KRISHNA VISHWA VIDYAPEETH (DEEMED TO BE UNIVERSITY), KARAD

Accredited By NAAC With 'A+' Grade

Revised Syllabus (CBCS) For

Bachelor of Science Microbiology

(In a Phase Manner)

Prologue

The Institute of Allied Sciences (Then Krishna Institute of Biotechnology and Bioinformatics) was established in 2007 with Five Under graduate courses Microbiology, Biotechnology, Environmental Science, Nutrition & Dietetics and Food & Dairy Technology Currently Eighteen faculty members are engaged in Academic functions.

The seemingly overwhelming and ever expanding state of knowledge about microorganisms, their genetic material, Molecular Biology and Recombinant DNA Technology increases the scope of Biotechnology. This newly emerging branch of science offers something for everyone and it cultivates informed citizens who can make perceptive decisions on important events. Many discoveries made by Microbiologists and Biotechnologists have spawned new fields of science such as molecular Biology, Genetics, Enzyme Technology, Fermentation Technology, Bioengineering, Genetic Engineering, Immunology etc. Many studies have been made using Science and Biotechnology to understand the principles that govern life.

New developments are occurring constantly in these areas and thus Biotechnologies have become the mainstays of many technologies. This has necessitated the formation of the Biotechnology courses for the development of competent, smart and dynamic Biotechnologists that are required in Academic Institutes, Research organizations, Professional organizations and in various industries such as Pharmaceutical Industries, Enzyme Industries, Food and Dairy Industries, Wine and Alcohol Industries, Agro based Industries. **The Choice –Based Credits System(CBCS)** provides for a framework within which there is flexibility in the design of courses and their content, simultaneously also providing the students a choice of the courses he/she wishes to study. The courses are assigned credits based on teaching hours, which in turn is linked to courses content and structure

The rapid pace of discovery and their application dictates a somewhat selective inclusion of theory paper / topics and practical and proper training of the students. The course is designed in such a way that students remain constantly busy with their studies through the Lecture and Practical periods, Seminar periods, Home assignments, Mid – term examinations (Periodic tests), Preliminary or term end examinations and also gets exposure to outside world through visits to Research Laboratories / Science Institutes / Industries of Microbiological /Biotechnological interest. The course also makes the provision for training in research through the research project (during one or two semesters) and / or Industrial training in organization of Microbiological interest. (During one semester / one summer vacation.)

Over all it is aimed to design **Three year under graduate (B.Sc.) course in Microbiology** with a balanced coverage of traditional and “cutting edge technology” along with the necessary courses (Communication skills, Biostatistics, Computer science, Scientific writing and Presentation, Research training / Industrial training) as per the UGC guidelines and produce competent Biotechnologists to meet the demand of Industries, Research organizations and Academic Institutes in the country and abroad.

Process of Curriculum Design

The Choice-Based Credit System (CBCS) provides a framework within which there is flexibility in the design of courses and their content. At the same time it also provides the student a choice of the courses he/she wishes to study. The courses are assigned credits based on teaching hours, which in turn is linked to course content and structure.

Curriculum Designing Process

Following procedure was adopted for curriculum designing: For curriculum development first need analysis was done and then based on need analysis draft syllabus was prepared in the Departmental Curriculum Committee meeting and it was subsequently discussed in College Curriculum Committee meeting were all faculty members participated in the discussion and debated over the draft syllabus. The draft syllabus approved in the College Curriculum Committee meeting was sent to BOS were given by external subject experts were considered and incorporated in the final draft. The draft syllabus finalized in BOS was sent to Academic Council for it's approval.

When revising the syllabi for the courses, the courses to be implemented as well as the content of each course was extensively discussed and debated on, feedback obtained from students, faculty, subject experts from academic institutes, industry experts, alumni were extensively discussed and debated in the meetings of curriculum committees and BOS and the inputs were considered. Thus for the development of syllabus contributions came from external subject experts, faculty members, feedback obtained from students, alumni, external experts and members of industry.

B.Sc. Microbiology program objectives

After completion, the students are expected to understand the:

a) Basic and applied aspects of microbial diversity and systematic taxonomy, Physiology, biochemistry and applications of basic aspects of microbial diversity.
b) Principles, working and application of bioinstruments used in isolation and identification of microbes and structural determination of biomolecules,
c) characteristics and significance of archea, algae, fungi, viruses,
d) Impact of various groups of microbes on earth atmosphere, human, plant and animal health and technology development,
e) structure, properties, pathways, significance and applications of microbial biomolecules,
f) basic and applied aspects of Genetic makeup of bacteria, algae, fungi and viruses,
g) causes, mechanisms and consequences of defect in gene/genome of microorganisms, and
h) basic concepts of microbial enzymes, enzyme kinetics, regulation of enzyme activity, industrial applications of enzymes, enzyme function in non-aqueous environment.

Structure of B.Sc. program in Microbiology B.Sc. **Microbiology** program is of two years duration and is conducted in four semesters. As recommended by UGC university has adopted a outcome-based education approach. The various courses of the program are designed to include classroom teaching, laboratory work, project work, seminars, home assignments, industrial visit etc.

Program Educational Objectives:

The objectives of the **B. Sc. Programme in Microbiology** is:

i) To equip the students with the basic and applied knowledge of molecular mechanisms of cellular processes in living systems including microbes, plants, animals and humans.
ii) To provide the students with laboratory (experimental) training so that they are competent enough to work in industries.
iii) To provide the students with the current updates in the areas of Analytical Techniques , Industrial Fermentations, Environmental Biotechnology.
iv) To train students with research work methodology through small project work.
v) To generate competent skilled human resource for industries and research organization.

Eligibility

Candidates must have passed B.Sc. With minimum 50% marks with Biotechnology/ Microbiology/ Industrial Microbiology/ Zoology/Botany as principal subject or with Biochemistry/ Microbiology/ Botany/ Zoology as subsidiary subjects at B.Sc. II level

Course fees

As shown in Admission Broacher of respective year (Subject to change as and when required)

Duration

The duration of B.Sc. (Microbiology) degree program shall consist of two academic years divided in to four semesters. Each Semester consist of 90 working days. Each theory and practical course must be completed in 60 lectures/Practical periods, respectively of 60 min duration.

Medium of instruction

The medium of instruction and examination for each course shall be English.

Credit to contact hour

One credit is equivalent to 15 periods of 60 minutes each for theory course lecture. While credit weightage for self-learning based on e-content shall be 50% or less than that for lectures.

Attendance

The student enrolled for B.Sc. Microbiology must have 75% attendance in each course in order to appear for term end examinations, otherwise the candidate may not be allowed to appear for term end examination as per ordinance.

1] The entire B.Sc. course in Microbiology shall be covered in 28 [Twenty Eight] theory papers, 28 [Twenty Eight] practical courses [semester I, II, III] and a project work / Industrial training [in lieu of one practical courses of semester IV] each semester there shall be four theory papers each carrying 100 marks and for first three semesters viz. semester I, II and III, there shall be two practical courses each practical course shall carry 100 marks. However, for semester IV there shall be a research project work / Industrial training of 100 [one hundred] marks in lieu of one practical course in addition to four-theory paper and one practical course.

Semester I: Eight theory papers and Eight practical courses.

Semester II: Eight theory papers and Eight practical courses.

Semester III: Six theory papers and Six practical courses.

Semester IV: Six theory papers. Six practical course and a project work/Industrial training practical course for every student.

2] Each theory paper will be covered in four lectures of 60 minutes each per week.

Practical course shall be covered in 04 practical turns of 04 clock hours practical periods per week.

3] A practical batch shall be of 12 [twelve] to 15 [fifteen] students.

4] For university practical examination the duration should be as shown below,

For every semester there shall be two/three days practical examination for not less than 5 ½ hours.

5] Each candidate must produce a certificate from the Head of the Department in his/her college / Institute / University stating that he/she has completed, in a satisfactory manner, a practical course on the lines laid down from time to time by Academic Council on the recommendations of Board of studies and that the laboratory journal has been properly maintained. Every candidate must have recorded his/her observation in the laboratory journal and a written report on each exercise performed. Every journal is to be checked and signed periodically by a member of teaching staff and certified by the Head of the Department at the end of each semester. Candidates are to produce their journal at the time of practical examination.

6] There shall be one compulsory seminar of minimum 15 min. delivery per paper per semester for each student and there shall be two marks for each seminar in Internal evaluation.

During semester I & II students shall have to undertake an academic tour to visit a minimum one place of academic interests like Academic Institute/ Research Institution / R&D Department/Industry. The student should submit the report of their visit at the time

of practical examination. The report should be duly certified by the Head of the Department of Microbiology, Biotechnology.

7] During semester Student is to undertake a research project [as part of the semester IV] which is to be started in the beginning of semester III so as to give enough time for duly completion of project. In the project student is to study research methodology Information collection (reference work) selection of topic, outline of the work, thinking and planning, project report writing in the form of dissertation or small Project Report and the submission of the project report [Introduction, Aims and objectives, Material and method, Results and Discussions, summary, Conclusions and Bibliography] For the research project work out of one hundred marks, fifty marks shall be given by university examiners though assessment of Project Report at the time of semester IV practical examination. The remaining fifty marks shall be given by the Committee for Internal Evaluation of Projects (CIEP) as an internal evaluation. CIEP is to be constituted by the Principal (and which shall be consisting of HOD, Guide/Teacher in - charge and at least one other faculty members). The method and process of Internal evaluation is to be worked out by the CIEP.

a) **The Institute or guide of student should locate the industry and depute the student in the industry for the period of one month.
b) Student should complete its industrial training cum industrial project in the vacation period after semester II
c) Student should study microbiological and / or biotechnological aspects in industry and submit its report in the form of dissertation or small Project Report duly signed by industry authority, concerned guide and Head of the Department of Microbiology, Biotechnology.

Three-year

B.Sc. Microbiology

Programme (Programme Code: .)

