Lehninger's Principles of Biochemistry: Nelson & Cox

(b) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B Sc. (Hons.) Biotechnology
Semester: IV Semester
Course Title: Enzymology
Course Code: 03BC401

Course Outcome (Cos)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-03BC401.1: Familiarization with the basic concepts, key principles and mechanism of actions of enzymes.	2	2	3	2	3	3	2	2	2	1	3	2	3	2	3
CO2-03BC401.2: Acquired Skills to analyze mechanism of single substrate enzyme catalyzed reaction and enzyme inhibition kinetics	2	1	2	1	2	2	2	1	1	2	2	1	2	3	3
CO3-03BC401.3: Equipped to comprehend the fundamentals of bi and multi substrate kinetics and enzyme catalysis	2	2	2	2	2	2	3	2	2	1	2	2	1	1	3
CO4-03BC401.4: Recognize various methods related to Protein Ligand binding enzyme immobilization and Protein engineering.	1	1	3	1	3	3	3	1	2	2	3	1	2	2	3
CO5-03BC401.5: Explore role of enzyme extraction and purification and diverse applications of enzymes in various fields.	2	1	3	1	3	3	3	1	1	2	3	1	2	2	2

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO1-03BC401.1:** Familiarization with the basic concepts, key principles and mechanism of actions of enzymes.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8	1.1,1.2,1.3,1.4,1.5	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8,	1SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO2-03BC401.2:** Acquired Skills to analyze mechanism of single substrate enzyme catalyzed reaction and enzyme inhibition kinetics	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8	2.1,	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,	2SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO3-03BC401.3:** Equipped to comprehend the fundamentals of bi and multi substrate kinetics and enzyme catalysis	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9 SO2.10 SO3.11	3.1,3.2,3.3	3.1,3.2,3.3,3.4,3.5, 3.6, 3.7, 3.8, 3.9, 3.10 3.11	3SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO4-03BC401.4:** Recognize various methods related to Protein Ligand binding enzyme immobilization and Protein engineering.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10 SO4.11 SO4.12	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, 4.11, 4.12	4SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO5-03BC401.5:** Explore role of enzyme extraction and purification and diverse applications of enzymes in various fields.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6		5.1,5.2,5.3,5.4,5.5, 5.6,	5SL-1,2,3,4,5

Program Name	**B.Sc. (Hons.) Biotechnology**	
Semester	**IVth**	
Course Code:	**03MB401**	
Course title:	**Medical Microbiology**	**Curriculum Developer**: Mrs. Maahi Choure, Guest Faculty
Pre-requisite:	Understanding fundamental concepts in biology, including cell biology, genetics, and basic microbiology.	
Rationale:	Medical microbiology is essential for understanding the role of microorganisms in human health and disease. This field provides critical insights into how pathogens cause disease, how the immune system responds, and the mechanisms of action for antibiotics and vaccines. Knowledge gained from medical microbiology is crucial for diagnosing, treating, and preventing infectious diseases, which remains a significant challenge in global health.	
Course Outcomes (COs):	**CO1-03MB401.1:** Understand the fundamentals of microbial ecology and human microbiota **CO2-03MB401.2:** Analyze the morphology, pathogenesis, and laboratory diagnosis of gram-positive bacterial infections **CO3-03MB401.3:** Examine the characteristics and management of gram-negative bacterial infections **CO4-03MB401.4:** Analyze the etiology and characteristics of viral infections **CO5-03MB401.5:** Evaluate the clinical features and treatment of fungal and protozoan infections	

Scheme of Studies:

Board of Study	**Course Code**	**Course Title**	**Scheme ofstudies (Hours/Week)**					**Total Credits (C) (L:T:P=3:0:1)**
			Cl	LI	SW	SL	**Total Study Hours (CI+LI+SW+SL)**	
Generic Elective	03MB401	Medical Microbiology	3	2	1	2	8	3+1=4

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

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
Generic Elective	03MB401	Medical 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)		
Generic Elective	03MB401-L	Medical Microbiology	35	5	5	5	50	50	100

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**ApproximateHours** **Item** | Cl | LI | SW | SL | Total **Approx.Hrs** | 09 | 02 | 01 | 02 | 14

Course outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction(CI)	Self-Learning(SL)
CO1-03MB401.1: : Understand the fundamentals of microbial ecology and human microbiota	**SO1.1** Introduction to Normal Microflora	**LI1.1** Learn how to handle pathogens	**CI1.1** Introduction to Normal Microflora	**SL1.1** Remember Carriers in Disease Transmission
	SO1.2 Role and Importance of Normal Microflora		**CI1.2** Role and Importance of Normal Microflora	**SL1.2** Explore microflora of university
	SO1.3 Introduction to Nosocomial Infections		**CI1.3** Introduction to Nosocomial Infections	
	SO1.4 Carriers in Disease Transmission		**CI1.4** Carriers in Disease Transmission	
	SO1.5 Septic Shock and Septicemia		**CI1.5** Septic Shock and Septicemia	
	SO1.6 Concept of Pathogenicity		**CI1.6** Concept of Pathogenicity	
	SO1.7 Virulence Factors		**CI1.7** Virulence Factors	
	SO1.8 Types and Mechanisms of Toxins		**CI1.8** Types and Mechanisms of Toxins	
	SO1.9 Biosafety Levels		**CI1.9** Biosafety Levels	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Summarizes theAnalysis on Septic Shock.
	SW1.2 Mini Project	DemonstrateTypes and Mechanisms of Toxins.
	SW1.3 Other Activities (Specify)	

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	1	1	2	13

Course Outcome (CO)	SessionOutcomes (SOs)	LaboratoryInstruction (LI)	ClassroomInstruction (CI)	Self Learning (SL)
CO2-03MB401.2: Analyze the morphology, pathogenesis, and laboratory diagnosis of gram-positive bacterial infections	**SO2.1** Introduction to Gram-Positive Bacteria	**LI2.1** Prepare morphology and Pathogenesis of *S. aureus* wet lab	**CI2.1** Introduction to Gram-Positive Bacteria	**SL2.1** Research on M. tuberculosis
	SO2.2 Morphology and Pathogenesis of *S. aureus*		**CI2.2** Morphology and Pathogenesis of *S. aureus*	**SL2.2** Case Study on C. diphtheriae
	SO2.3 Symptoms and Laboratory Diagnosis of *S. aureus*		**CI2.3** Symptoms and Laboratory Diagnosis of *S. aureus*	
	SO2.4 Preventive Measures and Chemotherapy for *S. aureus*		**CI2.4** Preventive Measures and Chemotherapy for *S. aureus*	
	SO2.5 Morphology, Pathogenesis, and Symptoms of *S. pyogenes*		**CI2.5** Morphology, Pathogenesis, and Symptoms of *S. pyogenes*	
	SO2.6 Laboratory Diagnosis and Chemotherapy for *S. pyogenes*		**CI2.6** Laboratory Diagnosis and Chemotherapy for *S. pyogenes*	
	SO2.7 Pathogenesis and Symptoms of *B. anthracis*		**CI2.7** Pathogenesis and Symptoms of *B. anthracis*	
	SO2.8 Preventive Measures and Chemotherapy for *B. anthracis*		**CI2.8** Preventive Measures and Chemotherapy for *B. anthracis*	
	SO2.9 Clostridium Species (*C. perfringens, C. tetani, C. botulinum*)		**CI2.9** Clostridium Species (*C. perfringens, C. tetani, C. botulinum*)	

Suggested Sessional Work (SW):*anyone*	**SW2.1** Assignments	Justify the role ofPreventive Measures and Chemotherapy.
	SW2.2 Mini Project	Understand the pathogenesis of M. leprae.
	SW2.3 Other Activities (Specify)	Remember laboratory diagnosis technique.

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

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction (CI)	Self-Learning(SL)
CO3-03MB401.3: Examine the characteristics and management of gram-negative bacterial infections	**SO3.1** Introduction to Gram-Negative Bacteria	**LI3.1** Identification of gram negative bacteria	**CI3.1** Introduction to Gram-Negative Bacteria	**SL3.1**Practice local alignment
	SO3.2 Morphology and Pathogenesis of *E. coli*	**LI3.2** Identification of gram positive bacteria	**CI3.2** Morphology and Pathogenesis of *E. coli*	**SL3.2**Practice global alignment
	SO3.3 Symptoms and Laboratory Diagnosis of *N. gonorrhoeae*		**CI3.3** Symptoms and Laboratory Diagnosis of *N. gonorrhoeae*	
	SO3.4 Preventive Measures and Chemotherapy for N. meningitidis		**CI3.4** Preventive Measures and Chemotherapy for *N. meningitidis*	
	SO3.5 Pathogenesis and Symptoms of *P. aeruginosa*		**CI3.5** Pathogenesis and Symptoms of *P. aeruginosa*	
	SO3.6 Laboratory Diagnosis and Chemotherapy for *S. typhi*		**CI3.6** Laboratory Diagnosis and Chemotherapy for *S. typhi*	
	SO3.7 Morphology and Pathogenesis of *S. dysenteriae*		**CI3.7** Morphology and Pathogenesis of *S. dysenteriae*	
	SO3.8 Preventive Measures and Chemotherapy for *Y. pestis*		**CI3.8** Preventive Measures and Chemotherapy for *Y. pestis*	
	SO3.9 Overview of *T. pallidum M. pneumoniae, Rickettsiaceae, Chlamydiae.*		**CI3.9** Overview of *T. pallidum M. pneumoniae, Rickettsiaceae, Chlamydiae.*	

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

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

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO4-03MB401.4: Analyze the etiology and characteristics of viral infections	**SO4.1** Introduction to Viral Diseases	**LI4.1** Compare and contrast the pathogenesis, symptoms, and treatment of different viral families	**CI4.1** Introduction to Viral Diseases	**SL4.1** Learn techniques of preventive measures
	SO4.2 Morphology and Pathogenesis of Picornaviruses	**LI4.2** How to identify the HIV/AIDS	**CI4.2** Morphology and Pathogenesis of Picornaviruses	**SL4.2** Understand symptoms of various diseases
	SO4.3 Symptoms and Laboratory Diagnosis of Orthomyxoviruses		**CI4.3** Symptoms and Laboratory Diagnosis of Orthomyxoviruses	
	SO4.4 Preventive Measures and Chemotherapy for Paramyxoviruses		**CI4.4** Preventive Measures and Chemotherapy for Paramyxoviruses	
	SO4.5 Pathogenesis and Symptoms of Rhabdoviruses		**CI4.5** Pathogenesis and Symptoms of Rhabdoviruses	
	SO4.6 Laboratory Diagnosis and Chemotherapy for Reoviruses		**CI4.6** Laboratory Diagnosis and Chemotherapy for Reoviruses	
	SO4.7 Morphology and Pathogenesis of Pox Virus and Herpes Virus		**CI4.7** Morphology and Pathogenesis of Pox Virus and Herpes Virus	
	SO4.8 Preventive Measures and Chemotherapy for Papova Virus		**CI4.8** Preventive Measures and Chemotherapy for Papova Virus	
	SO4.9 Overview of Retroviruses (including HIV/AIDS) and Hepatitis Viruses		**CI4.9** Overview of Retroviruses (including HIV/AIDS) and Hepatitis Viruses	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Write aboutMorphology and Pathogenesis ofHerpes Virus.
	SW4.2 Mini Project	
	SW4.3 Other Activities (Specify)	Search and learn via YouTube how to take Preventive Measures and Chemotherapy for the Papova Virus.

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

Course Outcome (CO)	SessionOutcomes(SOs)	LaboratoryInstruction(LI)	ClassroomInstruction(CI)	Self-Learning(SL)
CO5-03MB401.5: Evaluate the clinical features and treatment of fungal and protozoan infections	**SO5.1** Introduction to Fungal and Protozoan Infections	**LI5.1** How to perform pathogenesis test for fungus	**CI5.1** Introduction to Fungal and Protozoan Infections	**SL5.1**Learn how Chemotherapy for Systemic Infections
	SO5.2 Morphology and Pathogenesis of Dermatophytoses	**LI5.2** Prepare suitable media for the protozoans	**CI5.2** Morphology and Pathogenesis of Dermatophytoses	**SL5.2** Classify all Fungal and Protozoan Infections
	SO5.3 Symptoms and Laboratory Diagnosis of Subcutaneous Infection		**CI5.3** Symptoms and Laboratory Diagnosis of Subcutaneous Infection	
	SO5.4 Preventive Measures and Chemotherapy for Systemic Infections		**CI5.4** Preventive Measures and Chemotherapy for Systemic Infections	
	SO5.5 Pathogenesis and Symptoms of Opportunistic Fungal Infections		**CI5.5** Pathogenesis and Symptoms of Opportunistic Fungal Infections	
	SO5.6 Laboratory Diagnosis and Chemotherapy for Gastrointestinal Infections		**CI5.6** Laboratory Diagnosis and Chemotherapy for Gastrointestinal Infections	
	SO5.7 Morphology and Pathogenesis of Blood-borne Infections		**CI5.7** Morphology and Pathogenesis of Blood-borne Infections	
	SO5.8 Preventive Measures for Malaria		**CI5.8** Preventive Measures for Malaria	
	SO5.9 Chemotherapy for Malaria		**CI5.9** Chemotherapy for Malaria	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Write aboutTreatment Strategies for Fungal and Protozoan Infections.
	SW5.2 Mini Project	
	SW5.3 Other Activities (Specify)	Try to learn and apply preventive Measures and Chemotherapy for Malaria.

Course duration (in hours) to attain Course Outcomes:

Course Title: Medical Microbiology **Course Code:03MB401**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-03MB401.1: : Understand the fundamentals of microbial ecology and human microbiota	9	2	2	1	14
CO2-03MB401.2: Analyze the morphology, pathogenesis, and laboratory diagnosis of gram-positive bacterial infections	9	1	2	1	13
CO3-03MB401.3: Examine the characteristics and management of gram-negative bacterial infections	9	4	2	1	16
CO4-03MB401.4: Analyze the etiology and characteristics of viral infections	9	4	2	1	16
CO5-03MB401.5: Evaluate the clinical features and treatment of fungal and protozoan infections	9	4	2	1	16
Total Hours	45	15	10	05	75

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

Course Title: Medical Microbiology **Course Code:03MB401**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-03MB401.1: : Understand the fundamentals of microbial ecology and human microbiota	02	03	04	1	10
CO2-03MB401.2: Analyze the morphology, pathogenesis, and laboratory diagnosis of gram-positive bacterial infections	03	04	02	1	10
CO3-03MB401.3: Examine the characteristics and management of gram-negative bacterial infections	02	05	02	1	10
CO4-03MB401.4: Analyze the etiology and characteristics of viral infections	02	05	02	1	10
CO5-03MB401.5: Evaluate the clinical features and treatment of fungal and protozoan infections	03	04	03	1	11
Total Marks	12	21	13	05	51

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

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Essentials of Medical Microbiology Sastry Apurba S , Bhat SandhyaJaypee Brothers Medical Publishers 2020
2	Medical Microbiology RajanMJP Publishers 2021

(b) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B.Sc. Biotechnology
Semester: IV
Course Title: Medical Microbiology
Course Code: 03MB401

CO/PO/PSO Mapping															
Course Outcome (Cos)	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-03MB401.1: : Understand the fundamentals of microbial ecology and human microbiota	-	-	-	**1**	**2**	**2**	**1**	-	**1**	**2**	**2**	**3**	**3**	**3**	**1**
CO2-03MB401.2: Analyze the morphology, pathogenesis, and laboratory diagnosis of gram-positive bacterial infections	-	-	-	-	-	-	**3**	-	**2**	**2**	**3**	**3**	**1**	**1**	**2**
CO3-03MB401.3: Examine the characteristics and management of gram-negative bacterial infections	-	**1**	**1**	**1**	-	-	**2**	-	**3**	**1**	**1**	**2**	**1**	**1**	**1**
CO4-03MB401.4: Analyze the etiology and characteristics of viral infections	-	**1**	**1**	-	**2**	**2**	**2**	**3**	-	**1**	-	-	**1**	**2**	**3**
CO5-03MB401.5: Evaluate the clinical features and treatment of fungal and protozoan infections	**1**	**1**	**1**	-	-	**2**	**3**	**3**	**1**	**2**	**2**	**2**	**1**	-	**2**

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-03MB401.1: :** Understand the fundamentals of microbial ecology and human microbiota	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	1.1	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	**CO2-03MB401.2:** Analyze the morphology, pathogenesis, and laboratory diagnosis of gram-positive bacterial infections	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	2.1	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	**CO3-03MB401.3:** Examine the characteristics and management of gram-negative bacterial infections	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	3.1,3.2	3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9,	**3SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-03MB401.4:** Analyze the etiology and characteristics of viral infections	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	4.1,4.2	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	**CO5-03MB401.5**: Evaluate the clinical features and treatment of fungal and protozoan infections	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 S05.9	5.1,5.2	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9,	**5SL-1**

Program Name	**Bachelor of Science B.Sc.(H)-Biotechnology**	
Semester	IV	
Course Code:	**04BT401**	
Course title:	Entrepreneurship Development	**Curriculum Developer**: Mr. Dhirendra Mishra, Teaching Associate
Pre-requisite:	Students should have basic knowledge of Entrepreneurship Development	
Rationale:	Entrepreneurs perform a vital function in economic development. They have been referred to as the human agents needed "to mobilize capital, to exploit natural resources, to create markets and to carry on trade". It might well be said that the entrepreneurial input spells the difference between prosperity and poverty among nations. Many economic theories emphasize the significant roles played by individual entrepreneurs as they combine talents, abilities, and drive to transform resources into profitable undertakings. Joseph Schumpeter, the first major writer to highlight the human agent in the process of economic development, believed that the economy was propelled by the activities of persons. Who wanted to promote new goods and new methods of production, or to exploit a new source of materials or new market not merely for profit but also to the purpose of creating.	
CourseOutcomes (COs):	**CO1-04BT401.1:** Basic aspects of establishing a business in a competitive environment **CO2-04BT401.2:** Apply the basic understanding to examine the existing business ventures **CO3-04BT401.3:** Examine various business considerations such as marketing, financial and teaming etc. **CO4-04BT401.4:** Assessing strategies for planning a business venture **CO5-04BT401.5:** Create business ideas that can drive the innovative society	

Scheme of Studies:

Board of Study	**Course Code**	**Course Title**	**Scheme of studies (Hours/Week)**					**Total Credits(C) (L:T:P=2:0:0)**
			Cl	LI	SW	SL	**Total Study Hours (CI+LI+SW+SL)**	
Skill Enhancement Course	**04BT401**	Entrepreneurship Development	2	0	1	3	7	2+0=2

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies);
SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL 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)		
Skill Enhancement Course	**04BT401**	Entrepreneurship Development	15	20	10	5	50	50	100

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** Cl LI SW SL Total **Approx. Hrs** 05 00 01 04 10

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction(CI)**	**Self-Learning (SL)**
CO1-04BT401.1: Basic aspects of establishing a business in a competitive environment	**SO1.1** Aims and objectives of entrepreneurship		**Unit 1 Meaning of Entrepreneurship Development** **CI1.1** Needs and Importance of Entrepreneurship	**SL1.1** Visit various reference books and study material to start the learning of Entrepreneurship.
	SOI.2 Concept of Needs and Importance of Entrepreneurship		**CI1.2** Factors influencing entrepreneurship	**SL1.2** Promotion of entrepreneurship
	SOI.3 Know The process of Promotion of entrepreneurship		**CI1.3** Promotion of entrepreneurship	**SL1.3** Learn about Factors influencing entrepreneurship
	SOI.4 Understand Factors influencing entrepreneurship		**CI1.4** Factors influence entrepreneurship	**SL1.4** Establishing a business in a competitive environment
	SOI.5 Understand Features of a successful Entrepreneurship		**CI1.5** Features of a successful Entrepreneurship.	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Interview one successful and one unsuccessful entrepreneur in your place/location. Identify five major characteristics of both
	SW1.2 Mini Project	Meet one or two Government officials involved in the promotion of small enterprise. Ask them about the specific facilities the government offers to entrepreneurs to establish small-scale facilities. Also try to know the extent of use of these facilities by the entrepreneurs and major problems faced by them in this regard.
	SW1.3 Other Activities (Specify)	**Case study –N.R. Narayana Murthy**

Item	Cl	LI	SW	SL	Total
Approx. Hrs	05	00	01	02	08

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
CO2-04BT401.2: Apply the basic understanding to examine the existing business ventures .	**SO2.1** To understand aims and objective of enterprise.		**Unit-II** **CI2.1** Forms of Business Organization.	**SL2.1** Read the Process of Project Identification
	SO2.2 To describe various forms of business organization.		**CI2.2** Project Identification.	**SL2.2** Learn various steps of Selection of the product.
	SO2.3 To explain project identification.		**CI2.3** Selection of project.	
	SO2.4 To elaborate selection of product		**CI2.4** Project formulation.	
	SO2.5 Describe about various methods and techniques used for project feasibility		**CI2.5** Assessment of project feasibility.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Suppose you propose two-three enterprise like travel agency in a tourist place like neonatal. Elaborate form of ownership you will chose and why?
	SW2.2 Mini Project	Selection of the product.
	SW2.3 Other Activities (Specify)	How an entrepreneurs do assessment of project feasibility

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

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-04BT401.3: Examine various business considerations such as marketing, financial and teaming etc.	**SO3.1** Explain the importance of finance.		**Unit-III** **CI3.1** Finance the enterprise Importance of finance.	**SL3.1** On the basis of extent of performance, financial needs are classified into fixed capital and working capital.
	SO3.2 Define and describe loan and repayment.		**CI3.2** General idea about loan and repayment.	**SL3.2** Capital structure is composition of long-term and short-term loans.
	SO3.3 Describe the characteristics of business finance.		**CI3.3** Characteristics of business finance.	
	SO3.4 Describe the fixes capital management.		**CI3.4** Fixed capital management.	
	SO3.5 Explain role of working capital in business.		**CI3.5** Working capital management.	
	SO3.6 Explain in detail Of inventory Define direct and indirect inventory.		**CI3.6** Inventory management.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Issue of debenture is source of short term loans.
	SW3.2 Mini Project	Visit to an enterprise and find out its financial position whether it is over-capitalized or under – capitalized. Give your suggestion to correct the situation whatever be the case.
	SW3.3 Other Activities (Specify)	Find out some you tube videos based on financing the enterprise.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	08	00	01	03	12

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO4-04BT401.4: Assessing strategies for planning a business venture	**SO4.1** Describe the Marketing management.		**Unit-IV** **CI4.1** Marketing Management, Marketing mix	**SL4.1** Learn about marketing management.
	SO4.2 Explain the Marketing mix.		**CI4.2** Product management	**SL4.2** Discuss various steps of marketing mix based on self-study
	SO4.3 Evaluate the product line		**CI4.3** Product mix	**SL4.3** Learn about various types of distribution channel involves in Marketing management.
	SO4.4 Define and describe the product mix.		**CI4.4** Product line	
	SO4.5 Define the marketing research.		**CI4.5** Stages of Life cycle.	
	SO4.6 Describe the marketing research.		**CI4.6** Marketing research and importance of survey.	
	SO4.7 Stock management.		**CI4.7** Physical distribution	
	SO4.8 Stock management.		**CI4.8** stock management.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain life cycle of product.
	SW4.2 Mini Project	Meet an entrepreneur running a manufacturing enterprise. Ask him how he/she took decision on marketing mix and prepare systematic report on the same.
	SW4.3 Other Activities (Specify)	Find out some you tube videos based on Marketing Management.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	06	00	01	03	10

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO5-04BT401.5: Create business ideas that can drive the innovative society	**SO5.1** Explain the Meaning of international business.		**Unit-V** **CI5.1** Meaning of international business,	**SL5.1** Find out the role of International market in terms of business.
	SO5.2 Express the view of selection of product for international business.		**CI5.2** Selection of product in for international business .	**SL5.2** Explore the various kinds of selection method for product selection in international market.
	SO5.3 Able to execute to perform the cultivation of fungi.		**CI5.3** Selection of product for international business	**SL5.3** Read research on advancement in fungi
	SO5.4 Evaluate the various selection methods of product selection for		**CI5.4** Selection of market for international business international business.	
	SO5.5 Describe the export fiancé process.		**CI5.5** Export financing,	
	SO5.6 Describe about institutions support for export.		**SL5.6** Institutional support for international business.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Write about Institutional support for exports for international business.
	SW5.2 Mini Project	Make a list of financial institute those support for export and also write about their polices for export
	SW5.3 Other Activities (Specify)	Find out some you tube videos based on International business.

Course duration (in hours) to attain Course Outcomes:

Course Title: Entrepreneurship Development **Course Code:** 04BT401

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-04BT401.1: Basic aspects of establishing a business in a competitive environment	5	0	4	1	10
CO2-04BT401.2: Apply the basic understanding to examine the existing business ventures	5	0	2	1	8
CO3-04BT401.3: Examine various business considerations such as marketing, financial and teaming etc.	6	0	2	1	9
CO4-04BT401.4: Assessing strategies for planning a business venture	8	0	3	1	12
CO5-04BT401.5: Create business ideas that can drive the innovative society	6	0	3	1	10
Total Hours	30	00	14	05	49

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

Course Title: Entrepreneurship Development **Course Code:** 04BT401

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-04BT4015.1: Understand basic aspects of establishing a business in a competitive environment.	2	1	1	1	5
CO2-04BT401.2: Apply the basic understanding to examine the existing business ventures.	2	4	2	2	10
CO3-04BT4015.3: Examine various business considerations such as marketing, financial and teaming etc.	3	5	5	2	15
CO4-04BT401.4: Assessing strategies for planning a business venture	2	3	3	2	10
CO5-04BT401.5: Create business ideas that can drive the innovative society	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

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

Suggested learning Resources:

(a) Books:

(b)

S.No.	Title/Author/Publisher details
1	Holt DH. Entrepreneurship: New Venture Creation
2	Kaplan JM Patterns of Entrepreneurship.
3	Gupta CB, Khanka SS. Entrepreneurship and Small Business Management, Sultan Chand & Sons

(c) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: Bachelor of Science B.Sc.(H)-Biotechnology
Semester: IV Semester
Course Title: Entrepreneurship Development
Course Code: 04BT401

CO/PO Mapping															
Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-04BT4015.1: Understand basic aspects of establishing a business in a competitive environment.	3	3	1	1	-	-	2	1	1	3	3	2	2	2	2
CO2-04BT401.2: Apply the basic understanding to examine the existing business ventures.	1	1	2	2	2	-	1	1	-	2	3	2	2	2	1
CO3-04BT401.3: Examine various business considerations such as marketing, financial and teaming etc.	1	3	2	3	2	-	-	2	3	1	1	2	3	3	1
CO4-04BT401.4: Assessing strategies for planning a business venture.	2	3	3	2	2	2	-	1	1	2	1	-	1	1	3
CO5-04BT401.5: Create business ideas that can drive the innovative society.	2	-	2	-	1	3	2	2	1	3	2	2	3	2	3

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-04BT401.1:** Understand basic aspects of establishing a business in a competitive environment	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		1.1,1.2,1.3,1.4,1.5	**1SL-1,2,3,4**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-04BT401.2:** Apply the basic understanding to examine the existing business ventures	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5		2.1, 2.2, 2.3, 2.4, 2.5,	**2SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3-04BT401.3:** Examine various business considerations such as marketing, financial and teaming etc.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6		3.1,3.2,3.3,3.4,3.5 3.6	**3SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-04BT401.4:** Assessing strategies for planning a business venture.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8		4.1,4.2,4.3,4.4,4.5, 4.6,4.7, 4.8	**4SL-1,2,3**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO5-04BT401.5:** Create business ideas that can drive the innovative society.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6		5.1,5.2,5.3,5.4,5.5 5.6	**5SL-1,2,3**

Program Name	**Bachelor of Science (Hons.) in Biotechnology (B.Sc. (Hons.) BT)**	
Semester	IV	
Course Code:	04BT402	
Course title:	Basics of forensic science	**Curriculum Developer**: Chahana Desai, Teaching Associate
Pre-requisite:	Students should have basic knowledge and understanding about forensic biology and concept of forensic science.	
Rationale:	• Students will develop an understanding of the scientific principles of crime scene investigation and reconstruction, including evidence collection and preservation. • Students will receive intensive hands-on training in forensic laboratory methodologies with respect to the analysis of evidence. • Additionally, students will develop an understanding of the importance of the interaction between law enforcement, scientists and the legal profession.	
Course Outcomes (COs):	**CO1-04BT402.1:-** Elucidate the overview of forensic science. **CO2-04BT402.2:-** Acquire knowledge regarding causes of crime and types of injuries **CO3-04BT402.3:-** Applied knowledge about ballistics and handwriting examination. **CO4-04BT402.4:-** To gain the knowledge about toxicology and fingerprinting analysis. **CO5-04BT402.5:-** Elucidate the detailing of DNA profiling and cyber security.	

Scheme of Studies:

Board of Study	**Course Code**	**Course Title**	**Scheme ofstudies (Hours/Week)**					**Total Credits(C) (L:T:P=2:0:0)**
			Cl	LI	SW	SL	**Total Study Hours(CI+LI+SW+SL)**	
Skill enhancement course (SEC)	04BT402	Basics of forensic science	2	0	1	1	4	2+0=2

Legends: CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others);
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other instructional strategies); SW: Sessional Work (includes assignment, seminar, mini project etc.);
SL: Self Learning;
C: Credits.
Note: SW & SL 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+CAT+SA+AT)		
SEC	**04BT402**	**Basics of Forensic science**	**15**	**20**	**10**	**5**	**50**	**50**	**100**

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx. Hrs** | 06 | 00 | 01 | 01 | 08

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-04BT402.1: Elucidate the overview of forensic science.	**SO1.1** Explain the concept and principles of forensic science.		**Unit-1-Introduction to forensic science** **CI1.1** Introduction and principles of forensic science,	**SL1.1** Read some articles about forensic studies.
	SO1.2 Elucidate the functions and importance of forensic science laboratory		**CI1.2** forensic science laboratory	
	SO1.3 Elaborate the role of FSL and its organization and service.		**CI1.3** FSL and its organization and service,	
	SO1.4 Elucidate the various tools and techniques used in forensic science.		**CI1.4** tools and techniques in forensic science,	
	SO1.5 Elaborate the different branches of forensic science and its involvement.		**CI1.5** branches of forensic science.	
	SO1.6 Elaborate the different branches of forensic science and its involvement.		**CI1.6** branches of forensic science.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe various principles of forensic science.
	SW1.2 Mini Project	Elaborate different branches of forensic science with its role.
	SW1.3 Other Activities (Specify)	Make a power point presentation on forensic science laboratory and its service.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx. Hrs** | 06 | 00 | 01 | 01 | 08

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-04BT402.2: Acquire knowledge regarding causes of crime and types of injuries	**SO2.1** Explain the different types of causes which leads to crime.		**Unit-2 types of injuries and deaths.** **CI2.1** Causes of crime	**SL2.1** Note down the reasons which can lead to crime.
	SO2.2 Elucidate the Role of modus operandi in criminal investigation.		**CI2.2** Role of modus operandi in criminal investigation.	
	SO2.3 Elaborate the classification of injuries.		**CI2.3** Classification of injuries	
	SO2.4 Elucidate the medico-legal aspects of injuries.		**CI2.4** Medico-legal aspects of injuries.	
	SO2.5 Explanation about the method of assessing various types of deaths.		**CI2.5** method of assessing various types of deaths.	
	SO2.5 Explanation about the method of assessing various types of deaths.		**CI2.5** method of assessing various types of deaths.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe the Role of modus operandi in criminal investigation.
	SW2.2 Mini Project	Make a chart on classification of injuries.
	SW2.3 Other Activities (Specify)	Make Power point presentation on method of assessing various types of deaths

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

Approximate Hours

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

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO3-04BT402.3: Applied knowledge about ballistics and handwriting examination.	**SO3.1** Elucidate the classification of fire arms and explosives.		**Unit-3 Application of ballistics and handwriting examination:** **CI3.1** Classification of fire arms and explosives	**SL3.1** Read about various examples of handwriting examination
	SO3.2 Explain about the internal, external and terminal ballistics.		**CI3.2** introduction to internal, external and terminal ballistics.	
	SO3.3 Elaborate the chemical evidence for explosives.		**CI3.3** Chemical evidence for explosives.	
	SO3.4 To learn the general and individual characteristics of handwriting.		**CI3.4** General and individual characteristics of handwriting,	
	SO3.5 Explanation about the examination of handwritings and analysis of ink various samples.		**CI3.5** examination of handwritings and analysis of ink various samples.	
	SO3.6 Explanation about the comparison of handwritings and analysis of ink various samples		**CI3.6 c**omparison of handwritings and analysis of ink various samples.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Flow chart on fire arms and explosives
	SW3.2 Mini Project	Describe the different characteristics of handwriting.
	SW3.3 Other Activities (Specify)	Prepare one Power point presentation on analysis of ink in handwriting analysis.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx. Hrs** | 06 | 00 | 01 | 01 | 08

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-04BT402.4: To gain the knowledge about toxicology and fingerprinting analysis.	**SO4.1** Elucidate about the role of toxicologist		**Unit-4overview about toxicology and fingerprinting analysis** **CI4.1** Role of the toxicologist,	**SL4.1** Read about the functions of toxicological studies.
	SO4.2 Elaborate about the significance of toxicological findings		**CI4.2** significance of toxicological findings,	
	SO4.3 Explanation about the fundamental principles of fingerprinting.		**CI4.3** Fundamental principles of fingerprinting,	
	SO4.4 To learn about the detailed classification of fingerprints		**CI4.4** classification of fingerprints,	
	SO4.5 Explanation about the development of finger print		**CI4.5** development of finger print,	
	SO4.6 Explanation about science for personal identification		**CI4.6** science for personal identification,	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Determine the various applications and importance of toxicological analysis
	SW4.2 Mini Project	Flow chart on classification of fingerprints.
	SW4.3 Other Activities (Specify)	Make a Power point presentation on how the fingerprint development happens for personal identification.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx. Hrs** | 06 | 00 | 01 | 01 | 08

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-04BT402.5: Elucidate the detailing of DNA profiling and cyber security	**SO5.1** Elucidate the principle of DNA fingerprinting.		**Unit-5 DNA fingerprinting and cyber security:** **CI5.1** Principle of DNA fingerprinting,	**SL5.1** Basic knowledge about the hybridization techniques.
	SO5.2 Elaborate the application of DNA profiling in forensic medicine.		**CI5.2** application of DNA profiling in forensic medicine,	
	SO5.3 Describe the investigating tools used in forensic studies, eDiscovery.		**CI5.3** Investigation Tools, eDiscovery,,	
	SO5.4 Elucidate about the how Evidence Preservation can be done?		**CI5.4** Evidence Preservation	
	SO5.5 Explanation about the Search and Seizure of Computers,		**CI5.5** Search and Seizure of Computers,	
	SO5.6 Elaborate about the basic concept of Cyber security.		**CI5.6** Introduction to Cyber security	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Principle and steps of DNA profiling.
	SW5.2 Mini Project	Explanation about the search and seizure of computers.
	SW5.3 Other Activities (Specify)	Prepare power point presentation on cyber security.