Course Structure

B.Sc. Microbiology Part I, Semester I (Horizontal Mobility)

B.Sc. Environmental Sciences Part I, Semester I (w.e.f. 2022-2023)													
	Sr. No	Course Code	Course Title	Teaching Hours/ Week			Marks					Credits
							Internal		External		Total	
				T	P	Total	T	P	T	P		
	CGPA Theory Courses											
CGPA	1	UG ES – T101 **CC**	Fundamentals of Microbial and Biological World	2	-	2	10	-	40	-	50	2
	2	UG ES – T102 **CC**	Fundamentals of Physics and Biophysics for Biologists	2	-	2	10	-	40	-	50	2
	3	UG ES – T103 **CC**	Fundamentals of Chemistry for Biologists	2	-	2	10	-	40	-	50	2
	4	UG ES – T104 **CC**	Fundamentals of Biosciences – Botany and Zoology	2	-	2	10	-	40	-	50	2
	5	UG ES – T105 **CC**	Basics of Bacteriology, Virology and Rickettsialogy	2	-	2	10	-	40	-	50	2
	6	UG ES – T106 **CC**	Basics of Mycology, Phycology and Protozoalogy	2	-	2	10	-	40	-	50	2
	7	UG ES – T107 **CCS**	Introduction to the world of amazing microorganisms	2	-	2	10	-	40	-	50	2
	8	UG ES – T108 **DSC**	Basics techniques in Microbiology, Biotechnology and Environmental Sciences	2	-	2	10	-	40	-	50	2
	CGPA Practical Courses											
CGPA	9	UG ES – P101 **CC**	Practicals related to the theory paper - Fundamentals of Microbial and Biological World	-	2	2	-	10	-	40	50	1
	10	UG ES – P102 **CC**	Practicals related to the theory paper - Fundamentals of Physics and Biophysics for Biologists	-	2	2	-	10	-	40	50	1
	11	UG ES – P103 **CC**	Practicals related to the theory paper - Fundamentals of Chemistry for Biologists	-	2	2	-	10	-	40	50	1
	12	UG ES – P104 **CC**	Practicals related to the theory paper - Fundamentals of Biosciences – Botany and Zoology	-	2	2	-	10	-	40	50	1
	13	UG ES – P105	Practicals related to the theory paper - Basics of	-	2	2	-	10	-	40	50	1

		CC	Bacteriology, Virology and Rickettsialogy									
	14	UG ES – P106 **CC**	Practicals related to the theory paper - Basics of Mycology, Phycology and Protozoalogy	-	2	2	-	10	-	40	50	1
	15	UG ES – P107 **CCS**	Practicals related to the theory paper - Introduction to the world of amazing microorganisms	-	2	2	-	10	-	40	50	1
	16	UG ES – P108 **DSC**	Practicals related to the theory paper - Basics techniques in Microbiology, Biotechnology and Environmental Sciences	-	2	2	-	10	-	40	50	1
			Total	16	16	**32**	80	80	320	320	**800**	**24**
	Mandatory Non CGPA Courses											
Non - CGPA	18	UG ES – T109 **SECC**	Yoga and Meditation	0.5	-	0.5	25	-	-	-	25	0.5
	19	UG ES – T110 **AECC**	Spoken English - I	0.5	-	0.5	25	-	-	-	25	0.5
			Total	1	-	**1**	50	-	-	-	**50**	**1**

Total Credits for Semester I : 25 (T = Theory: 16, P = Practical : 8, Non-CGPA : 1)
CC : Core Course, CCS : Core Course Specialization, DSC : Discipline Specific Course, DSE : Discipline Specific Elective,
SECC = Skill Enhancement Compulsory Course : 0.5, AECC = Ability Enhancement Compulsory Course : 0.5,
Total Credits for Semester I CGPA Course = 20.5 credits

B.Sc. Microbiology Part I, Semester II (Horizontal Mobility)

B.Sc. Environmental Sciences Part I, Semester II (w.e.f. 2022-2023)													
	Sr. No	**Course Code**	**Course Title**	**Teaching Hours/ Week**			**Marks**					**Credits**
							Internal		**External**		**Total**	
				T	**P**	**Total**	**T**	**P**	**T**	**P**		
	CGPA Theory Courses											
CGPA	1	UG ES – T201 **CC**	Basics of Cell Biology and Physiology	2	-	2	10	-	40	-	50	1.5
	2	UG ES – T202 **CC**	Basics of Biochemistry – Biomolecules - I	2	-	2	10	-	40	-	50	1.5
	3	UG ES – T203 **CC**	Basics of Biochemistry – Biomolecules - II	2	-	2	10	-	40	-	50	1.5
	4	UG ES – T204 **CC**	Microbial Nutrition and Growth	2	-	2	10	-	40	-	50	1.5
	5	UG ES – T205 **CC**	Advanced Chemistry and Physics for Biologists	2	-	2	10	-	40	-	50	1.5
	6	UG ES – T206 **CC**	Applied Plant and Animal Sciences	2	-	2	10	-	40	-	50	1.5
	7	UG ES – T207 **CCS**	Basics of Ecology, Ecosystem and Geosciences	2	-	2	10	-	40	-	50	1.5
	8	UG ES – T208 **DSC**	Applied Microbiology and Basics of Environmental Pollution	2	-	2	10	-	40	-	50	1.5
	CGPA Practical Courses											
CGPA	9	UG ES – P201 **CC**	Practicals related to the theory paper - Basics of Cell Biology and Physiology	-	2	2	-	10	-	40	50	1
	10	UG ES – P202 **CC**	Practicals related to the theory paper - Basics of Biochemistry – Biomolecules - I	-	2	2	-	10	-	40	50	1
	11	UG ES – P203 **CC**	Practicals related to the theory paper - Basics of Biochemistry – Biomolecules - II	-	2	2	-	10	-	40	50	1
	12	UG ES – P204 **CC**	Practicals related to the theory paper - Microbial Nutrition and Growth	-	2	2	-	10	-	40	50	1
	13	UG ES – P205 **CC**	Practicals related to the theory paper - Advanced Chemistry and Physics for Biologists	-	2	2	-	10	-	40	50	1

	14	UG ES – P206 **CC**	Practicals related to the theory paper - Applied Plant and Animal Sciences	-	2	2	-	10	-	40	50	1
	15	UG ES – P207 **CCS**	Practicals related to the theory paper - Basics of Ecology, Ecosystem and Geosciences	-	2	2	-	10	-	40	50	1
	16	UG ES – P208 **DSC**	Practicals related to the theory paper - Applied Microbiology and Basics of Environmental Pollution	-	2	2	-	10	-	40	50	1
CGPA	17	UG ES – P209 **PP**	Project I	-	1	1	-	5	-	-	5	1
			Total	16	17	**33**	80	85	320	320	**805**	**21**
	Mandatory Non CGPA Courses											
Non-CGPA	18	UG ES – T209 **SECC**	Soft Skill and Personality Development	0.5	-	0.5	25	-	-	-	25	0.5
	19	UG ES – T210 **AECC**	Spoken English – II (Communication Skills)	0.5	-	0.5	25	-	-	-	25	0.5
			Total	1	-	**1**	50	-	-	-	**50**	**1**

Total Credits for Semester II : 22 (T = Theory: 12, P = Practical : 8, Project : 1, Non-CGPA : 1)

CC : Core Course, CCS : Core Course Specialization, DSC : Discipline Specific Course, DSE : Discipline Specific Elective, PP : Project

SECC = Skill Enhancement Compulsory Course : 0.5, AECC = Ability Enhancement Compulsory Course : 0.5,

Total Credits for Semester II CGPA Course = 21 credits

B.Sc. Microbiology Part II, Semester III (Horizontal Mobility)

B.Sc. Environmental Sciences Part II, Semester III (w.e.f. 2023-2024)													
	Sr. No	Course Code	Course Title	Teaching Hours/ Week			Marks					Credits
							Internal		External		Total	
				T	P	Total	T	P	T	P		
	CGPA Theory Courses											
CGPA	1	UG ES – T301 **CC**	Genetics – I	2	-	2	10	-	40	-	50	2.5
	2	UG ES – T302 **CC**	Introduction to Agricultural Biotechnology and Microbiology	2	-	2	10	-	40	-	50	2.5
	3	UG ES – T303 **CC**	Basics of Medical Microbiology and Immunology	2	-	2	10	-	40	-	50	2.5
	4	UG ES – T304 **CC**	Basics of Industrial Microbiology and Biotechnology	2	-	2	10	-	40	-	50	2.5
	5	UG ES – T305 **CCS**	Basics of Pharmaceutical Microbiology	2	-	2	10	-	40	-	50	2.5
	6	UG ES – T306 **DSC**	Biodiversity, Natural Recourses Conservation and Management	2	-	2	10	-	40	-	50	2.5
	CGPA Practical Courses											
CGPA	7	UG ES – P301 **CC**	Practicals related to the theory paper - Genetics – I	-	1	1	-	10	-	40	50	1
	8	UG ES – P302 **CC**	Practicals related to the theory paper - Introduction to Agricultural Biotechnology and Microbiology	-	1	1	-	10	-	40	50	1
	9	UG ES – P303 **CC**	Practicals related to the theory paper - Basics of Medical Microbiology and Immunology	-	1	1	-	10	-	40	50	1
	10	UG ES – P304 **CC**	Practicals related to the theory paper - Basics of Industrial Microbiology and Biotechnology	-	1	1	-	10	-	40	50	1
	11	UG ES – P305 **CCS**	Practicals related to the theory paper - Basics of Pharmaceutical Microbiology	-	1	1	-	10	-	40	50	1
	12	UG ES – P306 **DSC**	Practicals related to the theory paper - Biodiversity, Natural Recourses Conservation and	-	1	1	-	10	-	40	50	1

			Management									
			Total	12	6	**18**	60	60	240	240	**600**	**21**
	Mandatory Non CGPA Courses											
Non-CGPA	14	UG ES – T306 **SECC**	Leadership Development	0.5	-	0.5	25	-	-	-	25	0.5
	15	UG ES – T307 **AECC**	Environmental Studies – I	0.5	-	0.5	25	-	-	-	25	0.5
			Total	1	-	**1**	50	-	-	-	**50**	**1**

Total Credits for Semester III : 22 (T = Theory: 15, P = Practical : 6, Non-CGPA : 1)
CC : Core Course, CCS : Core Course Specialization, DSC : Discipline Specific Course, DSE : Discipline Specific Elective,
SECC = Skill Enhancement Compulsory Course : 0.5, AECC = Ability Enhancement Compulsory Course : 0.5,
Total Credits for Semester III CGPA Course = 21 credits

B.Sc. Microbiology Part II, Semester IV (Horizontal Mobility)

B.Sc. Environmental Sciences Part II, Semester IV (w.e.f. 2023-2024)													
	Sr. No	Course Code	Course Title	Teaching Hours/ Week			Marks					Credits
							Internal		External		Total	
				T	P	Total	T	P	T	P		
	CGPA Theory Courses											
CGPA	1	UG ES – T401 **CC**	Basics of Enzymology	3	-	3	10	-	40	-	50	2.5
	2	UG ES – T402 **CC**	Introduction to Food Biotechnology and Microbiology	3	-	3	10	-	40	-	50	2.5
	3	UG ES – T403 **CC**	Introduction to Dairy Biotechnology and Microbiology	3	-	3	10	-	40	-	50	2.5
	4	UG ES – T404 **CC**	Genetics – II	3	-	3	10	-	40	-	50	2.5
	5	UG ES – T405 **CCS**	Introduction to Clinical Microbiology and Pathology	3	-	3	10	-	40	-	50	2.5
	6	UG ES – T406 **DSC**	Basics of Biostatistics, Mathematics, Bioinformatics and Computers for Biologists	3	-	3	10	-	40	-	50	2.5
	CGPA Practical Courses											
CGPA	7	UG ES – P401 **CC**	Practicals related to the theory paper - Basics of Enzymology	-	1	1	-	10	-	40	50	1
	8	UG ES – P402 **CC**	Practicals related to the theory paper - Introduction to Food Biotechnology and Microbiology	-	1	1	-	10	-	40	50	1
	9	UG ES – P403 **CC**	Practicals related to the theory paper - Introduction to Dairy Biotechnology and Microbiology	-	1	1	-	10	-	40	50	1
	10	UG ES – P404 **CC**	Practicals related to the theory paper - Genetics – II	-	1	1	-	10	-	40	50	1
	11	UG ES – P405 **CCS**	Practicals related to the theory paper - Introduction to Clinical Microbiology and Pathology	-	1	1	-	10	-	40	50	1
	12	UG ES – P406 **DSC**	Practicals related to the theory paper - Basics of Biostatistics, Mathematics, Bioinformatics and Computers for Biologists	-	1	1	-	10	-	40	50	1