Course duration (in hours)to attain Course Outcomes:

Course Title: Basics of forensic science **Course Code: 04BT402**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-04BT402.1: Elucidate theoverview of forensic science.	6	0	1	1	08
CO2-04BT402.2: Acquire knowledge regarding causes of crime and types of injuries.	6	0	1	1	08
CO3-04BT402.3: Applied knowledge about ballistics and handwriting examination.	6	0	1	1	08
CO4-04BT402.4: To gain the knowledge about toxicology and fingerprinting analysis.	6	0	1	1	08
CO5-04BT402.5: Elucidate the detailing of DNA fingerprinting and cyber security	6	0	1	1	08
Total Hours	30	00	05	05	40

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

Course Title: Basics of forensic science **Course Code: 04B402**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-04BT402.1: Elucidate theoverview of forensic science.	2	1	1	1	5
CO2-04BT402.2: Acquire knowledge regarding causes of crime and types of injuries.	2	4	5	1	12
CO3-04BT402.3: Applied knowledge about ballistics and handwriting examination.	3	5	5	1	14
CO4-04BT402.4: To gain the knowledge about toxicology and fingerprinting analysis.	2	3	5	1	11
CO5-04BT402.5: Elucidate the detailing of DNA fingerprinting and cyber security.	2	4	1	1	10
Total Marks	**11**	**17**	**17**	**05**	**50**

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

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
2	B.B. Nanda and R.K. Tiwari, Forensic Science in India: A Vision for the Twenty First Century, Select Publishers, New Delhi (2501).
3	M.K. Bhasin and S. Nath, Role of Forensic Science in the New Millennium, University of Delhi, Delhi (2502).
4	S.H. James and J.J. Nordby, Forensic Science: An Introduction to Scientific and Investigative Techniques, 2nd Edition, CRC Press, Boca Raton (2505).
5	W.G. Eckert and R.K. Wright in Introduction to Forensic Sciences, 2nd Edition, W.G. Eckert (ED.), CRC Press, Boca Raton (1997).
6	R. Saferstein, Criminalistics, 8th Edition, Prentice Hall, New Jersey (2504).
7	W.J. Tilstone, M.L. Hastrup and C. Hald, Fisher's Techniques of Crime Scene Investigation, CRC Press, Boca Raton (2013).

(b) 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: B.Sc. (Hons.) Biotechnology
Semester: IV Semester
Course Title: Basics of forensic science.
Course Code: 04BT402

Course Outcome (Cos)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-04BT402.1: Elucidate the overview of forensic science.	1	2	-	1	2	1	2	1	2	-	1	2	2	2	1
CO2-04BT402.2: Acquire knowledge regarding causes of crime and types of injuries.	-	1	1	-	-	-	1	-	1	1	-	-	1	1	2
CO3-04BT402.3: Applied knowledge about ballistics and handwriting examination.	1	1	2	1	-	1	1	1	1	2	1	-	3	1	1
CO4-04BT402.4: To gain the knowledge about toxicology and fingerprinting analysis.	1	1	1	-	2	1	1	1	1	1	-	2	1	1	3
CO5-04BT402.5: Elucidate the detailing of DNA fingerprinting and cyber security.	2	1	1	-	-	2	1	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 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-04BT402.1:** Elucidate the overview of forensic science.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6		1.1,1.2,1.3,1.4,1.5,1.6,	**1SL-1**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-04BT402.2:** Acquire knowledge regarding causes of crime and types of injuries.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6		2.1, 2.2, 2.3,2.4,2.5,2.6,	**2SL-1**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3-04BT402.3:** Applied knowledge about ballistics and handwriting examination.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6		3.1,3.2,3.3,3.4,3.5,3.6,	**3SL-1**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-04BT402.4:**To gain the knowledge about toxicology and fingerprinting analysis.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5SO4.6		4.1,4.2,4.3,4.4, 4.5, 4.6,	**4SL-1**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO5-04BT402.5:**Elucidate the detailing of DNA fingerprinting and cyber security.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6		5.1,5.2,5.3,5.4,5.5,5.6	**5SL-1**

Program name	**Bachelor of Science (B.Sc.)- Biotechnology**	
Semester	V	
Course Code:	01BT501	
Course title:	Genetic Engineering & Technology	Developer: Dr. Kamlesh Kumar Soni, Assistant Professor
Pre-requisite:	Student should have basic knowledge biology and biotechnology	
Rationale:	The B.Sc. Biotechnology program's "Genetic Engineering & Technology" paper offers the chance to study the operation and use of the many genetic tools used in genetic engineering. This course will explore the fundamental and cutting-edge techniques for creating transgenics and using them for the good of humanity.	
CourseOutcomes (COs):	**CO1-01BT501 .1**: Understand the essential molecular tools to the genetic engineering **CO2-01BT501 .2**: Advance the principle and application of different genetic transforming techniques **CO3-01BT501 .3**: Understand the need of genetic engineering to the animal technology **CO4-01BT501 .4:** Relative understanding of plant and animal biotechnology and their applications **CO5-01BT501 .5**: Basic principles and applications of various molecular techniques	

Scheme of Studies:

	CourseCode	CourseTitle	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=4:0:2)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
MAJOR	01BT501	Genetic Engineering & Technology	4	4	1	3	12	4+2=6

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	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)		
MAJOR	01BT501	Genetic Engineering & 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)		
MAJOR	**01BT501-L**	Genetic Engineering & Technology	35	5	5	5	50	50	100

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

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	03	22

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-01BT501 .1: Understand the essential molecular tools to the genetic engineering	SO 1.1: Will be visualizing the working molecular tools	LI 1.1Isolation of chromosomal DNA from plant cells	Unit -1 CI 1.1:Introduction to Molecular tools	1.1: Study about the basic of molecular tools of genetic engineering
	SO 1.2 Learn the importance of tools	LI 1.2 Isolation of chromosomal DNA from E. coli	CI 1.2 Applications of molecular tools -	1.2: Learn about defence mechanism in lower organism
	SO 1.3 Understand the role of polymerases in RDT	LI 1.3 Isolation of chromosomal DNA from animal cell	CI 1.3 Polymerases,	1.3: study the fundamentals of molecular biology
	SO 1.4 Know the importance of molecular tools		CI 1.4 Restriction enzymes, ligases, alkaline phosphatase	
	SO 1.5: Copresence the knowledge about recombination methods		1.5Gene Recombination	
	SO 1.6 Learn how gene is transferred to other system		CI 1.6 Gene transfer	
	SO 1.7 Fundamental of Plasmid and its properties		CI 1.7 Plasmids	
	SO 1.8 Learn the types of vector used in RDT		CI1.8 Cloning vectors- concept and types	
	SO 1.9In depth study Plasmid and bacteriophage vector		CI1.9 Plasmids, Bacteriophage-derived vectors,	
	SO 1.10 In depth study artificial chromosome vector		CI1.10 artificial chromosomes vectors	
	SO 1.11 In depth study cosmid and phagmid		CI1.11 Cosmid, phasmid	
	SO 1.12 In depth study yeast vector		CI 1.12 Yeast vector	

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Brief the different enzymes used in molecular cloning
	SW1.2 Mini Project	Explain different types of vectors and their applications
	SW1.3 Other Activities (Specify)	Watch animation on cloning of a gene in expression vector

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

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	03	22

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-01BT501 .2: Advance the principle and application of different genetic transforming techniques	SO 2.1Will be understanding the fundamental differences on genomic	LI 2.1Qualitative and quantitative analysis of DNA using spectrophotometer	Unit-2 CI 2.1Preparation and comparison of Genomic and	SL 2.1: Study about the genomic DNA and cDNA library
	SO 2.2 Will be understanding the fundamental differences on cDNA library	LI 2.2 Vector construction and cloning of a gene (demonstration)	CI 2.2 Introduction to cDNA	SL 2.2: Gain basic information transformation methods
	SO 2.3 Learn how the cDNA library is prepared	LI 2.2 demonstration of DNA Library preparation	CI 2.3 Preparation of cDNA library	SL 2.2: Gain basic information screening of recombinants
	SO 2.4 Will understand how direct method of transformation is done		CI 2.4 Introduction to transformation-	
	SO 2.5 Learn principle of microinjection and application		CI 2.5 Microinjection,	
	SO 2.6 In-depth of electroporation techniques		CI 2.6Electroporation,	
	SO 2.7 detail understanding of Ultrasonication and its applications		CI 2.7Ultrasonication,	
	SO 2.8 Learn how the recombinants are screened over the non-recombinants		CI 2.8 Chemical mediated method	
	SO 2.9 Learn about particle gun method		CI 2.9 Particle gun method	
	SO 2.10 explain lipofection		CI 2.10 Lipofection	
	SO 2.11 Explain macroinjection		CI 2.11 Macroinjection	
	SO 2.12 Learn how the recombinants are screened		CI 2.12 Screening of recombinants	

Suggested Sessional Work (SW): *anyone*	SW1.1 Assignments	Explain the intron and exon and how cDNA differ from genomic DNA
	SW1.2 Mini Project	Prepare the poster explaining all direct method of transformation
	SW1.3 Other Activities (Specify)	Explain how recombinants are selected

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

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	05	24

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO3-01BT501 .3: Understand the need of genetic engineering to the animal technology	SO 3.1Discuss about how DNA sequence is inserted or removed or mutated	LI 3.1: Screening of transformant	Unit-3 CI 3.1 Introduction to Genetic engineering in animals	SL 3.1Build-up the concept on the cDNA and intron
	SO 3.2 learn how the transgenic animals are produced	LI 3.2Conformation of transformed cells	CI 3.2Production of transgenic animals	SL3.2Advance the knowledge that how retrovirus is useful tools
	SO 3.3 Understand the application of GM animals	LI 3.3 Role of selectable and scorable marker	CI 3.3 Application of transgenic animals	SL 3.3 Clear the basic concept of the gene regulation
	SO 3.4 Develop skill on retrovirus as vectors to transfect the gene of interest into the target genome		CI 3.4 Retrovirus	SL 3.4 Boost your knowledge on bacterial protein expression and purification
	SO 3.5Able to realize application of Genetic Engineering		CI 3.5 its application in genetic engineering	
	SO 3.6 fundamental on genetic engineering for the therapeutic products.		CI 3.6 Applications of Genetic Engineering	SL 3.4 Boost your knowledge on application of RDNA Technology
	SO 3.7 Develop skill on how therapeutic products are produced		CI 3.7: Therapeutic products produced by genetic engineering-introduction	
	SO 3.8 Skill on how therapeutic products are designed and developed		CI 3.8 Therapeutic products produced by genetic engineering	
	SO 3.8 Skill on how blood proteins are designed and developed		CI 3.9 -blood proteins,	
	SO 3.8 Skill on how Human hormones are designed and developed		CI 3.10 human hormones,	
	SO 3.8 Skill on how immune modulators are designed and developed		CI 3.11 immune modulators (one example each)	
	SO 3.8 Skill on how vaccines are designed and developed		CI 3.12 Therapeutic products produced by genetic engineering -vaccines as example	

Suggested Sessional Work (SW): *anyone*	Assignments:	Describe the insulin production by bacterial system
	Mini Project:	Draw structure of cloning of a gene of interest in Cosmid
	Other Activities (Specify):	Literature survey on the application of genetic engineering on immune modulator:; case study

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

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	05	24

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO4-01BT501 .4: Relative understanding of plant and animal biotechnology and their applications	SO 4.1: learning why plant genetic engineering is important	LI 4.1: Ti-Plasmid vector system (restriction digestion)	Unit-4 CI 4.1Genetic engineering in plants	SL 4.1Create a vector having a gene cloned on it (sketch)
	SO4.2: Discus how infections is associated with crown gall diseases in plant root	LI 4.2: *Agrobacterium*culture and growth conditions	CI4.2 Biology of *Agrobacterium*	SL4.2: Study the biology of *Agrobacterium*
	SO 4.3 Skill on how *Agrobacterium* is exploited to the scientific purpose	LI 4.3: Development of modified T-DNA (demonstration)	CI4.3 Application of *Agrobacterium tumefaciens* and *A. rhizogenes*	SL 4.3 Draw a Ti-Plasmid vector and label all the genes on it
	SO 4.4 Understand the importance of TiPlasmind and its application		CI 4.4 Ti plasmids,	SL 4.4: Literature the application of plant virus vector for transformation
	SO 4.4 Understand the structure of T DNA		CI 4.5 Structure of T-DNA,	SL 4.5: Literature the application of transgenic plants
	SO 4.5 Analyse the importance of vir genes		CI 4.6 Vir region in Ti-Plasmid	
	SO 4.5 Analyse mechanism of T DNA transfer		CI 4.7 T DNA transfer	
	SO 4.6Create various strategies of plant transformation		CI 4.8 Strategies for gene transfer to plant cells	
	SO 4.6 study transformation methods		CI 4.9 Direct gene transfer methods	
	SO 4.7 Create the viral as vector for the plant transformation		CI 4.10 Plant viral vector	
	SO 4.7 study different viral vector used for the plant transformation		CI 4.11 types and use	
	SO 4.5: Learn how plant can be raised against a particular stress e.g. Bt-Cotton		CI4.12 Application of Transgenic plants	

Suggested Sessional Work (SW): *anyone*	Assignments:	Explain the *Agrobacterium*mediated plant transformation
	Mini Project:	Literature the Bt cotton; name the gene and its mode of action against the insect
	Other Activities (Specify):	Think and deliver a presentation; how plant can be made drought stress resistant

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

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	05	24

Course outcome (COs)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO5-01BT501 .5: Basic principles and applications of various molecular techniques	SO5.1 learn the principle of PCR	LI 5.1: PCR; Gene amplification	Unit -5 CI 5.1: Polymerase chain reaction (PCR)-Principle	SL 5.1: Principle of PCR; understand
	SO 5.2 realize how PCR can be used for DNA amplification and creation of mutations	LI 5.2: Demonstration of Southern blotting	CI 5.2 Polymerase chain reaction (PCR)-Applications	SL5.2: Study the hybridization
	SO5.3 Visualize how probes binds and spot the gene position and copy number	LI 5.2: Demonstration of DNA fingerprinting	CI 5.3 Southern hybridization	SL 5.3: Study why each individual is different and what are the satellite DNA
	SO 5.4 Analyze the expression of RNA at particular stage or tissue.		CI 5.4 Northern hybridization	SL 5.4: Study different types of mutations & factors causes the mutagenesis
	SO5.5 Learn about western hybridization		CI 5.5 Western hybridization	SL 5.5: Learn in detail the Genetic Codes and protein structure
	SO 5.6 Learn how genome is mapped		CI 5.6 Genome mapping	
	SO 5.7 Understand how fingerprinting is used in forensic		CI 5.7 DNA fingerprinting	
	SO 5.8 explore steps of fingerprinting		CI 5.8 steps and application	
	SO 5.9 Understand about mutagens and how the create mutation		. CI 5.9 Introduction to mutagenesis	
	SO 5.10 skill on how mutations are created		CI 5.10 Random Site-directed mutagenesis	
	SO 5.11 building the concept of protein engineering		CI 5.11 Protein engineering concepts	
	SO 5.12 protein engineering and their application in welfare		CI 5.12 Applications of Protein engineering	

Suggested Sessional Work (SW): Anyone	Assignments:	In details list the application of PCR
	Mini Project:	Discuss about the blotting techniques and their applications in detection
	Other Activities (Specify):	Literature and presentation; protein engineering and its application; a case study

Course duration (in hours) to attain Course Outcomes **(Course title:** Genetic Engineering & Technology**)** **(Course code: 01BT501)**					
Course Outcomes(COs)	**Class lecture(CI)**	**LaboratoryInstruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-01BT501 .1: Understand the essential molecular tools to the genetic engineering	12	6	3	1	22
CO2-01BT501 .2: Advance the principle and application of different genetic transforming techniques classifications	12	6	3	1	22
CO3-01BT501 .3: Understand the need of genetic engineering to the animal technology	12	6	5	1	24
CO4-01BT501 .4: Relative understanding of plant and animal biotechnology and their applications	12	6	5	1	24
CO5-01BT501 .5: Basic principles and applications of various molecular techniques	12	6	5	1	24
Total Hours	60	30	21	05	116

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome: **Course title:** Genetic Engineering & Technology**) (Course code:)**					
Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-01BT501 .1: Understand the essential molecular tools to the genetic engineering	2	1	1	1	5
CO2-01BT501 .2: Advance the principle and application of different genetic transforming techniques classifications	2	4	2	2	10
CO3-01BT501 .3: Understand the need of genetic engineering to the animal technology	3	5	5	2	15
CO4-01BT501 .4: Relative understanding of plant and animal biotechnology and their applications	2	3	3	2	10
CO5-01BT501 .5: Basic principles and applications of various molecular techniques	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	Gene Cloning and DNA Analysis	Brown TA	Blackwell Publishing, Oxford, U.K	6& 2010
2	Biotechnology: Applying the Genetic Revolution	Clark DP and Pasternik NJ	Elsevier Academic Press, USA	2 & 2015
3	Principles of Gene Manipulation and Genomics	Primrose SB and Twyman RM	Blackwell Publishing, Oxford, U.K	7 & 2006
4	Molecular Cloning-A Laboratory Manual	Sambrook J and Russell D	Cold Spring Harbor Laboratory Press	4 & 2012

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 and PSO Mapping

Program Title: B. Sc. Biotechnology, 5thSem
Course Code: 01BT501
Course Title: Genetic Engineering & Technology

CO/PO Mapping															
Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-01BT501 .1: Understand the essential molecular tools to the genetic engineering	**3**	**3**	**1**	**2**	**2**	**3**	**2**	**2**	**1**	**3**	**3**	**3**	**2**	**2**	**3**
CO2-01BT501 .2: Advance the principle and application of different genetic transforming techniques classifications	**3**	**2**	**1**	**2**	**2**	**3**	**3**	**2**	**-**	**2**	**3**	**3**	**3**	**3**	**3**
CO3-01BT501 .3: Understand the need of genetic engineering to the animal technology	**2**	**3**	**2**	**2**	**3**	**3**	**3**	**2**	**1**	**3**	**1**	**3**	**2**	**2**	**3**
CO4-01BT501 .4: Relative understanding of plant and animal biotechnology and their applications	**2**	**3**	**3**	**3**	**3**	**3**	**3**	**2**	**1**	**3**	**1**	**3**	**3**	**3**	**3**
CO5-01BT501 .5: Basic principles and applications of various molecular techniques	**3**	**3**	**2**	**3**	**3**	**3**	**3**	**2**	**1**	**3**	**1**	**3**	**3**	**3**	**3**
Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3															

Program Title: B. Sc. Biotechnology, 5th Sem
Course Code: 01BT501
Course Title: Genetic Engineering & Technology

Course Curriculum Map:					
POs & PSOs No.	COs No	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-01BT501 .1: Understand the essential molecular tools to the genetic engineering**	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10 SO1.11 SO1.12	LI1, LI2 LI3,	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 SL-1,2,3
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-01BT501 .2: Advance the principle and application of different genetic transforming techniques** classifications	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9 SO2.10 SO2.11 SO2.12	LI1, LI2 LI3,	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 SL-1,2,3
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3-01BT501 .3: Understand the need of genetic engineering to the animal technology**	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7SO3.8 SO3.9 SO3.10 SO3.11 SO3.12	LI1, LI2 LI3	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 SL-1,2,3,4,5
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-01BT501 .4: Relative understanding of plant and animal biotechnology and their applications**	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10 SO4.11 SO4.12	LI1, LI2 LI3,	4.1,4.2,4.3,4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10,4.11,4.12	4 SL-1,2,3,4,5
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO5-01BT501 .5: Basic principles and applications of various molecular techniques**	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9 SO5.10 SO5.11 SO5.12	LI1, LI2, LI3,	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 SL-1,2,3,4,5

Program Name	**B.Sc. (Hons.) in Biotechnology**	
Semester	**V**	
Course Code:	**05BT501**	
Course title:	Environmental Biotechnology	**Curriculum Developer**: Mr. Paras Koshe, Assistant Professor
Pre-requisite:	Student should have basic knowledge of Environmental science and Biotechnology.	
Rationale:	The Environmental Biotechnology course aims to introduce and elaborate the fundamental concepts and applications of biotechnology 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 biotechnology for harnessing microbial potential in environmental applications. The course is structured to provide the students with fundamental concepts of environmental biotechnology, 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, biohydrometallurgy, biofuel, 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, bioenergy, biomaterial to enzyme discovery. .	
Course Outcomes (COs):	**CO1-05BT501. 1.** Explain the use and environmental impact of conventional and modern fuels, **CO2-05BT501. 2.** Understand the role of bioremediation in cleaning of waste from environment **CO3- 05BT501 3**. Interpretate the mechanism of biodegradation of pesticides and other toxic chemicals by micro-organisms **CO4 05BT501 4**. Explain waste treatment of municipal waste and Industrial effluents and use and types of biofertilizer and nitrogen fixation **CO5-05BT501. 5.** Learn about the process of bioleaching and environmental significance of genetically modified organisms.	

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)	
Discipline Specific Core Course	05BT501	Environmental Biotechnology	3	2	1	3	9	3+1=4

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

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)		
Discipline Specific Core Course	05BT501	Environmental Biotechnology	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)		
Discipline Specific Core Course	05BT501-L	Environmental Biotechnology	35	5	5	5	50	50	100

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

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)
CO1-05BT501. 1. Explain the use and environmental impact of conventional and modern fuels,	**SO1.1** Define various types of energy sources,	**LI1** Isolation and Characterization of Bacteria from Crude Petroleum Oil Contaminated Soil	**CI1.1** Conventional fuels and their environmental impact	**SL1.1** Role of Biotechnology in environment
	SO1.2 Focus on conventional energy sources like firewood	**LI1.2** Growth Response of Bacteria on Petroleum Fuel (Diesel)	**CI1.2** Firewood, Plant, Animal,	**SL1.2** Types of energy sources used in your locality (Area)
	SO1.3 Explain the importance and use of water as energy source		**CI1.3** Water, Coal and Gas.	
	SO1.4 Provide importance of modern fuel		**CI1.4** Modern fuels and their environmental impact	**SL1.3** Learn some recent modern fuels produced by biotech and compare cost
	SO1.5 Illustrate the types and use of methanogenic bacteria		**CI1.5** Methanogenic bacteria	**SL1.4** visit any biogas production plant and try to learn it practically
	SO1.6 Define biogas and its components		**CI1.6** biogas production	**SL1.5** Use of ethanol as energy source and try to find out limitation of ethanol production
	SO1.7 Explain Microbial hydrogen production		**CI1.7** Microbial hydrogen production	
	SO1.8. Over viewing Ethanol production		**CI1.8** Conversion of sugars to ethanol.	
	SO1.9. Demonstrate and procedure of Gasohol experiment		**CI1.9** Gasohol experiment	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	i. Write about the Environmental biotechnology and its role in human welfare. ii. Write about modern fuels and latest technology and their impact on environment.
	SW1.2 Mini Project	Which types of energy sources are more used .in your area? Visit any Biogas plant and make a rough sketch of Biogas production?
	SW1.3 Other Activities (Specify)	visit any fermentation plant and make a rough sketch of ethanol production

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

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
CO2-05BT501. 2. Understand the role of bioremediation in cleaning of waste from environment	**SO2.1** Understand Concept of Bioremediation and its types.	**LI2.1** Determination of dissolved oxygen of water sample.	**CI2. 1** In -situ bioremediation techniques**.**	**SL2.1** Understand the basic knowledge of biodegradation and correlate with bioremediation.
	SO2.2 Outline different methods for the Ex-situ bioremediation techniques.	**LI2.2** Determination of biological oxygen demand	**CI2.2** Ex-situ bioremediation techniques.	**SL2.2** Observe different types of solid waste. And their impacts.
	SO2.3 Elucidate the process of Bioremediation of soil contaminated with oil spills	**LI2.3** Determination of chemical oxygen demand (COD) of water sample.	**CI2.3** Bioremediation of soil contaminated with oil spills	**SL2.3** Gain knowledge about some other method such as landfills, incineration etc.
	SO2.4 Elucidate the process of Bioremediation of soil contaminated with oil spills.	.	**CI2.4** Bioremediation of soil contaminated with oil spills**.**	**SL2.4** Exploring the concept of 5 R's and disposal of different types of waste
	SO2.5 Understand the use of microorganism in the degradation and removal of heavy metals.		. **CI2.5** heavy metals	
	SO2.6 Understand the use of microorganism in the degradation and removal of Detergents.		**CI2.6.** Detergents	
	SO2.7 Explain degradation of lignin using microbes.		**CI2.7** Degradation of lignin using microbes	
	SO2.8 Explain degradation of cellulose using microbes.		**CI2.8** Degradation of cellulose using microbes	
	SO2.9 Define phyto-remediation and its role in cleaning environment		**CI2.9** Phytoremediation: Types and its applications,	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Comparative study Bioremediation and.phytoremediation. Write about different biodegradation methods that are used in your city
	SW2.2 Mini Project	Make a poster on Bioremediation techniques.
	SW2.3 Other Activities (Specify)	Analyze the role of Plants in bioremediation

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

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3- 05BT501 3. Interpretate the mechanism of biodegradation of pesticides and other toxic chemicals by micro-organisms	**SO3.1** Explain the role of Bioremediation in environmental cleaning.	**LI3.1** To study the effect of heavy metal on the growth of microorganism	**Unit-3 Biodegradation: CI 3**.	**SL3.1**. Explore the basic concepts of bioremediation and its types .correlate with unit 1 and energy generation from bioremediation
	SO3.2 Understand the use of bioremediation in removal of pesticides by micro-organisms		**CI 3.2** Degradation of pesticides by micro-organisms	**SL3.2** Learn different other techniques used in bioremediation of soil and water.
	SO3.3 Understand the use of bioremediation in removal of toxic chemicals		**CI 3.3** Degradation of pesticides by micro-organisms	
	SO3.4 Outline the process of Degradation of toxic chemicals by micro-organisms		**CI 3.4**, Degradation of toxic chemicals by micro-organisms	.**SL3.3** Find out new approaches of bioremediation and use of microorganisms in bioremediation
	SO3.5 Outline the process of Degradation of toxic chemicals by micro-organisms		**CI 3.5** Degradation of toxic chemicals by micro-organisms	
	SO3.6 Illustrate the mechanism of Biodegradation of chlorinated hydrocarbons		CI 3. Biodegradation of chlorinated hydrocarbons	
	SO3.7 Illustrate the mechanism of Biodegradation of chlorinated hydrocarbons		**CI 3.7** Biodegradation of chlorinated hydrocarbons	
	SO3.8 Explain Biodegradation of xenobiotic compounds.		**CI 3.8** Biodegradation of xenobiotic compounds.	
	SO3.9 Learn about the utility of Bioremediation.		**CI 3.9** Importance of Biodegradation.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	• Explain diagrammatically about in situ and ex situ bioremediation techniques with examples. • Write about different types of Bio indicators.
	SW3.2 Mini Project	How bioreactors are used in bioremediation. Explain different types of bioreactors used.
	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 bio indicators.

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

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO4 05BT501 4. Explain waste treatment of municipal waste and Industrial effluents and use and types of biofertilizer and nitrogen fixation	**SO4.1** To learn the Treatment of municipal waste and Industrial effluents	LI4.1 Isolation of Rhyzobium	**Unit-IV** **CI 4.1** Treatment of municipal waste and Industrial effluents	**SL4.1** Observing the physical and chemical properties of water. And focus on save water.
	SO4.2 To learn the Treatment of municipal waste and Industrial effluents	LI4.2 Isolation of Azotobector	**CI 4.2** Treatment of municipal waste and Industrial effluents	**SL4.2** Understanding the role bio fertilizers and bio pesticides in crop improvement
	SO4.3 Define biofertilizers		**CI 4.** Bio-fertilizers	
	SO4.4 Elucidate the production of Biofertilizer from different micro organism		**CI 4.4.** Bio-fertilizers	
	SO4.5 Explain the types of biofertilizers		**CI 4.5.** Bio-fertilizers	
	SO4.6 Discuss the Role of symbiotic and asymbiotic nitrogen fixing bacteria in the enrichment of soil.		**CI 4.6** Role of symbiotic and asymbiotic nitrogen fixing bacteria in the enrichment of soil.	
	SO4.7 Discuss the Role of symbiotic and asymbiotic nitrogen fixing bacteria in the enrichment of soil.		**CI 4.7** Role of symbiotic and asymbiotic nitrogen fixing bacteria in the enrichment of soil.	
	SO4.8 Explain algal biofertilizers		**CI 4.8** Algal biofertilizers	
	SO4.9 Explain fungal biofertilizers(VAM)		**CI 4.9** fungal biofertilizers (VAM	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	1. Explain Treatment of municipal waste and Industrial effluents. 2. Describe bio fertilizer in detail.
	SW4.2 Mini Project	Try to find out the earthworm varieties found in your area and find most variety used in vermicomposting, write an article for the same.
	SW4.3 Other Activities (Specify)	Make comparative study between bio fertilizer and chemical fertilizer.

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

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction(LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO5-05BT501. 5. Learn about the process of bioleaching and environmental significance of genetically modified organisms.	**SO5.1** Analyze role of microorganism in bioleaching		**Unit-V** **CI5.1** Bioleaching	**SL5.1** Learn the steps of bioleaching Identify strain of microorganism used for bioleaching and try to culture and extract.
	SO5.2 Explain principles and process of bioleaching		**CI5.2** Principles and process	**SL5.2** Study role of RDT in the production of GMO's
	SO5.3 Analyze bioleaching of important metals and role of microorganism in bioleaching		**CI5.3** Enrichment of ores by microorganisms (Gold, Copper and Uranium).	**SL5.3** Learn about transgenic plants
	SO5.4 Analyze bioleaching of important metals and role of microorganism in bioleaching.		**CI5.4** Enrichment of ores by microorganisms (Gold, Copper and Uranium	**SL5.4** Learn about transgenic animals.
	SO5.5 Focus on Environmental significance of genetically modified microbes, plants and animals		**CI5.5** Environmental significance of genetically modified microbes, plants and animals	
	SO5.5 study significance of genetically modified microbes,		**CI5.6** Environmental significance of genetically modified microbes,	
	SO5.5 assess significance of genetically modified plants		**CI5.7** Environmental significance of genetically modified plants	
	SO5.5 explore significance of genetically modified m animals		**CI5.8** Environmental significance of genetically modified animals	
	SO.5.6 Learn the demerits of GMO's		**CI5.9** Disadvantages of using GMO's	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	1. Describe the process of Bioleaching.
	SW5.2 Mini Project	Make a chart showing Enrichment of ores by microorganisms (Gold, Copper and Uranium
	SW5.3 Other Activities (Specify)	Prepare one article on the bioleaching and also focus on diamond mining.

Course duration (in hours) to attain Course Outcomes:

Course Title: Environmental Biotechnology **Course Code: 05BT501**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-05BT501. 1. Explain the use and environmental impact of conventional and modern fuels,	9	4	5	1	19
CO2-05BT501. 2. Understand the role of bioremediation in cleaning of waste from environment	9	6	4	1	20
CO3- 05BT501 3. Interpretate the mechanism of biodegradation of pesticides and other toxic chemicals by micro-organisms	9	2	4	1	16
CO4 05BT501 4. Explain waste treatment of municipal waste and Industrial effluents and use and types of bio fertilizer and nitrogen fixation	9	3	4	1	17
CO5-05BT501. 5. Learn about the process of bioleaching and environmental significance of genetically modified organisms	9	0	4	1	14
Total Hours	45	15	21	05	86

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

Course Title: Environmental Biotechnology **Course Code: 05BT501**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-05BT501. 1. Explain the use and environmental impact of conventional and modern fuels,	2	1	1	1	5
CO2-05BT501. 2. Understand the role of bioremediation in cleaning of waste from environment	2	4	2	2	10
CO3- 05BT501 3. Interpretate the mechanism of biodegradation of pesticides and other toxic chemicals by micro-organisms	3	5	5	2	15
CO4 05BT501 4. Explain waste treatment of municipal waste and Industrial effluents and use and types of biofertilizer and nitrogen fixation	2	3	3	2	10
CO5-05BT501. 5. Learn about the process of bioleaching and environmental significance of genetically modified organisms	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

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

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	• Environmental Microbiology, W.D. Grant & P.E. Long, Blakie, Glassgow and London.
2	• Environmental Biotechnology by Bruce Rittmann and Perry McCarty
3	• Environmental biotechnology, 1995 S.N.Jogdand. Himalaya Publishing House, Bombay, Delhi, Nagpur.
4	• Bioremediation 1994 Baker, K.H.and Herson, D.S. McGraw Hill, Inc.New York.
5	• Environmental Microbiology, W.D. Grant & P.E. Long, Blakie, Glassgow and London.
6	• Environmental Science, S.C. Santra
7	• Environmental Biotechnology, Pradipta Kumar Mohapatra
8	• Environmental Biotechnology – Concepts and Applications, Hans-Joachim Jordening and Jesef Winter

(b) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B.Sc. Biotechnology (Honors)
Semester: V Semester
Course Title: Environmental Biotechnology
Course Code: 05BT501

Course Outcome (Cos)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-05BT501. 1. Explain the use and environmental impact of conventional and modern fuels,	2	-	-	1	2	2	-	-	1	2	2	-	2	2	1
CO2-05BT501. 2. Understand the role of bioremediation in cleaning of waste from environment	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2
CO3- 05BT501 3. Interpretate the mechanism of biodegradation of pesticides and other toxic chemicals by micro-organisms	-	1	1	1	-	-	1	1	1	-	-	1	1	1	1
CO4 05BT501 4. Explain waste treatment of municipal waste and Industrial effluents and use and types of bio fertilizer and nitrogen fixation	-	1	1	-	2	-	1	1	-	2	-	1	1	1	3
CO5-05BT501. 5. Learn about the process of bioleaching and environmental significance of genetically modified organisms	1	1	1	-	-	1	1	1	-	-	1	1	1	3	2

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO1-05BT501. 1.** Explain the use and environmental impact of conventional and modern fuels,	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	**LI 1** **LI 2**	1.1,1.2,1.3,1.4,1.5 1.6 1.7 1.8 1.9	**1SL-1,2,3,4,5**
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO2-05BT501. 2.** Understand the role of bioremediation in cleaning of waste from environment	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	**LI 1** **LI 2** **LI 3**	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7 2.8 2.9	**2SL-1,2,3,4,**
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO3- 05BT501 3**. Interpretate the mechanism of biodegradation of pesticides and other toxic chemicals by micro-organisms	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, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO4 05BT501 4**. Explain waste treatment of municipal waste and Industrial effluents and use and types of bio fertilizer and nitrogen fixation	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 4.8 4.9	**4SL-1,2,3,4**
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO5-05BT501. 5.** Learn about the process of bioleaching and environmental significance of genetically modified organisms	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**

Program Name	**Bachelor of Science (Hons.) in Biotechnology**	
Semester	V	
CourseCode:	**05BT502**	
Coursetitle:	Food Biotechnology	**Curriculum Developer**: Mr. Piyush Kant Rai, Assistant Professor
Pre-requisite:	Student should have basic knowledge of Biotechnology, Microbiology and Biochemistry needed for food analysis.	
Rationale:	The Food Biotechnology course in a B.Sc. Hons. Biotechnology program serves a crucial role by providing students with comprehensive knowledge and practical skills in the study of food ingredients and quality control. Food biotechnology is provide essential skills for enhancing food quality, safety, and nutritional value, while also increasing agricultural productivity and sustainability to meet the demands of a growing global population.	
CourseOutcomes (COs):	**CO1-05BT502.1:** Familiarization with the basic concepts of microorganism involved in food processing and food spoilage. **CO2-05BT502.2:**Acquired Skills to analyze beneficial and harmful impact of microorganisms on food and food ingredients **CO3-05BT502.3:**Equipped to comprehend the fundamentals of microorganism used for development of functional food **CO4-05BT502.4:** Recognize various methodsused for microbiological examination of food and food ingredients **CO5-05BT502.5:** Explore role of the microbes on the basis of their morphological characteristics.	