	13	UG ES – P407 **PP**	Project II	-	1	1	-	10	-	10	20	1
	Total			18	7	**25**	60	70	240	240	**610**	**22**
	Mandatory Non CGPA Courses											
Non-CGPA	14	UG ES – T406 **SECC**	Indian Constitution and Governance	0.5	-	0.5	25	-	-	-	25	0.5
	15	UG ES – T407 **AECC**	Environmental Studies – II	0.5	-	0.5	25	-	-	-	25	0.5
	Total			1	-	**1**	50	-	-	-	**50**	**1**

Total Credits for Semester IV : 23 (T = Theory: 15, P = Practical : 6, Project : 1, Non-CGPA : 1)

CC : Core Course, CCS : Core Course Specialization, DSC : Discipline Specific Course, DSE : Discipline Specific Elective, , PP : Project

SECC = Skill Enhancement Compulsory Course : 0.5, AECC = Ability Enhancement Compulsory Course : 0.5,

Total Credits for Semester IV CGPA Course = 22 credits

B.Sc. Microbiology Part III, Semester V

B.Sc. Microbiology Part III, Semester V (w.e.f. 2024-2025)													
	Sr. No	**Course Code**	**Course Title**	**Teaching Hours/ Week**			**Marks**					**Credits**
							Internal		**External**		**Total**	
				T	**P**	**Total**	**T**	**P**	**T**	**P**		
	CGPA Theory Courses											
CGPA	1	UG MB – T501 **DSC**	Advances in Pharma Microbiology	4	-	4	20	-	80	-	100	4
	2	UG MB – T502 **CC**	Molecular Biology and r-DNA Technology	4	-	4	20	-	80	-	100	4
	3	UG MB – T503 **CCS**	Basics of Fermentation Technology	4	-	4	20	-	80	-	100	4
	4	UG MB – T504 **DSE**	Advanced Medical Microbiology, Immunology and Virology	4	-	4	20	-	80	-	100	4
	5	UG MB – T505 **DSE**	Wastewater Technology									
	CGPA Practical Courses											
CGPA	6	UG MB – P501 **DSC**	Practicals related to the theory paper - Advances in Pharma Microbiology	-	1	1	-	10	-	40	50	1
	7	UG MB – P502 **CC**	Practicals related to the theory paper - Molecular Biology and r-DNA Technology	-	1	1	-	10	-	40	50	1
	8	UG MB – P503 **CCS**	Practicals related to the theory paper - Basics of Fermentation Technology	-	1	1	-	10	-	40	50	1
	9	UG MB – P504 **DSE**	Practicals related to the theory paper - Advanced Medical Microbiology, Immunology and Virology	-	1	1	-	10	-	40	50	1
	10	UG MB – P505 **DSE**	Practicals related to the theory paper - Wastewater Technology									
			Total	12	4	**16**	80	40	320	160	**605**	**20**
	Mandatory Non CGPA Courses											
Non-CGPA	12	UG MB – T506 **SECC**	Personal Hygiene and Cleanliness	0.5	-	0.5	25	-	-	-	25	0.5
	13	UG MB – T507	Cyber Security	0.5	-	0.5	25	-	-	-	25	0.5

		AECC									
		Total	1	**-**	**1**	50	**-**	**-**	-	**50**	**1**

Total Credits for Semester V : 21(T = Theory: 16, P = Practical : 4, Non-CGPA : 1)
CC : Core Course, CCS : Core Course Specialization, DSC : Discipline Specific Course, DSE : Discipline Specific Elective,
SECC = Skill Enhancement Compulsory Course : 0.5, AECC = Ability Enhancement Compulsory Course : 0.5,
Total Credits for Semester V CGPA Course = 20 credits

B.Sc. Microbiology Part III, Semester VI

B.Sc. Microbiology Part III, Semester VI (w.e.f. 2024-2025)													
	Sr. No	**Course Code**	**Course Title**	**Teaching Hours/ Week**			**Marks**					**Credits**
							Internal		**External**		**Total**	
				T	**P**	**Total**	**T**	**P**	**T**	**P**		
	CGPA Theory Courses											
CGPA	1	UG MB – T601 **DSC**	Advanced Taxonomy of Microorganisms	4	-	4	20	-	80	-	100	4
	2	UG MB – T602 **CCS**	Fermentation Technology	4	-	4	20	-	80	-	100	4
	3	UG MB – T603 **CC**	Metabolism and Metabolic Pathways	4	-	4	20	-	80	-	100	4
	4	UG MB – T604 **DSE**	Nanobiotechnology	4	-	4	20	-	80	-	100	4
	5	UG MB – T605 **DSE**	Environmental Microbiology and Biotechnology									
	CGPA Practical Courses											
CGPA	6	UG MB – P601 **DSC**	Practicals related to the theory paper - Advanced Taxonomy of Microorganisms	-	1	1	-	10	-	40	50	1
	7	UG MB – P602 **CCS**	Practicals related to the theory paper - Fermentation Technology	-	1	1	-	10	-	40	50	1
	8	UG MB – P603 **CC**	Practicals related to the theory paper - Metabolism and Metabolic Pathways	-	1	1	-	10	-	40	50	1
	9	UG MB – P604 **DSE**	Practicals related to the theory paper - Nanobiotechnology	-	1	1	-	10	-	40	50	1
	10	UG MB – P605 **DSE**	Practicals related to the theory paper - Environmental Microbiology and Biotechnology									
CGPA	11	UG MB – P606 **PP**	Project III	-	1	1	-	15	-	10	25	1
			Total	12	5	**17**	80	55	320	170	**625**	**21**
	Mandatory Non CGPA Courses											
Non-CGPA	12	UG MB – T606 **SECC**	Human Rights and Human Values	0.5	-	0.5	25	-	-	-	25	0.5
	1	UG MB –	Biotechnology Data Care	0.5	-	0.5	2	-	-	-	25	0.5

	3	T607 **AECC**	Management				5					
			Total	1	**-**	**1**	50	**-**	**-**	-	**50**	**1**

Total Credits for Semester VI : 22 (T = Theory: 16, P = Practical : 4, Project : 1, Non-CGPA : 1)
CC : Core Course, CCS : Core Course Specialization, DSC : Discipline Specific Course, DSE : Discipline Specific Elective, PP : Project
SECC = Skill Enhancement Compulsory Course : 0.5, AECC = Ability Enhancement Compulsory Course : 0.5,
Total Credits for Semester VI CGPA Course = 21 credits

B. Sc. Part I Semester – I

UG HM - T101: Fundamentals of Microbial and Biological World

3-Credits-60-hours

Unit I	**20 Hrs**	**History – Three centuries of Microbiology** **A. Development of Microbiology as a discipline:-** Discovery of microscope and microorganisms (Antony Van Leeuwenhoek and Robert Hooke), abiogenesis versus biogenesis (Aristotle's notion about spontaneous generation, Francesco Redi's experiment, Louis Pasteur and Tyndall's experiments) B. **Golden era of Microbiology –** Contributions of Louis Pasteur (Fermentation, Rabies vaccine, pasteurization and cholera vaccine – Foul cholera experiment), Robert Koch (Koch's postulates, germ theory of diseases, Tuberculosis and Cholera – isolation and staining techniques of causative agent, pure culture techniques), Ferdinand Cohn (Endospore Discovery), discovery of viruses (TMV- Ivanowsky and bacteriophages- deHerrale), Rivar's postulates, Contributions of Joseph Lister (Antiseptic Surgery), Paul Ehrlich (chemotherapy), Elie Metchnikoff (Phagocytosis), Edward Jenner (Vaccination), Alexander Flemming (Penicillin) and Selman Waksman (Streptomycin) in the establishment of fields of medical microbiology and immunology. Contributions of Martinus W. Beijeirinck (Enrichment culture technique, Rhizobium), Sergei. N. Winogradsky (Nitrogen Fixation, azatobacter and Chemolithotrophy) in the development of fields of soil microbiology. C. **Modern era of Microbiology** Prokaryotic and Eukaryotic Classification – Three domain and five domain systems, Carl Woese classification based on 16S rRNA gene sequencing. Significance and applications of human microbiome, nanobiotechnology, space microbiology, geomicrobiology and r-DNA technology Nobel Laureates in Life Sciences of 21st Century
Unit II	**15 Hrs**	**Types of Microorganisms and their differentiating features** **A) Cellular forms** – Prokaryotic and eukaryotic

		Bacteria (Eubacteria, archaebacteria, Rickettsia, Mycoplasma and Actinomycetes) Protozoa , Fungi, Algae **B) Acellular Forms** – Viruses, Viroids, Prions, Virusoid
Unit III	**25 Hrs**	**Beneficial and harmful effects of microorganisms in various fields of Microbiology, Biotechnology and Environmental Sciences:** a) Medical Microbiology (Enlist diseases caused by various microorganisms, vaccines and antibiotics) b) Immunology (Normal Flora, Immune Sera, Three lines of defenses) c) Food and Dairy Microbiology (Food spoilage, food borne diseases, prebiotics, probiotics and fermented foods) d) Industrial microbiology (Microorganisms producing antibiotics, enzymes, growth factors, solvents and SCP; contaminants in industry– bacteria, fungi and phages) e) Agricultural Microbiology (Enlist plant diseases, biofertilizers, plant growth promoters and biocontrol agents) f) Space microbiology (Space microbes as a tool to study origin of life on the earth) g) Geomicrobiology (Metal leaching from ores) h) Nanobiotechnology (Production of nanoparticles using microorganisms)

UG HM - P101: Practical course based on theory paper

Fundamentals of Microbial and Biological World

30 hrs.

1	Introduction, operation, precautions and use of common laboratory instruments used in life sciences [Incubator, Hot air oven, Autoclave, Colorimeter, Centrifuge, Laminar air flow, pH meter, Digital balance, Microscopes, Anaerobic jar, Colony counter, Seitz Filter, Distillation Unit, Membrane Filter]	06 Hrs.
2	Learning basic techniques in life science laboratory [Washing, plugging and wrapping of glassware, biological waste disposal, aseptic transfer techniques – broth, plate, slant and butt transfers]	04 Hrs.
3	Observation of motility in bacteria by hanging drop/ swarming growth method	02 Hrs.
4	Checking efficiency of chemical disinfectants - Phenol coefficient by Rideal- Walker method	8 Hrs.
5	Special staining techniques- Cell wall (Chance's method), flagella (Bailey's method/Leifson's method), acid fast staining (permanent slide)	10 Hrs

B. Sc. Part I Semester – I

UG HM - T102: Fundamentals of Physics and Biophysics for Biologists

3-Credits-60-h

Unit I	**6 Hrs**	**Measurements** • Physical quantities, fundamental and derived units, system of units, order of magnitude • Length: radius of proton to astronomical distances • Mass: atomic mass unit to mass of earth • Time: fast elementary particle to age of earth • Amount of substance, luminous intensity, interconversions of units
Unit II	**7 Hrs**	**Introduction to biophysics** • Scope and definition of biophysics, biophysics at macroscopic, microscopic and molecular level. • Biophysical properties: Surface tension, adsorption, diffusion, osmosis, dialysis, wetting and colloids
Unit III	**10 Hrs**	**Fluid Mechanics: (5)** • Fluids: definition, pressure, density, variation of pressure with depth in a fluid at rest, • Measurement of pressure- Various units of pressure and their interconversion, streamline and turbulent flow • Equation of Continuity, Poiseulle's equation, Reynold's number, flow of liquids through capillaries, viscosity, Newton's law of viscosity, coefficient of viscosity, Ostwald's viscometer, Relevance to life Science, Bernoulli's theorem and its applications, methods of measurement of viscosity
Unit IV	**8 Hrs**	**Surface Tension & Surface Energy** • Cohesive and adhesive forces, Capillary action, angle of contact, wettability, measurement of surface tension by capillary rise, Jaeger's and Quincke's method, factor affecting surface tension, applications, relevance to life sciences
Unit V	**12 Hrs**	**Waves & Oscillations** • Difference between waves and oscillations, Types of waves (Transverse & Longitudinal), Reflection of waves, Principle of superposition of waves, standing & travelling waves, Sound waves as pressure waves, Audible ultrasonic & infrasonic waves, characteristics of sound waves, vibration systems and source of sound, beats, Doppler's effect, Applications in life sciences, measurement of sound, decibel scale (dB).
Unit VI	**7 Hrs**	**Geometrical Optics** • Reflection, Refraction, Snell's Law, types of lenses, combinational lenses, radius of curvature, focal length, lens maker equation.
Unit VII	**10 Hrs**	**Radioactivity:** • Nucleus: Properties – size, shape, charge distribution, spin and purity binding and empirical mass formula, nuclear stability and radioactive decay, nuclear forces, nuclear models (Liquid drop & Shell model), radioactive nucleus Nuclear Radiations & their properties, Alpha, Beta & Gamma, half life, Physical & biological handling of alpha & beta emitting isotopes, UV and X-rays – properties, X-ray spectrum, Braig's law and applications GM Counter – Principle, construction & working

UG HM - P102: Practicals related to theory paper Fundamentals of Physics and Biophysics for Biologists

30 hrs.

1	Study of Vernier callipers & micrometer screw gauge	03 hrs.
2	To Study the components & working of travelling microscope	04 hrs.
3	Surface tension measurement using Jaeger's method/ Soap bubble method	03 hrs.
4	To Study plane diffraction grating	04 hrs.
5	Special staining techniques- Cell wall (Chance's method), flagella (Bailey's method/Leifson's method), acid fast staining (permanent slide)	04 hrs
6	Study the process of osmosis	02 hrs
7	Determination of diffusion pressure deficit using potato tuber	02 hrs
8	Precipitation & Dialysis	02 hrs
9	Working of GM counter	02 hrs
10	Sonometer	02 hrs
11	Determine surface tension of liquids	02 hrs

B. Sc. Part I Semester – I

UG HM - T103 Fundamentals of Chemistry for Biologists

3-Credits-60-h

Unit I	**10 Hrs**	**Atomic Structure** Historical background, electronic structure of atom, JJ Thomson and Rutherford model, Bohr's Model and its postulates, atomic and molecular orbitals, four quantum numbers, shapes of atomic orbitals, selection rules to find out electronic configuration of elements, Plank's quantum theory, Wave particle duality, Uncertainty principle, Pauly's exclusion principle, Ionisation Potential, electronegativity, electron affinity
Unit II	**6 Hrs**	**Molecules** Diatomic molecules, valance bond theory, VSEPR theory, hybridization involving s, p, d orbitals (sp, sp^2, sp^3, dsp^2,sp^2d, sp^3d^2), homo and heteronuclear diatomic molecules, bond order, magnetic properties
Unit III	**6 Hrs**	**. Chemical Bonding** Types of bonds: covalent, coordinate, metallic, ionic, hydrogen bonding, inter and intramolecular hydrogen bonding, dipole-dipole, dipole induced dipole interaction, structure of water molecule, oxidation state, hydrophobic and hydrophilic interactions
Unit IV	**10 Hrs**	**Basics of Organic and Stereochemistry and mechanisms** • IUPAC nomenclature, • reactions of functional groups : alkane, alkene, alkyne, alcohol, amine, alkyl halide, ether, • organic reactions : oxidation, reduction, elimination, addition, substitution (electrophilic/ nucleophilic), inductive, mesomeric and electrometric effects, reactive intermediates – carbonations, carbon ion, free radicals, carbines, Arynes and Nytrins • Conformations, configurations, isomerism (structural and stereo isomers), enantiomers, diesteroisomers, chiral centers, geometric isomers, optical isomerism • Newman's and Fisher projection formulae, epimers, anomers, furanose, and pyranose forms, free radical reactions
Unit V	**6 Hrs**	**. Ionic Equilibrium** • pH, buffer, equilibrium constant, common ion effect, Le Chatelier's principle, acids and bases, strength of acids and bases, dissociation constant, pH, pK values, solubility product, acid-base titrations, indicators used in titration, titration curves, Bronstied-Lowery theory, Levis theory, Acid-base concept in non gaseous solvents, Soft hard acid bases (SHAB) concept • Ionic product, condition for precipitation, colligative properties of solutions • Handerson – Hasselbalch equation and related problems, osmosis, law of osmotic pressure and its measurement, determination of molecular

		weight from osmotic pressure • Properties of water, water as reactant, interactions of biomolecules with water
Unit VI	**7 Hrs**	**Chemical Kinetics** • Rates of reactions, order - zero, first and second order reactions and molecularity • Differential and integrated rate equation, methods of determining order of reactions, catalysis and elementary enzyme reactions • Half- life periods, Arrhenius equation, collision theory of reaction rate, temperature dependent reaction rates
Unit VII	**10 Hrs**	**Thermodynamics** Introduction, types of system, intensive and extensive properties, equilibrium and non-equilibrium states, reversible and irreversible processes, laws of thermodynamics, internal energy, enthalpy, entropy – basic concept, physical significance, principle of increase in natural processes, endothermic and exothermic reactions, free energy and work, Gibb's Helmholtz equations, Isothermal and adiabatic relation, work done during isothermal and adiabatic changes, Carnot's engine and Carnot's cycle and its efficiency, Practical cycle used in internal combustion in engine (diesel engine)
Unit VIII	**5 Hrs**	**Basics of Mole Concept** • Mole concept, determination of molecular weight by gram molecular volume relationship, problems based on mole concept, solutions, colligative properties • Methods of expressing concentrations, strength, normality, molarity and molality, ppm • Volumetric experiments – acidometry, alkalometry, permanganometry, dichrometry, iodometry

UG HM - P103: Fundamentals of Chemistry for Biologists

30 hrs.

1	**Titrations** a. To study acid – base titration by indicator and conductivity meter b. To determine alkali content on antacid tablet using HCl	04 hrs.
2	**Chemical kinetics** To study kinetics of ester's hydrolysis	03 hrs.
3	**Thermochemistry** To determine enthalpy and entropy change of a reaction e.g.(1) $2FeCl_3 + 3Mg = 2Fe + 3MgCl_2$ Activation energy for an acid catalyzed hydrolysis of methyl acetate	03 hrs.
4	**Hardness of water** To estimate hardness of water by using EDTA	02 hrs.
5	**Qualitative analysis** To perform qualitative test for hydrocarbons, alcohols, aldehydes, ketones, aniline and amide	06 hrs
6	**pH meter** To determine pK value of given weak acid by pH meter titration with strong base	02 hrs
7	**Biochemical calculation** Preparation of solutions and buffers (Normality, Morality, molality, parts per million - ppm, weight by volume - w/v, volume by volume - v/v, percent - %, atomic weight, molecular weight, equivalent weight) Preparation of dilute solution from given stock solution (concentrated saline citrate, dilute saline citrate, normal/standard saline citrate)	04 hrs
8	To study different conformation of biomolecules using models	02 hrs
9	Organic preparations – Pthalimide, Methyl Salicylate	02 hrs
10	Sonometer	02 hrs
11	Inorganic preparations – Hexamine Nickel (II) chloride	02 hrs

B. Sc. Part I Semester – I

UG HM - T104 : Fundamentals of Biosciences - Botany and Zoology

3-Credits-60-h

Unit I	**12 Hrs**	**Introduction to plant world and classification (Plant Diversity)** ➢ General and unique features of plants ➢ Principles, aims, objectives and outline of plant classification with examples ➢ A general account of different groups and their characters with one example each of o Thallophytes (Algae, Fungi and Lichens) o Bryophytes o Pteridophytes o Gymnosperms o Angiosperms (Dicot and Monocot)
Unit II	**18 Hrs**	**Structure and organization of plant body** ➢ Structure of plant cell, characteristic feature and cell wall ➢ Morphology & modifications of plant organs o Vegetative plant organs – Stem, Leaf and Root o Reproductive plant organs – Flower and Types of Inflorescence ➢ Plant tissues and tissue systems o Meristematic tissue and its type o Permanent tissue - Simple and Complex ➢ Primary structure of shoot, root & leaf ➢ Secondary growth, growth rings formation: cambium and its activities, periderm- cork cambium, secondary cortex and cork
Unit III	**20 Hrs**	**Introduction to Kingdom Animalia** ➢ Outline classification of non-chordates with examples o General characters and classification up to classes of phylum Porifera, Cnidaria, Platyhelminthes, Nemathelminthes, Annelida, Arthropoda, Mollusca, Echinodermata and Hemicordata ➢ Outline classification of chordates with examples o General characters and classification up to classes of phylum Protochordates, Agnatha, Pisces, Amphibia, Reptiles, Aves and Mammals
Unit IV	**10 Hrs**	**Animal Tissues (Histology)** ➢ Structure, location, classification and functions of animal tissues o epithelial tissue o connective tissue o muscular tissue o nervous tissue ➢ Bone and Cartilage - structure and types

UG HM - P104: Practical in Biosciences – Botany and Zoology

30 hrs.