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)**	
Discipline Specific Core Course	05BT502	Food Biotechnology	3	2	1	3	9	3+1=4

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

Scheme of Assessment:Theory

Board of Study	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)		
Discipline Specific Core Course	05BT502	Food Biotechnology	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)		
Discipline Specific Core Course	05BT502-L	Food Biotechnology	35	5	5	5	50	50	100

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction, including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**ApproximateHours** **Item** | Cl | LI | SW | SL | Total **Approx.Hrs** | 09 | 04 | 01 | 03 | 17

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Classroom Instruction (CI)**	**Self-Learning (SL)**
CO1-05BT502.1: Familiarization with the basic concepts of microorganism involved in food processing and food spoilage.	SO1.1 Introduction to Microbial Ecology in Food	LI1.1 Observe the effects of different factors on microbial growth in a food sample (e.g., varying pH, temperature).	CI1.1 Introduction to Microbial Ecology in Food	SL1.1 Remember intrinsic factors affecting the growth of microbes
	SO1.2 Intrinsic Factors Affecting Microbial Growth	LI1.2 Measure microbial growth in milk samples under different storage conditions.	CI1.2 Intrinsic Factors Affecting Microbial Growth	SL1.2 Self-paced learning to understand the spoilage of milk
	SO1.3 Extrinsic Factors Affecting Microbial Growth		CI1.3 Extrinsic Factors Affecting Microbial Growth	SL1.3 Revise microbial ecology in food
	SO1.4 Microbial Spoilage of Milk		CI1.4 Microbial Spoilage of Milk	
	SO1.5 Microbial Spoilage of Meat		CI1.5 Microbial Spoilage of Meat	
	SO1.6 Microbial Spoilage of Plant Products		CI1.6 Microbial Spoilage of Plant Products	
	SO1.7 Impact of Storage Conditions on Microbial Growth		CI1.7 Role of Storage Conditions in Food Microbiology	
	SO1.8 Introduction to Food Preservation Techniques		CI1.8 Overview of Food Preservation Techniques	
	SO1.9 Application of Microbial Knowledge in Food Safety		CI1.9 Applying Microbial Knowledge in Food Safety	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Design mini-project research a specific microbial spoilage problem in a food product of choice and present findings, including the microorganism involved, spoilage mechanisms, and prevention strategies.
	SW1.2 Mini Project	Group Assignment –microbial spoilage
	SW1.3 Other Activities (Specify)	Evaluate students based on their technique, accuracy, and lab equipment skills.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	4	1	3	17

Course Outcome (CO)	**SessionOutcomes (SOs)**	**LaboratoryInstruction (LI)**	**ClassroomInstruction (CI)**	**Self-Learning (SL)**
CO2-05BT502.2: Acquired Skills to analyze beneficial and harmful impact of microorganisms on food and food ingredients	SO2.1 Introduction to Foodborne Diseases	LI2.1 Analyze common food samples for the presence of bacterial contaminants.	CI2.1 Introduction to Foodborne Diseases	SL2.1 Study the history and significance of foodborne diseases
	SO2.2 Bacterial Agents of Foodborne Illness - Clostridium	LI2.2 Isolate and identify Clostridium species from food samples.	CI2.2 Bacterial Agents of Foodborne Illness: Clostridium	SL2.2 Learn about the pathogenicity and control of Clostridium in food
	SO2.3 Bacterial Agents of Foodborne Illness - Listeria		CI2.3 Bacterial Agents of Foodborne Illness: Listeria	SL2.3 Study the risk factors for Listeria contamination in food
	SO2.4 Bacterial Agents of Foodborne Illness - Salmonella		CI2.4 Bacterial Agents of Foodborne Illness: Salmonella	
	SO2.5 Bacterial Agents of Foodborne Illness - Shigella		CI2.5 Bacterial Agents of Foodborne Illness: Shigella	
	SO2.6 Bacterial Agents of Foodborne Illness - Staphylococcus		CI2.6 Bacterial Agents of Foodborne Illness: Staphylococcus	
	SO2.7 Bacterial Agents of Foodborne Illness - Vibrio		CI2.7 Bacterial Agents of Foodborne Illness: Vibrio	
	SO2.8 Non-Bacterial Agents of Foodborne Illness - Helminthes and Protozoa		CI2.8 Non-Bacterial Agents of Foodborne Illness: Helminthes and Protozoa	
	SO2.9 Toxigenic Algae, Fungi, and Viruses in Foodborne Illness		CI2.9 Toxigenic Algae, Fungi, and Viruses in Foodborne Illness	

Suggested Sessional Work (SW):*anyone*	**SW2.1** Assignments	Write about the Staphylococcus: Characteristics, toxins (enterotoxins), diseases (staphylococcal food poisoning), sources, and prevention.
	SW2.2 Mini Project	Make a taxonomy table of Bacterial Agents of Foodborne Illness
	SW2.3 Other Activities (Specify)	Find out some you tube videos based on the pathogens, clinical manifestations,.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	4	1	3	17

Course Outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Classroom Instruction (CI)**	**Self-Learning(SL)**
CO3-05BT502.3: Equipped to comprehend the fundamentals of microorganism used for development of functional food	SO3.1 Introduction to Fermented Foods	LI3.1 Prepare a basic fermented food product (e.g., yogurt) in the lab and observe microbial activity.	CI3.1 Introduction to Fermented Foods	SL3.1 Study the historical and cultural significance of fermented foods
	SO3.2 Fermented Milk Products	LI3.2 Analyze the microbial content in different fermented milk products.	CI3.2 Fermented Milk Products	SL3.2 Explore the health benefits of fermented milk products
	SO3.3 Cheese Fermentation		CI3.3 Cheese Fermentation	SL3.3 Learn about the types of cheese and their microbial processes
	SO3.4 Fermented Vegetables - Sauerkraut		CI3.4 Fermented Vegetables: Sauerkraut	
	SO3.5 Fermented Meat Products		CI3.5 Fermented Meat Products	
	SO3.6 Fermented Beverages - Beer		CI3.6 Fermented Beverages: Beer	
	SO3.7 Vinegar Production		CI3.7 Vinegar Production	
	SO3.8 Mould Fermentation		CI3.8 Mould Fermentation	
	SO3.9 Advancements in Fermentation Technology		CI3.9 Advancements in Fermentation Technology	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Rememberfermentation
	SW3.2 Mini Project	Prepare a flow chart of how Alcoholic and Acetic Acid Fermentation occur
	SW3.3 Other Activities (Specify)	Explore online tutorials and resources on meat processing.

Item	CI	LI	SW	SL	Total
Approx.Hrs	09	2	1	3	15

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO4-05BT502.4: Recognize various methods used for microbiological examination of food and food ingredients	SO4.1 Introduction to Microbiological Examination of Foods	LI4.1 Perform a direct microscopic examination of a food sample to observe microbial content.	CI4.1 Introduction to Microbiological Examination of Foods	SL4.1 Study the significance of microbiological examination in food safety
	SO4.2 Culture Techniques in Food Microbiology		CI4.2 Culture Techniques in Food Microbiology	SL4.2 Learn about different culture media used in food microbiology
	SO4.3 Most Probable Number (MPN) Method		CI4.3 Most Probable Number (MPN) Method	SL4.3 Explore the applications of the MPN method in water and food testing
	SO4.4 Dye-Reduction Assay		CI4.4 Dye-Reduction Assay	
	SO4.5 Immunological Methods in Food Microbiology		CI4.5 Immunological Methods in Food Microbiology	
	SO4.6 Advanced Techniques in Food Microbiology		CI4.6 Advanced Techniques in Food Microbiology	
	SO4.7 Rapid Methods for Microbial Detection		CI4.7 Rapid Methods for Microbial Detection	
	SO4.8 Quality Assurance in Microbiological Testing		CI4.8 Quality Assurance in Microbiological Testing	
	SO4.9 Case Studies on Foodborne Outbreaks		CI4.9 Case Studies on Foodborne Outbreaks	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Various culture techniques
	SW4.2 Mini Project	Prepare the chart for Most Probable Number (MPN) Count
	SW4.3 Other Activities (Specify)	Understand dye reduction assay

Approx.Hrs	09	1	1	3	14

Course Outcome (CO)	**SessionOutcomes(SOs)**	**LaboratoryInstruction(LI)**	**ClassroomInstruction(CI)**	**Self-Learning(SL)**
CO5-05BT502.5: Explore role of the microbes on the basis of their morphological characteristics.	SO5.1 Introduction to Food Preservation	LI5.1 Perform a lab experiment to study the effects of physical preservation methods on food samples.	CI5.1 Introduction to Food Preservation	SL5.1 Study the history and evolution of food preservation techniques
	SO5.2 Physical Methods of Food Preservation	.	CI5.2 Physical Methods of Food Preservation	SL5.2 Learn about different physical preservation methods (e.g., pasteurization, irradiation)
	SO5.3 Chemical Methods of Food Preservation		CI5.3 Chemical Methods of Food Preservation	SL5.3 Understand the mechanisms and applications of various chemical preservatives
	SO5.4 Biological Methods of Food Preservation		CI5.4 Biological Methods of Food Preservation	
	SO5.5 Quality Control in Food Preservation		CI5.5 Quality Control in Food Preservation	
	SO5.6 Microbiological Criteria for Food Safety		CI5.6 Microbiological Criteria for Food Safety	
	SO5.7 Good Manufacturing Practices (GMP)		CI5.7 Good Manufacturing Practices (GMP)	
	SO5.8 Hazard Analysis and Critical Control Points (HACCP)		CI5.8 Hazard Analysis and Critical Control Points (HACCP)	
	SO5.9 Recordkeeping and Documentation in Food Safety		CI5.9 Recordkeeping and Documentation in Food Safety	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	illustrate the role of quality control for Industrial Bioproducts
	SW5.2 Mini Project	Make a tabulated record of HACCP
	SW5.3 Other Activities (Specify)	Rewrite the HACCP

Course duration (in hours) to attain Course Outcomes:

Course Title: Food Biotechnology **Course Code: 05BT502**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-05BT502.1: Familiarization with the basic concepts of microorganism involved in food processing and food spoilage.	9	4	3	1	17
CO2-05BT502.2: Acquired Skills to analyze beneficial and harmful impact of microorganisms on food and food ingredients	9	4	3	1	17
CO3. Identify microbes for the development of functional food	9	4	3	1	17
CO4-05BT502.4: Recognize various methods used for microbiological examination of food and food ingredients	9	2	3	1	15
CO5-05BT502.5: Explore role of the microbes on the basis of their morphological characteristics.	9	1	3	1	14
Total Hours	45	15	15	5	80

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

Course Title: Food Biotechnology **Course Code:05BT502**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-05BT502.1: Familiarization with the basic concepts of microorganism involved in food processing and food spoilage.	02	03	04	1	10
CO2-05BT502.2: Acquired Skills to analyze beneficial and harmful impact of microorganisms on food and food ingredients	02	05	02	1	10
CO3. Identify microbes for the development of functional food	04	04	01	1	10
CO4-05BT502.4: Recognize various methods used for microbiological examination of food and food ingredients	03	04	02	1	10
CO5-05BT502.5: Explore role of the microbes on the basis of their morphological characteristics.	04	03	02	1	11
Total Marks	15	19	11	05	51

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

Suggested learning Resources:

(a) Books:

S. No.	Title/Author/Publisher details
1	Prescott, Harley and Klein, ‘ Microbiology’, MC Graw Hill, International Edition.
2	Willian C. Fraizier and Dennis C. Westhoff, ‘Food Microbiology’, Tata McGraw Hill Publishing Company , New Delhi.
3	Perry Johnson-Green, Fergus M. ClydesdaleIntroduction to Food BiotechnologyContemporary Food Science 2002
4	Food BiotechnologyWPI PublishingS.C. Bhatia 2017
5	Food Biotechnology KNORR D.TAYLOR & FRANCIS 2017

(b) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B. Tech. Biotechnology
Semester:5th Sem
Course Title: Food Biotechnology
Course Code: 05BT502

CO/PO/PSO Mapping															
Course Outcome (Cos)	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-05BT502.1: Familiarization with the basic concepts of microorganism involved in food processing and food spoilage.	-	1	-	1	1	2	1	-	3	1	3	1	-	1	-
CO2-05BT502.2: Acquired Skills to analyze beneficial and harmful impact of microorganisms on food and food ingredients	-	1	-	-	-	-	3	-	3	2	3	3	-	1	-
CO3. Identify microbes for the development of functional food	-	2	1	1	-	-	3	-	3	1	3	3	-	2	1
CO4-05BT502.4: Recognize various methods used for microbiological examination of food and food ingredients	1	1	1	-	2	2	2	3	-	1	3	3	1	1	1
CO5-05BT502.5: Explore role of the microbes on the basis of their morphological characteristics.	1	1	2	-	-	2	3	3	-	2	3	3	1	1	2

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO1-05BT502.1:** Familiarization with the basic concepts of microorganism involved in food processing and food spoilage.	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, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO2-05BT502.2:** Acquired Skills to analyze beneficial and harmful impact of microorganisms on food and food ingredients	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-1,2,3**
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO3-05BT502.3:** Identify microbes for the development of functional food	SO3.1 SO3.2 SO3.3 SO3.4 ,3.5,SO3.6,SO3.7,SO3.8,SO3.9	**IL 1** **IL 2**	3.1,3.2,3.3,3.4.3.5,3.6,3.7,3.8,3.9	**3SL-1,2,3**
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO4-05BT502.4:** Recognize various methods used for microbiological examination of food and food ingredients	SO4.1 SO4.2 SO4.3 SO4.4 ,SO4.5,SO4.6,SO4.7,SO4.8,SO4.9	**IL 1** **IL 2**	4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8,4.9	**4SL-1,2,3**
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO5-05BT502.5:** Explore role of the microbes on the basis of their morphological characteristics.	SO5.1 SO5.2 SO5.3 SO5.4 ,SO5.5,SO5.6,SO5.7,SO5.8,SO5.9	**IL 1** **IL 2**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9	**5SL-1,2,3**

Program Name	**Bachelor of Science (Hons.) -Biotechnology**	
Semester	V	
Course Code:	04BT501	
Course title:	Biosafety, Bioethics, IPRs and Patenting	**Curriculum Developer**: Dr. Deepak Mishra, Professor
Pre-requisite:	Student should have basic knowledge of Biotechnology, Genetic Engineering and Research.	
Rationale:	The paper on Biosafety, Bioethics, IPRs and Patenting in a B Sc. (Hons.) Biotechnology program is interconnected concepts that serve to ensure the responsible and ethical use of biotechnology and biological resources. They encompass various aspects, from safety and ethics in research to the protection of intellectual property. The primary goal biosafety is to ensure the safe handling, transport, and disposal of biological materials, especially those with hazardous potential. This is crucial in laboratories, research facilities, and industrial settings where biological research is conducted. Bioethics guides decision-making, ensuring that scientific progress respects human rights, dignity, and welfare. It covers informed consent, privacy, research ethics, animal welfare, and issues surrounding emerging technologies like genetic engineering and cloning. IPRs incentivize innovation by allowing researchers and inventors to profit from their work.	
Course Outcomes (COs):	**CO1-04BT501.1:** Familiarization with the basic concepts, key principles and regulations of biosafety in biotechnological research. **CO2-04BT501.2:** Acquired Skills to analyze and address ethical, legal, and socioeconomic, health and safety implications of biotechnology. **CO3-04BT501.3:** Equipped to comprehend the fundamentals of IPRs, including the legal frameworks and laws. **CO4-04BT501.4:** Recognize various methods related to patents and the patenting process law and regulations in India. **CO5-04BT501.5:** Explore role of regulatory framework for recombinant DNA research, Biotechnology and food safety laws.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=2:0:1)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
Skill Enhancement course	04BT501	Biosafety, Bioethics, IPRs and Patenting	2	2	1	5	10	2+1=3

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

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (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)		
Skill Enhancement course	04BT501	Biosafety, Bioethics, IPRs and Patenting	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)		
Skill Enhancement course	04BT501-L	Biosafety, Bioethics, IPRs and Patenting	35	5	5	5	50	50	100

Course-Curriculum:

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

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	08	02	01	05	16

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

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-04BT501.1: Familiarization with the basic concepts, key principles and regulations of biosafety in biotechnological research.	**SO1.1** Define and Describe concept, History and objectives of Biosafety	**LI1.1** Case study on risk assessment of lab	**Unit-1** **CI1.1** Biosafety: Introduction, Historical prospective, objectives,	**SL1.1** Search various reference books and study material to start the learning of Biosafety
	SO1.2 Study of risk assessment and its regulation		**CI1.2** risk assessment in biotechnological research and their regulation	
	SO1.3 Study the concept of containment		**CI1.3** physical and biological contaminants	**SL1.2** Examine biosafety in your institution's lab
	SO1.4 Study planned introduction of GMOs		**CI1.4,** field trial and planned introduction of GMOs,	
	SO1.5 Describe the biosafety guidelines		**CI1.5** Biosafety guidelines in India	**SL1.3** Classify your lab based on biosafety level
	SO1.6 Explain biosafety level of microbial research		**CI1.6** Biosafety levels for microbial researches.	
	SO1.7 Explain biosafety level of plant research		**CI1.7** Biosafety levels for Plant researches	**SL1.4** To prepare the biosafety manual for your lab
	SO1.8 . Explain biosafety level of animal research		**CI1.8** Biosafety levels for animal researches.	**SL1.5** To implement guideline in biotech laboratory.

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail biosafety guidelines for regulation of RDT research in India.
	SW1.2 Mini Project	Prepare biosafety symbols and implement in your laboratory.
	SW1.3 Other Activities (Specify)	Preparation of biosafety manual for biotechnology laboratory.

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-04BT501.2: Acquired Skills to analyze and address ethical, legal, and socioeconomic, health and safety implications of biotechnology.	**SO2.1** Explore the concept bioethics and ethical issue of biotechnology	**LI2.1** Case Study on Women Health Ethics	**Unit-II** **CI2.1** Bioethics: Introduction, Ethical issues related to biotechnology, Ethical concerns of gene cloning	**SL2.1** Search various books and resources for study the bioethics.
	SO2.2 Reflecting impact of biotech research in society	**LI2.2** Case Study on Medical Negligence	**CI2.2** legal and socioeconomic impacts of biotechnology	**SL2.2** study about failure of biotech products- case study
	SO2.3 Explain health and safety issues of biotech		**CI2.3** health and safety issues	**SL2.3** to learn about control measures for biotech research
	SO2.4 Assessing the benefits of cloning		**CI2.4** possible benefits of successful cloning	**SL2.4** standardize the protocol for successful cloning
	SO2.5 Explaining hazards of GMOs on environment		**CI2.5** hazards of environmental engineering	**SL2.5** to learn hazards of cloning

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Assess the impact on RDT research on human and environment.
	SW2.2 Mini Project	Designing of poster for showing benefits of cloning
	SW2.3 Other Activities (Specify)	To perform case studies on GMOs and their impact.

Item	Cl	LI	SW	SL	Total
Approx. Hrs	07	04	01	05	17
Item	Cl	LI	SW	SL	Total
Approx. Hrs	05	05	01	05	16

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction (CI)	Self-Learning(SL)
CO3-04BT501.3: Equipped to comprehend the fundamentals of IPRs, including the legal frameworks and laws.	**SO3.1** Explain the role of IPRs.-concept and types	**LI3.1** Case Study on clinical trial of drugs	**Unit-III** **CI3.1** Intellectual Property Rights-: Introduction, types	**SL3.1** Collection of books and study materials for IPRs
	SO3.2 Assessing the different types of IPRs		**CI3.2** trade secret patent, copyright, plant variety protection	**SL3.2** Study different types of intellectual property
	SO3.3 Describe about WIPO GATT and Trips	**LI3.2** preparation of business plan	**CI3.3** WIPO, GATT, TRIPs,:	**SL3.3** categorization of different types of intellectual property
	SO3.4 Explaining concept of PBR		**CI3.4** plant breeder's rights	**SL3.4** Study of role of WIPO for IPR protection
	SO3.5 Describe about PPVFR Act		**CI3.5** protection of plant varieties and former's right act (2001),	**SL3.5** Assess law and legislation for IPRs

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe in detail about different types of intellectual properties.
	SW3.2 Mini Project	Describe the role of different Laws for protection of intellectual property.
	SW3.3 Other Activities (Specify)	Prepare a list of plant varieties protected through PBR Act and PPVFR Act.

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain about patent and patent processing procedure.
	SW4.2 Mini Project	Study the silent features of different law of patenting worldwide
	SW4.3 Other Activities (Specify)	Prepare one article on international status of patenting

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO4-04BT501.4: Recognize various methods related to patents and the patenting process law and regulations in India.	**SO4.1** Exploring the concept of Patents and Patenting process	**LI4.1** Proxy Filling of Process Patent	**Unit-IV** **CI4.1** Patents and patent processing: Introduction Essential requirements	**SL4.1** Learn about different categories of Patents
	SO4.2 Explaining the concept of patent law	**LI4.2** Proxy filling of Product Patent	**CI4.2** International scenario of patents	
	SO4.3 Explaining the role of patent for biologics.		**CI4.3** patenting of biological materials	**SL4.2** Compare Rules of different countries
	SO4.4 Evaluate impact of patent in india		**CI4.4** significance of patents in India	**SL4.3** Learn about various criteria for patentnig
	SO4.5 Describe the impact of patenting.		**CI4.5** Patent application, Procedures and granting	**SL4.4** Case studies related to patenting in India
	SO4.6 Describe the patent law 1970		**CI4.6** Patent Act (1970)	**SL4.5** Case studies related to biological patents
	SO4.7 Describe the patent Act 2002		**CI4.7** Patent (Amendments) Act (2002).	

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

CO5-04BT501.5: Explore role of regulatory framework for recombinant DNA research, Biotechnology and food safety laws.	**SO5.1** Define the concept of regulation of RDT research		**Unit-V** **CI5.1** Regulatory framework in India governing GMOs	**SL5.1** learn about basic concept & requirement of GMOs development
	SO5.2 Study the Recombinant DNA Guideline 1990		**CI5.2** Recombinant DNA Guidelines (1990)	**SL5.2**Review concept of RDT research
	SO5.3 Elaborate Revised Guideline for Research in Transgenic Plants (1998)		**CI5.3** Revised Guidelines for Research in Transgenic Plants (1998)	**SL5.3**learn how to apply Law to regulate food products
	SO5.4 Elaborate the role of Prevention Food Adulteration Act (1955)		**CI5.4** Prevention Food Adulteration Act (1955)	**SL5.4** Learn about novel characters of GM Plants
	SO5.5 Elaborate the role of Food Safety and Standards Bill (2005		**CI5.5** Food Safety and Standards Bill (2005)	**SL5.5** Learn about Role of FSSAI

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

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general characteristics and silent features of RDNA laws.
	SW5.2 Mini Project	Describe the role of Law and legislations for development of new varieties.
	SW5.3 Other Activities (Specify)	Prepare a detail document on international Food law and regulations

Course duration (in hours) to attain Course Outcomes:

Course Title: Biosafety, Bioethics and IPRs **Course Code:**04BT501

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-04BT501.1: Familiarization with the basic concepts, key principles and regulations of biosafety in biotechnological research.	8	2	5	1	16
CO2-04BT501.2: Acquired Skills to analyze and address ethical, legal, and socioeconomic, health and safety implications of biotechnology	5	4	5	1	15
CO3-04BT501.3: Equipped to comprehend the fundamentals of IPRs, including the legal frameworks and laws.	5	5	5	1	16
CO4-04BT501.4: Recognize various methods related to patents and the patenting process law and regulations in India	7	4	5	1	17
CO5-04BT501.5: Explore role of regulatory framework for recombinant DNA research, Biotechnology and food safety laws.	5	0	5	1	11
Total Hours	30	15	25	05	75

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

Course Title: Biosafety, Bioethics and IPRs **Course Code:** 04BT501

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-04BT501.1: Familiarization with the basic concepts, key principles and regulations of biosafety in biotechnological research.	2	1	1	1	5
CO2-04BT501.2: Acquired Skills to analyze and address ethical, legal, and socioeconomic, health and safety implications of biotechnology	2	4	2	2	10
CO3-04BT501.3: Equipped to comprehend the fundamentals of IPRs, including the legal frameworks and laws.	2	3	3	2	10
CO4-04BT501.4: Recognize various methods related to patents and the patenting process law and regulations in India	3	5	5	2	15
CO5-04BT501.5: Explore role of regulatory framework for recombinant DNA research, Biotechnology and food safety laws.	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

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

Suggested learning Resources:

(a) Books:

(b)

S. No.	Title/Author/Publisher details
1	Sateesh MK (2010) Bioethics and Bio safety, I. K. International Pvt Ltd.
2	Sree Krishna V (2007) Bioethics and Bio safety in Biotechnology, New age international publishers
3	The law and strategy of Biotechnological patents by Sibley. Butterworth publications.
4	Intellectual property rights – Ganguli – Tat McGraw-Hill
5	Biotechnology-B. D. Singh- Kalyani Publications

(c) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B.Sc. Hons Biotechnology
Semester: V Semester
Course Title: Biosafety, Bioethics and IPRs
Course Code: 04BT501

Course Outcome (Cos)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO 2	PO3	PO 4	PO5	PO6	PO 7	PO8	PO 9	PO10	PO11	PO1 2	PSO1	PSO2	PSO3
CO1-04BT501.1: Familiarization with the basic concepts, key principles and regulations of biosafety in biotechnological research.	1	1	2	2	3	1	2	3	2	1	2	3	2	2	3
CO2-04BT501.2: Acquired Skills to analyze and address ethical, legal, and socioeconomic, health and safety implications of biotechnology	1	1	1	1	2	1	2	2	1	2	2	2	2	3	3
CO3-04BT501.3: Equipped to comprehend the fundamentals of IPRs, including the legal frameworks and laws.	1	1	2	2	2	1	3	2	2	1	2	2	1	2	3
CO4-04BT501.4: Recognize various methods related to patents and the patenting process law and regulations in India	1	1	2	1	3	1	3	3	2	2	1	3	1	2	3
CO5-04BT501.5: Explore role of regulatory framework for recombinant DNA research, Biotechnology and food safety laws.	1	1	2	1	3	1	3	3	1	2	2	3	1	2	2

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO1-04BT501.1:** Familiarization with the basic concepts, key principles and regulations of biosafety in biotechnological research.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8	1.1	1.1,1.2,1.3,1.4,1.5, 1.6, 1.7, 1.8,	1SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO2-04BT501.2:** Acquired Skills to analyze and address ethical, legal, and socioeconomic, health and safety implications of biotechnology	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5	2.1, 2.2	2.1, 2.2, 2.3, 2.4, 2.5,	2SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO3-04BT501.3:** Equipped to comprehend the fundamentals of IPRs, including the legal frameworks and laws.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5	3.1,3.2	3.1,3.2,3.3,3.4,3.5,	3SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO4-04BT501.4:** Recognize various methods related to patents and the patenting process law and regulations in India	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7	4.1,4.2	4.1,4.2,4.3,4.4, 4.5, 4.6, 4.7,	4SL-1,2,3,4,5
PO 1,2,3,4,5, 6, 7,8,9,10,11, 12 PSO 1,2,3	**CO5-04BT501.5:** Explore role of regulatory framework for recombinant DNA research, Biotechnology and food safety laws.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5		5.1,5.2,5.3,5.4,5.5,	5SL-1,2,3,4,5

Program Name	**Bachelor of Science (Hons.) in Biotechnology (B.Sc. (Hons.) BT)**	
Semester	V	
Course Code:	05BT402	
Course title:	Yoga Science	**Curriculum Developer**: Dr. Dileep Kumar Tiwari, Assistant Professor
Pre-requisite:	Student should have basic knowledge of Applications of Yoga and Meditation and its concepts	
Rationale:	The Yoga Science course in a B.Sc. Hons. Biotechnology program serves a crucial role by providing students with a legal understanding of Yoga and its original text Yoga. At the same time, they should also have adequate knowledge of Yoga and Meditationin which they should have knowledge of its basic principles and elements.	
Course Outcomes (COs):	**CO1-05BT402.1:-** Elucidate the overview of Yoga Science **CO2-05BT402.2:-** Acquire knowledge regarding Yoga and Pranayam with practices of Bandha and Mudra **CO3-05BT402.3:-** Applied knowledge about yoga and Meditation	

Scheme of Studies:

Board of Study	**Course Code**	**Course Title**	**Scheme ofstudies (Hours/Week)**					**Total Credits(C) (L:T:P=0:0:2)**
			Cl	LI	SW	SL	**Total Study Hours(CI+LI+SW+SL)**	
Skill enhancement course (SEC)	05BT402	Yoga Science	0	4	1	1	4	0+1=1

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

Scheme of Assessment: 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)		
SEC	**05BT402**	**Yoga Science**	35	5	5	5	50	50	100

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx. Hrs** | 00 | 10 | 01 | 01 | 12

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-05BT402.1:- Elucidate the overview of Yoga Science	**SO1.1** Explain the concept and principles of yoga	**Unit-1.** Introduction to Yoga and Yogic Practices **LI 1.1** Yoga: Etymology, definitions, aim, objectives and misconceptions		**SL1.1** Read some articles about Yoga
	SO1.2 Elucidate the origin history of yoga	**LI 1.2** Yoga: Its Origin, history and development		
	SO1.3 Elaborate the rules of yoga	**LI 1.3**. Rules and regulations to be followed by Yoga ractitioners		
	SO1.4 Elucidate the various yoga practices	**LI 1.4** Introduction to Yoga practices		
	SO1.5 Elaborate the different steps of yoga sadhana	**LI 1.5** Shatkarma: meaning, purpose and their significance in Yoga Sadhana		
	SO1.6 Elaborate the different yogic loosening practices.	**LI 1.6**. Introduction to Yogic Loosening practices and Surya Namaskar		

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe various principles of yoga science.
	SW1.2 Mini Project	Elaborate different branches of yoga with its role.
	SW1.3 Other Activities (Specify)	Make a demonstration on yoga.

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** | 00 | 10 | 01 | 01 | 12

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-05BT402.2:- Acquire knowledge regarding Yoga and Pranayam with practices of Bandha and Mudra	**SO2.1** Explain the different types of yoga practices	**Unit-2.0:** Yogic Practices. Breathing Practices and Pranayama **LI 2.1**. Sectional Breathing (Abdominal, Thoracic and Clavicular)		**SL2.1** Note down the impact of yoga in life.
	SO2.2 Elucidate the Role of deep breathing in yoga	**LI 2.2**.Yogic Deep Breathing		
	SO2.3 Elaborate the concept of puraka, Rechaka and Kumbhaka	**LI 2.3**.Concept of Puraka, Rechaka and Kumbhaka		
	SO2.4 Elucidate the bandha and mudra	**LI 2.4**. Concept of Bandha and Mudra		
	SO2.5 Explanation about the anuloma viloma	**LI 2.5** .Anuloma Viloma/ Nadi Shodhana		
	SO2.5 Explanation about the shitali and bhamari .	**LI 2.6** Shitali. Bhramari		

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe the Role of yoga mudra.
	SW2.2 Mini Project	Make a chart on classification of yoga practices
	SW2.3 Other Activities (Specify)	Describe methods of prranayam

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** | 00 | 10 | 01 | 01 | 12

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-05BT402.3:- Applied knowledge about yoga and Meditation	**SO3.1** Elucidate the meditation concept	**Unit-3** Practices leading to Meditation **LI 3.1**.Recitation of Pranava Mantra		**SL3.1** Read about various examples of meditation
	SO3.2 Explain about the prayers.	**LI 3.2**. Recitation of Hymns, in vocations and prayers		
	SO3.3 Elaborate the Anter Maun	**LI 3.3** Anter Maun		
	SO3.4 To learn the general about breath meditation	**LI 3.4** Breath Meditation		
	SO3.5 Explanation about om dhyana	**LI 3.5** 0m Dhyana		

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Flow chart on different types of meditation
	SW3.2 Mini Project	Describe the different characteristics of meditation
	SW3.3 Other Activities (Specify)	Demonstration on meditation

Course duration (in hours)to attain Course Outcomes:

Course Title: Yoga Science **Course Code: 05BT402**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-05BT402.1:- Elucidate the overview of Yoga Science	0	10	1	1	12
CO2-05BT402.2:- Acquire knowledge regarding Yoga and Pranayam with practices of Bandha and Mudra.	0	10	1	1	12
CO3-05BT402.3:- Applied knowledge about yoga and Meditation	0	10	1	1	12
Total Hours	00	30	03	03	36

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

Course Title: Yoga Science **Course Code: 04B402**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-05BT402.1:- Elucidate the overview of Yoga Science	3	8	7	2	20
CO2-05BT402.2:- Acquire knowledge regarding Yoga and Pranayam with practices of Bandha and Mudra.	3	4	5	2	14
CO3-05BT402.3:- Applied knowledge about yoga and Meditation	4	5	5	2	16
Total Marks	**10**	**17**	**17**	**06**	**50**

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

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Singh S.P. & yogi Mukesh ,Foundation of yoga , standard publication , new Delhi ,2010
2	Swami dherendrabrhamchari , yogasanavigyaan , dherendra yoga prakshan , new Delhi 1966
3	Sarswati , swami satyananda , asan pranayama mudra bandha ,yogprakshan trust munger ,2013
4	H.R. nagendra , asan pranayama mudra bandha,swami Vivekananda yogprakshan ,banglore 2002
5	IshwerBhardwaj , saralyogashan , satyam publication house , new Delhi 2018
6	Shri ram chauhaan , mudra rahasya , bhartiyeyogsansthan , new delhi 2014
7	DrVishwanath Prasad sangha , dhyanyog,bhartiyeyogsansthan , new delhi 1987
8	ShriDeshraj ,Dhyansadhna ,bhartiyeyogsansthan , new delhi 2015
9	bhartiyeyogsansthan , new delhi 2014

(b) 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: B.Sc. (Hons.) Biotechnology
Semester: IV Semester
Course Title: Yoga Science.
Course Code: 05BT402

Course Outcome (Cos)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1-05BT402.1:- Elucidate the overview of Yoga Science	1	2	-	1	2	1	2	1	2	-	1	2	2	2	1
CO2-05BT402.2:- Acquire knowledge regarding Yoga and Pranayam with practices of Bandha and Mudra.	-	1	1	-	-	-	1	-	1	1	-	-	1	1	2
CO3-05BT402.3:- Applied knowledge about yoga and Meditation	1	1	2	1	-	1	1	1	1	2	1	-	3	1	1

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

Course Curriculum:

POs & PSOs No.	Cos	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-05BT402.1:- Elucidate the overview of Yoga Science**	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6	1.1,1.2,1.3,1.4,1.5,1.6,		**1SL-1**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-05BT402.2:- Acquire knowledge regarding Yoga and Pranayam with practices of Bandha and Mudra**.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6	2.1, 2.2, 2.3,2.4,2.5,2.6,		**2SL-1**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3-05BT402.3:- Applied knowledge about yoga and Meditation**	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5	3.1,3.2,3.3,3.4,3.5,		**3SL-1**

Program name	**Bachelor of Science (B.Sc.) - Biotechnology**	
Semester	VI	
Course Code:	01BT601	
Course title:	Immunology & Immune Technology	Developer: Dr. Kamlesh Kumar Soni, Assistant Professor
Pre-requisite:	Student should have basic knowledge biology and biochemistry	
Rationale:	The paper on "Immunology and Immune Technology" in B.Sc. Biotechnology program give the opportunity to predict the working principle and application of numerous cells involve in defense responses. This subject will build up the basic and advanced mechanism of immune responses during the different stresses. This subject offers the students the opportunity to advance the knowledge of immunology	
Course Outcomes (COs):	CO1-01BT601 .1: Understand the essential of immune system cells to the organism CO1-01BT601 .2: Know the fundamentals of immunoglobulins, antigens, and their classifications CO1-01BT601 .3: In-depth study about action of immune responses and their genetic regulations CO1-01BT601 .4: Elaborate the various immunodeficiency related diseases and functionality of immune system CO1-01BT601 .5: Basic principles and applications of various immunization techniques as well as the various vaccinations	

Scheme of Studies:

Board ofStudy	Course Code	CourseTitle	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=4:0:2)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
MAJOR	01BT601	Immunology & Immune Technology	3	1	1	3	8	4+2=6

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	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)		
MAJOR	01BT601	Immunology & Immune 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)		
MAJOR	01BT601-L	Immunology & Immune Technology	35	5	5	5	50	50	100

Unit-I:

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	12	06	01	05	24

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-01BT601 .1: Understand the essential of immune system cells to the organism	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	**Unit 1:** CI 1.1:History and major milestones of Immunology	SL1.1: Study about the basic of immune systems
	SO1.2: Understanding fundamental of immune system	LI 1.2:Differential leucocytes count	CI 1.2: General concepts of the immune system	SL1.2: Learn about defense mechanism in lower organism
	SO1.3: In depth study about the non-specific immune systems	LI 1.3:Blood Group Determination	CI 1.3: Innate immunity	SL 1.3: Read the working principle of non-specific immune system
	SO 1.4 In details on immune responses		CI 1.4 Adaptive immunity	SL 1.4: study the 1st line of defence
	SO1.5: Categorizing the primary and secondary responses		CI 1.5: Primary immune response,	SL 1.5: Compare the B-cells and T-cells
	SO 1.6 learn how secondary response works		CI 1.6 Secondary immune response	
	SO 1.7 Know how the blood cells are produced		CI 1.7 Haematopoiesis	
	SO1.8: Basic and advanced understanding of B and T cells.		CI 1.8: Structure, properties of the immune cells	
	SO 1.9 Know about types of Lymphoid organs		CI 1.9 Types of Lymphoid Organs	
	SO 1.10 Know structure of Primary Lymphoid Organs		CI 1.10 Structure of Primary Lymphoid Organs	
	SO 1.11 Know structure of Secondary Lymphoid Organs		CI 1.11 Structure of Secondary Lymphoid Organs	
	SO 1.12 Know how the immune systems work		CI 1.12 Function of Lymphoid Organs	

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 defence

Unit-II:

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	12	06	01	04	23

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-01BT601 .2: Know the fundamentals of immunoglobulins, antigens, and their classifications	SO2.1: Discuss the properties of antigens	LI 2.1: Demonstration of Antibody-antigen interaction	CI 2.1:Antigens: Properties	SL2.1: Fundamental structure of immunoglobins
	SO2.2: Discuss the types of antigens		CI 2.2 Types	SL 2.2: Basic information about Protein-protein interaction
	SO 2.3 Know how small molecules induces the immunity	LI 2.2: Total leucocytes count	CI 2.3: Haptens and Adjuvants	SL 2.3: Read the working principle of non-specific immune system
	SO 2.4: Build up the concept of antibody	LI 2.3: Determination of BT and CT	CI 2.4: Antibodies:	SL 2.4: Read in details about the monoclonal and polyclonal antibody
	SO 2.5: Build up the concept classes of antibody		CI 2.5: Antibodies: Types,	
	SO 2.6: Build up the concept about the antibody's structures		CI 2.6: Molecular structure of Immuno-globulins	
	SO 2.7 Know how antibodies work		CI 2.7 function of Antibody	
	SO 2.8 Know how binding and inheritance occurs		CI 2.8 Allotypes & idiotypes	
	SO 2.9: Summarizing the mode of action of B-cells		CI 2.9Humoral immune responses	
	SO 2.10: Know how T-Cells in defence response works		CI 2.10 Cellular immune response	
	SO 2.11: Learn mechanism of complement system		CI 2.11: Complement System	
	SO 2.12 Study to know why cytokines are important		CI 2.12 Introduction to cytokines	

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

Unit-III:

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

ApproximateHours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	04	23

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-01BT601 .3: In-depth study about action of immune responses and their genetic regulations	SO3.1: Discuss about how immune cell are activated	LI 3.1: Total RBC count	CI 3.1: Genome organization and rearrangements during B-lymphocyte differentiation	SL3.1: Figure out the fundamental differences between humoral and cell mediated immune responses
	SO3.2: Learn About B cell differentiation	LI 3.2: RID	CI 3.2: B-lymphocyte differentiation	SL3.2: Advance the knowledge of regulation of B & T cell on exposure to the antigens
	SO 3.3 Learn how antibody affinity works	LI 3.3: RIA	CI 3.3: Antibody affinity	SL 3.3: Clear the basic concept of the gene regulation
	SO 3.4 Linking different fundamental differences among the Antibodies		CI 3.4: maturation	SL 3.4: Boost your knowledge on antibody-antigen interaction mechanism
	SO 3.3: Able to visualize how the class switching occurs		CI 3.5: Antibody class switching,	
	SO 3.6: Learn how antibody capture the specific antigen send them to trash		CI 3.6: Antibody diversity	
	SO 3.7 How gene get assembled		CI 3.7 Regulation of immunoglobulin gene expression	
	SO 3.8 learn about clonal selection theory		CI 3.8 clonal selection theory	
	SO 3.9: Discuss germ line Hypothesis		CI 3.9: germ line Hypothesis	
	SO 3.10: Explain somatic mutation Hypothesis		CI 3.10: somatic mutation Hypothesis	
	SO 3.11: How T cell receptor works		CI 3.11: T cell receptor	
	SO 3.12: Discuss Assembly of T-cell receptor genes by somatic recombination		CI 3.12: Assembly of T-cell receptor genes by somatic recombination	

Suggested Sessional Work (SW): *anyone*	Assignments:	Describe in hybridoma technology
	Mini Project:	Draw structure of different types of antibodies
	Other Activities (Specify):	Watch animation on explaining the functionality of cell mediated immune system

Unit IV:

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	12	06	01	04	23

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-01BT601 .4: Elaborate the various immunodeficiency related diseases and functionality of immune system	SO4.1: Discuss about the cell surface protein and their role on foreign recognition	LI 4.1: Separation of serum from blood	CI 4.1: Major Histocompatibility complexes	SL4.1: Study the MHCs
	SO 4.2 How MHC I functions	LI 4.2: Double immunodiffusion test	CI 4.2 Class I MHC	SL 4.2: Learn what are the interferons
	SO 4.3 Learn how MHC II is different from MHC I	LI4.3: VDRL Test	CI 4.3 Class II MHC	SL 4.3: Study the MAMPs and PAMPs
	SO 4.4 Learn how antigens are processed and cleaned		CI 4.4 Antigen processing	SL 4.4: Study the nature of HIV and why is it not curable so far
	SO 4.5: Discus how infections is associated with interferons and role of interferons to protect the body from pathogen		CI 4.5: Immunity to infection	
	SO 4.6 How various organ have mechanism to activate the immunity		CI 4.6 Immunity to different organisms	
	SO 4.7: How pathogen escape from recognition by the host's immune system by alternating the structure of the recognized MAMPs		CI 4.7: Pathogen defence strategies	
	SO 4 8: Discuss various immune attacking diseases		CI 4.8: avoidance of recognition	
	SO 4.9: Learn about Autoimmune diseases		CI 4.9: Autoimmune diseases	
	SO 4.10: Illustrate about Primary Immunodeficiency		CI 4.10: Primary Immunodeficiency	
	SO 4.11: Explain Secondary Immunodeficiency		CI 4.11: Secondary Immunodeficiency	
	SO 4.12: Discuss about AIDS		CI 4.12: AIDS	

Suggested Sessional Work (SW): *anyone*	Assignments:	Elaborate the function of MHCs
	Mini Project:	Describe the AIDS in details
	Other Activities (Specify):	Make a poster explaining how pathogen make fool and escape from host immune machineries

Unit-V:

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

ApproximateHours

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

Course outcome (COs)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-01BT601 .5: Basic principles and applications of various immunization techniques as well as the various vaccinations	SO5.1: Explain body fight against the infection	5.1: Demonstration of ELISA	CI 5.1: Vaccines	SL 5.1: Apply idea of Infection to suppress the immunity to human health
	SO 5.2 Know how the vaccination is done	5.1: Demonstration of RIA	CI 5.2 Vaccination	SL 5.2: Rerevise the ELSIA for several diseases' diagnosis
	SO 5.3 How small molecules participate in immunity	5.1: Demonstration of Immunoelectrophoresis	CI 5.3 Adjuvants, cytokines,	
	SO 5.4 How DNA is exploited to make vaccine		CI 5.4DNA vaccines,	
	SO 5.5 Explain Recombinant vaccines,		CI 5.5 Recombinant vaccines,	
	SO 5.6 Explain bacterial vaccines and viral vaccines,		CI 5.6 bacterial vaccines, viral vaccines,	
	SO 5.7 Discuss about vaccines to other infectious agents		CI 5.7 vaccines to other infectious agents	
	SO 5.8: Explore Passive immunization		CI 5.8: Passive immunization	
	SO 5.9 Explore Active immunization		CI 5.9 Active immunization	
	SO 5.10 know about immunodiagnostics		CI 5.10 Introduction to immunodiagnostics	
	SO 5.11 Learn about RIA		CI 5.11 RIA	
	SO 5.12 learn about ELISA		CI 5.12: ELISA	

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 differ from RIA ; Study in details

Course duration (in hours) to attain Course Outcomes (Course title: Immunology& Immune Technology) (Course code:)					
Course Outcomes(COs)	**Class lecture(CI)**	**LaboratoryInstruction (LI)**	**Self-Learning (SL)**	**Sessional work (SW)**	**Total Hours (Li+CI+SL+SW)**
CO1-01BT601 .1: Understand the essential of immune system cells to the organism	12	06	5	1	24
CO1-01BT601 .2: Know the fundamentals of immunoglobulins, antigens, and their classifications	12	06	4	1	23
CO1-01BT601 .3: : In-depth study about the action of immune responses and their regulations	12	06	4	1	23
CO1-01BT601 .4: Elaborate the various immunodeficiency related diseases and functionality of immune system	12	06	4	1	23
CO1-01BT601 .5: Recognize the various immunization techniques as well as the various vaccinations	12	06	2	1	21
Total Hours	60	30	19	05	114

End semester Assessment Scheme for setting up question paper and assessment to evaluate the Course Outcome: Course title: Immunology& Immune Technology) (Course code:)					
Course Outcomes	**Marks Distribution**				**Total Marks**
	A	**An**	**E**	**C**	
CO1-01BT601 .1: Understand the essential of immune system cells to the organism	2	1	1	1	5
CO1-01BT601 .2: Know the fundamentals of immunoglobulins, antigens, and their classifications	2	4	2	2	10
CO1-01BT601 .3: : In-depth study about the action of immune responses and their regulations	3	5	5	2	15
CO1-01BT601 .4: Elaborate the various immunodeficiency related diseases and functionality of immune system	2	3	3	2	10
CO1-01BT601 .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 and PSO Mapping

Program Title: B. Sc. Biotechnology, 6thSem
Course Code: 01BT601
Course Title: Immunology& Immune Technology

CO/PO Mapping															
Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-01BT601 .1: Understand the essential of immune system cells to the organism	**3**	**3**	**2**	**1**	**-**	**1**	**1**	**1**	**2**	**1**	**2**	**2**	**2**	**2**	**3**
CO1-01BT601 .2: Know the fundamentals of immunoglobulins, antigens, and their classifications	**3**	**1**	**1**	**2**	**2**	**1**	**1**	**1**	**-**	**2**	**3**	**2**	**2**	**2**	**3**
CO1-01BT601 .3: : In-depth study about the action of immune responses and their regulations	**3**	**3**	**3**	**1**	**-**	**-**	**2**	**-**	**3**	**1**	**1**	**2**	**3**	**3**	**3**
CO1-01BT601 .4: Elaborate the various immunodeficiency related diseases and functionality of immune system	**2**	**3**	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**2**	**-**	**1**	**2**	**2**	**3**
CO1-01BT601 .5: Recognize the various immunization techniques as well as the various vaccinations	**2**	**2**	**2**	**-**	**1**	**2**	**3**	**2**	**1**	**2**	**1**	**2**	**2**	**1**	**3**
Legends: CO/PO/PSO Mapping Range: Low, 1; Medium, 2; High, 3															

Program Title: B. Sc. Biotechnology, 6th Sem
Course Code: 01BT601
Course Title: Immunology& Immune Technology

Course Curriculum Map:					
POs & PSOs No.	COs No	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-01BT601 .1:** Understand the essential of immune system cells to the organism	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10 SO1.11 SO1.12	1.1,1.2,1.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.12	SL-1,2,3,4,5
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-01BT601 .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 SO2.10 SO2.11 SO2.12	2.1, 2.2, 2.3,	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11, 2.12	SL-1,2,3,4
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-01BT601 .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 SO3.11 SO3.12	3.1,3.2,3.3	3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12	SL-1,2,3,4
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-01BT601 .4:** Elaborate the various immunodeficiency related diseases and functionality of immune system	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10 SO4.11 SO4.12	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, 4.11, 4.12	4 SL-1,2,3,4
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-01BT601 .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 S05.9 SO5.10 SO5.11 SO5.12	5.1,5.2,5.3	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 SL-1,2

Program name	Bachelor of Science (B. Sc.(Hons))- Biotechnology	
Semester	VIth	
Course Code:	05BT601	
Course title:	Animal Biotechnology	**Curriculum Developer**: Dr. Monika Soni, Assistant Professor
Pre-requisite:	Students should have basic knowledge of animal biotechnology	
Rationale:	Animal Biotechnology explores genetic manipulation, reproductive technologies, and molecular biology applications in animals. The subject aims to enhance livestock production, develop disease-resistant breeds, and advance medical research through transgenic animals. It encompasses ethical considerations, environmental impact assessment, and regulatory frameworks. This multidisciplinary field contributes to food security, medical breakthroughs, and sustainable agriculture. The focus is on innovative techniques for genetic enhancement, disease prevention, and biopharmaceutical production in animals. As a dynamic field, Animal Biotechnology integrates biology, genetics, and technology to address global challenges while promoting responsible and sustainable practices in animal science.	
Course Outcomes (COs):	**CO1-05BT601.1**: To demonstrate the proficiency in animal biotechnology techniques and laboratory managements. **CO2-05BT601.2**: To demonstrate the competence in animal cell culture techniques and bioprocessing. **CO3-05BT601.3**: To understand the transgenesis and gene transfer methods in animals. **CO4-05BT601.4**: To understand the animal propagation techniques and as well as the stem cells technology. **CO5-05BT601.5**: To understand the genetic modification in medicine, gene therapy, and engineering technology.	

Scheme of Studies:

Board of Study	**Course Code**	**Course Title**	**Scheme of studies (Hours/Week)**					**Total Credits(C) (L:T:P=3:0:1)**
			CI	LI	SW	SL	**Total Study Hours(CI+LI+SW+SL)**	
Major (DSC)	05BT601	Animal Biotechnology	2	2	1	2	7	3+1=4

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

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
Major (DSC)	05BT601	Animal Biotechnology	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)		
Major (DSC)	05BT601	Animal Biotechnology	35	5	5	5	50	50	100

Course-Curriculum:

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

Item	CI	LI	SW	SL	Total
Approx. Hours	9	4	1	5	19

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO1-05BT601.1: To demonstrate the proficiency in animal biotechnology techniques and laboratory managements.	**SO1.1** Explain in detail introduction of animal biotechnology and its applications.		**CI1.1** Brief detail of introduction of animal biotechnology and its applications.	**SL1.1** Search various reference books and other study material to start the learning about animal tissue culture and animal biotechnology.
	SO1.2 Explain the history of animal biotechnology.		**CI1.2** Brief detail of history of animal biotechnology.	**SL1.2**Explore the historical evolution and recent advancements in animal biotechnology.
	SO1.3 Describe the basic laboratory techniques in animal biotechnology.		**CI1.3** Study the basic laboratory techniques in animal biotechnology.	**SL1.3**Understand the essential infrastructure and equipment needed for an animal biotechnology laboratory.
	SO1.4 Explain in detail the cell culture media.	**LI1.1** To prepare and sterilize the cell culture media.	**CI1.4** Study the cell culture media.	**SL1.4**Learn about the formulation and sterilization of culture media used in animal cell culture experiments.
	SO1.5 Describe and define the sterilization techniques		**CI1.5** Study the sterilization techniques.	
	SO1.6 Explain in detail to primary and secondary cell culture method.	**LI1.2** To isolate and culture primary cells from animal tissues.	**CI1.6** Brief in detail to primary and secondary cell culture method.	**SL1.5**Acquire proficiency in isolating and culturing primary cells from animal tissues.
	SO1.7 Explain in detail the recent advances in animal biotechnology research.		**CI1.7** Discuss the recent advances in animal biotechnology research.	
	SO1.8 Describe the ethical considerations in animal biotechnology.		**CI1.8** Discuss the ethical considerations in animal biotechnology.	
	SO1.9 Explain in detail the future directions and opportunities in animal biotechnology.		**CI1.9** Discussthe future directions and opportunities in animal biotechnology.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail the history of animal biotechnology.
	SW1.2 Mini Project	Describe and define the cell culture methods.
	SW1.3 Other Activities (Specify)	Explain the process of media preparation and sterilization.

Course-Curriculum:

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

Item	CI	LI	SW	SL	Total
Approx. Hours	9	4	1	5	19

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO2-05BT601.2: To demonstrate the competence in animal cell culture techniques and bioprocessing	**SO2.1**Describe and define the cell culture contaminants.	**LI2.1** To identify and prevent the common cell culture contaminants.	**CI2.1** Brief detail of introduction to cell culture contaminants.	**SL2.1** Search various reference books and other study material to start the learning about cell culture.
	SO2.2 Explain in detail the cell cloning and selection methods.		**CI2.2**Discuss the cell cloning and selection methods.	
	SO2.3 Describe the transfection and transformation of cells.	**LI2.2** To perform a transfection experiment and analyse the efficiency of gene transfer in cultured cells.	**CI2.3**Study the transfection and transformation of cells.	**SL2.2**Gain proficiency in transfection and transformation methods used to introduce foreign DNA into cultured cells.
	SO2.4 Explain in detail the scaling up of animal cell culture.		**CI2.4**Study the scaling up of animal cell culture.	**SL2.3**Acquire knowledge of the principles and techniques involved in scaling up animal cell cultures for large-scale production.
	SO2.5 Explain in detail the preservation of animal cells.		**CI2.5**Study the preservation of animal cells.	**SL2.4**Familiarize yourself with methods for preserving and characterizing animal cells in culture for research and biotechnology applications.
	SO2.6 Explain in detail the characterization of animal cells.		**CI2.6**Study the characterization of animal cells.	
	SO2.7 Explain in detail the cytotoxicity assays in cell culture.		**CI2.7** Describe the cytotoxicity assays in cell culture.	**SL2.5**Develop proficiency in performing cytotoxicity and viability assays to assess the effects of compounds or treatments on cultured cells.
	SO2.8 Explain in detail the viability assays in cell culture.		**CI2.8** Describe the viability assays in cell culture.	
	SO2.9 Describe the integration and applications in cell culture.		**CI2.9** Discuss the integration and applications in cell culture.	

Suggested Sessional Work (SW): *anyone*		
	SW2.1 Assignments	Describe and define the cell cloning and selection methods.
	SW2.2 Mini Project	Detail study of scaling up of animal cell culture.
	SW2.3 Other Activities (Specify)	Study one review article on cell cytotoxicity and viability assays.

Course-Curriculum:

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

Item	CI	LI	SW	SL	Total
Approx. Hours	9	4	1	2	16

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO3-05BT601.3: To understand the transgenesis and gene transfer methods in animals.	**SO3. 1**Explain in detail introduction to transgenesis and its applications.		**CI3.1** Brief details of introduction to transgenesisand its applications.	**SL3.1** Search various reference books and other study material to start the learning abouttransgenesis and gene transfer methods.
	SO3.2 Explain in detail the transgenic animals' model-		**CI3.2** Study the transgenic animals' model-mice and cow.	
	SO3.3 Explain in detail the transgenic animals' model- pig and sheep.		**CI3.3** Study the transgenic animals' model-pig and sheep.	
	SO3.4 Explain in detail the transgenic animals' model- goat and bird.		**CI3.4** Study the transgenic animals' model-goat and bird.	
	SO3.5 Explain in detail the transgenic animals' model- insects.		**CI3.5** Study the transgenic animals' model-insects.	
	SO3.6 Explain in detail the embryo transfer techniques.	**LI3.1**To practice embryo transfer techniques for the production of transgenic animals.	**CI3.6**Brief detail of embryo transfer techniques.	**SL3.2**Explore the different methods used to transfer genes into animals and their mechanisms and applications.
	SO3.7 Explain in detail the gene transfer methods in animals-microinjection.	**LI3.2**To demonstrate the microinjection technique for introducing foreign DNA into animal embryos.	**CI3.7** Study the gene transfer methods in animals- microinjection.	
	SO3.8 Explain in detail the gene transfer methods in animals-embryonic stem cell gene transfer.		**CI3.8** Study the gene transfer methods in animals- embryonic stem cell gene transfer.	
	SO3.9 Explain in detail the gene transfer methods in animals-retrovirus mediated gene transfer.		**CI3.9** Study the gene transfer methods in animals- retrovirus mediated gene transfer.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe the transgenesis and its applications.
	SW3.2 Mini Project	Describe the gene transfer methods in animals.
	SW3.3 Other Activities (Specify)	Explain in detail embryo transfer techniques.

Course-Curriculum:

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

Item	CI	LI	SW	SL	Total
Approx. Hours	9	2	1	4	16

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO4-05BT601.4: To understand the animal propagation techniques and as well as the stem cells technology	**SO4. 1**Explain in detail fundamentals of animal reproduction.		**CI4.1** Brief detailof fundamentals of animal reproduction.	**SL4.1** to start the learning about animal propagation and stem cells technology.
	SO4.2 Explain in detail the artificial insemination techniques.		**CI4.2** Study the artificial insemination techniques.	**SL4.2**To explores the principles and techniques of artificial insemination (AI) in animals.
	SO4.3 Discuss the advantages and challenges of artificial insemination.	**LI4.1**To the principles and procedures of artificial insemination in animals.	**CI4.3** Discuss the advantages and challenges of artificial insemination.	
	SO4.4 Describe and define the animal cloning.		**CI4.4** Study the principle and techniques of animal cloning.	**SL4.3**To independently explore the principles and methodologies of animal cloning
	SO4.5 Explain in detail the applications of animal cloning.		**CI4.5** Discuss the applications of animal cloning.	
	SO4.6 Describe and define the stem cells technology.		**CI4.6** Brief in detail to introduction of stem cells technology.	**SL4.4**To explores the principles, methods, and applications of stem cell technology.
	SO4.7 Explain in detail the stem cells culture techniques.		**CI4.7**Study the stem cells culture techniques.	
	SO4.8 Explain the applications of stem cells technology.		**CI4.8**Discuss the applications of stem cells technology.	
	SO4.9 Discuss the ethical and regulatory considerations in reproductive technologies and stem cell research.		**CI4.9**Discussthe ethical and regulatory considerations in reproductive technologies and stem cell research.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe the animal cloning and its applications.
	SW4.2 Mini Project	Explain in detail to stem cells technology and their applications.
	SW4.3 Other Activities (Specify)	Write a one review article on artificial insemination in animal cells.

Course-Curriculum:

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

Item	CI	LI	SW	SL	Total
Approx. Hours	9	1	1	3	14

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO5-05BT601.5: To understand the genetic modification in medicine, gene therapy, and engineering technology.	**SO5.1** Explain in detail the introduction to genetic modifications in medicine.		**CI5.1** Brief in detail of introduction to genetic modifications in medicine.	**SL5.1** Search various reference books and other study material to start the learning about genetic modifications and gene therapy.
	SO5.2 Explain in detail the types of gene therapy.		**CI5.2** Study the types of gene therapy.	**SL5.2**Explore the various types of gene therapy approaches and their applications in medicine.
	SO5.3 Explain in detail the vectors in gene therapy.	**LI5.1**To analyze and compare the characteristics of viral and non-viral vectors used in gene therapy.	**CI5.3** Study the vectors in gene therapy.	
	SO5.4 Explain in detail molecular genetic engineering.		**CI5.4** Detail explanation of molecular genetic engineering.	**SL5.3**Explore the molecular engineering techniques utilized in genetic modification
	SO5.5 Explain in detail human genetic engineering.		**CI5.5**Detail explanation of human genetic engineering.	
	SO5.6 Describe and define the gene therapy for genetic disorders.		**CI5.6**Study the gene therapy for genetic disorders.	
	SO5.7 Explain in detail the gene therapy for cancer.		**CI5.7**Study the gene therapy for cancer.	
	SO5.8 Discuss the ethical issues in genetic modification.		**CI5.8**Discuss the ethical issues in genetic modification.	
	SO5.9 Discuss the regulatory frameworks towards genetic modification and gene therapy.		**CI5.9** Discuss the regulatory frameworks and future directions towards genetic modification and gene therapy.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain in detail genetic modifications in medicine.
	SW5.2 Mini Project	Describe in the detail the gene therapy.
	SW5.3 Other Activities (Specify)	One case research study on gene therapy for genetic disorder.

Course duration (in hours) to attain Course Outcomes:

Course Title: Animal Biotechnology **Course Code:** 05BT601

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-05BT601.1: To demonstrate the proficiency in animal biotechnology techniques and laboratory managements.	9	4	5	1	19
CO2-05BT601.2: To demonstrate the competence in animal cell culture techniques and bioprocessing.	9	4	5	1	19
CO3-05BT601.3: To understand the transgenesis and gene transfer methods in animals.	9	4	2	1	16
CO4-05BT601.4: To understand the animal propagation techniques and as well as the stem cells technology.	9	2	4	1	16
CO5-05BT601.5: To understand the genetic modification in medicine, gene therapy, and engineering technology.	9	1	3	1	14
Total Hours	45	15	19	05	84

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

Course Title: Animal Biotechnology **Course Code:** 05BT601

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

Course Outcomes	Marks Distribution				Total Marks
	R	**U**	**A**	**A**	
CO1-05BT601.1: To demonstrate the proficiency in animal biotechnology techniques and laboratory managements.	2	2	3	2	9
CO2-05BT601.2: To demonstrate the competence in animal cell culture techniques and bioprocessing.	2	3	3	2	10
CO3-05BT601.3: To understand the transgenesis and gene transfer methods in animals.	2	2	3	4	11
CO4-05BT601.4: To understand the animal propagation techniques and as well as the stem cells technology.	2	2	3	3	10
CO5-05BT601.5: To understand the genetic modification in medicine, gene therapy, and engineering technology.	2	2	2	4	10
Total Marks	**10**	**11**	**14**	**15**	**50**

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1.	Ranga M.M., Animal Biotechnology. Agrobios India Limited, 2002.
2.	Ramadass P, Meera Rani S., Text Book of Animal Biotechnology. Akshara Printers, 1997.
3.	R. Ian Freshney, Culture of Animal cells, A Manual of basic technique 4th Edition 2002.
4.	Masters J.R.W., Animal Cell Culture: Practical Approach. Oxford University Press,2000.
5.	Eapen Cherian, G Nandhini, Anil Kurian., Stem Cells. Jaypee Brothers Medical Publishers (P) Ltd. 2011.

(b) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B. Sc. Biotechnology

Semester: VIth Semester

Course Title: Animal Biotechnology

CO/PO/PSO Mapping															
Course Outcome (Cos)	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-05BT601.1: To demonstrate the proficiency in animal biotechnology techniques and laboratory managements.	3	2	-	2	2	1	-	-	1	1	2	-	2	2	2
CO2-05BT601.2: To demonstrate the competence in animal cell culture techniques and bioprocessing.	3	3	1	2	3	1	-	-	-	2	3	1	2	2	3
CO3-05BT601.3: To understand the transgenesis and gene transfer methods in animals.	2	1	1	2	2	2	-	2	-	2	1	1	3	2	1
CO4-05BT601.4: To understand the animal propagation techniques and as well as the stem cells technology.	2	3	-	3	2	2	-	2	-	2	2	1	3	2	2
CO5-05BT601.5: To understand the genetic modification in medicine, gene therapy, and engineering technology.	3	3	-	3	2	2	2	2	1	2	2	2	3	2	2

Course Code: 05BT601

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO1-05BT601.1**: To demonstrate the proficiency in animal biotechnology techniques and laboratory managements.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	LI 1 LI 2	1.1,1.2,1.3,1.4,1.5 1.6,1.7,1.8,1.9	1SL-1,2,3,4,5
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO2-05BT601.2**: To demonstrate the competence in animal cell culture techniques and bioprocessing.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	LI 1 LI 2	2.1,2.2,2.3,2.4,2.5, 2.6,2.7,2.8,2.9	2SL-1,2,3,4,5
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO3-05BT601.3**: To understand the transgenesis and gene transfer methods in animals.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	LI 1 LI 2	3.1,3.2,3.3,3.4,3.5, 3.6,3.7,3.8,3.9	3SL-1,2
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO4-05BT601.4**: To understand the animal propagation techniques and as well as the stem cells technology.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	LI 1	4.1,4.2,4.3,4.4,4.5, 4.6,4.7,4.8,4.9	4SL-1,2,3,4
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO5-05BT601.5**: To understand the genetic modification in medicine, gene therapy, and engineering technology.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	LI 1	5.1,5.2,5.3,5.4,5.5, 5.6,5.7,5.8,5.9	5SL-1,2,3

Program Name	**Bachelor of Science (Hons.) in Biotechnology (B.Sc. (Hons.) BT)**	
Semester	VI	
CourseCode:	05BT602	
Coursetitle:	Agriculture Biotechnology	**Curriculum Developer**: Chahana Desai, Teaching Associate
Pre-requisite:	Students should have basic knowledge and understanding about traditional agricultural practices and concept of genetic engineering.	
Rationale:	• The objectives of the Agricultural Biotech course are to provide students with a comprehensive understanding of the principles and applications of biotechnology in the field of agriculture. • The course aims to equip students with the knowledge and skills necessary to utilize biotechnological tools and techniques for enhancing crop productivity, improving plant genetics, and developing sustainable agricultural practices. • Additionally, the course seeks to foster critical thinking and ethical awareness among students regarding the potential benefits, risks, and societal implications associated with agricultural biotechnology.	
CourseOutcomes (COs):	**CO1-05BT602.1:** Elucidate the overview of Biotechnology in agriculture. **CO1-05BT602.2-** Acquire knowledge regarding transgenesis and genetic engineering **CO1-05BT602.3-** Applied knowledge about transgenesis and transgenic technology. **CO1-05BT602.4-** To gain the knowledge about biopesticides and different types of biofertilizers with its importance and characteristics. **CO1-05BT602.5-** Elucidate the characteristics and anatomy of mushrooms.	

Scheme of Studies:

Board of Study	Course Code	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)	
Major (DSC)	05BT602	Agriculture Biotechnology	3	2	1	2	8	3+1=4

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

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
Major (DSC)	05BT602	Agriculture Biotechnology	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)		
Major (DSC)	05BT602-L	Agriculture Biotechnology	35	5	5	5	50	50	100

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**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)
CO1-05BT602.1 Elucidate theoverview of Biotechnology in agriculture.	**SO1.1** Explainthe concept of agriculture biotechnology	**LI1.1** Preparation of artificial seeds.	**Unit-1-Introduction to agriculture biotechnology** **CI1.1** Introduction to Agricultural biotechnology,	**SL1.1** Find out some examples of Germplasm conservation.
	SO1.2 Determine thebasics of historical perspective,	**LI1.1**Isolation of Azotobactor	**CI1.2** Historical perspective,	**SL1.2** Detailing about major crop plants.
	SO1.3 Determine benefits & applications of biotech. in agriculture.		**CI1.3** Benefits and Applications,	
	SO1.4 Elaborate the risks associated with agriculture biotechnology.		**CI1.4** Risk Associatedwith Agriculture Biotechnology	
	SO1.5 Elucidate the major crop plants and their improvement strategies.		**CI1.5** Major crop plants and their improvement	
	SO1.6 Elaborate the plant breeding methods		**CI1.6** Plant Breeding methods.	
	SO1.7 Explanation about the concept of molecular breeding		**CI1.7** Molecular Breeding	
	SO1.8 To learn about the concept, methods and importance of germplasm conservation		**CI1.8** Germplasm Conservation	
	SO1.9 Explanation about the concept and applications of seed bank		**CI1.9** Seed bank	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe various risks associated with agriculture biotechnology.
	SW1.2 Mini Project	Elaborate various types of major crop plant improvements techniques.
	SW1.3 Other Activities (Specify)	Make a power point presentation on plant breeding methods.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**ApproximateHours** **Item** | Cl | LI | SW | SL | Total **Approx. Hrs** | 09 | 04 | 01 | 03 | 17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-05BT602.2 Acquire knowledgeregarding transgenesis and genetic engineering	**SO2.1** Explain the introduction of genetic engineering in crop plants.	**LI2.1** Isolation of plant genomic DNA (Pea shoot tip – CTAB,)	**Unit-2 Genetic Engineering in Crop Plants:** **CI2.1** Genetic Engineering in Crop Plants: Introduction,	**SL2.1** Note down the structure of DNA
	SO2.2 Elucidate the structure and functions of agrobacterium, Ti and Ri plasmid.	**LI2.1** Isolation of plant genomic DNA (Cauliflower –SDS)	**CI2.2** Agro bacterium, Ti and Ri Plasmid,	**SL2.2** Read the latest research on genetic engineering.
	SO2.3 Elaborate the structure of T-DNA and functions of Vir genes.		**CI2.3** structure of T-DNA, Vir gene	**SL2.3** Write down few points on recombinant DNA technology
	SO2.4 Elucidate mechanism of T-DNA transfer		**CI2.4** Mechanism of T-DNA Transfer,	
	SO2.5 Explanation about the Ti plasmid derived vector systems		**CI2.5** Ti plasmid derived vector systems	
	SO2.6 To learn about the various physical methods of transferring genes to plants-		**CI2.6** Physical methods of transferring genes to plants - Microprojectile bombardment,	
	SO2.7 Explanation about the mechanism and function of electroporation method**.**		**CI2.7** Electroporation,	
	SO2.8 Elucidate the various plant viral vectors		**CI2.8** Plant Viral vectors	
	SO2.8 Elucidate recombinant selection		**CI2.9** Recombinant selection.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe the mechanism of T-DNA transfer.
	SW2.2 Mini Project	Structure of T-DNA, Ti plasmid and Ri plasmid.
	SW2.3 Other Activities (Specify)	Make Power point presentation on physical methods of gene transfer,

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx. Hrs** | 09 | 04 | 01 | 03 | 17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-05BT602.3 Applied knowledge about transgenesis and transgenic technology.	**SO3.1**Elucidate the various applications of transgenic technology	**LI3.1**Isolation of Rhyzobium	**Unit-3 Application of Transgenic Technology: CI3.1**Applications of Transgenic Technology	**SL3.1** Find out the impact of herbicides on plants
	SO3.2 Explain about the development of herbicide tolerance mechanism.	**LI3.2**Demonstration of Biofertilizers Production	**CI3.2**development of herbicide tolerance,	**SL3.2** Read the process of manufacturing of golden rice.
	SO3.3 Elaborate the mechanism of insect/pest resistance		**CI3.3**insect/pest resistance-bt-cotton,disease resistance,	**SL3.3**Read about the edible vaccines experiemnts.
	SO3.4 Elaborate mechanism of drought resistance.		**CI3.4**drought resistance	
	SO3.5 Explane production and importance of golden rice		**CI3.5**Production of therapeutic molecule in plants- Golden Rice,	
	SO3.6 Elucidate mechanism of edible vaccines production		**CI3.6** Ediblevaccines,	
	SO3.7 Explane about how the seed quality improved with different strategies.		**CI3.7** Improvement in seed quality-	
	SO3.8 Elaborate mechanism, of delaying fruit ripening		**CI3.8** Delaying fruit ripening,	
	SO3.8 Elaborate Flavr Savr Tomato.		**CI3.9** Flavr Savr Tomato.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Flow chart on production of golden rice.
	SW3.2 Mini Project	Describe the importance of transgenesis.
	SW3.3 Other Activities (Specify)	Prepare one Power point presentation on delaying fruit ripening.