1	Study of - Thallophytes (Algae, Fungi and Lichens), Bryophytes, Pteridophytes, Gymnosperms with one example each	04 hrs.
2	Study of morphological parameters of Angiosperms (Dicot and Monocot	03 hrs.
3	Study on anatomy of root, stem, leaf of monocot and dicot plants	04 hrs.
4	Study of Paramecium – morphology, reproduction, binary fission, conjugation	04 hrs.
5	Study of phylum – Porifera, Cnidaria, Platyhelminthes, Nemathelminthes, Annelida, Arthropoda, Mollusca, Echinodermata, Protochordates, Agnatha, Pisces, Amphibia, Reptiles, Aves and Mammals with one example each (specimen)	10 hrs
6	Study of Drosophila: characters, sexual dimorphism – eye & wing mutations, life cycle, culturing of Drosophila	03 hrs
7	Staining of Animal and Plant Cells	02 hrs

B. Sc. Part I Semester – I

UG HM - T105: Basics of bacteriology, Virology & Rickettsiology

3-Credits-60-h

Unit I	**20 Hrs**	**Bacteriology** Types of bacteria as per their carbon and energy requirements (nutritional classification), advanced classification of bacteria with example using G + C content, DNA –RNA hybridisation, 16 S rRNA gene sequencing & fatty acid lipid profile
Unit II	**20 Hrs**	**Virology** Discovery, nature of viruses, types of viruses, outline classification with example, structure of viruses • **Bacteriophages** -T4 cycle & cultivation (Coliphages) • **Animal Viruses** – Types, cultivation, AIDS, Swine Flu, Dengue, Corona viruses – Life cycle & control • **Plant viruses** – Outline classification with examples, life cycle, and control mechanisms. • Applications of viral genomes in biotechnology, microbiology & Environmental sciences • Viroids, prion and virusoides
Unit III	**20 Hrs**	**Rickettsiology** Unique features of Rickettsia, Outline Classification, cultivation, significance, control measures Vaccines in Rickettsial infections *Coxiella burnetii*, *Chlamydia & Mycoplasmas* – General characteristics & significance

UG HM - P105: Practical in Basics of bacteriology, Virology & Rickettsiology

30 hrs.

1	Isolation of pigment producing yeast / bacteria from nature	06 hrs.
2	Isolation & cultivation of autotrophs and heterotrophs	06 hrs.
3	Isolation & titration of bacteriophages (Coliphages) from sewage	06 hrs.
4	Inoculation of Viruses - Egg inoculation technique & cultivation of viruses	06 hrs.
5	Animal viruses - AIDS, Swine Flu, Dengue, Corona, Chikungunia (chart/ animation)	02 hrs
6	Plant Viruses - TMV / Leaf curl virus (chart/ animation)	02 hrs
7	Rickettsia- life cycle study (Photos / Demonstration/ Charts/ Digital/ Animation)	02 hrs

B. Sc. Part I Semester – I

UG HM - T106: Fundamentals of Mycology, Phycology & Protozoology

3-Credits-60-h

Unit I	**20 Hrs**	**Mycology – Yeasts and molds** - Outline classification, characteristics, structure and reproduction - Cultivation of yeasts and molds - Life cycle of yeasts and molds - Biological and economic importance - Important features and significance of slime molds, myxomycetes, mycorrhiza and mushrooms
Unit II	**20 Hrs**	**Phycology – Algae** - Outline classification, morphological characteristics, cultivation, reproduction and significance - Characteristics of algae, pigments, major groups – an overview - Biological, medical and economic importance of algae - Differences between algae and cyanobacteria - Examples of toxic algal forms in drinking water
Unit III	**20 Hrs**	**Protozoology – Protozoa** - Outline classification, morphological characteristics, cultivation, reproduction and significance - Major categories of protozoa based on motility and reproduction - Medically important protozoa - Life cycle of *Entamoeba histolytica*

UG HM - P106: Practical Fundamentals of Mycology, Phycology & Protozoology

30 hrs.

1	Isolation and cultivation of algae/ cyanobacteria [Spirulina/Chlorella/Scytonemia]	06 hrs.
2	SCP – Extraction from Spirulina/ Study of mushroom/ Study of lichens	06 hrs.
3	Isolation & titration of bacteriophages (Coliphages) from sewage	06 hrs.
4	Isolation of wine yeasts from spoiled pomegranate and preparation of wine	06 hrs.
5	Isolation and cultivation of *Aspergillus niger* [from onion]/ *Penicillium*/ *Mucor*/ *Rhizopus*/ *Fusarium spp.* from soil	02 hrs
6	Plant Viruses - TMV / Leaf curl virus (chart/ animation)	02 hrs
7	Detection, isolation [single cell isolation technique] and cultivation of protozoa from water bodies, [Zooplanktons/ Paramecium/Amoeba/Euglena/ Vorticella studies from water]	02 hrs

B. Sc. Part I Semester – I

UG HM - T107: Introduction to the world of amazing microorganism

3-Credits-60-h

Unit I	**3 Hrs**	Autotrophic microorganisms- occurrence, characteristics, mechanism, energetics, significance & examples; Biocorrosion and Bioleaching (*Thiobacillus*)
Unit II	**6 Hrs**	Bioluminescent forms- Luminescence in nature, bioluminescence, bioluminescent bacteria & fungi- characteristics, occurrence, mechanism, energetics & significance in nature
Unit III	**6 Hrs**	Magnetostatic forms- Magnetotactic bacteria occurrence, mechanism, mechanism of magnet axis, their role in detection of exotic (in space) life, significance in nature; Astrobiology (introduction to space environment and space microbiology)
Unit IV	**6 Hrs**	Extremophiles- Psychrophiles, acidophiles, xerophiles, barophiles, halophiles, radiophiles, thermophiles, basophiles, piezophiles, osmophiles - occurrence, characteristics, mechanism of survival, energetics, significance & examples
Unit V	**6 Hrs**	Bdellovibrio forms- examples, occurrence, characteristics, nature of parasitism, hmechanism & significance
Unit VI	**6 Hrs**	Bacteria visible by naked eye (largest bacteria) - examples, occurrence & significance
Unit VII	**6 Hrs**	Obligate intracellular parasitic microorganisms - examples - *Rickettsia*, viruses- (animal viruses, plant viruses, bacterial viruses)
Unit-VIII	**6 Hrs**	Actinomycetes & Myxobacteria
Unit-IX	**6 Hrs**	Unculturable Microorganisms (metagenomic study) - *Mycobacterium leprae* - The organism not following Koch's postulates, their significance in nature
Unit-X	**3 Hrs**	Nitrogen fixing bacteria in nature, examples, mechanism and significance
Unit XI	**6 Hrs**	Aromatic Compounds, plastic, Cyanide degrading microorganism – *Pseudomonas putida* (Anand Chakravorty)

UG HM - P107: Practical Introduction to the world of amazing microorganism

30 hrs.

1	Isolation, cultivation & characterization of bioluminescent bacteria	06 hrs.
2	Isolation, cultivation & characterization of Magnetotactic bacteria (Optional)	06 hrs.
3	Isolation & cultivation of Actinomycetes/Myxobacteria	04 hrs.
4	Isolation, Cultivation and Characterization of Bdellovibrio forms	06 hrs.
5	Isolation of bacteria degrading microplastic/ aromatic compounds/ cyanide	02 hrs
6	Isolation of *Azotobacter*/*Rhizobium* (Optional)	02 hrs
7	Isolation cultivation & characterization of Extremophiles – Psychrophiles/ Thermophiles/ Barophiles/ radiophiles/ basophiles/ acidophiles/ xerophiles/ piezophiles/ halophiles/ osmophiles	02 hrs
8	Slide of *Mycobacterium leprae*- acid fast stains, demonstration (Optional)	02 hrs

B. Sc. Part I Semester – I

UG HM - T108: Basics Tools and Techniques in Microbiology, Biotechnology and Environmental Sciences
3-Credits-60-h

Unit I	12 Hrs	Safety in Life Sciences laboratory • Means of laboratory infections • Potentially hazardous procedures • Responsibility • Risk assessment • Restricted access • Safety equipments and measures • Immunization and medical records • Training of personnel • Laboratory procedures (SOPs) • Levels of containments
Unit II	12 Hrs	Microscopy A. Bright field microscopy: a. Electromagnetic spectrum of light b. Simple and compound microscope - working of and ray diagram; concepts of magnification, numerical aperture and resolving power. Types functions of - eyepieces and objectives; aberrations in lenses - spherical, chromatic, comma and astigmatism c. Phase contrast microscopy – mechanism and applications d. Fluorescence Microscopy – mechanism and applications e. Electron Microscopy – Basic principle, mechanism, TEM, SEM, STM and their applications - B. Dark field microscopy: Mechanism and applications
Unit III	4 Hrs	Chromatography – Paper and TLC, theory, instrument and applications
Unit IV	12 Hrs	Observation of cells: A. Stains and staining techniques a. Definition of Stain; Types of stains (Basic, Acidic and Neutral), Properties and role of Fixatives, Mordants, Decolourisers and Accentuators b. Staining procedures for bacteria – Monochrome (Simple) staining and Negative (Relief) staining c. Differential staining - Gram staining and Acid-fast staining – mechanism and procedure d. Special staining- mechanism and procedure - Capsule, Cell wall, Endospore, Flagella, Nuclear material, Lipid granules, metachromatic granules

		e. staining of animal and plant cells f. staining of algae, protozoa and fungi B. Unstained preparations – wet mount and hanging drop techniques of bacteria, yeasts, molds, algae and protozoa
Unit V	**20 Hrs**	**Control of Microorganisms** a. Definitions of frequently used terms – sterilization, disinfection, antiseptic, antisepsis, germicide, microbiostasis, sanitization, bacteriocide, Fungicide, viruside, sporicide, fundamentals of control, conditions influencing effectivity of antimicrobial agent, factors affecting death rate b. Physical agents used to control microorganisms – • Heat - Dry and Moist; Radiations-Ionizing (X-ray, gamma and cathode) and Non-ionizing (UV rays); filtration- depth filters and membrane filters (cellulose acetate and polycarbonate filters, plastic – Teflon and Nylon), low and high temperature, osmotic pressure, desiccation, Sound waves – Ultrasonication • Checking the efficacy of sterilization – biological and chemical indicators c. Chemical agents used to control microorganisms and their mode of action and applications– • Characteristics of an ideal disinfectant • Aldehydes, Halogens, Quaternary ammonium compounds, Phenol and Phenolics, peroxigens • Heavy metals (Cu, Hg, Ag), alcohols, dyes, surface active agents, detergents, gaseous agents – ethylene oxide, beta propiolactone, formaldehyde, glutardaldehyde, clorhexidine and benzolkonium chloride • Checking efficiency of disinfectant – phenol coefficient (Rideal-Walker method) • Chemotherapeutic agents (enlist) and their site of action

UG HM - P108: Practical Basics Tools and Techniques in Microbiology, Biotechnology and Environmental Sciences

30 hrs.