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 | 02 | 01 | 02 | 14

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-05BT602.4 To gain the knowledge about biopesticides and different types of biofertilizers with its importance and characteristics.	**SO4.1** Elucidate about the fungal and bacterial pesticides.	**LI4.1** Isolation of phosphate solubilizing microorganisms from soil sample.	**Unit-4Biopesticides used in Agriculture** **CI4.1** bacterial, fungal pesticides.	**SL4.1** List down the impacts of chemical pesticides.
	SO4.2 Elaborate about the integrated pest management.		**CI4.2** Integrated pest management,	**SL4.2** Read the role of integrated pest management
	SO4.3 Explanation different types of biofertilizers		**CI4.3** Biofertilizers in agriculture	
	SO4.4 Explanation rhizobium, azatobactor, mycorrhiza	.	**CI4.4** rhizobium, azatobactor, mycorrhiza	
	SO4.5 To learn method, types & vermicomposting		**CI4.5** Vermicomposting	
	SO4.6 Explanation mechanism of Microbial agents for control of Plant diseases.		**CI4.6** Microbial agents for control of Plant diseases,.	
	SO4.7 Elucidate the mode of infection of different types of plant diseases.		**CI4.7** Plant diseases-mode of infection,	
	SO4.8 Explanation about the dispersal of plant pathogen		**CI4.8** dispersal of plant pathogens	
	SO4.9 Elaborate about the control of pathogen		**CI4.9** Control of plant pathogen	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Determine the various applications and importance of biopesticides
	SW4.2 Mini Project	Explain mode of infection of plant pathogens.
	SW4.3 Other Activities (Specify)	Make a Power point presentation on vermicomposting technology.

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	01	01	02	13

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO1-05BT602.5 Elucidate the characteristics and anatomy of mushrooms.	**SO5.1** Elucidate the structure and function of edible and poisonous mushrooms.	**LI5.1** Testing of antagonism.	**Unit-5 Mushroom Production: CI5.1**Introduction, Anatomy, edible and poisonous mushrooms,	**SL5.1** Basic knowledge about requirement of microbiology laboratory.
	SO5.2 Elaborate medicinal values of mushrooms		**CI5.2** medicinal value,	**SL5.2** Importance of mushrooms in various fields**.**
	SO5.3 Describe life cycle of cultivated mushrooms.		**CI5.3** Life cycleof cultivated mushrooms,	
	SO5.4 Elucidate the maintenance of pure culture, Preparation of substrate for mushroom cultivation.		**CI5.4** maintenance of pure culture, Preparation of substrate for mushroom cultivation,	
	SO5.5 Explanation about the preparation of spawn.		**CI5.5** preparation of spawn.	
	SO5.6 Elaborate Cultivation technology of *Agaricus bisporus,*		**CI5.6** Cultivation technology of *Agaricus bisporus*	
	SO5.7 aborate Cultivation technology of *Pleurotus sp.,*		**CI5.7** Cultivation technology of *Pleurotus sp.,*	
	SO5.8 Elucidate the post harvest processing		**CI5.8** post-harvest processing	
	SO5.9 Elucidate the value addition		**CI5.9** value addition	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Life cycle of cultivated mushrooms
	SW5.2 Mini Project	Explanation about required instruments and glassware for mushroom cultivation.
	SW5.3 Other Activities (Specify)	Prepare power point presentation on procedure for mushroom cultivation.

Course duration (in hours)to attain Course Outcomes:

Course Title: Agriculture Biotechnology **Course Code:05BT602**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-05BT602.1 Elucidate theoverview of biotechnology in agriculture.	9	4	1	2	16
CO1-05BT602.2 Acquire knowledge regarding transgenesis and genetic engineering.	9	4	1	3	17
CO1-05BT602.3 Applied knowledge about transgenesis and transgenic technology.	9	4	1	3	17
CO1-05BT602.4 To gain the knowledge about biopesticides and different types of biofertilizers with its importance and characteristics.	9	2	1	2	14
CO1-05BT602.5 Elucidate the characteristics and anatomy of mushrooms.	9	1	1	2	13
Total Hours	45	15	05	12	77

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

Course Title: Agriculture biotechnology **Course Code:05BT602**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-05BT602.1 Elucidate theoverview of biotechnology in agriculture.	2	1	1	1	5
CO1-05BT602.2 Acquire knowledge regarding transgenesis and genetic engineering.	2	4	5	1	12
CO1-05BT602.3 Applied knowledge about transgenesis and transgenic technology.	3	5	5	1	14
CO1-05BT602.4 To gain the knowledge about biopesticides and different types of biofertilizers with its importance and characteristics.	2	3	5	1	11
CO1-05BT602.5 Elucidate the characteristics and anatomy of mushrooms.	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	Biotechnology fundamental and application (4th edition) - S.S.Purohit.
2	Plant Biotechnology – B.D.Singh
3	Plants, Genes and agriculture by Maartein, J.Christpeels, David E.Sdava.
4	Crop Biotechnology by P.R.Yadav, Rajiv Tyagi.
5	Plant Biotechnology by Chawla. Gendel,

(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: B.Sc. (Hons.) biotechnology
Semester:VI Semester
Course Title: Agriculture Biotechnology.
Course Code: 05BT602

CO/PO Mapping															
Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-05BT602.1 Elucidate the overview of biotechnology in agriculture	-	-	-	1	2	2	2	-	1	2	2	3	3	2	1
CO1-05BT602.2 Acquire knowledge regarding transgenesis and genetic engineering	-	-	-	-	-	-	3	-	2	2	3	3	2	1	2
CO1-05BT602.3 Applied knowledge about transgenesis and transgenic technology.	-	1	1	1	-	-	2	-	3	1	1	2	1	2	1
CO1-05BT602.4 To gain the knowledge about biopesticides and different types of biofertilizers with its importance and characteristics	-	1	1	-	2	2	2	3	-	1	-	-	2	2	3
CO1-05BT602.5 Elucidate the characteristics and anatomy of mushrooms.	1	1	1	-	-	2	3	3	1	2	2	2	2	1	2

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

Course Curriculum:

POs & PSOs No.	Cos	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-05BT602.1-** Elucidate theoverview of biotechnology in agriculture.	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	**CO1-05BT602.2-** Acquire knowledge regarding transgenesis and genetic engineering	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	**LI 1** **LI 2**	2.1, 2.2, 2.3,2.4,2.5,2.6,2.7,2.8, 2.9	**2SL-1,2,3**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-05BT602.3-** Applied knowledge about transgenesis and transgenic technology.	SO3.1 SO3.2 SO3.3 SO3.4SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	**LI 1** **LI 2**	3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9	**3SL-1,2,3**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-05BT602.4-** To gain the knowledge about biopesticides and different types of biofertilizers with its importance and characteristics.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	**LI 1**	4.1,4.2,4.3,4.4, 4.5, 4.6,4.6,4.7,4.8, 4.9	**4SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-05BT602.5-** Elucidate the characteristics and anatomy of mushrooms.	SO5.1 SO5.2 SO5.3 SO5.4SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	**LI 1**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8, 5.9	**5SL-1,2**

Program Name	**B.Sc. (Hons.) in Biotechnology**	
Semester	VI	
Course Code:	05BT603 &05BT603-L	
Course title:	Nano Biotechnology	**Curriculum Developer**: Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of Physical & Biological Science	
Rationale:	Nano Biotechnology is a rather young discipline, which came up in the nineties. Nevertheless, Nanotech has gained so much importance within the last years that universities at all rankings have introduced or are going to introduce Nanotechnology teaching programs. Predictions say that NT will change our lives and society more than computer technology and electricity have done together. The course will provide an overview over NT. It will show that the nano regime is so different from other regimes because both classical and quantum effects can be active thus leading to unique properties of nano devices.It is a highly interdisciplinary science, which will be reflected in the course by making reference to chemistry, physics, biology, pharmacy, and nano-engineering. Applications of Nanotechnology, as they are already in use today or as they are planned for the future, will be discussed.	
Course Outcomes (COs):	**CO1-05BT603.1.** Explain fundamentals of Nanotechnology **CO2-05BT603.2.** Define the role of biotechnology in nanoscience **CO3-05BT603.3.** Comprehend the working mechanism of nanoparticles in cancer treatment **CO4-05BT603.4.** Interpretate the mechanism of drug delivery and designing **CO5-05BT603.5.** Examine the mechanism of nano-sensors & demonstrate the significance of biosensors in industries.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits(C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
Major (DSC)	05BT603	Nano Biotechnology	3	2	1	5	11	3+1=4

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

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
Major (DSC)	05BT603	Nano Biotechnology	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)		
Major (DSC)	05BT603-L	Nano Biotechnology	35	5	5	5	50	50	100

Course-Curriculum:

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

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)05BT603-L	Class room Instruction (CI)	Self-Learning (SL)
CO1-05BT603.1 Explain fundamentals of Nanotechnology	**SO1.1** Summarize concept of Nanotechnology	**LI1.1** Basic instruments used in nanotechnology	**Unit-1 Fundamental Concepts** **CI1.1** Concept of Nanoscience, introduction to Nanotechnology	**SL1.1** Nanoscale comparison
	SO1.2 Define Basic terminology, scope and application	**LI1.2** To observe the working of different kinds of microscope	**CI1.2** Nanomechanics-Nanotribology Scanning probe microscopy	**SL1.2** Other Nanodevices around you
	SO1.3 Provide use of nanotechnology		**CI1.3** Nanomaterials and its handling	**SL1.3** Use of nanoscience in biology
	SO1.4 Overviewing of various tools of nanotechnology		**CI1.4** Nanofuture, nano-fying Electronics	**SL1.4** Nanotechnology natural occurrence.
	SO1.5 Overviewing nano assisted techniques		**CI1.5** Nanofibres,nanopore and nanotubes	**SL1.5** Use of different nano assisted devices
	SO1.6 Explain the term Nanopores		**CI1.6** Nanopores and its application	
	SO1.7 Define CNTs and types		**CI1.7** Carbon Nanotubes	
	SO1.8 Elaborate the concept of Nanobots		**CI1.8** Nanobots	
	SO1.9 Elaborate application of Nanobots		**CI1.9** its application	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail about the Nanoparticles
	SW1.2 Mini Project	Draw a well labelled diagram of a microscope
	SW1.3 Other Activities (Specify)	Write an article on “Latest research in the field of Nanotechnology”

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

Approximate Hours

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

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)05BT603-L**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-05BT603.2 Define the role of biotechnology in nanoscience	**SO2.1** Expalin Concept of nanomaterials	**LI2.1** Working of a microscope	**CI2.1** Introduction to Nanoscience Techniques used in Nanobiotechnology	**SL2.1** List down the nanoparticle which is present around you
	SO2.2 Relate the concept of how nanomaterials been categorized.	**LI2.2** Study of Electron Microscope database (EMD)	**CI2.2** Optical Microscopy	**SL2.2** Find some literature on Atomic Force Microscopy
	SO2.3 Outline difference between silver and gold nanoparticles		**CI2.3** MALDI-TOF, Production of nanoparticles.	**SL2.3** List down the various kinds of nano-fertilizers used in India
	SO2.4 Analyzing the working of Electron microscope and Atomic Force Microscopy		**CI2.4** Nanoparticles agglomeration and applications	
	SO2.5 Describe the physicochemical properties and working of nano-aerogels		**CI2.5** Nano-aerogels	
	SO2.6 Explain technical aspects of nano fertilization		**CI2.6** Nano fertilizers	
	SO2.7 Demonstrate the working of AF microscope		**CI2.7** Atomic ForceMicroscopy	
	SO2.8 Demonstrate the working of SEM		**CI2.8** SEM Microscopy	
	SO2.9 Demonstrate the working of TEM		**CI2.9** TEM Microscopy	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Make a table to distinguish different nanoparticles with their biological applications
	SW2.2 Mini Project	Write down the protocol for the production of Nanoparticle in laboratory
	SW2.3 Other Activities (Specify)	Attain at least one seminar or online talk on Nanotechnology and its applications

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

Approximate Hours

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

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)05BT603-L**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO3-05BT603.3 Comprehend the working mechanism of nanoparticles in Cancer treatment	**SO3.1** Explain the role of Nanotechnology in cancer	**LI3.1** To retrieve the oncological based data from Cancer Genome Atlas	**Unit-3** **CI3.1** Cancer and current approach to its cure through nanoparticles (CDDS, Cancer Drug Delivery System)	**SL3.1** Explore the research of Nano-oncology
	SO3.2 Learn the concept of cancer drug delivery	**LI3.2** Bioformulation of microbial consortia	**CI3.2** Characteristics of tumor tissues	**SL3.2** Learn novel nano-tools used in drug delivery
	SO3.3 Define the working of anti-cancerous drugs		**CI3.3** Physio-chemical properties of nanoparticles in cancer therapy	**SL3.3** Find out new nano-materials with biocompatibility
	SO3.4 Elaborate the working of nanomaterial as carrier molecule		**CI3.4** Site specific delivery of therapeutic drugs	**SL3.4** Learn the basic mechanism of tumor formation
	SO3.5 Analyse the role of nanomaterial in site specific drug delivery		**CI3.5** Technique to deliver chemotherapeutic agents using nanoparticles	**SL3.5** Find out the disadvantages associated with chemotherapy
	SO3.6 Explain Drug delivery to tumor		**CI3.6** Drug delivery to tumor	
	SO3.7 Define chemotherapy		**CI3.7** Chemotherapy	
	SO3.8 Explain aspects of nano-radiotherapy		**CI3.8** Nano-Radiotherapy	
	SO3.9 Explain aspects of nano-radiotherapy		**CI3.9** its application	

Suggested Sessional Work (SW): *anyone*		
	SW3.1 Assignments	Make a table to distinguish different nanoparticles with their biological applications
	SW3.2 Mini Project	Write down the protocol for the production of Nanoparticle in laboratory
	SW3.3 Other Activities (Specify)	Attain at least one seminar or online talk on Nanotechnology and its applications

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

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	02	01	05	17

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)05BT603-L**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO4-05BT603.4 Interpretate the mechanism of drug delivery and nanoparticle-based designing	**SO4.1** Observing the role of Viral and Non-viral gene therapy	**LI4.1** To retrieve the oncological based data from Cancer Genome Atlas	**Unit-4** **CI4.1** Non-viral Gene Therapy with nanoparticles: Introduction	**SL4.1** Read the novel papers relevant to non-viral gene therapy
	SO4.2 Comprehend the working of novel non-viral gene therapy		**CI4.2** Hyperthermia	**SL4.2** Find out the microorganism becoming lethal due to MDR conditions
	SO4.3 Analyze the working of anti-cancerous drugs		**CI4.3** Nanoparticles to circumvent MDR	**SL4.3** Find out new nanomaterials with biocompatibility
	SO4.4 Recognize the various applications of nanotechnology in other fields		**CI4.4** Potential problems using nanoparticles	**SL4.4** Discover out disadvantages associated with nanoparticles
	SO4.5 Discover the applications of Nanotechnology in Agriculture		**CI4.5** Application of Nanotechnology in Agriculture	**SL4.5** Explore common application of nanotechnology in given fields
	SO4.6 Explain the role of nanotech in biomedical science		**CI4.6** Application of Nanotechnology in Biomedical science	
	SO4.7 Determine the role of nanotech in biotechnology		**CI4.7**Application of Nanotechnology in Biotechnology	
	SO4.8 Interpret the role of controlled delivery of chemo- drugs		**CI4.8** Controlled delivery of chemotherapeutic drugs	
	SO4.9 Interpret application of controlled delivery of chemo- drugs		**CI4.9** its application	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Write an article on "Role of Nanoparticles in Non-Viral Gene Therapy"
	SW4.2 Mini Project	List down the conditions of MDR, XDR and TDR in microbes
	SW4.3 Other Activities (Specify)	Make a presentation on Non-Viral Gene therapy techniques

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Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	09	01	01	05	16

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)05BT603-L**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO5-05BT603.5 To Examine the mechanism of nano-sensors & demonstrate the significance of biosensors in industries.	**SO5.1** Identify different classes of biosensors and describe their functioning principles	**LI5.1** To retrieve the oncological based data from Cancer Genome Atlas	**CI5.1** Introduction to Biosensors, types and working of biosensors	**SL5.1** Find out the role of Biosensors
	SO5.2 Recognize limitations of biosensors in real-life applications		**CI5.2** Importance of biosensors, parts of biosensors and its function	**SL5.2** Explore the various kinds of biosensors
	SO5.3 Analyze the principles and concepts of transducers and their application in biosensor design		**CI5.3** Membrane Biosensors Based on Ion Channel Gating	**SL5.3** Read research on advancement in biosensors
	SO5.4 Define the fundamentals of diagnostic devices and biomarker testing in biological fluids		**CI5.4** Nanofabrication, medicine-Potential Biomedical Applications	**SL5.4** Observe the natural biosensors around us
	SO5.5 Discover the Applications of Polymer Nanostructures		**CI5.5** Applications of Polymer Nanostructures	**SL5.5** Find out the meaning of Biomimicry
	SO5.6 Explain nanosensors in detail		**CI5.6** Types of Nanosensors	
	SO5.7 Derive LAB-On-A-CHIP		**CI5.7** LAB-On-A-CHIP	
	SO5.8 Determine Channel Gating Biomimetic Membranes		**CI5.8** Channel Gating Biomimetic Membranes	
	SO5.9 Applications of Channel Gating Biomimetic Membranes		**CI5.9** its Application	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Write an article on “Role of Biosensors and its mechanism”
	SW5.2 Mini Project	List down the principles of biosensors and Nanosensors
	SW5.3 Other Activities (Specify)	Make a presentation on Lab-On-A-Chip technique with applications

Course duration (in hours)to attain Course Outcomes:

Course Title: Nano Biotechnology **Course Code:**05BT603

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Sessional work (SW)	Self-Learning (SL)	Total Hours (Li+CI+SW+SL)
CO1-05BT603.1: Explain fundamentals of Nanotechnology	9	4	1	5	19
CO2-05BT603.2: Define the role of biotechnology in nanoscience	9	4	1	3	17
CO3-05BT6033: To Comprehend the working mechanism of nanoparticles in Cancer treatment	9	4	1	5	19
CO4-05BT603.4: Interpretate the mechanism of drug delivery and nanoparticle-based designing	9	2	1	5	17
CO4-05BT603.5: To Examine the mechanism of nano-sensors & demonstrate the significance of biosensors in industries.	9	1	1	5	16
Total Hours	45	15	05	23	88

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

Course Title: Nano Biotechnology **Course Code:**05BT603

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-05BT603.1: Explain fundamentals of Nanotechnology	2	1	1	1	5
CO2-05BT603.2: Define the role of biotechnology in nanoscience	3	4	2	1	10
CO3-05BT6033: To Comprehend the working mechanism of nanoparticles in Cancer treatment	4	5	5	1	15
CO4-05BT603.4: Interpretate the mechanism of drug delivery and nanoparticle-based designing	3	4	3	0	10
CO4-05BT603.5: To Examine the mechanism of nano-sensors & demonstrate the significance of biosensors in industries.	5	4	1	0	10
Total Marks	**17**	**18**	**12**	**03**	**50**

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

Suggested learning Resources:

Books:

S. No.	Title/Author/Publisher details
1	Bharat Bhushan., Nanotribology and Nanomechanics - An introduction, Springer.
2	Mark, Ratner Daniel Ratner, Nanobiotechnology- next big idea.
3	Challa S.S.R.Kumar, Joseph Hornes, Carola Leuschner, Nanofabrication towards Biomedical applications.
4	Pharmaceutical Nanobiotechnology for Targeted Therapy, Hamed Barabadi, Ebrahim Mostafavi, Muthupandian Saravanan, Springer 2022
5	Charles P. Poole, Jr., Frank J. Owens; "Introduction to Nanotechnology", John Wiley& Sons, 2003,
6	Biotechnology – Questioning The Reasons, Ed 1 & 2, Book Rivers Publication, India, 2022

(a) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B.Sc. Biotechnology
Semester: VI Semester
Course Title: Nano Biotechnology
Course Code: 05BT603

CO/PO Mapping															
Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-05BT603.1: Explain fundamentals of Nanotechnology	-	-	-	1	2	2	2	-	1	2	2	3	3	3	1
CO2-05BT603.2: Define the role of biotechnology in nanoscience	-	-	-	-	-	-	3	-	2	2	3	3	1	1	2
CO3-05BT6033: To Comprehend the working mechanism of nanoparticles in Cancer treatment	-	1	1	1	-	-	2	-	3	1	1	2	1	1	1
CO4-05BT603.4: Interpretate the mechanism of drug delivery and nanoparticle-based designing	-	1	1	-	2	2	2	3	-	1	-	-	1	2	2
CO4-05BT603.5: To Examine the mechanism of nano-sensors & demonstrate the significance of biosensors in industries.	1	1	1	-	-	2	3	3	1	2	2	2	1	1	2

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-05BT603.1:** Explain fundamentals of Nanotechnology	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	**LI 1** **LI 2**	1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8, 1.9	**1SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-05BT603.2:** Define the role of biotechnology in nanoscience	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	**LI 1** **LI 2**	2.1, 2.2, 2.3,2.4,2.5,2.6,2.7,2.8, 2.9	**2SL-1,2,3**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3-05BT6033:** To Comprehend the working mechanism of nanoparticles in Cancer treatment	SO3.1 SO3.2 SO3.3 SO3.4SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	**LI 1** **LI 2**	3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9	**3SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-05BT603.4:** Interpretate the mechanism of drug delivery and nanoparticle-based designing	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	**LI 1**	4.1,4.2,4.3,4.4, 4.5, 4.6,4.6,4.7,4.8, 4.9	**4SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO4-05BT603.5:** To Examine the mechanism of nano-sensors & demonstrate the significance of biosensors in industries.	SO5.1 SO5.2 SO5.3 SO5.4SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	**LI 1**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8, 5.9	**5SL-1,2,3,4,5**

Program Name	**B.Sc. Biotechnology**	
Semester	VI	
Course Code:	05BT604	
Course title:	BIOSTATISTICS	**Curriculum Developer**: Dr. Keerti Samdariya, Assistant Professor
Pre-requisite:	Student should have basic knowledge of biostatistics, their role, and their application in the biological field.	
Rationale:	The paper on BIOSTATISTICS in a B.Sc. Biotechnology program explores the role of biostatistics and their activity in biological systems.Biostatistics pertains to the acquisition and interpretation of quantitative information in medical research. Finding the correct mathematical hypotheses, biological models, and statistical tests is essential for adequate study designs as a mandatory prerequisite for useful study outcomes.	
Course Outcomes (COs):	**CO1-05BT604.1**: Describe the roles biostatistics serves in the discipline of public health. **CO2-05BT604.2**: Apply basic statistical concepts commonly used in public health and Health Sciences **CO3-05BT604.3**: Demonstrate basic analytical techniques to generate results **CO4-05BT604.4**: Interpret results of commonly used statistical analyses in written summaries **CO5-05BT604.5**: Demonstrate statistical reasoning skills accurately and contextually	

Scheme of Studies:

Board of Study	**Course Code**	**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)**	
Major (DSC)	05BT604	Biostatistics	3	2	1	2	8	3+1=4

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

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
Major (DSC)	05BT604	Biostatistics	15	20	10	5	50	50	100

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
Major (DSC)	05BT604-L	Biostatistics	35	5	5	5	50	50	100

Course-Curriculum:

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Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO1-05BT604.1 Describe the roles biostatistics serves in the discipline of public health.	**SO 1.1** Explain the concept of Biostatistics	**LI 1.1** Calculate and form a frequency distribution	**CI 1.1** Biostatistics-Definitions, Historical Resume	**SL1.1** Understand the role of biostatistics
	SO 1.2 Illustrate application of Biostatistics	**LI 1.2** Calculate the sampling errors	**CI 1.2** Biostatistics-Applications.	**SL1.2** Learn the Methods of Sampling.
	SO 1.3 Explain Methods of Sampling		**CI 1.3** Methods of Sampling	
	SO 1.4 study the random Sampling,		**CI 1.4** random Sampling,	
	SO 1.5 study the Non random Sampling,		**CI 1.5** Non random Sampling,	
	SO 1.6 study the Sampling Errors, non-sampling errors.		**CI 1.6** Sampling Errors, non-sampling errors.	
	SO 1.7 Explain Presentation of data:		**CI 1.7** Presentation of data:	
	SO 1.8 Illustrate Types of data,		**CI 1.8** Types of data,	
	SO 1.9 Explain Data collection, Frequency distribution		**CI 1.9** Data collection, Frequency distribution	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Differentiate between Random Sampling and Non-random sampling and give Importance of biostatistics and their applications.
	SW3.2 Mini Project	Measures of central Tendency by suitable examples.
	SW3.3 Other Activities (Specify)	Find out some you tube videos based on history, methods, and application of biostatistics.

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Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO2-05BT604.2 - Extend practical skills in laboratory techniques and methods for producing, purifying, and analyzing pharmaceutical biotechnology products	**SO2.1** Explain about measures of central tendency	**LI 2.1** focuses on the Calculation of mean, Median, and Mode	**Unit 2** **CI 2.1** Measures of Central Tendency	**SL2.1** Understand the role of mean median and mode.
	SO2.2 illustrate about calculation of mean	**LI 2.2** To explain the Merits and demerits of Mean, Median, and Mode	**CI 2.2** Calculation of mean.	**SL2.2** Learn mean deviation by numerically.
	SO2.3 illustrate about calculation of median	**LI 2.3** List out formulations of mean median and mode.	**CI 2.3** Calculation of Median	
	SO2.4 Elucidate calculation of mode		**CI 2.4** Calculation of Mode	
	SO2.5 explain merits of Mean, Median and Mode		**CI 2.5** Merits of Mean, Median and Mode	
	SO2.6 explain demerits of Mean, Median and Mode.		**CI 2.6** demerits of Mean, Median and Mode	
	SO2.7 Explain Measures of Dispersion- Range,.		**CI2.7** Measures of Dispersion-Range,	
	SO2.8 Illustrate Mean deviation,		**CI2.8**, Mean deviation,	
	SO2.9 Explain Standard deviation.		**CI2.9** Standard deviation.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Calculate mean median and mode by related questions.
	SW2.2 Mini Project	Measures of central Tendency by suitable examples.
	SW2.3 Other Activities (Specify)	Find out some YouTube videos based on the calculation method of mean median and mode.

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)**
CO3-05BT604.3 Demonstrate basic analytical techniques to generate results	**SO3.1** Summarize the concept of probability	**LI 1.1** Basics of probability	**CI3.1** Definition of probability,	**SL3.1** Understand the role of probability theorems.
	SO3.2 Explain theorems of Probability	**LI 1.2** Working of any Addition rule and multiplication rule	**CI3.2** Theorems of Probability	**SL3.2** Learn the application of probability
	SO3.3 Provide use of the Addition rule of probability		**CI3.3** Addition rule, and multiplication rule.	
	SO3.4 Apply the multiplication rule.		**CI3.4** Apply multiplication rule.	
	SO3.5 Analyse probability distribution-		. **CI3.5** Probability distribution	
	SO3.6 Analyse Binomial distribution,		**CI3.6** Binomial distribution,	
	SO3.7 Explain Poisson distribution,		**CI3.7** Poisson distribution,	
	SO3.8 Explain Normal distribution.		**CI3.8** Normal distribution.	
	CI3.9 Illustrate Applications of probability		**CI3.9** Applications of probability	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Write about the probability distribution Calculate probability by suitable examples
	SW3.2 Mini Project	how is probability important in biological systems?
	SW3.3 other activity	Find out some youtube videos based on probability theorems.

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 | 01 | 01 | 02 | 13

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO4-05BT604.4 Interpret results of commonly used statistical analyses in written summaries	**SO4.1** Outline the Correlation	**LI4.1** Understand the working of regression equation by given data.	**CI4.1** Correlation and Regression-Introduction,	**SL4.1** Understand the Positive or Negative Correlation.
	SO4.2 Explain Regression.		**CI4.2**Explain Regression.	**SL4.2** Learn regression equation
	SO4.3 Explain types of correlation		**CI4.3** Types of Correlation	.
	SO4.4 Analyse the Positive Correlation		**CI4.4** Positive or Negative Correlation,	
	SO4.5 Analyse the Negative Correlation		**CI4.5** Analyse the Negative Correlation	
	SO4.6 Explain Correlation coefficient,		**CI4.6** Correlation coefficient	
	SO4.7 Illustrate Linear regression		**CI4.7** Linear regression	
	SO4.8 Illustrate the Regression equation.		**CI4.8** Regression equation.	
	SO4.9 Explain Application of Regression and Correlation		**CI4.9** Application of Regression and Correlation.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Illustrating Principles of Correlation and Regression
	SW4.2 Mini Project	How regression equation is important in the area of biological research?
	SW4.3 Other Activities (Specify)	Find out some youtube videos based on Correlation and Regression.

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 | 02 | 12

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
CO5-05BT604.5 Interpret results of commonly used statistical analyses in written summaries	**SO5.1** Introduce the Procedure of Testing Hypothesis		**CI 5.1** Introduce the Procedure of Testing Hypothesis	**SL5.1** Understand the Null and Alternative Hypothesis.
	SO5.2 Explain Null Hypothesis.		**CI 5.2** Null Hypothesis.	**SL5.2** Differentiation between T-Test and Chi-Square test.
	SO5.3 Explain Alternative Hypothesis.		**CI 5.3** Alternative Hypothesis.	
	SO5.4 UnderstandT-Test for small samples.		**CI 5.4** T-Test for small samples.	
	SO5.5 Explain Properties of t-Test.		**CI 5.5** Properties and Application of t-Test.	
	SO5.6 Explain the Application of the t-Test		**CI 5.6** Application of t-Test	
	SO5.7 Understandthe Chi-Square test		**CI 5.7** Chi-Square test	
	SO5.8 ExplainProperties of chi distribution.		**CI 5.8** Properties of chi distribution.	
	SO5.9 Explain the Application of chi distribution		**CI 5.9** Application of chi distribution	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Differentiate Null and Alternative Hypothesis.
	SW5.2 Mini Project	How T-Test and Chi-Square test are playing important role in biostatistics?
	SW5.3 Other Activities (Specify)	Find out some you tube videos based on Test of significance.

Course duration (in hours) to attain Course Outcomes:

Course Title: Biostatistics **Course Code: 05BT604**

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-05BT604.1Describe the roles biostatistics serves in the discipline of public health.	**9**	4	2	**1**	16
CO2-05BT604.2Apply basic statistical concepts commonly used in public health and Health Sciences	**9**	6	2	**1**	18
CO3-05BT604.3: Demonstrate basic analytical techniques to generate results	9	4	2	**1**	16
CO4-05BT604.4Interpret results of commonly used statistical analyses in written summaries	9	1	2	**1**	13
CO5-05BT604.5: Demonstrate statistical reasoning skills accurately and contextually	9	0	2	**1**	12
Total Hours	**45**	**15**	**10**	**05**	**75**

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

Course Title: Biostatistics **Course Code:05BT604**

Course Outcomes	Marks Distribution			Total Marks
	R	U	A	
CO1-05BT604.1Describe the roles biostatistics serves in the discipline of public health.	03	02	04	09
CO2-05BT604.2Apply basic statistical concepts commonly used in public health and Health Sciences	04	05	02	11
CO3-05BT604.3: Demonstrate basic analytical techniques to generate results	02	06	02	11
CO4-05BT604.4Interpret results of commonly used statistical analyses in written summaries	03	05	02	10
CO5-05BT604.5: Demonstrate statistical reasoning skills accurately and contextually	03	04	03	10
Total Marks	**15**	**22**	**13**	**50**

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

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	BIOSTATISTICS, P.N.Arora, P.K.Malhan, Himalaya Publishing House,edition2 & 2005
2	Fundamentals of biostatistics, Khan and Khanam, Ukaaz Publication 2 & 2004
3	Elements Of Biostatistics, Prasad Rastogi Publication, edition, 3& 2009

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B. Sc. Biotechnology
Semester: VI Semester
Course Title: BIOSTATISTICS
Course Code: 05BT604

CO/PO Mapping															
Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-05BT604.1Describe the roles biostatistics serves in the discipline of public health.	-	-	-	1	2	2	2	-	1	2	2	3	3	2	1
CO2-05BT604.2Apply basic statistical concepts commonly used in public health and Health Sciences	-	-	-	-	-	-	3	-	2	2	3	3	2	1	2
CO3-05BT604.3: Demonstrate basic analytical techniques to generate results	-	1	1	1	-	-	2	-	3	1	1	2	1	2	1
CO4-05BT604.4Interpret results of commonly used statistical analyses in written summaries	-	1	1	-	2	2	2	3	-	1	-	-	2	2	3
CO5-05BT604.5: Demonstrate statistical reasoning skills accurately and contextually	1	1	1	-	-	2	3	3	1	2	2	2	2	1	2

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	CO1-05BT604.1Describe the roles biostatistics serves in the discipline of public health.	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	CO2-05BT604.2Apply basic statistical concepts commonly used in public health and Health Sciences	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	**LI 1** **LI 2** **LI 3**	2.1, 2.2, 2.3,2.4,2.5,2.6,2.7,2.8, 2.9	**2SL-1,2,**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	CO3-05BT604.3: Demonstrate basic analytical techniques to generate results	SO3.1 SO3.2 SO3.3 SO3.4SO3.5 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	CO4-05BT604.4Interpret results of commonly used statistical analyses in written summaries	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	**LI 1**	4.1,4.2,4.3,4.4, 4.5, 4.6,4.6,4.7,4.8, 4.9	**4SL-1,2**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	CO5-05BT604.5: Demonstrate statistical reasoning skills accurately and contextually	SO5.1 SO5.2 SO5.3 SO5.4SO5.5 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**

Program Name	***B.Sc. (HONOURS) BIOTECHNOLOGY***	
Semester	VII	
Course Code:	**01BT701**	
Course title:	COMPUTATIONAL BIOLOGY AND BIOINFORMATICS	**Curriculum Developer**: Mr. Piyush Kant Rai, Assistant professor
Pre-requisite:	Biology fundamentals (molecular biology, genetics), programming (Python), statistics, mathematics, bioinformatics tools, genomics, NGS technologies, Linux/Unix, version control, and effective communication.	
Rationale:	The proposed syllabus integrates essential elements for bioinformatics proficiency. It combines foundational biology with practical programming skills, statistical and mathematical methods, and database management. This comprehensive approach ensures students acquire the necessary tools to analyze biological data, fostering a robust understanding of bioinformatics principles and applications.	
Course Outcomes (COs):	**01BT701.1:** The unit will explain bioinformatics history, homology, and utilize sequence databases (EMBL, GENBANK, Entrez, Unigene). **01BT701.2:** Analyze protein information from PDB, SWISS-PROT, TREMBL databases, mastering their structures for effective utilization in research. **01BT701.3:** Operates diverse data generation techniques, understand bioinformatics challenges, and apply problem-solving skills in biological analyses. **01BT701.4:** Master sequence and phylogeny analysis, detect ORFs, understand sequence assembly, mutation matrices, BLAST usage, and interpret results. **01BT701.5:** Navigate databases, execute similarity searches (BLAST, FASTA), and annotate genomes, integrating pattern finding and gene identification.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme ofstudies (Hours/Week)					Total Credits(C) (L:T:P=4:0:2)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
MAJOR	**01BT701**	COMPUTATIONAL BIOLOGY AND BIOINFORMATICS	4	4	1	2	11	4+2=6

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)		
MAJOR	**01BT701**	COMPUTATIONAL BIOLOGY AND BIOINFORMATICS	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)		
MAJOR	**01BT701**	COMPUTATIONAL BIOLOGY AND BIOINFORMATICS	35	5	5	5	50	50	100

Course-Curriculum:

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

Approximate Hours

Item	Cl	LI	SW	SL	Total
Approx. Hrs	12	06	01	03	22

Course outcome (CO)	**Session Outcomes(SOs)**	**Laboratory Instruction(LI)**	**Class room Instruction(CI)**	**Self-Learning(SL)**
CO1-01BT701.1: The unit will explain bioinformatics history, homology, and utilize sequence databases (EMBL, GENBANK, Entrez, Unigene).	SO1.1: The notion of Homology. Sequence Information Sources.	LI1.1: Learn how to use a computer for bioinformatics tasks.	CI1.1: Introduction to the notion of Homology. Sequence Information Sources.	SL1.1: Visit and explore EMBL website.
	SO1.2: EMBL database.	LI1.2: Learn how to use a ONLINE DATABASE	CI1.2: Explore the EMBL database structure and applications.	SL1.2: Explore NCBI website for related resources.
	SO1.3: DDBJ, Swiss-Prot databases.		CI1.3: Introduction to DDBJ and Swiss-Prot databases.	
	SO1.4: GENBANK database.		CI1.4: Introduction to the GENBANK database and its structure.	
	SO1.5: Entrez and Unigene databases.		CI1.5: Overview of Entrez and Unigene databases.	
	SO1.6: Understanding the structure of each database and how to use it on the web.		CI1.6: Practical understanding of using sequence information sources on the web.	
	SO1.7: Explore sequence data types in bioinformatics.	LI1.3: Use web-based tools to retrieve sequence data from databases.	CI1.7: Classification of sequence data types in databases.	SL1.3: Research different types of biological sequences (DNA, RNA, Protein).
	SO1.8: Basic concepts of nucleotide and protein sequences.		CI1.8: Introduction to nucleotide and protein sequences.	
	SO1.9: Key bioinformatics tools for sequence retrieval.		CI1.9: Key bioinformatics tools and how they help retrieve sequence data.	
	SO1.10: Sequence submission methods.		CI1.10: How to submit biological sequences to public databases.	
	SO1.11: Use of public databases for research.		CI1.11: How researchers use public databases for biological data analysis.	
	SO1.12: Ethical considerations in sequence submission.		CI1.12: Ethical guidelines and best practices in data submission.	