1	a) Safety measures and good laboratory practices in the laboratory b) Preparation of SOPs for the instruments c) Introduction and use of common laboratory glass wares	05 hrs.
2	Construction, working and care of compound microscope	04 hrs.
3	Basic staining techniques- Monochrome, Negative and Gram's staining, Acid-fast staining (demo slide)	10 hrs.
4	Special staining techniques- Endospore, Capsule, Lipid granules, Nuclear material, Metachromatic granules, Flagella	11 hrs.

B. Sc. Part I Semester – I

UG HM - T109SECC: Yoga and Meditation

3-Credits-15-h

Unit I	3 Hrs	Introduction, Meaning, definition, Objectives; Introduction to Ashtangyoga; Performing Yogabhyasa
Unit II	**2 Hrs**	**Suryanamaskar:** Introduction, Postures, Benefits and practice
Unit III	**7 Hrs**	**Asanas** Vajrasan, Padmasan, Vakrasan, UttanPadmasan, Pawanmuktasan, Shavasan, Bhujangasan, Shalabhasan, Makrasan, Tadasan, Verasan, Ardhachakrasan- Introduction, Postures, Benefits and practice.
Unit IV	**3 Hrs**	**Pranayamanas** AnulomVilom, Bhramari, Kapalbhati and Bhasrika; Omkar Sadhana, Prayer and Guruvandana
Unit V	**2 Hrs**	**Using a Dictionary**: Definition of the dictionary, types of dictionaries, information in the dictionary, use of a dictionary
Unit VI	**2 Hrs**	**Use of good English**: Noun, pronoun, adjective, verb, adverb, conjunction, preposition, interjection, the article, tenses, spelling, use, and misuse of words, abbreviations, active and passive voice, punctuation, remove 'too'.
Unit VII	**2 Hrs**	**Phonology**: Pronunciation of vowels and consonants in English
Unit VIII	**1 Hrs**	Public speaking in English and oral presentation in English.

B. Sc. Part I Semester – I

UG HM - T110SECC: Spoken English

3-Credits-15-h

Unit I	**1 Hr**	**Language:** English as a foreign language
Unit II	**3 Hrs**	**Writing English**: Sentence structure, Essay composition, Summary writing, precise writing and comprehension
Unit III	**2 Hrs**	**Reading English**: Importance of reading, the process, and mechanics of reading, Intensive and extensive reading: Rapid reading, making notes as you read, writing book review.
Unit IV	**2 Hrs**	**Use of Vocabulary**: Meaning of words, precise usages, synonyms and antonyms, technical terms, context, superfluous words
Unit V	**2 Hrs**	**Using a Dictionary**: Definition of the dictionary, types of dictionaries, information in the dictionary, use of a dictionary
Unit VI	**2 Hrs**	**Use of good English**: Noun, pronoun, adjective, verb, adverb, conjunction, preposition, interjection, the article, tenses, spelling, use, and misuse of words, abbreviations, active and passive voice, punctuation, remove 'too'.
Unit VII	**2 Hrs**	**Phonology**: Pronunciation of vowels and consonants in English
Unit VIII	**1 Hrs**	Public speaking in English and oral presentation in English.

F.Y. B.Sc. Semester II

UG HM – T201: Fundamentals of Cell Biology & Physiology

Unit I	**3 Hrs**	**Introduction to cell:** Discovery of cell, cell theory – Definition, three assumptions of cell theory, exceptions, organismal theory, protoplasm theory.
Unit II	**4 Hrs**	**Organization of Prokaryotic cells :** size (Micrometry), shape & arrangement of bacterial cells, Structure of typical bacterial cells, Structure & functions of cell wall & cell membrane (Fluid Mosaic Model), composition & functions of capsule, slime layer, flagella, Pili, fimbriae, Cytoplasmic matrics – inclusion bodies, magnetosomes, ribosomes, gas vacuoles, metachromatic granules, Carboxysomes, PHB granules, endospores, Nucleoid & plasmids
Unit III	**12 Hrs**	**Eukaryotic cell structure** – Micrometry (Plant & animal cell), Overview of ▪ eukaryotic cell structure, plasma membrane & membrane structure. Cytoplasmic matrix, microfilaments, intermediate filaments & microtubules ▪ **Organelles of biosynthesis** – Secretary & endocytic pathways – Endoplasmic Reticulum & Golgi apparatus, Definition of Lysosome, Endocytosis, phagocytosis, autophagy & proteosome ▪ Eukaryotic Ribosomes, Peroxisomes, Mitochondria, Chloroplast (plastids), Nucleus (Introduction, morphology, occurrence, shape, size, number, position, ultra structure of nucleus, nuclear membrane, nucleoplasma, nucleopore complex, nucleolus, chromosomes – euchromatin & hetero chromatin chromosome number, size, general structure & nomenclature, organization of nucleus, specialized chromosomes - polytene & lampbrush) ▪ External cell covering – Cilia & flagella ▪ Comparison of prokaryotic & eukaryotic cells
Unit IV	**10 Hrs**	**Cell membrane & membrane transport :** Types of membrane transport – Passive transports – simple diffusion, facilitated diffusion, osmosis, Active transport – Primary & secondary transport, Na –pump, Na+ - K+ ATPase pump, bulk transport, endocytosis & exocytosis.
Unit V	**5 Hrs**	**Cell cycle** Introduction, phases & check prints – cell division in microorganism & plant, animals (Mitosis & Meiosis) – G_0, G_1, G_2 & M phases & significance
Unit VI	**10 Hrs**	**Cell Signalling** Signalling molecules, Signalling receptors (cell surface receptors), =autocrine, syncrine & paracrine signalling G-protein signalling & calcium signalling, membrane junctions
Unit VII	**6 Hrs**	**Cell death** Aging, Theories of aging, apoptosis & necrosis, neoplasia, autophagy, ferroptosis & pyroptosis
Unit VIII	**10 Hrs**	Diseases associated with lysosomes (Tay Sachs disease), Peroxysomes (Zell Wager syndrome), Mitochondria (Leber Hereditary Optic Neuropathy -LHON & Mitochondrial encephalomyopathy, lactic acidosis and stroke-like episodes - MELAS)

UG HM – P201: Practical related to paper Fundamentals of Cell Biology & Physiology

30 hrs

1	Study of prokaryotic cell structure and study of electron micrographs of all important cell organelles	**5 h**
2	Study of eukaryotic cell structure and study of electron micrographs of all important cell organelles	**5 h**
3	Micrometry- measurement of cell size taking different types of cell	**2 h**
4	Staining and observation of human cheek epithelial cells	**2 h**
5	Isolation and characterization of the following subcellular components using appropriate sample by differential centrifugation - nuclei (staining and counting), mitochondria (succinate dihydrogenase assay), Chloroplast (microscopic observation), lysosome (Acid phosphatase assay)	**6 h**
6	Methods of cell lysis and confirmation	**2 h**
7	Study of different stages of mitosis	**2 h**
8	Study of effects of colchicine on mitosis	**2 h**
9	Study of different stages of meiosis in *Tradescantia*	**2 h**
10	Study of polytene chromosomes (Drosophilla/Chironomous larvae)	**2 h**

B. Sc. Part I Semester II Biotechnology/Microbiology

UG HM T202: Fundamentals of Biochemistry and Biomolecules – I

Unit I	**3 Hrs**	**Historical perspective** Origin of life with respect to abiotic production of biomolecules, cellular and chemical foundation of life- an overview
Unit II	**13 Hrs**	**Chemical foundation-(Overview)** a) Biomolecules as compounds of carbon with variety of functional groups b) Universal set of small molecules, macromolecules as the major constituents of cells: configuration and conformation with definitions and suitable example only, Types of stereoisomers and importance of stereoisomers in biology, types of bonds and their importance - electrovalent, covalent, ester, phosphodiester, thioester, peptide and glycosidic bonds
Unit III	**4 Hrs**	**Water** - properties of water, hydrogen bonding, structure ionization, interactions of biological molecules in water, osmosis, concept of pH and buffers, Buffering system in living cells
Unit IV	**20 Hrs**	**Carbohydrates** Definition, classification, biological role, structure, sugars and non-sugars, Monosaccharides- families of monosaccharides- aldoses, ketoses, trioses, tetraoses, pentoses and hexoses Definition, classification and brief account of monosaccharides (based on aldehyde and ketone groups), D and L configuration, mutarotation, epimers, anomers, chemical and physical, properties, glycosidic bond- properties and reaction of glucose and fructose-isomerism, oxidation and reduction, esterification and glycoside formation, osazone- structure of ribose, deoxyribose, glucose, galactose and fructose **Oligosaccharides and disaccharides-** concept of reducing non-reducing sugars, glycosides bonds, structure of lactose, sucrose, maltose, cellobiose, inversion of sugars **Polysaccharides**- its classification based on function- storage polysaccharides, homopolymers - starch and glycogens, heteropolymere - inuline, Structural polysaccharides- cellulose and chitin, peptidoglycan –functions of carbohydrates
Unit V	**20 Hrs**	**Lipids :** Blur's Classification, Storage and Structural lipids, Simple lipids (Triacylglycerol and waxes), Compound and complex lipids, phospholipids – phosphatydyl colin, ethanol amine, glycerolipids, sphingolipids, glycolipids, sterols, derived lipids, sphingomyline, cetebrosides, gangliosides, lipoproteins - LDL,VLDL,HDL; Lysosome Chylomicrones **Fatty acids** – nomenclature structure and properties (up to C18), Properties of lipids - Physical properties (state, colour, odour, melting point, solubility, specific gravity, geometric isomerism, emulsification and surface tension), Chemical properties (SAP value, Acid value, iodine number, rancidity), Functions of lipids

UG HM P202: Basics of Biochemistry – Biomolecules - I

30 hrs

1	Biochemical calculations - preparation of solutions and buffers (pKa values) – w/v, v/v, %, ppm, ppb, mg/L, normality, molarity, molality	**3 h**
2	Study of colorimetry and preparation of standard graph and calculation of λ_{max} for given samples (Tyrosine/ purines/ pyrimidines), Verification of be Beer-Lambert law by using Ammonium Copper compound, identification of purines from λ_{max}	**3 h**
3	Isolation and identification of Starch from plant source	**2 h**
4	Saponification number - To find out saponification number of given lipid	**3 h**
5	Qualitative analysis for sugars and lipids	**2 h**
6	To estimate concentration of reducing sugar by DNSA method	**3 h**
7	To estimate concentration of Cholesterol in given sample (Iron reagent)	**2 h**
8	To separate and identify sugars by paper chromatography/ TLC	**2 h**
9	Detection of unknown carbohydrate from mixture (glucose, fructose, maltose, xylose, starch and sucrose)	**2 h**
10	To estimate reducing sugar from apple juice by Benedicts methods/Molish Test	**2 h**
11	Validation of glass pipettes and balance	**2 h**
12	Standardization of solution (0.25 N $K_2Cr_2O_7$) using 0.1 N ferrous ammonium sulphate and ferroin indicator	**2 h**
13	Determination of pH of different food samples by using pH paper/ universal pH standards	**2 h**