Suggested Sessional Work (SW): *anyone*		
	SW1.1 Assignments	Summarizes the GenBank, EMBL and DDBJ. .
	SW1.2 Mini Project	Demonstrate how to retrieve data from EMBL.
	SW1.3 Other Activities (Specify)	correlate the data redundancy among INSDC databases.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	6	1	3	22

Course Outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
CO2-01BT701.2: Analyze protein information from PDB, SWISS-PROT, TREMBL databases, mastering their structures for effective utilization in research.	SO2.1: Introduction to protein data sources.	LI2.1: Learn how to access protein databases using web tools.	CI2.1: Overview of protein databases: PDB, SWISSPROT, and TREMBL.	SL2.1: Visit PDB and explore available protein structures.
	SO2.2: SWISSPROT and TREMBL database structure.	LI2.2: Perform BLAST	CI2.2: Explore the structure and function of SWISSPROT and TREMBL.	SL2.2: Analyze a protein entry in SWISSPROT.
	SO2.3: Understanding the Protein Data Bank (PDB).		CI2.3: Introduction to PDB: How it stores 3D protein structures.	
	SO2.4: Retrieving protein sequences.		CI2.4: Methods for retrieving protein sequences from databases.	
	SO2.5: Interpretation of protein structure data.	LI2.3: Practice retrieving and interpreting protein sequences from PDB.	CI2.5: How to interpret data from protein structure sources.	
	SO2.6: Using protein databases for research.		CI2.6: Application of protein databases in biological research.	
	SO2.7: SWISSPROT annotations and their significance.		CI2.7: Understanding the annotation features of SWISSPROT.	
	SO2.8: Cross-references between protein databases.		CI2.8: How to use cross-references between PDB, SWISSPROT, and TREMBL.	
	SO2.9: Importance of protein classification systems.		CI2.9: How protein classification systems organize protein data.	SL2.3: Research the role of protein classification in bioinformatics.
	SO2.10: Protein sequence alignment tools.		CI2.10: Introduction to protein sequence alignment and available tools.	
	SO2.11: Understanding protein domains and motifs.		CI2.11: How protein domains and motifs are annotated in databases.	
	SO2.12: Protein structure prediction methods.		CI2.12: Introduction to protein structure prediction techniques.	

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

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	6	1	3	22

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction (CI)	Self-Learning(SL)
CO3-01BT701.3: Operates diverse data generation techniques, understand bioinformatics challenges, and apply problem-solving skills in biological analyses.	SO3.1: Introduction to data generating techniques in bioinformatics.	LI3.1: Learn to identify data generated from different biological experiments.	CI3.1: Overview of restriction digestion, chromatograms, blots, PCR, and microarrays.	SL3.1: Study the key steps in the PCR process.
	SO3.2: Understanding restriction digestion and its applications.		CI3.2: How restriction digestion is used in bioinformatics.	SL3.2: Research on how restriction digestion aids in sequence analysis.
	SO3.3: Chromatograms and their role in sequencing data.		CI3.3: Introduction to chromatograms: how they visualize sequence data.	
	SO3.4: Use of blotting techniques in bioinformatics.	LI3.2: Practical use of blotting techniques in bioinformatics labs.	CI3.4: Explanation of blotting techniques (Southern, Northern, Western).	
	SO3.5: Polymerase Chain Reaction (PCR) in data generation.		CI3.5: Overview of PCR and its importance in bioinformatics.	
	SO3.6: Microarrays and their applications in data analysis.		CI3.6: Introduction to microarray technology for large-scale data analysis.	
	SO3.7: Understanding Mass Spectrometry.		CI3.7: The role of mass spectrometry in protein identification and analysis.	
	SO3.8: Bioinformatics problems posed by these techniques.		CI3.8: Issues in handling and analyzing data from various biological experiments.	
	SO3.9: Tools used to process data from restriction digestion and PCR.	LI3.3: Practice analyzing data from restriction digestion and PCR experiments.	CI3.9: Introduction to software tools for analyzing PCR and restriction digestion data.	
	SO3.10: Analysis of data from chromatograms and microarrays.		CI3.10: Overview of software tools for analyzing chromatogram and microarray data.	SL3.3: Research on how software tools how it use .
	SO3.11: Challenges in processing large-scale data from mass spectrometry.		CI3.11: Understanding the bioinformatics challenges in mass spectrometry data analysis.	
	SO3.12: Integration of data from multiple techniques for analysis.		CI3.12: How to integrate data from restriction digestion, blots, PCR, and microarrays for a comprehensive analysis.	

Suggested Sessional Work (SW): *anyone*		
	SW3.1 Assignments	Read about the conventional and non-conventional PCR.
	SW3.2 Mini Project	Draw the flow chart model of mass spectrometry.
	SW3.3 Other Activities (Specify)	How to integrate data from restriction digestion, blots, PCR, and microarrays

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	6	1	3	22

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO4-01BT701.4: Master sequence and phylogeny analysis, detect ORFs, understand sequence assembly, mutation matrices, BLAST usage, and interpret results.	SO4.1: Introduction to sequence and phylogeny analysis.	LI4.1: Learn how to identify sequences using web-based tools.	CI4.1: Overview of sequence and phylogeny analysis methods.	SL4.1: Study the basics of phylogenetic trees.
	SO4.2: Detecting Open Reading Frames (ORFs).		CI4.2: Understanding ORFs and their importance in gene prediction.	SL4.2: Explore online tools for detecting ORFs in sequences.
	SO4.3: Outline of sequence assembly.	LI4.2: How to interpret and analyze BLAST search results	CI4.3: Introduction to sequence assembly processes and tools.	SL4.3: Explore sequence assembly processes and tools..
	SO4.4: Understanding mutation and substitution matrices.		CI4.4: Explanation of mutation/substitution matrices used in sequence alignment.	
	SO4.5: Introduction to BLAST.	LI4.3: Practice using BLAST for sequence similarity searches.	CI4.5: Introduction to the BLAST algorithm and its applications.	
	SO4.6: Interpreting BLAST results.		CI4.6: How to interpret and analyze BLAST search results.	
	SO4.7: Pairwise sequence alignment.		CI4.7: Introduction to pairwise sequence alignment techniques.	
	SO4.8: Multiple sequence alignment.		CI4.8: How to perform multiple sequence alignments (MSA).	
	SO4.9: Phylogenetic analysis methods.		CI4.9: Introduction to methods used for phylogenetic analysis.	
	SO4.10: Constructing phylogenetic trees.		CI4.10: Understanding the construction of phylogenetic trees from sequence data.	
	SO4.11: Comparison of phylogenetic analysis tools.		CI4.11: Compare different phylogenetic analysis tools (e.g., MEGA, PHYLIP).	
	SO4.12: Challenges in sequence and phylogeny analysis.		CI4.12: Discussion on the challenges faced in sequence and phylogenetic analyses.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Propose ideas on comparative gene studies
	SW4.2 Mini Project	Compare different phylogenetic analysis tools (e.g., MEGA, PHYLIP).
	SW4.3 Other Activities (Specify)	Explore the Amrita lab for phylogenetic studies.

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	6	1	3	22

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO5-01BT701.5: Navigate databases, execute similarity searches (BLAST, FASTA), and annotate genomes, integrating pattern finding and gene identification.	SO5.1: Introduction to database searching.	LI5.1: Learn to search databases using tools like BLAST and FASTA.	CI5.1: Overview of searching biological databases using SRS and Entrez.	SL5.1: Explore how to search for nucleotide and protein sequences on NCBI.
	SO5.2: Sequence similarity searches using BLAST.		CI5.2: Understanding sequence similarity search methods: BLAST.	SL5.2: Research how FASTA is used for sequence comparison.
	SO5.3: Introduction to FASTA for sequence searches.		CI5.3: How to use FASTA for sequence similarity searches.	
	SO5.4: Data submission to biological databases.		CI5.4: Introduction to data submission processes for biological databases.	
	SO5.5: Key concepts of genome annotation.	LI5.2: Practice genome annotation using online tools.	CI5.5: Overview of genome annotation processes and tools.	
	SO5.6: Pattern and repeat finding in genome sequences.	LI5.2: Practice Sequence matching	CI5.6: Techniques for identifying patterns and repeats in genome sequences.	
	SO5.7: Tools for gene identification in genomes.		CI5.7: Introduction to gene identification tools (e.g., AUGUSTUS, Glimmer).	
	SO5.8: Gene prediction and its significance.		CI5.8: Explanation of gene prediction methods and their applications.	
	SO5.9: Comparison of genome annotation tools.		CI5.9: Discuss the pros and cons of genome annotation tools.	SL5.3: Investigate the latest advancements in genome annotation techniques.
	SO5.10: Importance of functional annotation in genomics.		CI5.10: Introduction to functional annotation and its role in genomics.	
	SO5.11: Ethical considerations in genome data sharing.		CI5.11: Ethical guidelines for sharing and using genome data.	
	SO5.12: Future trends in genome annotation.		CI5.12: Discussion on emerging trends and technologies in genome annotation.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	make a flow chart of the genome comparison.
	SW5.2 Mini Project	Discuss the pros and cons of genome annotation tools.
	SW5.3 Other Activities (Specify)	Try to learn and apply repeat findings and patterns for protein.

Course duration (in hours)to attain Course Outcomes:

Course Title: Computational biology and bioinformatics **Course Code:01BT701**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-01BT701.1: The unit will explain bioinformatics history, homology, and utilize sequence databases (EMBL, GENBANK, Entrez, Unigene).	12	6	3	1	22
CO2-01BT701.2: Analyze protein information from PDB, SWISS-PROT, and TREMBL databases, mastering their structures for effective utilization in research.	12	6	3	1	22
CO3-01BT701.3: Operates diverse data generation techniques, understand bioinformatics challenges, and apply problem-solving skills in biological analyses.	12	6	3	1	22
CO4-01BT701.4: Master sequence and phylogeny analysis, detect ORFs, understand sequence assembly, mutation matrices, BLAST usage, and interpret results.	12	6	3	1	22
CO5-01BT701.5: Navigate databases, execute similarity searches (BLAST, FASTA), and annotate genomes, integrating pattern finding and gene identification.	12	6	3	1	22
Total Hours	60	30	15	5	110

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

Course Title: computational biology and bioinformatics **Course Code:01BT701**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-01BT701.1: The unit will explain bioinformatics history, homology, and utilize sequence databases (EMBL, GENBANK, Entrez, Unigene).	02	03	04	1	10
CO2-01BT701.2: Analyze protein information from PDB, SWISS-PROT, and TREMBL databases, mastering their structures for effective utilization in research.	04	02	02	2	10
CO3-01BT701.3: Operates diverse data generation techniques, understand bioinformatics challenges, and apply problem-solving skills in biological analyses.	03	03	02	2	10
CO4-01BT701.4: Master sequence and phylogeny analysis, detect ORFs, understand sequence assembly, mutation matrices, BLAST usage, and interpret results.	03	04	02	1	10
CO5-01BT701.5: Navigate databases, execute similarity searches (BLAST, FASTA), and annotate genomes, integrating pattern finding and gene identification.	04	03	02	1	10
Total Marks	17	14	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	BioinformaticsThomas Dandekar , Meik Kunz Springer-Verlag GmbH Germany, part of Springer Nature 2023
2	Introduction to bioinformaticsArthur LeskOxford University Press 2023
3	Essential bioinformatics Jin Xiong Cambridge University Press 2007

(c) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B.Sc. Biotechnology
Semester: Vth Sem
Course Title: COMPUTATIONAL BIOLOGY AND BIOINFORMATICS
Course Code: 01BT701

CO/PO/PSO Mapping															
Course Outcome (Cos)	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-01BT701.1: The unit will explain bioinformatics history, homology, and utilize sequence databases (EMBL, GENBANK, Entrez, Unigene).	-	-	-	**1**	**2**	**2**	**1**	-	**1**	**2**	**2**	**3**	**3**	**3**	**1**
CO2-01BT701.2: Analyze protein information from PDB, SWISS-PROT, and TREMBL databases, mastering their structures for effective utilization in research.	-	-	-	-	-	-	**3**	-	**2**	**2**	**3**	**3**	**1**	**1**	**2**
CO3-01BT701.3: Operates diverse data generation techniques, understand bioinformatics challenges, and apply problem-solving skills in biological analyses.	-	**1**	**1**	**1**	-	-	**2**	-	**3**	**1**	**1**	**2**	**1**	**1**	**1**
CO4-01BT701.4: Master sequence and phylogeny analysis, detect ORFs, understand sequence assembly, mutation matrices, BLAST usage, and interpret results.	-	**1**	**1**	-	**2**	**2**	**2**	**3**	-	**1**	-	-	**1**	**2**	**3**
CO5-01BT701.5: Navigate databases, execute similarity searches (BLAST, FASTA), and annotate genomes, integrating pattern finding and gene identification.	**1**	**1**	**1**	-	-	**2**	**3**	**3**	**1**	**2**	**2**	**2**	**1**	-	**2**

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 4,5,6 7,9,10,11,12 PSO 1,2, 3	**CO1-01BT701.1:** The unit will explain bioinformatics history, homology, and utilize sequence databases (EMBL, GENBANK, Entrez, Unigene).	SO1.1, SO1.2, SO1.3, SO1.4, SO1.5, SO1.6, SO1.7, SO1.8, SO1.9, SO1.10, SO1.11, SO1.12	**IL 1** **IL 2** **IL 3**	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.12	**1SL-1,2,3**
PO 7,9,10,11,12 PSO 1,2, 3	**CO2-01BT701.2:** Analyze protein information from PDB, SWISS-PROT, and TREMBL databases, mastering their structures for effective utilization in research.	SO2.1, SO2.2, SO2.3, SO2.4, SO2.5, SO2.6, SO2.7, SO2.8, SO2.9, SO2.10, SO2.11, SO2.12	**IL 1** **IL 2** **IL 3**	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11, 2.12	**2SL-1,2,3**
PO 2,3,4, 7,9,10,11,12 PSO 1,2, 3	**CO3-01BT701.3:** Operates diverse data generation techniques, understand bioinformatics challenges, and apply problem-solving skills in biological analyses.	SO3.1, SO3.2, SO3.3, SO3.4, SO3.5, SO3.6, SO3.7, SO3.8, SO3.9, SO3.10, SO3.11, SO3.12	**IL 1** **IL 2** **IL 3**	3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12	**3SL-1,2,3**
PO 2,3,5,6 7,8,10,11,12 PSO 1,2, 3	**CO4-01BT701.4:** Master sequence and phylogeny analysis, detect ORFs, understand sequence assembly, mutation matrices, BLAST usage, and interpret results.	SO4.1, SO4.2, SO4.3, SO4.4, SO4.5, SO4.6, SO4.7, SO4.8, SO4.9, SO4.10, SO4.11, SO4.12	**IL 1** **IL 2** **IL 3**	4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10, 4.11, 4.12	**4SL-1,2,3**
PO 1,2,3,6 7,8,9,10,11,12 PSO 1, 3	**CO5-01BT701.5:** Navigate databases, execute similarity searches (BLAST, FASTA), and annotate genomes, integrating pattern finding and gene identification.	SO5.1, SO5.2, SO5.3, SO5.4, SO5.5, SO5.6, SO5.7, SO5.8, SO5.9, SO5.10, SO5.11, SO5.12	**IL 1** **IL 2** **IL 3**	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 5.10, 5.11, 5.12	**5SL-1,2,3**

Program Name	B.Sc. (Hons) in Biotechnology	
Semester	VII	
Course Code:	02RM701	
Course title:	Research Methodology	**Curriculum Developer**: Dr. Deepak Mishra, Professor
Pre-requisite:	Student should have basic and advanced knowledge of Biotechnology and practical as well as research skills.	
Rationale:	The paper on Research Methodology in a B.Sc. (Hons.) in Biotechnology program explores the critical role of specialized research and scientific tools in analyzing Biotechnological research. It delves into the use of precise instruments for monitoring and analyzing data and literature, development of research skills and scientific aptitudes. This study enables students to understand how systematic research process helps us for doing any research in a systematic manner along with data publication. It also explores the publication ethics and plagiarism knowledge.	
Course Outcomes (COs):	**CO1-02RM701.1:** Students are being knowledgeable with essentials of research methodology through various tools available. **CO2-02RM701.2:** Development of critical thinking skills for evaluating scientific literature and identifying research problems. **CO3-02RM701.3:** Proficiency in communicating research findings through various written forms. **CO4-02RM701.4:** Recognize various issues related to research ethics, data processing and integrity, research commercialization. **CO5-02RM701.5:** Proficiency in report writing, plagiarism rectification, making deliberations and presentation.	

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)	
Minor (RM)	02RM701	Research Methodology	3	2	1	5	11	3+1=4

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

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
Minor (RM)	02RM701	Research Methodology	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)		
Minor (RM)	02RM701-L	Research Methodology	35	5	5	5	50	50	100

Course-Curriculum:

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

Course outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Class room Instruction(CI)	Self-Learning(SL)
CO1-02RM701.1: Students are being knowledge-able with essentials of research methodology through various tools available	**SO1.1** Define and Describe concept of scientific writing and research, its types	**LI 1.1** Study Online Data Bases	**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	**LI 1.2** Study about sampling	**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		**CI1.8** Generalization	
	SO1.9 Study about interpretation of research findings		**CI1.9** interpretation.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe in detail research and its types
	SW1.2 Mini Project	Collection of data and literature related to any biotechnological research problem
	SW1.3 Other Activities (Specify)	Searching of online database available on internet and their application in research

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

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-02RM701.2: 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** Writing review articles	**Unit-II** **CI2.1** Writing review articles,	**SL2.1** Search various contents for writing a review article
	SO2.2 Describe the contents of research article		**CI2.2** Writing Journal articles, bibliography	**SL2.2** designing of a research article
	SO2.3 Reflecting about the concept and contents of books and monograph		**CI2.3** books, and monographs-	**SL2.3** Learn about contents of an ideal book
	SO2.4 Explain about contents of an ideal thesis	**LI2.12** study structure of 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 research designs.		**CI2.8** Research Designs.	
	SO2.8 explain about different types of research designs.		**CI2.9** Types of Research Design	

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)**
CO3-02RM701.3: Proficiency in communicating research findings through various written forms.	**SO3.1** Explain the role of different types of data in research.	**LI3.1** Study about methods of data collection	**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** Study about scaling methods	**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:	**SL3.4** Collection of different research journals
	SO3.7 Assessing the role of research journals and their standards		**CI3.7** Standard of research Journals	**SL3.5** Assess role of impact factor and citation index in research
	SO3.8 Describe about concept of impact factor		**CI3.8** Impact factor,	
	SO3.9 Describe about concept of citation index		**CI3.9** citation index	

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	02	01	05	17

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO4-02RM701.4: Recognize various issues related to research ethics, data processing and integrity, research commercialization	**SO4.1** Exploring the concept of data processing	**LI4.1** Study research ethics	**Unit-IV** **CI4.1** Data processing	**SL4.1** Learn about data processing approaches and its implementation.
	SO4.2 Explaining the analytical/ statistical methods involved in research		**CI4.2** Qualitative and Quantitative analytical / statistical methods involved in research.	**SL4.2** Learn about analytical and scientific methods of research.
	SO4.3 Assessing the sources of ethical issues in science and biotechnology		**CI4.3** Research Ethics- The source of ethical issues in science and biotechnology	**SL4.3** Discuss ethical concern of research in science and biotechnology
	SO4.4 Explaining the concept of objectivity and integrity		**CI4.4** research and reporting objectivity and integrity,	**SL4.4** Learn about various types of reports
	SO4.5 Explaining the plagiarism and related issues		**CI4.5** the problem of plagiarism and related issues	**SL4.4** Case studies related to plagiarism
	SO4.6 Evaluate impact of international norms and standards.		**CI4.6** international norms and standards	
	SO4.7 Describe the impact of scientific temper and virtues		**CI4.7** Scientific temper and virtues expectations from scientific community	
	SO4.8 Assessing the ethical issues and environmental impact		**CI4.8** Ethical issues and Environmental impact aspects	**SL4.5** Case studies related to ethical impact of research
	SO4.9 Describe about the commercializing research.		**CI4.9** Commercializing research- Copy right, IPRs	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain about Qualitative and Quantitative analytical / statistical methods involved in research.
	SW4.2 Mini Project	Describe the various ethical issues related to biotechnological research.
	SW4.3 Other Activities (Specify)	Prepare one article on commercialization of research

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	01	01	05	16

Course Outcome (CO)	Session Outcomes(SOs)	Laboratory Instruction(LI)	Classroom Instruction(CI)	Self-Learning(SL)
CO5-02RM701.5: Proficiency in report writing, plagiarism rectification, making deliberations and presentation	**SO5.1** Define the concept and types and components of scientific reports		**Unit-V** **CI5.1** Structure, Types and components of scientific reports	**SL5.1** learn about basic concept & requirement of research report
	SO5.2 Able to execute steps layout and structure of research.		**CI5.2** Steps, Layout and structure; Illustrations and tables	**SL5.2**Review different layouts of report
	SO5.3 Apply the role of Bibliography, referencing and footnotes		**CI5.3** Bibliography, referencing and footnotes	**SL5.3**learn how prepare a report
	SO5.4 Evaluate the concept of plagiarism in research	**LI5.1** Use of visual aids- Importance of effective communication	**CI5.4** Reproduction of published material Plagiarism,	**SL5.4** Learn about plagiarism checking
	SO5.5 Evaluate the citation and bibliography		**CI5.5** Citation and acknowledgement	
	SO5.6 Describe about reproducibility and accountability		**CI5.6** Reproducibility and accountability	
	SO5.7 Describe about Seminars; Symposia; Workshops, Conferences		**CI5.7** General idea about: Seminars; Symposia; Workshops, Conferences	
	SO5.8 Elaborate the role of deliberations in research		**CI5.8** Making deliberations (Oral presentation)	**SL5.5** Learn about role of deliberation.
	SO5.9 Describe about methods of presentation preparation		**CI5.9** Planning - Preparation and Making presentation	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general characteristics and components of research report
	SW5.2 Mini Project	Describe the role of deliberation in research
	SW5.3 Other Activities (Specify)	Prepare a detail document on Use of visual aids- Importance of effective communication

Course duration (in hours) to attain Course Outcomes:

Course Title: Research Methodology **Course Code:** 02RM701

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-02RM701.1: Students are being knowledgeable with essentials of research methodology through various tools available.	9	4	5	1	19
CO2-02RM701.2: Development of critical thinking skills for evaluating scientific literature and identifying research problems.	9	4	5	1	19
CO3-02RM701.3: Proficiency in communicating research findings through various written forms.	9	4	5	1	19
CO4-02RM701.4: Recognize various issues related to research ethics, data processing and integrity, research commercialization.	9	2	5	1	17
CO5-02RM701.5: Proficiency in report writing, plagiarism rectification, making deliberations and presentation.	9	1	5	1	16
Total Hours	45	15	25	05	90

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

Course Title: Research Methodology **Course Code:**02RM701

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-02RM701.1: Students are being knowledgeable with essentials of research methodology through various tools available.	2	1	1	1	5
CO2-02RM701.2: Development of critical thinking skills for evaluating scientific literature and identifying research problems.	2	4	2	2	10
CO3-02RM701.3: Proficiency in communicating research findings through various written forms.	2	3	3	2	10
CO4-02RM701.4: Recognize various issues related to research ethics, data processing and integrity, research commercialization.	3	5	5	2	15
CO5-02RM701.5: Proficiency in report writing, plagiarism rectification, making deliberations and presentation.	5	4	1	0	10
Total Marks	**14**	**17**	**12**	**07**	**50**

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

Suggested learning Resources:

(a) Books:

(b)

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

(c) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B.Sc. (Ho ns.) Biotechnology
Semester: VII Semester
Course Title: Research Methodology
Course Code: 02RM701

Course Outcome (Cos)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-02RM701.1: Students are being knowledgeable with essentials of research methodology through various tools available.	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3
CO2-02RM701.2: Development of critical thinking skills for evaluating scientific literature and identifying research problems.	2	2	3	2	3	2	2	3	2	2	3	2	2	3	3
CO3-02RM701.3: Proficiency in communicating research findings through various written forms.	2	2	3	2	3	2	2	3	2	2	3	2	2	3	3
CO4-02RM701.4: Recognize various issues related to research ethics, data processing and integrity, research commercialization.	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3
CO5-02RM701.5: Proficiency in report writing, plagiarism rectification, making deliberations and presentation.	3	3	3	3	2	3	3	3	3	3	3	3	3	3	2

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5 PSO 1,2,3	**CO1-02RM701.1:** Students are being knowledgeable with essentials of research methodology through various tools available.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 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	**CO2-02RM701.2:** Development of critical thinking skills for evaluating scientific literature and identifying research problems.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	**LI 1** **LI 2**	2.1, 2.2, 2.3,2.4,2.5,2.6,2.7,2.8, 2.9	2SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO3-02RM701.3:** Proficiency in communicating research findings through various written forms.	SO3.1 SO3.2 SO3.3 SO3.4SO3.5 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	**CO4-02RM701.4:** Recognize various issues related to research ethics, data processing and integrity, research commercialization.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	**LI 1**	4.1,4.2,4.3,4.4, 4.5, 4.6,4.6,4.7,4.8, 4.9	4SL-1,2,3,4,5
PO 1,2,3,4,5 PSO 1,2,3	**CO5-02RM701.5:** Proficiency in report writing, plagiarism rectification, making deliberations and presentation.	SO5.1 SO5.2 SO5.3 SO5.4SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	**LI 1**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8, 5.9	5SL-1,2,3,4,5

Program Name	**Bachelorof Science (Hons.) in Biotechnology (B.Sc. (Hons.) BT)**	
Semester	VII	
Course Code:	05BT701	
Course title:	Pharmaceutical Biotechnology	**Curriculum Developer**: Chahana Desai, Teaching Associate
Pre-requisite:	Students should have basic knowledge of biotechnology and the role of biotechnology in Pharmaceuticals.	
Rationale:	Pharmaceutical biotechnology is a field of biomedical sciences that uses novel technologies for production, formulation, and synthesis of biological substances from the living organisms,Which acts as drug molecules for the treatment and prevention of various diseases and syndromes.	
Course Outcomes (COs):	**CO1-05BT701.1:** Elucidate the basic fundamentals of antibiotics,chemical disinfectants, antiseptics and preservatives. **CO2-05BT701.2:** Explain the mode of action of different antibiotic and non-antibiotic antimicrobial agents as well as drug targeting anddrug delivery system **CO3-05BT701.3:** Applied knowledge about microbial production and Spoilage of pharmaceutical Products and new vaccine technology **CO4-05BT701.4:** Analyze the Government regulatory policies, biosensors and application of microbial enzymes in pharmaceuticals. **CO5-05BT701.5:** Evaluate Good Laboratory Practices(GLP) and Good Manufacturing Practices (GMP) and safety in microbiology laboratory.	

Scheme of Studies:

Board of Study	**Course Code**	**Course Title**	**Scheme of studies (Hours/Week)**					**Total Credits(C) (L:T:P=3:0:1)**
			Cl	LI	SW	SL	**Total Study Hours(CI+LI+SW+SL)**	
Major (DSC)	05BT701	Pharmaceutical Biotechnology	3	0	1	2	6	3+0=3

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

Scheme of Assessment: Theory

Board of Study	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)		
Major (DSC)	05BT701	Pharmaceutical Biotechnology	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)		
Major (DSC)	05BT701-L	Pharmaceutical Biotechnology	35	5	5	5	50	50	100

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** Cl LI SW SL Total **Approx. Hrs** 09 04 01 02 16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-05BT701.1: Elucidate the basic fundamentals of antibiotics,chemical disinfectants, antiseptics and preservatives.	**SO1.1** Explain the concept of antibiotics and antimicrobial agents	**LI1.1** To Demonstrate the comparison of various antibiotics against a variety of bacteria.	**Unit-1 Introduction to pharmaceutical biotechnology** **CI1.1** Antibiotics and synthetic antimicrobial agents	**SL1.1** Find out some examples of common antibiotics
	SO1.2 Determine the basics of antibiotics	**LI1.2**To perform the test for effects of disinfectants.	**CI1.2** Antibiotics	**SL1.2** Characteristics of disinfectants
	SO1.3 Elaborate the concept of synthetic anti microbial agents.		**CI1.3** synthetic antimicrobial agents,	
	SO1.4 study Aminoglycosides		**CI1.4** Aminoglycosides	
	SO1.5 Explain β-lactams, tetracyclines		**CI1.5** β-lactams, tetracyclines	
	SO1.6 Explain about ansamycins, macrolid antibiotics		**CI1.6** ansamycins, macrolid antibiotics	
	SO1.7study antitumor substances,		**CI1.7**antitumor substances,	
	SO1.8 Elaborate about Peptide antibiotics, Chloramphenicol, Sulphonamides and Quinolinone antimicrobial agents.		**CI1.8** Peptide antibiotics, Chloramphenicol, Sulphonamides and Quinolinone antimicrobial agents.	
	SO1.9 Illustrate Chemical disinfectants, antiseptics and preservatives.		**CI1.9** Chemical disinfectants, antiseptics and preservatives.	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Describe in detail antibiotics and its types.
	SW1.2 Mini Project	Elaborate various types of disinfectants.
	SW1.3 Other Activities (Specify)	Make a power point presentation on various antitumor substances.

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

ApproximateHours

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

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-05BT701.2: Explain the mode of action of different antibiotic and non-antibiotic antimicrobial agents as well as drug targeting and drug delivery system	**SO2.1** Explainthe mechanism of action of different antibiotics	**LI2.1** To perform Isolation of drug molecules	**Unit-2 Mechanism of action of antibiotics:** **CI2.1** Mechanism of action of antibiotics	**SL2.1** Note down the effects of bacterial resistance to antibiotics
	SO2.2 Elucidate the principles of drug targeting and drug delivery.	**LI2.2** To perform the Effect of drug on animal models	**CI2.2** (inhibitors of cell wall synthesis, nucleic acid and protein synthesis),	**SL2.2** Read the latest research on antibiotics.
	SO2.3 Elaborate the reaction of antimicrobial agents at the target site.		**CI2.3** Molecular principles of drug targeting.	**SL2.3** Write down few points on importance of gene therapy
	SO2.4 Drug delivery system in gene therapy		**CI2.4** Drug delivery system in gene therapy	
	SO2.5 Bacterial resistance to antibiotics,		**CI2.5** Bacterial resistance to antibiotics,	
	SO2.6 Mode of action of bacterial killing by quinolinones, Bacterial resistance to quionolinones		**CI2.6** Mode of action of bacterial killing by quinolinones, Bacterial resistance to quionolinones	
	SO2.7 IllustrateMode of action of non- antibiotic antimicrobial agents		**CI2.7** Mode of action of non-antibiotic antimicrobial agents	
	SO2.8 Discuss Penetrating defences, How the antimicrobial agents reach the targets		**CI2.8** Penetrating defences, How the antimicrobial agents reach the targets	
	SO2.9 Explain cellular permeability barrier, cellular transport system and drug diffusion		**CI2.9** (cellular permeability barrier, cellular transport system and drug diffusion).	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe the antibiotics which act as a cell wall synthesis inhibitor.
	SW2.2 Mini Project	Make a chart on antibiotics and its mechanism of action.
	SW2.3 Other Activities (Specify)	Make Power point presentation on drug delivery in gene therapy.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**ApproximateHours** **Item** | Cl | LI | SW | SL | Total **Approx.Hrs** | 09 | 04 | 01 | 03 | 17

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-05BT701.3: Applied knowledge about microbial production and Spoilage of pharmaceutical Products and new vaccine technology.	**SO3.1** Elucidate the knowledge about microbial contamination and spoilage of pharmaceutical products.	**LI3.1** To perform Physicochemical analysis of specific antibiotic.	**Unit-3Microbial production and Spoilage of harmaceutical Products:** **CI3.1** Microbial contamination and spoilage of pharmaceutical products	**SL3.1** Find out the process of sterilization techniques.
	SO3.2 Explain about the sterilization requirement for various types of contaminants.	**LI3.2** To perform sterilization for various compounds used pharmaceuticals.	**CI3.2**(sterile injectibles, non-injectibles, ophthalmic preparations and implants) and their sterilization.	**SL3.2** Read the process of pharmaceutical manufacturing.
	SO3.3 Analyse the different pharmaceuticals produced by microbial fermentation.		**CI3.3** Manufacturing procedures and in process control of pharmaceuticals	**SL3.3** Read about latest vaccine clinical trials
	SO3.4 explain pharmaceuticals produced by microbial fermentations		**CI3.4** Other pharmaceuticals produced by microbial fermentations	
	CI3.5 explain about streptokinase & streptodornase		**CI3.5** streptokinase, streptodornase	
	SO3.6 Elaborate the different types of vaccines		**CI3.6** New vaccine technology, DNA vaccines,	
	SO3.7 Elaborate the synthetic vaccines		**CI3.7** synthetic peptide vaccines,..	
	SO3.8 Elaborate the multivalent vaccine		**CI3.8** multivalent subunit vaccines	
	SO3.9 Elaborate vaccine clinical trial		**CI3.9** Vaccine clinical trials	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Flow chart on production of pharmaceuticals by microbial fermentation.
	SW3.2 Mini Project	Describe the importance of new vaccine technology to the world.
	SW3.3 Other Activities (Specify)	Prepare one Power point presentation on manufacturing process of pharmaceuticals.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx. Hrs** | 09 | 03 | 01 | 02 | 15

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-05BT701.4: Analyz the Government regulatory policies, biosensors and application of microbial enzymes in pharmaceuticals.	**SO4.1** Elucidate about the Government regulatory practices and policies,	**LI4.1** To perform the estimation of bioactive components of plants	**Unit-4Regulatory practices, biosensors and applications in Pharmaceuticals** **CI4.1** Financing R& D capital and market outlook. IP, BP, USP.	**SL4.1** List down the various regulatory policies for pharmaceuticals in India.
	SO4.2 Derive the rational drug design.	**LI4.2** To perform enzyme extraction methods	**CI4.2** Government regulatory practices and policies,	**SL4.2** Read the role and importance ofFDA
	SO4.3 FDA perspective.		**CI4.3** FDA perspective.	
	SO4.4 Illustrate Reimbursement of drugs and biologicals, legislative perspective		**CI4.4** Reimbursement of drugs and biologicals, legislative perspective	
	SO4.5 Rational drug design.		**CI4.5** Rational drug design.	
	SO4.6 Study Immobilization procedures for pharmaceutical applications (liposomes).		**CI4.6** Immobilization procedures for pharmaceutical applications (liposomes).	
	SO4.7 Study Macromolecular, cellular and synthetic drug carriers		**CI4.7** Macromolecular, cellular and synthetic drug carriers	
	SO4.8 Illustrate Biosensors in pharmaceuticals		**CI4.8** Biosensors in pharmaceuticals	
	SO4.9 Explain Application of microbial enzymes in pharmaceuticals.		**CI4.9** Application of microbial enzymes in pharmaceuticals.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Determine the various applications and importance of biosensors in pharmaceuticals.
	SW4.2 Mini Project	Explain among the cellular and synthetic drug carriers.
	SW4.3 Other Activities (Specify)	Make a Power point presentation on Government regulatory policies.

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

ApproximateHours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	09	00	01	02	11

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO5-05BT701.5: EvaluateGood Laboratory Practices(GLP) and Good Manufacturing Practices (GMP) and safety in microbiology laboratory.	**SO5.1** Elucidate the application and importance of GLP and GMP.		**Unit-5Quality Assurance and Validation** **CI5.1** Good Manufacturing Practices (GMP)	**SL5.1** Basic knowledge about requirement of microbiology laboratory.
	SO5.2 Good Laboratory Practices (GLP) in pharmaceutical industry.		**CI5.2** Good Laboratory Practices (GLP) in pharmaceutical industry.	**SL5.2** List down instruments used in m microbiology/ pharmacy laboratory
	SO5.3 Regulatory aspects of quality control.		**CI5.3** Regulatory aspects of quality control.	
	SO5.4 Quality assurance		**CI5.4** Quality assurance	
	SO5.5 quality management in pharmaceuticals		**CI5.5** quality management in pharmaceuticals	
	SO5.6 ISO,WHO and US certification		**CI5.6** ISO,WHO and US certification	
	SO5.7 Sterilization control.		**CI5.7** Sterilization control.	
	SO5.8 sterility testing		**CI5.8** sterility testing	
	SO5.9 Safety in microbiology laboratory.		**CI5.9** Safety in microbiology laboratory.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain the safety aspects in microbiology laboratory
	SW5.2 Mini Project	Describe the Good laboratory Practices in detail. Differentiate between quality control and quality assurance.
	SW5.3 Other Activities (Specify)	Prepare power point presentation on ISO, WHO and US certification for pharmaceuticals.

Course duration (in hours)to attain Course Outcomes:

Course Title: Pharmaceutical Biotechnology **Course Code:05BT701**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-05BT701.1: Elucidate the basic fundamentals of antibiotics,chemical disinfectants, antiseptics and preservatives.	9	4	1	2	16
CO2-05BT701.2: Explain the mode of action of different antibiotic and non-antibiotic antimicrobial agents as well as drug targeting and drug delivery system	9	4	1	3	17
CO3-05BT701.3: Applied knowledge about microbial production and Spoilage of pharmaceutical Products and new vaccine technology	9	4	1	3	17
CO4-05BT701.4: Analyze the Government regulatory policies, biosensors and application of microbial enzymes in pharmaceuticals	9	3	1	2	15
CO5-05BT701.5: Evaluate Good Laboratory Practices(GLP) and Good Manufacturing Practices (GMP) and safety in microbiology laboratory.	9	0	1	2	11
Total Hours	45	15	05	12	77

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

Course Title: Design and Operation of Bioreactor **Course Code:05BT701**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-05BT701.1: Elucidate the basic fundamentals of antibiotics,chemical disinfectants, antiseptics and preservatives.	2	1	1	1	5
CO2-05BT701.2: Explain the mode of action of different antibiotic and non-antibiotic antimicrobial agents as well as drug targeting and drug delivery system	2	4	5	1	12
CO3-05BT701.3: Applied knowledge about microbial production and Spoilage of pharmaceutical Products and new vaccine technology	3	5	5	1	14
CO4-05BT701.4: Analyz the Government regulatory policies, biosensors and application of microbial enzymes in pharmaceuticals	2	3	5	1	11
CO5-05BT701.5: EvaluateGood Laboratory Practices(GLP) and Good Manufacturing Practices (GMP) and safety in microbiology laboratory.	2	4	1	1	10
Total Marks	**11**	**17**	**17**	**05**	**50**

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

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1	Pharmaceutical Microbiology – Edt. By W.B.Hugo& A.D.Russell Sixth edition. Blackwell scientific Publications.
2	Analytical Microbiology –Edt by Frederick Kavanagh Volume I & II. Academic Press New York.
3	Quinolinone antimicrobial agents – Edt. by David C. Hooper, John S.Wolfson .ASM Washington DC.
4	Quality control in the Pharmaceutical Industry - Edt. by Murray S.Cooper Vol.2. Academic Press New York.
5	Biotechnology – Edt. by H.J.Rehm& G.Reed, Vol 4. VCH Publications, Federal Republic of Germany.
6	Pharmaceutical Biotechnology by S.P.Vyas& V.K.Dixit. CBS Publishers & Distributors, New Delhi.
7	Good Manufacturing Practices for Pharmaceuticals Second Edition, by Sydney H.Willig, Murray M.Tuckerman, William S.Hitchings IV. Mercel Dekker NC New York.
8	Advances in Applied Biotechnology Series Vol 10, Biopharmaceuticals in transition. Industrial Biotechnology Association by Paine Webber. Gulf Publishing Company Houston.
9	Drug Carriers in biology & Medicine Edt. by Gregory Gregoriadis. Academic Press New York.

(b) 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: B.Sc. (Hons.) biotechnology
Semester:VII Semester
Course Title: Pharmaceutical Biotechnology.
Course Code: 05BT701

CO/PO/PSO Mapping								
Course Outcome (COs)	**Program Outcomes (POs)**					**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CO1-05BT701.1: Elucidate the basic fundamentals of antibiotics,chemical disinfectants, antiseptics and preservatives.	1	2	-	1	2	2	2	1
CO2-05BT701.2: Explain the mode of action of different antibiotic and non-antibiotic antimicrobial agents as well as drug targeting and drug delivery system	-	1	1	-	-	1	1	2
CO3-05BT701.3: Applied knowledge about microbial production and Spoilage of pharmaceutical Products and new vaccine technology	1	1	2	1	-	3	1	1
CO4-05BT701.4: Analyz the Government regulatory policies, biosensors and application of microbial enzymes in pharmaceuticals	1	1	1	-	2	1	1	3
CO5-05BT701.5: EvaluateGood Laboratory Practices(GLP) and Good Manufacturing Practices (GMP) and safety in microbiology laboratory.	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	**CO1-05BT701.1: -**Elucidate the basic fundamentals of antibiotics,chemical disinfectants, antiseptics and preservatives.	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**
PO2,3, PSO 1,2, 3	**CO2-05BT701.2: -05BT701.2:** Explain the mode of action of different antibiotic and non-antibiotic antimicrobial agents as well as drug targeting and drug delivery system	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 PSO 1,2, 3	**CO3-05BT701.3: -**Applied knowledge about microbial production and Spoilage of pharmaceutical Products and new vaccine technology	SO3.1 SO3.2 SO3.3 SO3.4SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	**LI 1** **LI 2**	3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9	**3SL-1,2,3**
PO 1,2,3,5 PSO 1,2, 3	**CO4-05BT701.4: -**Analyz the Government regulatory policies, biosensors and application of microbial enzymes in pharmaceuticals	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, 4.6,4.6,4.7,4.8, 4.9	**4SL-1,2**
PO 1,2,3, PSO 1,2, 3	**CO5-05BT701.5: -**EvaluateGood Laboratory Practices(GLP) and Good Manufacturing Practices (GMP) and safety in microbiology laboratory.	SO5.1 SO5.2 SO5.3 SO5.4SO5.5 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**

Program name	Bachelor of Science. (Hons) Biotechnology	
Semester	VII	
Course Code:	05BT702	
Course title:	Stem Cell & Tissue Engineering	**Curriculum Developer**: Dr. Monika Soni, Assistant Professor
Pre-requisite:	Students should have basic knowledge of stem cell & tissue engineering	
Rationale:	The subject aims to provide an overview of stem cells & tissue engineering, and describe the current progress with stem cell research in tissue engineering, and the potential implications on medical treatment.	
Course Outcomes (COs):	**CO1-05BT702.1:** To comprehend the fundamentals of stem cells, including their properties, and the technology behind stem cell therapy. **CO2-05BT702.2:** To comprehend the isolation of embryonic stem cells, techniques, differentiation, and potential uses of stem cells in various medical conditions. **CO3-05BT702.3:** To demonstrate a comprehensive understanding of tissue engineering, and the application of cell transplantation. **CO4-05BT702.4:** To demonstrate a comprehensive understanding of biomaterials and their applications in tissue engineering. **CO5-05BT702.5:** Todemonstrate a comprehensive understanding of the principles and practices of gene therapy and its applications.	

Scheme of Studies:

Board of Study	**Course Code**	**Course Title**	**Scheme of studies (Hours/Week)**					**Total Credits(C) (L:T:P=3:0:1)**
			CI	LI	SW	SL	**Total Study Hours(CI+LI+SW+SL)**	
Major (DSC)	05BT702	Stem Cell & Tissue Engineering	3	2	1	2	8	3+1=4

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

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
Major (DSC)	05BT702	Stem Cell & Tissue Engineering	15	20	10	5	50	50	100

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
Major (DSC)	05BT702-L	Stem Cell & Tissue Engineering	35	5	5	5	50	50	100

Course-Curriculum:

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Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO1-05BT702.1: To comprehend the fundamentals of stem cells, including their properties, and the technology behind stem cell therapy.	**SO1.1** Describe and define the stem cells.		**Unit-1** **CI1.1** Brief in detail introduction of stem cells.	**SL1.1** Search various reference books and other study material to start the learning about stem cells.
	SO1.2 Explain in detail the properties of stem cells.	**LI1.1**To observe and understand the properties of stem cells.	**CI1.2** Describe the properties of stem cells.	**SL1.2**Gain a basic understanding of stem cells and their significance in biology and medicine.
	SO1.3 Explain in detail the types of stem cells.		**CI1.3** Describe the types of stem cells.	**SL1.3**Explore the different types of stem cells and their characteristics.
	SO1.4 Explain in detail the sources of stem cells.		**CI1.4** Describe the sources of stem cells.	**SL1.4**Investigate the various sources of stem cells and their significance in research and therapy.
	SO1.5 Explain in detail the umbilical cord stem cells.	**LI1.2**To isolate and culture umbilical cord stem cells for further study.	**CI1.5** Study the umbilical cord stem cells.	
	SO1.6 Describe thetechnology of stem cells.		**CI1.6** Describe the technology of stem cells therapy.	**SL1.5** Explore the technology and techniques used in stem cells therapy.
	SO1.7 Describe the applications of stem cells therapy.		**CI1.7** Discuss the applications of stem cells therapy.	
	SO1.8 Discuss the ethical and regulatory considerations.		**CI1.8** Discuss the ethical and regulatory considerations.	
	SO1.9 Discuss the future perspective and opportunities.		**CI1.9** Discuss the future perspective and opportunities.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignment	Describe in detail the sources of stem cells.
	SW1.2 Mini Project	Describe and define the stem cells and technology of stem cells therapy.
	SW1.3 Other Activities (Specify)	Explain in detail the ethical and regulatory considerations related to stem cells.

Item	CI	LI	SW	SL	Total
Approx. Hours	9	4	1	5	19

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO2-05BT702.2: To comprehend the isolation of embryonic stem cells, techniques, differentiation, and potential uses of stem cells in various medical conditions.	**SO2.1** Describe and define the embryonic stem cells.	**LI2.1**To understand the process of isolating ESCs and stimulating their differentiation *in vitro*.	**Unit-2** **CI2.1** Brief in detail introduction to embryonic stem cells.	**SL2.1** Search various reference books and other study material to start the learning about Stem cells.
	SO2.2 Explain in detail the isolation of embryonic stem cells.		**CI2.2** Study the isolation of embryonic stem cells.	**SL2.2**Gain an understanding of the processes involved in isolating and stimulating embryonic stem cells (ESCs) for differentiation.
	SO2.3 Explain in detail the stimulation of embryonic stem cells differentiation.		**CI2.3** Study the stimulation of embryonic stem cells differentiation.	
	SO2.4 Explain in detail the differentiation of adult stem cells.		**CI2.4** Study the differentiation of adult stem cells.	
	SO2.5 Describe and define the transdifferentiation and plasticity of adult stem cells	**LI2.2**To explore the differentiation potential and plasticity of adult stem cells.	**CI2.5** Describe and define the transdifferentiation and plasticity of adult stem cells.	**SL2.3**Explore the differentiation potential and plasticity of adult stem cells.
	SO2.6 Discuss the similarities and dissimilarities between embryonic and adult stem cells.		**CI2.6** Discuss the similarities and dissimilarities between embryonic and adult stem cells.	**SL2.4** Compare and contrast the properties of embryonic and adult stem cells.
	SO2.7 Explian in detail the potential uses of stem cells in parkinson's disease and limb amputation.		**CI2.7** Study the potential uses of stem cells in parkinson's disease and limb amputation.	**SL2.5**Explore the potential applications of stem cell therapy in treating different medical conditions.
	SO2.8 Explian in detail the potential uses of stem cells in heart disease and spinal cord injuries.		**CI2.8** Study the potential uses of stem cells in heart disease and spinal cord injuries.	
	SO2.9 Explian the potential uses of stem cells in diabetes, burns, and alzheimer's disease.		**CI2.9** Study the potential uses of stem cells in diabetes, burns, and alzheimer's disease.	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignment	Describe in detail the isolation and stimulations of embryonic stem cells.
	SW1.2 Mini Project	Explain in detail the differentiation, transdifferentiation, and plasticity of adult stem cells.
	SW1.3 Other Activities (Specify)	Explain in detail the potential uses of stem cells in parkinson's and alzheimer's disease.

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

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO3-05BT702.3: To demonstrate a comprehensive understanding of tissue engineering, and the application of cell transplantation.	**SO3.1**Describe and define the tissue engineering.		**Unit-3** **CI3.1** Brief in detail to introduction of tissue engineering.	**SL3.1** Search various reference books and other study material to start the learning about tissue engineering.
	SO3.2 Describe the fundamentals of tissue engineering.	**LI3.1**To introduces students to the concept and strategies of tissue engineering.	**CI3.2** Describe the fundamentals of tissue engineering.	**SL3.2**Gain a foundational understanding of tissue engineering concepts and its significance in modern medicine.
	SO3.3 Describe the general strategies for tissue replacement.		**CI3.3**Describe the general strategies for tissue replacement.	
	SO3.4 Describe the cellular therapies in tissue engineering.		**CI3.4**Describe the cellular therapies in tissue engineering.	**SL3.3**Explore the current status of tissue engineering research and applications.
	SO3.5 Describe the open system of cell transplantation.	**LI3.2**To demonstrate the process of tissue engineering using an open system of cell transplantation.	**CI3.5**Describe the open system of cell transplantation.	**SL3.4**Examine the potential future directions and emerging research areas in tissue engineering.
	SO3.6 Explain in detail the scaffold design and fabrication.		**CI3.6** Study the scaffold design and fabrication.	
	SO3.7 Explain in detail thebiomolecular strategies in tissue engineering.		**CI3.7**Study the bimolecular strategies in tissue engineering.	
	SO3.8 Discuss the present status of tissue engineering.		**CI3.8**Discuss the present status of tissue engineering.	
	SO3.9 Discuss the future aspects and research directions.		**CI3.9**Discuss the future aspects and research directions.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignment	Describe in detail to bimolecular strategies in tissue engineering.
	SW3.2 Mini Project	Explain in detail to open and close system of cell transplantation.
	SW3.3 Other Activities (Specify)	Prepare one review article on cellular therapies in tissue engineering.

Item	CI	LI	SW	SL	Total
Approx. Hours	9	2	1	4	16

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO4-05BT702.4: To demonstrate a comprehensive understanding of biomaterials and their applications in tissue engineering.	**SO4.1** Describe and define the biomaterials in tissue engineering.		**Unit-4** **CI4.1** Brief in detail introduction to biomaterials in tissue engineering.	**SL4.1** Search various reference books and other study material to start the learning about biomaterials and bioreactors in tissue engineering.
	SO4.2 Explain in detailthe degradable polymeric scaffolds.	**LI4.1**To fabricate degradable polymeric scaffolds and acellular bio-matrices, and seed them with cells for tissue engineering applications.	**CI4.2** Study the degradable polymeric scaffolds.	
	SO4.3 Explain in detail thea-cellular bio-matrices.		**CI4.3** Study the a-cellular bio-matrices.	
	SO4.4 Explain in detailthe biological-derived polymers in tissue engineering.		**CI4.4** Studythe biological-derived polymers in tissue engineering.	
	SO4.5 Explain in detailthe cell seeding of scaffolds.		**CI4.5** Study the cell seeding of scaffolds.	**SL4.2**Learn about various methods for seeding cells onto scaffolds in tissue engineering.
	SO4.6 Describe and define the allogenic cells.		**CI4.6** Describe the cell sources in tissue engineering: allogenic cells.	**SL4.3**Understand the different cell sources used in tissue engineering and their applications.
	SO4.7 Describe and define the autologous cells.		**CI4.7**Describe the cell sources in tissue engineering: autologous cells.	
	SO4.8 Describe and define the stem cells.		**CI4.8**Describe the cell sources in tissue engineering: stem cells.	
	SO4.9 Explain in detail thebioreactors in tissue engineering: naughton's and pulsatile bioreactors.		**CI4.9** Study the bioreactors in tissue engineering: naughton's and pulsatile bioreactors.	**SL4.4**Familiarize yourself with bioreactor systems used for culturing engineered tissues in tissue engineering.

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe and define the biomaterials in tissue engineering.
	SW4.2 Mini Project	Describe in the detail bioreactors in tissue engineering: naughton's and pulsatile bioreactors.
	SW4.3 Other Activities (Specify)	Study one research article on biomaterials used in tissue engineering.

Item	CI	LI	SW	SL	Total
Approx. Hours	9	1	1	3	14

Course outcomes (COs)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CIs)	Self-Learning (SL)
CO5-05BT702.5: To demonstrate a comprehensive understanding of the principles and practices of gene therapy and its applications.	**SO5.1**Describe and define the gene therapy.	**LI5.1**To design and construct gene delivery vectors for potential use in gene therapy applications.	**Unit-5** **CI5.1** Brief in detail introduction to gene therapy.	**SL5.1** Search various reference books and other study material to start the learning about gene therapy.
	SO5.2 Explain in detail therequirements of gene therapy.		**CI5.2** Studythe requirements of gene therapy.	
	SO5.3 Explain in detail the genetic defects and disease.		**CI5.3**Describe the genetic defects and disease.	
	SO5.4 Explain in detail the target cells for gene therapy.	**LI5.1**To perform in vitro transfection experiments and analyze gene expression in target cells.	**CI5.4**Study the target cells for gene therapy.	
	SO5.5 Describe the process of gene therapy.		**CI5.5**Describe the process of gene therapy.	
	SO5.6 Explain in detail thefactors responsible for effective gene therapy.		**CI5.6** Study the factors responsible for effective gene therapy.	
	SO5.7 Discuss the recent developments in gene therapy research.		**CI5.7** Discuss the recent developments in gene therapy research.	**SL5.2**Explore recent advancements and breakthroughs in the field of gene therapy.
	SO5.8 Discuss the ethical considerations of gene therapy.		**CI5.8**Discuss the ethical considerations of gene therapy.	**SL5.3**Investigate the ethical implications and considerations associated with gene therapy research and application.
	SO5.9 Describe the clinical applications and future directions.		**CI5.9**Describe the clinical applications and future directions.	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain in detail genetic defects and disease.
	SW5.2 Mini Project	Describe in detail the gene therapy.
	SW5.3 Other Activities (Specify)	One case study of gene therapy.

Course duration (in hours) to attain Course Outcomes:

Course Title: Stem cell & tissue engineering **Course Code:** 05BT702

Course Outcomes (COs)	Class lecture (CI)	Laboratory Instruction (LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-05BT702.1: To comprehend the fundamentals of stem cells, including their properties, and the technology behind stem cell therapy.	9	4	5	1	17
CO2-05BT702.2: To comprehend the isolation of embryonic stem cells, techniques, differentiation, and potential uses of stem cells in various medical conditions.	9	4	5	1	17
CO3-05BT702.3: To demonstrate a comprehensive understanding of tissue engineering, and the application of cell transplantation.	9	4	4	1	18
CO4-05BT702.4: To demonstrate a comprehensive understanding of biomaterials and their applications in tissue engineering.	9	2	4	1	16
CO5-05BT702.5: To demonstrate a comprehensive understanding of the principles and practices of gene therapy and its applications.	9	1	3	1	14
Total Hours	45	15	21	05	86

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

Course Title: Stem cell & tissue engineering **Course Code:** 05BT702

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

Course Outcomes	Marks Distribution				Total Marks
	R	**U**	**A**	**A**	
CO1-05BT702.1: To comprehend the fundamentals of stem cells, including their properties, and the technology behind stem cell therapy.	2	2	3	2	9
CO2-05BT702.2: To comprehend the isolation of embryonic stem cells, techniques, differentiation, and potential uses of stem cells in various medical conditions.	2	3	3	3	11
CO3-05BT702.3: To demonstrate a comprehensive understanding of tissue engineering, and the application of cell transplantation.	2	3	3	2	10
CO4-05BT702.4: To demonstrate a comprehensive understanding of biomaterials and their applications in tissue engineering.	2	3	3	2	10
CO5-05BT702.5: To demonstrate a comprehensive understanding of the principles and practices of gene therapy and its applications.	2	2	3	3	10
Total Marks	**10**	**13**	**15**	**12**	**50**

Suggested learning Resources:

(a) Books:

S.No.	Title/Author/Publisher details
1.	Robert Lanza, Robert Langer, Joseph P. Vacanti, and Antonios G. Mikos., Principles of Tissue Engineering. Academic Press.
2.	Jonathan Slack., Stem Cells: A Very Short Introduction. New York Oxford University Press, 2016.
3.	Robert Lanza, Anthony Atala, and Helen M. Blau., Essentials of Stem Cell Biology. Academic Press, 2014
4.	Eapen Cherian, G Nandhini, Anil Kurian., Stem Cells. Jaypee Brothers Medical Publishers (P) Ltd. 2011.

(b) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B. Sc. Biotechnology
Semester: VIIthSemester
Course Title: Stem cell & tissue engineering
Course Code: 05BT702

CO/PO/PSO Mapping															
Course Outcome (Cos)	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-05BT702.1: To comprehend the fundamentals of stem cells, including their properties, and the technology behind stem cell therapy.	3	1	-	2	2	2	-	2	2	1	2	1	3	3	2
CO2-05BT702.2: To comprehend the isolation of embryonic stem cells, techniques, differentiation, and potential uses of stem cells in various medical conditions.	1	2	-	2	2	2	2	2	1	1	2	1	2	2	2
CO3-05BT702.3: To demonstrate a comprehensive understanding of tissue engineering, and the application of cell transplantation.	2	2	1	2	2	1	1	2	1	1	2	1	3	2	2
CO4-05BT702.4: To demonstrate a comprehensive understanding of biomaterials and their applications in tissue engineering.	2	2	-	2	2	2	2	2	1	1	3	2	3	2	2
CO5-05BT702.5: To demonstrate a comprehensive understanding of the principles and practices of gene therapy and its applications.	3	2	1	2	3	3	2	1	1	2	2	1	3	2	3

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO1-05BT702.1:** To comprehend the fundamentals of stem cells, including their properties, and the technology behind stem cell therapy.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9	LI 1 LI 2	1.1,1.2,1.3,1.4,1.5 1.6,1.7,1.8,1.9	1SL-1,2,3,4,5
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO2-05BT702.2:** To comprehend the isolation of embryonic stem cells, techniques, differentiation, and potential uses of stem cells in various medical conditions.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	LI 1 LI 2	2.1, 2.2, 2.3, 2.4, 2.5,2.6,2.7,2.8,2.9	2SL-1,2,3,4,5
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO3-05BT702.3:** To demonstrate a comprehensive understanding of tissue engineering, and the application of cell transplantation.	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	LI 1 LI 2	3.1,3.2,3.3,3.4,3.5, 3.6,3.7,3.8,3.9	3SL-1,2,3,4
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO4-05BT702.4:** To demonstrate a comprehensive understanding of biomaterials and their applications in tissue engineering.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	LI 1	4.1,4.2,4.3,4.4,4.5, 4.6,4.7,4.8,4.9	4SL-1,2,3,4
PO1,2,3,4,5,6,7,8,9, 10,11,12 PSO 1,2,3	**CO5-05BT702.5:** To demonstrate a comprehensive understanding of the principles and practices of gene therapy and its applications.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	LI 1	5.1,5.2,5.3,5.4,5.5, 5.6,5.7,5.8,5.9	5SL-1,2,3

Program Name	**Bachelor of Science (B.Sc.)- Biotechnology**	
Semester	VIII	
Course Code:	01BT801	
Course title:	Genomics and Proteomics	**Curriculum Developer**: Sonal Gupta, Assistant Professor
Pre-requisite:	Students should have basic knowledge of biochemistry, molecular biology and bioinformatics	
Rationale:	Genomics is an entry point for looking at the other 'omics' sciences. Genomics provides an overview of the complete set of genetic instructions provided by the DNA, while transcriptomics looks into gene expression patterns. Proteomics studies dynamic protein products and their interactions. An application of proteomics is known as protein "expression profiling" where proteins are identified at a certain time in an organism as a result of the expression to a stimulus. Proteomics can also be used to develop a protein-network map where interaction among proteins can be determined for a particular living system.	
Course Outcomes (COs):	**CO1-01BT801.1:** Understand about the fundamentals of genomics and related techniques. **CO2-01BT801.2:** Outline the next-generation sequencing techniques and bioinformatic tools used in genomic studies. **CO3-01BT801.3:** Introduction of proteomics and various analytical approach to identify protein structures **CO3-01BT801.3:** Introduction of proteomics and various analytical approach to identify protein structures **CO5-01BT801.5:** Mass spectrometery and its application in proteomics.	

Scheme of Studies:

Board of Study	**Course Code**	**Course Title**	**Scheme ofstudies (Hours/Week)**					**Total Credits (C) (L:T:P=3:0:1)**
			Cl	LI	SW	SL	**Total Study Hours(CI+LI+SW+SL)**	
MAJOR	01BT801	Genomics and Proteomics	3	2	1	3	9	3+1=4

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

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
MAJOR	01BT801	Genomics and Proteomics	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)		
MAJOR	01BT801-L	Genomics and Proteomics	35	5	5	5	50	50	100

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx. Hrs** | 12 | 06 | 01 | 05 | 24

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-01BT801.1: Understand about the fundamentals of genomics and related techniques.	**SO1.1**An introduction of genomics	**LI1.1** List the basic software used for genomic study	**Unit-1Introduction of genomics** **CI1.1** Introduction to Genomics,	**SL1.1** Find out some examples softwares used for genome assembly
	SO1.2 Describe DNA sequencing	**LI1.2** Comparative study of DNA sequencing methods	**CI1.2** DNA sequencing	**SL1.2** Explain the manual methods of DNA sequencing
	SO1.3 Elaborate the methods of DNA sequencing	**LI1.2** Demonstration of DNA sequencing methods	**CI1.3** methods	**SL1.3** Write down methodology of shotgun sequencing method of genome sequencing
	SO1.4 Define the manual and automated sequencing		**CI1.4** manual and Automated Sequencing	**SL1.4** Write an overview on genomics and its types
	SO1.5 Describe Maxam & Gilbert method		**CI1.5** Maxam & Gilbert method	**SL1.5** Collect information on NGS methods
	SO1.6 Elaborate Sanger method		**CI1.6** Sangers method	
	SO1.7 Explain Pyrosequencing		**CI1.7** Pyrosequencing,	
	SO1.8 Genome Sequencing: Shotgun methods,		**CI1.8** Genome Sequencing: Shotgun methods,	
	SO1.9 Hierarchical (clone contig) methods,		**CI1.9** Hierarchical (clone contig) methods,	
	SO1.10 Study automated: and. Computer tools for		**CI1.10** automated: and. Computer tools for	
	SO1.11–Illustrate about sequencing projects		**CI1.11**–sequencing projects	
	SO1.12 Learn about Genome sequence assembly software.		**CI1.12** Genome sequence assembly software.	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Describe the role of bioinformatics and computational biology in genomics
	SW1.2 Mini Project	Differentiate between shot gun and hierarchical method of genome sequencing
	SW1.3 Other Activities (Specify)	Draw a flowchart compiling all steps of Sanger and Maxam Gilbert methods of DNA sequencing

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** | 12 | 06 | 01 | 05 | 24

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-01BT801.2: Outline the next-generation sequencing techniques and bioinformatic tools used in genomic studies.	**SO2.1** Explainweb-based server	**LI2.1** Make a list of various browsers used for genome analysis	**Unit-2** **Managing and Distributing Genome Data** **CI2.1**Managing Genome Data:	**SL2.1** Find out all the browser used to search genomic database
	SO2.2 Describe concept of distributing genome data	**LI2.2** Make a chart of first, second and next generation sequencing platforms	**CI2.2** Distributing Genome Data	**SL2.2** Read the latest research in genome sequencing
	SO2.3 Describe various web based servers		**CI2.3** Web based servers	**SL2.3** Write down a note on genome database
	SO2.4 Define the softwares used for genome analysis	**LI2.2** Demonstration of genome sequencing softwares	**CI2.4** software's for genome analysis	**SL2.4** Find out the different kinds of platforms used for genome sequencing projects
	SO2.5 Explain the ENS		**CI2.5** ENS	
	SO2.6 Explain EMBL		**CI2.6**EMBL	
	SO2.7 Describe VISTA		**CI2.7** VISTA	
	SO2.8 Learn about UCSC		**CI2.8** UCSC	
	SO2.9 Study Genome Browser		**CI2.9** Genome Browser	
	SO2.10 To know about NCBI genome.		**CI2.10** NCBI genome.	
	SO2.11 Study about Model Organisms'		**CI2.11** Selected Model Organisms'	
	SO2.12 Illustrate about Genomes and Databases.		**CI2.12** Genomes and Databases.	

Suggested Sessional Work (SW):*anyone*	**SW2.1** Assignments	Describe browsers and servers used for genomic studies
	SW2.2 Mini Project	Make a comparative chart on genomic databases
	SW2.3 Other Activities (Specify)	Make apower point presentation on "Next Generation Sequencing".