B. Sc. Part I Semester II

UG HM – T203: Basics of Biochemistry-Biomolecules - II

Unit I	**20 Hrs**	**Proteins:** i) Amino acids as building blocks of proteins, classifications of common amino acids (by R groups), uncommon amino acids and their functions, chemistry of amino acids, ionization of amino acid side chains, configuration, zwitterions, reactions of amino acids, titration of amino acids, isoelectric pH, reaction with Ninhydrin, Sanger reaction ii) Peptides and proteins:oligopeptides- structure and function of naturally occurring glutathione, insulin and synthetic aspartem Protein structure: importance of amino acid sequence; primary structures and concepts of N & C terminal, peptide bond formation, characteristics of peptide bonds; Secondary structures: Ramchandran Plot, alpha helix and beta sheets, secondary repeats; tertiary and quaternary structure of protein (Haemoglobin), forces holding the polypeptides together - hydrogen bonds, Vanderwaals forces, covalent, ionic bonds and salt linkages; Protein denaturation and renaturation; Classification of protein shape, structural, transport, chromosomal, phospho and glyco proteins and the biological role of proteins.
Unit II	**10 Hrs**	**Nucleic acids:** Occurrence, purines, pyrimidines, Pentoses (Ribose and Deoxyribose) phosphates, AMP and cAMP, ADP and ATP, TDP and TTP, GDP and GTP, NDA, NADP, FMN and FAD; Polynucleotides, covalent structure of DNA (different forms of DNA) and RNA (mRNA, tRNA, rRNA and SnRNA); Forces stabilizing nucleic acid structures, N-β glyosidic bonds, Phosphodiester bonds, Properties of nucleic acids, denaturation and renaturation, Watson and Crick's model of DNA structure, ribozyme, Biological role of nucleic acids
Unit III	**10 Hrs**	**Vitamins:** Occurrence and sources, rich sources of different Vitamins, classification, structure & biochemical functions of water soluble vitamins;Role as coenzymes: Thiamine, Riboflavin, Niacin, Pyridoxine, Pantothenic acid, Coenzyme A, Lypoic acid, Folic acid and B12; functions and deficiency symptoms
Unit IV	**5 Hrs**	**Minerals:** Role of Na, K, Mg,Fe, Zn, Co, Ca, P and I in physiology, general electronic configuration and their shape and significance in metalloenzymes
Unit V	**10 Hrs**	**Enzymes :** Definition, structure and concept of Apoenzyme, Coezyme, Cofactor Prosthetic group, Active site, Types of enzyme, Extracellular and intracellular, Constitutive and inducible, general overviews of enzyme-substrate reaction, mechanism of enzyme action, factors affecting enzyme reactions
Unit VI	**5 Hrs**	**Plant Pigments and Dyes:** Chlorophyll, Xanthophylls, Flavonids, Carotenes, etc.

UG HM – P203 Practical: Basics of Biochemistry-Biomolecules - II

30 hrs

1	Estimation of concentration of protein by Biuret method and Lowry method (Albumin)	**2 h**
2	Study of melting temperature of nucleic acid- to determine T_m of DNA and mole percent G+C content	**2 h**
3	To separate amino acid by TLC	**2 h**
4	To study amylase enzyme assay- and to study effects of pH, temperature, concentration of enzyme, activators and inhibitors	**2 h**
5	General tests for amino acids and detection of unknown amino acid from mixture (Arginine, cysteine, metheoinin. Tyrosine, histidine, proline and tryptophan)	**2 h**
6	Isolation and characterization casein from milk by Isoelectric pH method	**2 h**
7	Estimation of DNA by DPA and RNA by Orcinol methods	**2 h**
8	Preparation of titration curve of acidic, basic and neutral amino acids	**2 h**
9	Quantitative estimation of ascorbic acid	**2 h**
10	Bioassay of Vitamin B12	**2 h**
11	Separation of pigment and dyes by adsorption and ion exchange chromatography	**2 h**
12	Extraction of genomic DNA from onion/yeast/ rat liver/ bacteria and confirmation with DPA and agarose gel electrophoresis	**2 h**
13	Study of karyotype analysis (karyotyping)	**2 h**
14	Detection of significant industrial enzymes (amylase, protease, lipase, invertase, phosphatase and cellulase)	**2 h**
15	Enzymatic preparation of biomolecules - Dextrin- production of maltodextrin by using β amylase Glucose- Productive of glucose by bacterial α- amylase and amyloglucosidase Production of invert sugar by invertase Peptide preparation of proteolysis by using papain Softening of Chhole/Rajma/ Idli by using papain	**2 h**

B. Sc. Part I Semester II

UG HM T204: Microbial Nutrition, Growth and Bioenergetics

Unit I	**20 Hrs**	**Chemical composition of microbial cell** • Nutritional requirements: Carbon, Oxygen and Hydrogen, Nitrogen, Sulphur and Phosphorous, Minerals, growth factors and energy source -auxotroph, prototroph and fastidious microorganisms • Classification/categories of microorganisms • Microbial Nutrition, Cultivation and Isolation and Preservation • Design and preparation of culture media, Types of culture media - liquid and solid media, synthetic/ chemically defined media, semisynthetic complex non synthetic media, anaerobic growth media, selective and deferential media, indicator media, transport media; enrichment, isolation and pure culture techniques for microorganisms • Methods of purification of microorganisms - streak plate, spread plate, pour plate techniques, single cell isolation technique • Preservation of microbial cultures – slants, slants + mineral oil overlay, butt method (stabs), cryopreservation, freeze drying method (ampoules)
Unit II	**5 Hrs**	**Overviews of culture collection centres and their role:** Requirements and guidelines of National Biodiversity Authority (NBA) for culture collection centres
Unit III	**20 Hrs**	**Microbial growth:** Inoculation techniques and study of growth - Inoculation of liquid medium (broth), Solid media (slants, butts and plates), Study of colony characteristics of pigment and pigment non producing bacteria, Study of motility- hanging drop preparation and sloppy agar method, Kinetics of bacterial growth (exponential growth model), phases of growth, Growth curve - generation time, continuous (exponential), Chemostat, diauxic and synchronous growth Measurement of microbial growth methods of enumeration a) Microscopic methods (Direct microscopic count, haemocytometry method), counting cells using improved Neubauer-Petroft-Hosser's chamber b) Plate count (serial dilution technique) - total viable count/SPC/Breed's smear count, membrane filtration technique c) Turbidometric method- Nephelometry/ Electronic counter method (Coulter counter) Tetrazolium chloride method d) Brown's opacity tube method/MBRT and Resazurine estimation of biomass (dry mass packed cell volume) e) Chemical methods- Cell carbon and nitrogen estimation Determination of optimum growth conditions – pH, temperature, solute concentration (salt, sugars), heavy methods and incubation period
Unit IV	**5 Hrs**	**Microbial growth in natural environments:** Soil, Water, Food, Animal and Plant body, Microbial Parasites) Methods for cultivation of photosynthetic, extremophilic and chemolithotropic (chemoorganotrops) bacteria, anaerobic bacteria, algae, fungi (yeast and molds), protozoa, actinomycetes and viruses
Unit V	**10 Hrs**	**Bioenergetics**: Principle of bioenergetics, Role of ATP in metabolism, reducing power and its significance in metabolism, generation of ATP through substrate level phosphorylation, components of electrons transport chain (ETC)- Flavoproteins

		(FMN, FAD), Quinines (Ubiquinones, Menaquinons), Iron sulphur proteins, cytochromes - generation of ATP through ETC

UG HM P204: Practical: Microbial Nutrition, Growth and Bioenergetics

30 hrs

Sr. No.	Practical	Hours
1	Introduction & use of common laboratory glasswares / labwares – testtubes, culture tubes, suspension tube, screw capped tubes, Petriplate, Pipettes (Mohr & serological) Micropipettes,, Pasteur pipettes, Erleyer meyar flasks, Volumetric flasks, Glass spreaders, Durham's tubes, Cragie's tube & inoculating needle (wire loops, Stab needles)	**2 h**
2	Learning basic techniques in Microbiology – Wrapping of glasswares, cotton plugging, cleaning & washing of glassware, biological waste disposal	**1 h**
3	Preparation of simple laboratory media - nutrient agar, broth, Mac-Conkey's agar, Manitol salt agar, Peptone water, Sabouraud's agar & their sterilization, checking of sterilization efficacy of autoclave using biological indicator (*Bacillus stearothermophillus*)	**2 h**
4	Study of motility by hanging drop method and study of swarming phenomenon on sloppy agar medium	**1 h**
5	Preparation of Winogradsky's column & observation of different types of microorganisms using bright field microscope	**1 h**
6	Pure culture techniques – Streak, spread, pour plate methods & study of colony characteristics	**2 h**
7	Isolation, colony characteristics, gram staining, motility of following bacteria – *E. coli, Bacillus spp. Staphylococcus spp., Micrococcus spp.*, pigment & pigment non producing microorganisms	**1 h**
8	Wet mount and slide preparation for algae, fungi & protozoa using sample sources for Amoeba spp., Paramecium spp., Nostoc, Chlorella, Aspergillus, Mucor & Penicillium, Fusarium, *Rhizopus spp*.	**2 h**
9	Inoculation techniques & study of growth in liquid broth media, solid media, slants, butts & plates, coverslip & slide culture techniques for actinomycetes	**1 h**
10	Effect of environmental factors on growth of bacteria (*E. coli*, *Staphylococcus aureus*) - pH, temperature, salt concentration, heavy metals (oligodynamic action)	**1 h**
11	Study of normal flora of skin – observing & cultivating different morphoforms of microorganisms from skin & effect of washing of skin with soap & disinfectant on microflora	**2 h**
12	Preservation of culture on slants, in soil & on grain surfaces, butts, vials/ampoules/lyophils & revival of these cultures & lyophils	**2 h**
13	Enrichment, isolation & morphological studies of – Chemoautotrophs, Chemoorganotrops , Photoautotrophs, Photoorganotrops (one member each)	**2 h**
14	Study of growth curve, continuous growth / diauxic / synchronous growth	**2 h**
15	Measurement of bacteria by Direct Microscopic Count (DMC), Slide / Neubauer's chamber, direct plating (SPC) , Indirect – Nephalometery / Brown's opacity tube / MBRT	**2 h**
16	Estimation of ATP generation	**2 h**
17	Cultivation of anaerobic bacteria from natural sources	**2 h**