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** | 12 | 06 | 01 | 03 | 22

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-01BT801.3: Introduction of proteomics and various analytical approach to identify protein structures	**SO3.1** Introduction to concept of protein structure	**LI3.1** To perform the gel electrophoresis for protein separations	**Unit-3** **CI3.1** Introduction to protein structure,.	**SL3.1** Study the various chemical bonds stabilize protein structure
	SO3.2 Elaborate Chemical properties of proteins	**LI3.2** To perform SDS PAGE	**CI3.2**Chemical properties of proteins	**SL3.2** Read the process of protein separation by gel electrophoresis
	SO3.3 Learn about Physical interactions that determine the property of proteins.	**LI3.2** To perform Native PAGE	**CI3.3** Physical interactions that determine the property of proteins.	**SL3.3** Find out the process of centrifugation and its application in proteomics
	SO3.4 Determination of size of protein		**CI3.4** Short-range interactions, electrostatic forces,	
	SO3.5 Explain the role of bonds in protein structure		**CI3.5**, van der waal interactions, hydrogen bonds	
	SO3.6 Study Hydrophobic interaction in proteins		**CI3.6** Hydrophobic interactions	
	SO3.7 study about Determination of sizes		**CI3.7** Determination of sizes	
	SO3.8 study Sedimentation analysis		**CI3.8** Sedimentation analysis	
	SO3.9 Learn gel filteration		**CI3.9** gel filteration	
	SO3.10 Elaborate SDS-PAGE); Native PAGE,		**CI3.10** SDS-PAGE); Native PAGE,	
	SO3.11 Study about covalent structures		**CI3.11** Determination of covalent structures	
	SO3.12 Assess Edman degradation.		**CI3.12** Edman degradation.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Describe the properties of proteins
	SW3.2 Mini Project	Describe the role of SDS PAGE in proteomic studies
	SW3.3 Other Activities (Specify)	Prepare one Power point presentation on "Proteomics"

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	12	06	01	04	23

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO4 01BT801.4 Understand 2D PAGE and its significance in proteomic studies.	**SO4.1**Introduction and scope of proteomics;	**LI4.1**To perform the protein separation by gel electrophoresis	**Unit-4 Introduction and scope of proteomics** **CI4.1**An overview on proteomics	**SL4.1** Find out the applications of electrophoretic techniques in proteomics
	SO4.2 study its types	**LI4.2**To perform 2D PAGE	**CI4.2** its types	**SL4.2** List down various electrophoretic methods
	SO4.3 Elaborate its Scope		**CI4.3**Scope	**SL4.3** Study electrophoresis
	SO4.4 Learn its Application	**LI4.3**To perform the protein electrophoresis	**CI4.4**Application	**SL4.4** Describe role of 2D PAGE proteomic studies.
	SO4.5 Study of Separation of proteins by 2D PAGE		**CI4.5** Separation of proteins by using 2 D PAGE	
	SO4.6 Learn Concept of 2D PAGE		**CI4.6** Concept of 2D PAGE	
	SO4.7 Study Sample Preparation		**CI4.7** Sample Preparation	
	SO4.8 Study Process		**CI4.8** Process	
	SO4.9 Assess Solubilization		**CI4.9** Solubilization	
	SO4.10 study reduction		**CI4.10** reduction	
	SO4. Illustrate 2D PAGE:		**CI4.11**2D PAGE:	
	SO4.12 StudyResolution		**CI4.12** Resolution	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Describe the working principle of electrophoretic techniques and their applications in protein studies
	SW4.2 Mini Project	Read research articles on recent advancements in proteomics
	SW4.3 Other Activities (Specify)	Make a presentation on 2D PAGE

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

ApproximateHours

Item	Cl	LI	SW	SL	Total
Approx.Hrs	12	06	01	04	23

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO5-01BT801.5: Mass spectrometery and its application in proteomics.	**SO5.1**. Explain reproducibility of 2D PAGE	**LI5.1**Make a list mass spectrometric techniques used for proteomic	**Unit-5** **CI5.1**Reproducibility of 2 D PAGE	**SL5.1** Find out the industrial applications of functional proteomics
	SO5.2 Explain Mass spectrometery: Concept		**CI5.2** Mass spectrometery: Concept	**SL5.2** What is reproducibility in 2 D PAGE
	SO5.3 Assess Mass spectrometery: principle,		**CI5.3** Mass spectrometery: principle,	**SL5.3** An overview on Mass spectrometery
	SO5.4 Study Mass spectrometery: instrumentation	**LI5.2** Demonstration of mass spectrometric techniques	**CI5.4** Mass spectrometery: instrumentation	**SL5.4** Explain protein sequencing
	SO5.5 Learn Mass spectrometery: application in proteomics	**LI5.2** Perform mass spectrometric techniques	**CI5.5** Mass spectrometery: application in proteome study	
	SO5.6 Study various techniques used for protein identification		**CI5.6** various techniques used for protein identification	
	SO5.7 *Assess De novo* sequencing- Concept		**CI5.7** *De novo* sequencing- Concept	
	SO5.8 *Elaborate De novo* sequencing- Principle		**CI5.8** *De novo* sequencing- Principle	
	SO5.9 *Assess De novo* sequencing - Method		**CI5.9** *De novo* sequencing - Method	
	SO5.10 *Learn De novo* sequencing – Factors affecting		**CI5.10** *De novo* sequencing – Factors affecting	
	SO5.11 *Study De novo* sequencing - Applications		**CI5.11** *De novo* sequencing - Applications	
	SO5.12 *Study De novo* sequencing using mass spectrometric data		**CI5.12** *De novo* sequencing using mass spectrometric data	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain reproducibility of 2 D PAGE
	SW5.2 Mini Project	Describe various applications of proteomic studies
	SW5.3 Other Activities (Specify)	Prepare one article on the “Mass spectrometery”

Course duration (in hours)to attain Course Outcomes:

Course Title: Genomics and Proteomics **Course Code:**01BT801

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-01BT801.1: Understand about the fundamentals of genomics and related techniques.	12	6	01	05	24
CO2-01BT801.2: Outline the next-generation sequencing techniques and bioinformatic tools used in genomic studies.	12	6	01	05	24
CO3-01BT801.3: Introduction of proteomics and various analytical approach to identify protein structures	12	6	01	03	22
CCO3-01BT801.3: Introduction of proteomics and various analytical approach to identify protein structures	12	6	01	04	23
CO5-01BT801.5: Mass spectrometery and its application in proteomics.	12	6	01	04	23
Total Hours	60	30	05	21	116

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

Course Title: Genomics and Proteomics **Course Code:**01BT801

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-01BT801.1: Understand about the fundamentals of genomics and related techniques.	2	1	1	1	5
CO2-01BT801.2: Outline the next-generation sequencing techniques and bioinformatic tools used in genomic studies.	2	4	5	1	12
CO3-01BT801.3: Introduction of proteomics and various analytical approach to identify protein structures	3	5	5	1	14
CCO3-01BT801.3: Introduction of proteomics and various analytical approach to identify protein structures	2	3	5	1	11
CO5-01BT801.5: Mass spectrometery and its application in proteomics.	5	4	1	0	10
Total Marks	**14**	**17**	**17**	**04**	**52**

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

Suggested learning Resources:

(a) Books:

(b)

S.No.	Title/Author/Publisher details
1	Genes IX by Benjamin Lewin, Johns and Bartlett Publisher, 2006.
2	Modern Biotechnology, 2nd Edition, S.B. Primrose, Blackwell Publishing, 1987.
3	Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th Edition, B.R. Glick, J.J. Pasternak and C.L. Patten, 2010.
4	Molecular Cloning: A Laboratory Manual (3rd Edition) Sambrook and Russell Vol. I to III, 1989.
5	Principles of Gene Manipulation 6th Edition, S.B.Primrose, R.M.Twyman and R.W. Old. Blackwell Science, 2001.
6	Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
7	Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX Edition. Benjamin Cummings.
8	Russell, P. J. (2509). I Genetics- A Molecular Approach. III Edition. Benjamin Cummings.
9	Glick, B.R., Pasternak, J.J. (2503). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
10	Pevsner, J. (2509). Bioinformatics and Functional Genomics. II Edition. John Wiley & Sons.

(c) Online Resources:

Suggested instructions/Implementation strategies:

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

CO, PO and PSO Mapping

Program Name: B.Sc. (Hons.) Biotechnology
Semester:V Semester
Course Title: Genomics and proteomics
Course Code: 01BT801

CO/PO Mapping															
Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-01BT801.1: Understand about the fundamentals of genomics and related techniques.	-	1	-	1	2	2	3	-	3	3	3	3	1	2	1
CO2-01BT801.2: Outline the next-generation sequencing techniques and bioinformatic tools used in genomic studies.	-	-	-	-	-	-	2	-	3	2	3	3	3	-	2
CO3-01BT801.3: Introduction of proteomics and various analytical approach to identify protein structures	-	-	1	1	-	-	3	-	3	1	-	-	1	2	-
CCO3-01BT801.3: Introduction of proteomics and various analytical approach to identify protein structures	1	-	1	-	2	-	2	3	-	1	-	1	2	1	3
CO5-01BT801.5: Mass spectrometery and its application in proteomics.	1	1	1	-	-	2	3	3	1	2	3	3	1	1	2

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO1-01BT801.1: Understand about the fundamentals of genomics and related techniques.**	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6 SO1.7 SO1.8 SO1.9 SO1.10 SO1.11 SO1.12	1.1,1.2,1.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.12	**1SL-1,2,3,4,5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO2-01BT801.2: Outline the next-generation sequencing techniques and bioinformatic tools used in genomic studies.**	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9 SO2.10 SO2.11 SO2.12	2.1, 2.2, 2.3,	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11, 2.12	**2SL-1,2,3,4, 5**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO3-01BT801.3: Introduction of proteomics and various analytical approach to identify protein structures**	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5 SO3.6 SO3.7 SO3.8 SO3.9 SO3.10 SO3.11 SO3.12	3.1,3.2,3.3	3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12	**3SL-1,2,3,4**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CCO3-01BT801.3: Introduction of proteomics and various analytical approach to identify protein structures**	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9 SO4.10 SO4.11 SO4.12	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, 4.11, 4.12	**4SL-1,2,3,4**
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3	**CO5-01BT801.5: Mass spectrometery and its application in proteomics.**	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5 SO5.6 SO5.7 SO5.8 S05.9 SO5.10 SO5.11 SO5.12	5.1,5.2,5.3	5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 5.10, 5.11, 5.12	**5SL-1,2,3,4,5**

Program Name	**Bachelorof Science (Hons.) in Biotechnology (B.Sc. (Hons.) BT)**	
Semester	VIII	
Course Code:	02BC801	
Course title:	Mammalian Physiology	**Curriculum Developer**: Chahana Desai, Teaching Associate
Pre-requisite:	Students should have basic knowledge of biology, general chemistry and human anatomy.	
Rationale:	Mammalian Physiology is the study of physical and biological functions of mammals. Students will learn about the fundamental concepts of human physiology, homeostasis, molecular and cellular physiology and the functions of tissues, organs and organ systems.	
CourseOutcomes (COs):	**CO1-02BC801.1:** Elucidate the basic fundamentals of digestive system and respiratory system. **CO2-02BC801.2:** Explain the mechanism of circulatory system and cardiac system in humans. **CO3-02BC801.3:** Elaborate the detailed knowledge about muscle physiology and muscle movement as well as excretory system. **CO4-02BC801.4:** Analyze the Nervous system and endocrine systems in human body. **CO5-02BC801.5:** Evaluate different types of endocrine glands and mode of action of various hormones.	

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme ofstudies (Hours/Week)					Total Credits(C) (L:T:P=3:0:1)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
MINOR	02BC801	Mammalian Physiology	3	0	1	2	6	3+0=3

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

Scheme of Assessment: Theory

Board of Study	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)		
MINOR	02BC801	Mammalian Physiology	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)		
MINOR	02BC801-L	Mammalian Physiology	35	5	5	5	50	50	100

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx. Hrs** | 09 | 04 | 01 | 02 | 16

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-02BC801.1 Elucidate the basic fundamentals of digestive system and respiratory system.	**SO1.1** Explain the detailed concept of digestion and	**LI1.1** Demonstration of action of an enzyme involved in digestion.	**Unit-1Digestion and Respiration Digestion:** **CI1.1** Mechanism of digestion	**SL1.1** Write down important terminologies related to human physiology
	SO1.2 Explain the process of absorption	**LI1.2** Demonstration of mechanism of digestion.	**CI1.2**, absorption of carbohydrates, Proteins, Lipids and nucleic acids	**SL1.2** Write down enzymes involved in digestion of various biomolecules.
	SO1.3 Elaborate the composition of bile		**CI1.3** Composition of bile	
	SO1.4 Study about Saliva, Pancreatic juice		**CI1.4** Saliva, Pancreatic juice	
	SO1.5 Illustrate about gastric and intestinal juice		**CI1.5** gastric and intestinal juice	
	SO1.6 Explain respiration: Exchange of gases,		**CI1.6** Respiration: Exchange of gases,	
	SO1.7 Study transport of O2 and CO2		**CI1.7** Transport of O2 and CO2	
	SO1.8 Illustrate oxygen dissociation curve		**CI1.8** Oxygen dissociation curve	
	SO1.9 Discuss about Chloride shift		**CI1.9** Chloride shift	

Suggested Sessional Work (SW): *anyone*	**SW1.1** Assignments	Describe of O2 and **CO2** in detail. List out various organs involved in respiration.
	SW1.2 Mini Project	Draw human digestive system with respective functions mentioned.
	SW1.3 Other Activities (Specify)	Make a power point presentation onhow exchange of gases takes place during respiration.

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 | 08 | 01 | 02 | 20

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO2-02BC801.2 Explain the mechanism of circulatory system and cardiac system in humans	**SO2.1** Explain the composition of blood and types of blood cells and their importance.	**LI2.1** Finding the coagulation time of blood	**Unit-2Circulatory system and Cardiac system:** **CI2.1** Composition of blood,	**SL2.1** Note down the characteristics of different types of blood cells.
	SO2.2 Elucidate the principles and mechanism of blood clotting	**LI2.2** To determine blood groups	**CI2.2** Plasma proteins & their role,	**SL2.2** List out the normal range of different blood cells.
	SO2.3 Elaborate the mechanism and importance of cardiac activity	**LI2.3** Counting of mammalian RBCs	**CI2.3** Types and importance of blood cells,	
	SO2.4 Learn Mechanism of Haemopoisis,	**LI2.4** Determination of TLC and DLC	**CI2.4** Mechanism of Haemopoisis,	
	SO2.5 Study Mechanism of coagulation of blood.		**CI2.5** Mechanism of coagulation of blood.	
	SO2.6 Explain Mechanism of working of heart		**CI2.6** Mechanism of working of heart	
	SO2.7 Study Cardiac output,		**CI2.7** Cardiac output,	
	SO2.8 Elaborate cardiac cycle		**CI2.8** cardiac cycle	
	SO2.9 Discuss Origin & conduction of heart beat.		**CI2.9** Origin & conduction of heart beat.	

Suggested Sessional Work (SW): *anyone*	**SW2.1** Assignments	Describe the blood clotting process and various component involved in the process.
	SW2.2 Mini Project	Draw a detailed Cardiac cycle.
	SW2.3 Other Activities (Specify)	Make Power point presentation on origin and conduction of heart beat with required visuals.

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	10	02	01	02	15

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO3-02BC801.3 Elaborate the detailed knowledge about muscle physiology and muscle movement as well as excretory system.	**SO3.1** Elucidate the knowledge about structure of different types of muscle.	**LI3.1** To perform Physicochemical analysis of specific antibiotic.	**Unit-3Muscle physiology and excretory system:** **CI3.1** Muscle physiology and osmoregulation Structure of cardiac, smooth &skeletal muscle,	**SL3.1** Read about microtubules and microfilaments.
	SO3.2 Explain about the mechanism of excretory system		**CI3.2** threshold stimulus, All or None rule, ,	**SL3.2** Read theof characteristics of different types of muscle.
	SO3.3 Analyse the organs involved in muscle function.		**CI3.3** single muscle twitch, muscle tone	
	SO3.4 Illustrate about isotonic and isometric contraction,.		**CI3.4** isotonic and isometric contraction,.	
	SO3.5 Study physical, chemical and electrical events		**CI3.5** Physical, chemical and electrical events	
	SO3.6 Explain mechanism of muscle contraction.		**CI3.6** mechanism of muscle contraction.	
	SO3.7 Discuss excretion: modes of excretion		**CI3.7** Excretion: modes of excretion	
	SO3.8 Learn ornithine cycle		**CI3.8** Ornithine cycle	
	SO3.9 Discuss mechanism of urine formation.		**CI3.9** Mechanism of urine formation.	

Suggested Sessional Work (SW): *anyone*	**SW3.1** Assignments	Flow chart on mechanism of formation of Urine.
	SW3.2 Mini Project	Describe the importance of muscle movements.
	SW3.3 Other Activity	Prepare one Power point presentation on muscle contraction and relaxation.

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 | 01 | 01 | 01 | 12

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO4-02BC801.4 Analyze the Nervous system and endocrine systems in human body.	**Unit-4Nervous system** **SO4.1**Elucidate Nervous system	**LI4.1** Explain about the conduction of nerve impulse.	**Unit-4Nervous system** **CI4.1** Nervous system	**SL4.1** List down the various parts and its function involved in nervous system.
	SO4.2 Explore Nervous Coordination		**CI4.2**, Nervous Coordination	
	SO4.3 Study about Endocrine Coordination		**CI4.3** Endocrine Coordination	
	SO4.4 Discuss about nervous and endocrine coordination		**CI4.4** Nervous and endocrine coordination	
	SO4.5 Study Mechanism of generation		**CI4.5** Mechanism of generation	
	SO4.6 Explain propagation of nerve impulse		**CI4.6** propagation of nerve impulse	
	SO4.7 Discuss structure of synapse		**CI4.7** structure of synapse	
	SO4.8 Study synaptic conduction,		**CI4.8** synaptic conduction,	
	SO4.9 Illustrate about Neurotransmitters.		**CI4.9** Neurotransmitters.	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Determine the various types of neurotransmitters.
	SW4.2 Mini Project	Draw a detailed structure of synapse.
	SW4.3 Other Activities (Specify)	Make a Power point presentation on propagation of nerve impulse.

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**ApproximateHours** **Item** | Cl | LI | SW | SL | Total **Approx.Hrs** | 09 | 00 | 01 | 01 | 11

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO5-02BC801.5 Evaluate different types of endocrine glands and mode of action of various hormones.	**SO5.1** Elucidate the application and importance of endocrine system.		**Unit-5endocrine glands and hormones** **CI5.1**Mechanism of action of hormones	**SL5.1** Basic knowledge about importance of hormones.
	SO5.2 Describe the mechanism of action of Insulin and steroid		**CI5.2** (insulin and steroids).	
	SO5.3 Analyze the different endocrine glands with its role.		**CI5.3** Different endocrine glands– Hypothalamus, .	
	CI5.4 Explain role of pituitary gland		**CI5.4** pituitary,	
	CI5.5 Illustrate about pineal,		**CI5.5** pineal,	
	CI5.6 Study the role of thymus,		**CI5.6** thymus,	
	CI5.7 Study function of thyroid,		**CI5.7** thyroid,	
	CI5.8 Discuss about parathyroid and adrenals,		**CI5.8** parathyroid and adrenals,	
	CI5.9 Explain hypo & hyper-secretions of hormones		**CI5.9** hypo & hyper-secretions of hormones	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain the mechanism of hormones.
	SW5.2 Mini Project	Make a chart of different types of hormones, its source of secretion and source of action.
	SW5.3 Other Activities (Specify)	Prepare power point presentation on endocrine system.

Course duration (in hours)to attain Course Outcomes:

Course Title: Mammalian Physiology **Course Code:02BC801**

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-02BC801.1-Elucidate the basic fundamentals of digestive system and respiratory system.	9	4	2	1	15
CO2-02BC801.2-Explain the mechanism of circulatory system and cardiac system in humans	9	8	2	1	18
CO3-02BC801.3-Elaborate the detailed knowledge about muscle physiology and muscle movement as well as excretory system.	9	2	2	1	13
CO4-02BC801.4-Analyz the Nervous system and endocrine systems in human body.	9	1	1	1	14
CO5-02BC801.5-Evaluate different types of endocrine glands and mode of action of various hormones.	9	0	1	1	12
Total Hours	45	15	08	05	72

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

Course Title: Mammalian Physiology **Course Code:**

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-02BC801.1-Elucidate the basic fundamentals of digestive system and respiratory system.	2	1	1	1	5
CO2-02BC801.2-Explain the mechanism of circulatory system and cardiac system in humans	2	4	5	1	12
CO3-02BC801.3- Elaborate the detailed knowledge about muscle physiology and muscle movement as well as excretory system.	3	5	5	1	14
CO4-02BC801.4-Analyz the Nervous system and endocrine systems in human body.	2	3	5	1	11
CO5-02BC801.5-Evaluate different types of endocrine glands and mode of action of various hormones.	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	Guyton, A.C. & Hall, J.E. (2506). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B. Saunders Company.
2	Tortora, G.J. & Grabowski, S. (2506). Principles of Anatomy & Physiology. XI Edition. John wiley& sons,Inc.

(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: B.Sc. (Hons.) biotechnology
Semester: VIII Semester
Course Title: Mammalian physiology.
Course Code: 02BC801

CO/PO Mapping															
Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-02BC801.1- Elucidate the basic fundamentals of digestive system and respiratory system.	-	**1**	-	**1**	**2**	**2**	**1**	-	**3**	**1**	**3**	**1**	**1**	**2**	**1**
CO2-02BC801.2-Explain the mechanism of circulatory system and cardiac system in humans	-	**1**	-	-	-	-	**3**	-	**3**	**2**	**3**	**3**	**3**	-	**2**
CO3-02BC801.3-Elaborate the detailed knowledge about muscle physiology and muscle movement as well as excretory system	-	**2**	**1**	**1**	-	-	**3**	-	**3**	**1**	**3**	**3**	**1**	**1**	**1**
CO4-02BC801.4-Analyz the Nervous system and endocrine systems in human body.	**1**	-	**1**	-	**2**	**2**	**2**	**3**	-	**1**	**3**	**3**	**2**	**2**	**3**
CO5-02BC801.5- Evaluate different types of endocrine glands and mode of action of various hormones.	**1**	-	**2**	-	-	**2**	**3**	**3**	-	**2**	**3**	**3**	**1**	**1**	**2**

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

Course Curriculum:

POs & PSOs No.	Cos	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO1-02BC801.1-**Elucidate the basic fundamentals of digestive system and respiratory system.	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	**CO2-02BC801.2-** Explain the mechanism of circulatory system and cardiac system in humans.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	**LI 1** **LI 2** **LI 3** **LI 4**	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	**CO3-02BC801.3-**Elaborate the detailed knowledge about muscle physiology and muscle movement as well as excretory system.	SO3.1 SO3.2 SO3.3 SO3.4SO3.5 SO3.6 SO3.7 SO3.8 SO3.9	**LI 1**	3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9	**3SL-1,2**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO4-02BC801.4-**Analyz the Nervous system and endocrine systems in human body.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6 SO4.7 SO4.8 SO4.9	**LI 1**	4.1,4.2,4.3,4.4, 4.5, 4.6,4.6,4.7,4.8, 4.9	**4SL-1**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO5-02BC801.5-**Evaluate different types of endocrine glands and mode of action of various hormones.	SO5.1 SO5.2 SO5.3 SO5.4SO5.5 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**

Program Name	**Bachelor of Science (B.Sc.)- Biotechnology**	
Semester	VIII	
Course Code:	02MB801	
Course title:	Bioprocess Engineering	**Curriculum Developer**: Er. Arpit Srivastava, Assistant Professor
Pre-requisite:	Students should have basic knowledge of microbiology and fermentation	
Rationale:	Bioprocess engineering leans heavily on individuals who are capable of translating the complexity of both biomedical research and engineering into actionable processes that lead to the creation of new products.A bioprocess is any process that uses living cells to create a product, while engineering is the science of designing and building complex machines or processes. To that end, bioprocess engineering is the planning, construction, execution, and revision of the biological and mechanical processes required to create new products within the life sciences.Develop bioengineering skills for the production and purification of biochemical product usingintegrated biochemical processes.	
Course Outcomes (COs):	**CO1-02MB801.1:** Define various modes and techniques of fermentation **CO2-02MB801.2:** Differentiate and predict the suitability of the fermentation methods and vessels **CO3-02MB801.3:** Identify and develop the microbial inoculum for industrial processing **CO4-02MB801.4:** Interpret the mechanism of fermentation process in industry **CO5-02MB801.5:** Examine the mechanism of biological product development using microbes	

Scheme of Studies:

Board of Study	Course Code	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)	
MINOR	02MB801	Bioprocess Engineering	3	2	1	3	9	3+1=4

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

Scheme of Assessment: Theory

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (*2* best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Attendance (AT)	Total Marks (CA+CT+SA+AT)		
MINOR	02MB801	Bioprocess Engineering	15	20	10	5	50	50	100

Scheme of Assessment: Practical

Board of Study	Course Code	Course Title	Scheme of Assessment (Marks)						
			Progressive Assessment (PRA)					End Semester Assessment (ESA)	Total Marks (PRA+ ESA)
			Class/Home Assignment 5 number 7 marks each (CA)	Viva Voce I	Viva Voce II	Class Attendance (AT)	Total Marks (CA+VV1+VV2+SA+AT)		
MINOR	02MB801	Bioprocess Engineering	35	5	5	5	50	50	100

Course-Curriculum:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.	**Approximate Hours** **Item** | Cl | LI | SW | SL | Total **Approx.Hrs** | 09 | 04 | 01 | 04 | 18

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO1-03MB321.1. Define various modes and techniques of fermentation	**SO1.1**Explain the concept of Fermentation	**LI1.1**To Demonstrate the working of a Bench Top bioreactor	**Unit-1 Introduction to Fermentation** **CI1.1**Introduction to bioprocess technology	**SL1.1** Search various reference books and study material to start the learning of microorganisms
	SO1.2 Elaborate the about bioprocess technology	**LI1.2**To perform the isolation of microorganisms from different kinds of samples	**CI1.2**Range of bioprocess technology	**SL1.2** Find out the literature showing use of fermentation technology in ancient India
	SO1.3 Elaborate the historical perspective of fermentation		**CI1.3** its chronological development	**SL1.3** Derive the equation representing mode of fermentations
	SO1.4 Explain the basic principles of fermentation		**CI1.4** Basic principles,	**SL1.4** Explore different bioproducts manufacture in laboratory using various modes of fermentation
	SO1.5 Learn about components of fermentation technology		**CI1.5** components of fermentation technology	
	SO1.6 Study the modes of Fermentation		**CI1.6** Modes of Fermentation	
	SO1.7 Elaborate different categories of fermentation		**CI1.7** (Batch, Fed & continuous) with derivation of equations	
	SO1.8 Explain different types of microbial culture		**CI1.8** Types of microbial culture	
	SO1.9 Study its growth kinetics		**CI1.9** its growth kinetics	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Describe in detail "Applications of Microorganisms in various Sectors"
	SW1.2 Mini Project	Make a project on "Historical Process of Fermentation and Products produced in India"
	SW1.3 Other Activities (Specify)	List down the tables of different domains of microorganisms which are industrially important

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Approximate Hours

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

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO2-03MB321.2. Differentiate and predict the suitability of the fermentation methods and vessels	**SO2.1**Explain the role of industrial scope of fermentation and role of inoculum development	**LI2.1**To Demonstrate the working of Equipment's used in Sterilization	**Unit-2 Overview different fermentation parameters** **CI2.1**Design of bioprocess vessels	**SL2.1** Search various reference books and study material on to preparing inoculum/starter culture/seed culture
	SO2.2 Derive the roles of microbial growth kinetics	**LI2.2**To perform screening of microorganisms from different kinds of samples	**CI2.2** Significance of Impeller, Baffles, Sparger	**SL2.2** Find out the how Microbial growth phases occurs in laboratory-based protocols
	SO2.3 Compare different types of culture vessels	**LI2.3**To prepare the different kinds of nutrient media for microbial culture	**CI2.3**Types of culture/production vessels	**SL2.3** Derive the equation representing various mode of fermentations
	SO2.4 Differentiate among Modes of Fermentation		**CI2.4** Airlift; Cyclone Column	**SL2.4** Explore different bioproducts manufacture using various modes of fermentation
	SO2.5 Explain all fundamentals of Upstream Processing		**CI2.5** Packed Tower	
	SO2.6 Study types of Reactors on the basis of their applications		**CI2.6** Types of Reactors on the basis of their applications	
	SO2.7 Explain the Principles of upstream processing		**CI2.7** Principles of upstream processing	
	SO2.8 Explainn media preparation		**CI2.8** Media preparation	
	SO2.9 Study about noculum development and sterilization		**CI2.9** Inoculum development and sterilization	

Suggested Sessional Work (SW):*anyone*	**SW1.1** Assignments	Write down any 5 kinds of Unit Operations used in Sterilization
	SW1.2 Mini Project	Make a project on showing how microbial colonies grow on different kinds of Culture Media
	SW1.3 Other Activities (Specify)	Derive equations and Numerical problems based on "Modes of Fermentation"

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 | 05 | 15

Course outcome (CO)	Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self-Learning (SL)
CO3-03MB321.3 Identify and develop the microbial inoculum for industrial processing	**SO3.1** Explain the Basic design and construction of fermenter and ancillaries		**Unit-3** **CI3.1** Introduction to oxygen requirement in bioprocess.	**SL3.1** Search various reference books and study material to define various kinds of reactors used in industries
	SO3.2 Study mass transfer coefficient		**CI3.2** ; mass transfer coefficient;	**SL3.2** Find out the literature showing production of acids and slovents in industries
	SO3.3 Ebaborate the factors affecting		**CI3.3** factors affecting	**SL3.3** Find out how Biogas can be produced
	SO3.4 Study about KLa		**CI3.4** KLa	**SL3.4** Write about different bioproducts manufacture in laboratory
	SO3.5 Explore about Bioprocess measurement		**CI3.5** Bioprocess measurement	**SL3.5** Find out the applications of Solid-substrate fermentation in industries
	SO3.6 To know the control system		**CI3.6** control system	
	SO3.7 Study about Process Control		**CI3.7** Process Control	
	SO3.8 Assess control with computer		**CI3.8** Control with computer	
	SO3.9 Explain about computer aided process control		**CI3.9** computer aided process control	

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

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

Approximate Hours

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

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO4-03MB321.4. Interpretate the mechanism of fermentation process in industry	**SO4.**1Explain the concept of downstream processing	**LI4.1**To perform the Wine production using fruit wate and yeast	**Unit-4** **CI4.1** Introduction to downstream processing	**SL4.1** Find out more on Solvents and their production process
	SO4.2 Study about principle of Down Stream Processing	**LI4.2**To prepare the different kinds of Submerged Substrates for microbial culture	**CI4.2** Principle of Down Stream Processing	**SL4.2** List out the difference between Solid and Submerged State Fermentation
	SO4.3 Learn about methods of Downstream Processing		**CI4.3** Methods of Downstream Processing	**SL4.3** Explore the role of Diffusion, distribution and Dispersion in Mass transfer
	SO4.4 Explain about product recovery		**CI4.4** Product recovery	**SL4.4** Draw a well labelled diagram of different kinds of bioreactors and its parts
	SO4.5 Study the techniques of Product recovery		**CI4.5** Techniques of Product recovery	
	SO4.6 Study about Purification		**CI4.6** Purification	
	SO4.7 Learn principle and methods		**CI4.7** Principle and methods	
	SO4.8 Study the effluent treatment		**CI4.8** Effluent treatment	
	SO4.9 Learn about methods and application		**CI4.9** Methods and application	

Suggested Sessional Work (SW): *anyone*	**SW4.1** Assignments	Explain the role of Solid and Submerged State Fermentation
	SW4.2 Mini Project	Describe how therapeutics being produced in biotech-based industries
	SW4.3 Other Activities (Specify)	Make a list of different kinds of microorganisms which can produce fermented products

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	01	01	03	14

Course outcome (CO)	**Session Outcomes (SOs)**	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self-Learning (SL)**
CO5-03MB321.5 Examine the mechanism of biological product development using microbes	**SO5.1** Discuss about Basics of Downstream Processing	**LI5.1**To perform the downstream processing using various unit operations	**Unit-5Downstream Process** **CI5.1** Basics of Downstream Processing	**SL5.1** Explore the various kinds of biopolymers and their applications
	SO5.2 Explain the Role of Downstream processing in Fermentation Technology		**CI5.2** Role of Downstream processing in Fermentation Technology	**SL5.2** Read research on advancement in production of biofertilizers
	SO5.3 Discuss about Product recovery.		**CI5.3** Product recovery.	**SL5.3** Explore various protocols for the microbial production of other vitamins
	SO5.4 Explore about Purification		**CI5.4** Purification	
	SO5.5 Explain about Effluent treatment		**CI5.5** Effluent treatment	
	SO5.6 Study microbial production of ethanol		**CI5.6** Microbial production of ethanol	
	SO5.7 Discuss microbial production of amylase		**CI5.7** Microbial production of amylase	
	SO5.8 Discuss microbial production of lactic acid		**CI5.8** Microbial production of lactic acid	
	SO5.9 Explore microbial production of Single Cell Proteins		**CI5.9** Microbial production of Single Cell Proteins	

Suggested Sessional Work (SW): *anyone*	**SW5.1** Assignments	Explain general characteristics ofDownstream processing and its significance
	SW5.2 Mini Project	Describe the production process of acids and other biomolecules through fermentation
	SW5.3 Other Activities (Specify)	Make a power point presentation on “Downstream Processing and Unit Operations associated with it”

Course duration (in hours)to attain Course Outcomes:

Course Title: Bioprocess Engineering **Course Code:**02MB801

Course Outcomes(COs)	Class lecture (CI)	Laboratory Instruction(LI)	Self-Learning (SL)	Sessional work (SW)	Total Hours (Li+CI+SL+SW)
CO1-02MB801.1: Define various modes and techniques of fermentation	9	4	4	1	18
CO2-02MB801.2: Differentiate and predict the suitability of the fermentation methods and vessels	9	6	4	1	20
CO3-02MB801.3: Identify and develop the microbial inoculum for industrial processing	9	0	5	1	15
CO4-02MB801.4: Interpretate the mechanism of fermentation process in industry	9	4	4	1	18
CO5-02MB801.5: Examine the mechanism of biological product development using microbes	9	1	3	1	14
Total Hours	45	15	20	05	85

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

Course Title: Bioprocess Engineering **Course Code:**02MB801

Course Outcomes	Marks Distribution				Total Marks
	A	An	E	C	
CO1-02MB801.1: Define various modes and techniques of fermentation	2	1	1	0	5
CO2-02MB801.2: Differentiate and predict the suitability of the fermentation methods and vessels	2	4	3	0	10
CO3-02MB801.3: Identify and develop the microbial inoculum for industrial processing	3	5	4	1	15
CO4-02MB801.4: Interpretate the mechanism of fermentation process in industry	2	3	2	1	10
CO5-02MB801.5: Examine the mechanism of biological product development using microbes	5	4	2	2	10
Total Marks	**14**	**17**	**12**	**04**	**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
6	Principle of Fermentation Technology-P.F. Stanbury, A. Whitakerand S.J.Hall –Butterworth, 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 Industrial plant of fermentation industries
7. Demonstration
8. ICT Based teaching Learning
9. Brainstorming

CO, PO and PSO Mapping

Program Name: B. Sc. Biotechnology
Semester:V Semester
Course Title: Bioprocess Engineering
Course Code: 02MB801

CO/PO Mapping															
Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1-02MB801.1: Define various modes and techniques of fermentation	-	1	-	1	2	2	1	-	3	1	3	1	1	2	1
CO2-02MB801.2: Differentiate and predict the suitability of the fermentation methods and vessels	-	1	-	-	-	-	3	-	3	2	3	3	3	-	2
CO3-02MB801.3: Identify and develop the microbial inoculum for industrial processing	-	2	1	1	-	-	3	-	3	1	3	3	1	1	1
CO4-02MB801.4: Interpretate the mechanism of fermentation process in industry	1	-	1	-	2	2	2	3	-	1	3	3	2	2	3
CO5-02MB801.5: Examine the mechanism of biological product development using microbes	1	-	2	-	-	2	3	3	-	2	3	3	1	1	2

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

Course Curriculum:

POs & PSOs No.	COs	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self-Learning (SL)
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO1-02MB801.1:** Define various modes and techniques of fermentation	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**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO2-02MB801.2:**Differentiate and predict the suitability of the fermentation methods and vessels	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7 SO2.8 SO2.9	**LI 1** **LI 2** **LI 3**	2.1, 2.2, 2.3,2.4,2.5,2.6,2.7,2.8, 2.9	**2SL-1,2,3,4**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO3-02MB801.3:**Identify and develop the microbial inoculum for industrial processing	SO3.1 SO3.2 SO3.3 SO3.4SO3.5 SO3.6 SO3.7 SO3.8 SO3.9		3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9	**3SL-1,2,3,4,5**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO4-02MB801.4:** Interpretate the mechanism of fermentation process in industry	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, 4.6,4.6,4.7,4.8, 4.9	**4SL-1,2,3,4**
PO 1,2,3,4,5, 6, 7, 8, 9 10, 11, 12 PSO 1,2,3	**CO5-02MB801.5:**Examine the mechanism of biological product development using microbes	SO5.1 SO5.2 SO5.3 SO5.4SO5.5 SO5.6 SO5.7 SO5.8 SO5.9	**LI 1**	5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8, 5.9	**5SL-1,2,3**