B. Sc. Part I Semester II
UG HM -T205 Advanced Chemistry, Physics & Biophysics for Biologists

Unit	Hours	Topics
Unit I	**5**	**Chemistry of transition & non transition elements** ❖ Transition elements – General properties (d & f block elements), electronic configuration, oxidation state, magnetic movement & complexes of 3d & lanthanide elements ❖ Non – transition elements – General properties (s & p block elements); synthesis, properties & structure of halides & oxides of Carbon, silicon & Nobel gas compounds
Unit II	**4**	**Colloidal state** Colloidal system, classification & size range of colloids, preparation & purification of colloidal solutions, general properties of colloidal system, some properties of hydrophobic colloidal system (electrical & electrokinetics), Surfactants, emulsions, Gels, importance & applications of colloids
Unit III	**7**	**Electrochemistry** – Introduction, electrochemical cell, cell constant, half cell & potential reaction, reduction potential, transport number, conductance, Kohlrausch law, electrochemical series, thermodynamics, potential function from cell, potential measurement & it's applications, Emf, Nernst's equation, Galvanic cells, Liquid – junction potential, Huckel theory, over voltage / over potential Bioelectricity – Introduction, electricity observed in living system – examples, origin of bioelectricity, resting potential & action potential, conduction velocity, pace maker, ECG, EEG, EMG, EOG
Unit IV	**4**	**Name reactions** – Introduction, Mannich reaction, Hoffmann reaction, Diels – Alder reaction, Perken's reaction, Meerwein – Ponndorf – Verley (MPV) reduction
Unit V	**3**	**Elasticity** – Basic concept of stress & strain in solids, Hook's law, stress, strain curve, properties of fluids
Unit VI	**3**	**Thermometry** – Principles of thermometry, concept of temperature & it's measurement, Thermal energy, Platinum resistant thermometer, thermocouple, thermisters as thermometer
Unit VII	**6**	**Conventional & non- conventional energy sources & devices** – Introduction various types of conventional & non-conventional energy sources – Solar energy, direct use of solar energy – Silicon solar cells, principle of conversion of solar energy in to electricity & construction of solar cell (spectral distribution), efficacy, fill factor
Unit VIII	**4**	**Ideal & real gases** Ideal gas – Kinetic model, gas equation, kinetic interpretation of temperature, degree of freedom, equipartition of energy, real gas – deviation of behaviour of real gases from the ideal gases, critical constants of a gas (Pc, Vc & Tc), Vanderwaal's equation, liquification of gases.
Unit IX	**3**	**Current electricity** – Introduction, active & passive components, A. C., L-R, R-C, C-R circuits, half wave rectifier, full wave rectifier, bridge rectifier & transformers
Unit X	**4**	**Semiconductors** Introduction, definition & examples of conductor, semiconductor, insulator, intrinsic & extrinsic semiconductors, types of semiconductor diodes, Pn

		junction diode, Zener diode, Transistors – p-n-p & n-p-n transistors, common emitters & best circuits, light emitters diode (LED) and segment display, photodiode, optocoupler
Unit XI	**5**	**Optics** Introduction, interference, in parallel test thin films, wedge – shaped thin films, Newton's rings, Polorization of light & concept of optical activity, diffraction - types, diffraction – grating, experimental, determination of wavelength by diffraction grating, Lasers – properties, Lasers action, (energy level diagram), Concept of population inversion, optical pumping & Einstein's equation, Nicol's prism properties, Rubby laser
Unit XII	**3**	**Introduction to digital electronics** • Number system & logic gates • Small signal voltage amplifiers, number systems – decimal, binary, BCD, Basic logic gate, bit groupings, CoR, NoR, AND, NAND, NoT, DeMorgon's theorem, Half adder & full adder
Unit XIII	**3**	**Magnetism** Magnetic field, maghetism of earth, para, dia, ferro, nuclear & biomagnetism
Unit XIV	**4**	**Overview of green chemistry & synthesis** – Microwave assisted synthesis of organic compounds, retrosynthesis

UG HM -P205 Practical: Advanced Chemistry, Physics & Biophysics for Biologists

30 hrs

Sr. No.	Practical	Hours
1	Determination and adjustment of pH of solutions	**2 h**
2	Preparation of different buffer solutions	**2 h**
3	Determination of heat of solution of Benzoic acid / Salicylic acid by solubility measurements	**2 h**
4	Estimation of acetone by idometric titration method	**2 h**
5	Determination of conductivity of solutions	**3 h**
6	Determination of Optical activity by polorimeter	**3 h**
7	Study of depression in freezing point	**3 h**
8	Determination of dissociation constant of weak acid Study of substituent on dissociation constant of weak acid	**3 h**
9	Inorganic estimation of amount of magnesium from talcum powder by complexometric titration	**2 h**
10	Study of principle, working & construction of pH meter & conductivity meter	**2 h**
11	Demonstration of principle, working & construction of Refractometer, Laminar Air Flow	**4 h**
12	Purification of any two organic compound by recrystallization selecting suitable solvent	**2 h**

B. Sc. Part I Semester II

UG HM-T206 Applied Plant and Animal Sciences

Unit	Hours	Topics
Unit I	**10**	**Plant water relationship and its importance** Definition, significance and mechanism: i. Permeability; ii. Diffusion & imbibitions; iii. Osmosis & its types Relation between osmotic pressure (OP), turgor pressure (TP) and wall pressure (WP), Diffusion Pressure Deficit - DPD (Suction pressure) Absorption and Transport of water: Introduction and mechanism of Ascent of sap - transpiration and guttation, Translocation of mineral elements (Capillarity, Imbibition, Atmospheric pressure and Cohesion-tension)
Unit II	**4**	**Plant Metabolism:** Photosynthesis: - Photosynthesis pigments, concept of two photo systems, photophosphorylation, Calvin cycle, CAM (Crassulacean Acid Metabolism) plants, photorespiration, compensation point. Respiration: Mechanism - Glycolysis, Krebs's cycle and ETS Nitrogen metabolism- inorganic & molecular nitrogen fixation
Unit III	**4**	**Growth and development of plants :** Essential nutrients for Plant growth and their role Plant growth regulators Introduction to physiology of flowering: a) Photoperiodism b) Vernalisation Economic importance of plants: Cereals, Pulses, Oil seeds, Fiber plants, Medicinal Plants, Timber yielding, Beverages with examples
Unit IV	**10**	**Animal Physiology** Digestion: Structure and function of digestive glands; Digestion and absorption of carbohydrates, fats and proteins Respiratory: Physiology, External and internal Respiration, Transport of oxygen and carbon dioxide in blood, Factors affecting transport of gases. Functioning of Excitable Tissue (Nerve and Muscle) - Structure of neuron, Propagation of nerve impulse (myelinated and nonmyelinated nerve fibre); Structure of skeletal muscle, Mechanism of muscle contraction (sliding filament theory), Neuromuscular junction Endocrine and Reproductive Physiology - Structure and function of endocrine glands (pituitary, thyroid, parathyroid, pancreas, adrenal, ovaries, and testes), Brief account of spermatogenesis and oogenesis
Unit V	**3**	**Parasitology** Introduction to Host-parasite Relationship - Host, Definitive host, Intermediate host, Parasitism, Symbiosis, Commensalism Parasitic Protozoa: Life history and pathogenicity of *Plasmodium vivax* Parasitic Helminthes: Life history and pathogenicity of *Fasciola hepatica*, *Taenia solium*
Unit VI	**2**	**Economic Zoology** Vermiculture; Aquaculture; Sericulture and Apiculture
Unit VII	4	**Conventional & non- conventional energy sources & devices** Introduction - various types of conventional & non-conventional energy sources – Solar energy, direct use of solar energy – Silicon solar cells, principle of conversion of solar energy in to electricity & construction of solar cell (spectral distribution), efficacy, fill factor
Unit VIII	**4**	**Ideal & real gases** Ideal gas – Kinetic model, gas equation, kinetic interpretation of temperature, degree of freedom, equipartition of energy, real gas – deviation of behaviour of real gases from the ideal gases, critical constants of a gas (Pc, Vc & Tc),

		Vanderwaal's equation, liquification of gases.
Unit IX	3	Current electricity – Introduction, active & passive components, A. C., L-R, R-C, C-R circuits, half wave rectifier, full wave rectifier, bridge rectifier & transformers
Unit X	**4**	**Semiconductors** Introduction, definition & examples of conductor, semiconductor, insulator, intrinsic & extrinsic semiconductors, types of semiconductor diodes, Pn junction diode, Zener diode, Transistors – p-n-p & n-p-n transistors, common emitters & best circuits, light emitters diode (LED) and segment display, photodiode, optocoupler
Unit XI	**5**	**Optics** Introduction, interference, in parallel test thin films, wedge – shaped thin films, Newton's rings, Polorization of light & concept of optical activity, diffraction - types, diffraction – grating, experimental, determination of wavelength by diffraction grating, Lasers – properties, Lasers action, (energy level diagram), Concept of population inversion, optical pumping & Einstein's equation, Nicol's prism properties, Rubby laser
Unit XII	**3**	**Introduction to digital electronics** • Number system & logic gates • Small signal voltage amplifiers, number systems – decimal, binary, BCD, Basic logic gate, bit groupings, CoR, NoR, AND, NAND, NoT, DeMorgon's theorem, Half adder & full adder
Unit XIII	**3**	**Magnetism** Magnetic field, maghetism of earth, para, dia, ferro, nuclear & biomagnetism
Unit XIV	4	Overview of green chemistry & synthesis – Microwave assisted synthesis of organic compounds, retrosynthesis

UG HM -P206 Practical: Applied Plant and Animal Sciences

Sr. No.	Practical	Hours
1	Study the process of Osmosis and Turgor pressure and determination of Diffusion Pressure Deficit	**3 h**
2	Determination of rate of respiration	**3 h**
3	Estimation of chlorophyll content in photosynthesizing and non photosynthesizing leaf	**3 h**
4	Effect of plant growth regulators on germination of seeds	**4 h**
5	Studies on economically important plants: Students should prepare herbarium specimens with their uses	**3 h**
6	Study and dissection of Honey Bee , Mounting of Mouth parts, pollen basket, Antenna Cleaner, Sting Apparatus , legs and wings	**3 h**
7	Study of Plasmodium spp.	**3 h**
8	Study of Fasciola sp.	**3 h**
9	Enumeration of red blood cells using haemocytometer.	**3 h**
10	Collection, Classification and preservation of Insects - Drosophila	**2 h**

B. Sc. Part I Semester II

UG HM T207: Ecology, Ecosystem & Geosciences

Unit	Topics	Hours
Unit I	Fundamentals of ecology • Environments: definition, components – a) Atmosphere - origin, composition, structure, variables b) Hydrosphere – Characteristics, hydrological cycle, El Nino, La Nina c) Lithosphere – Formation, zonal structure, soil studies – origin, profile, properties, classification d) Biosphere – Characteristics & inter-relationships • Ecological spectrum & hierarchy, levels of organization, autecology, synecology, population, community, biomes & ecosystem ecology.	10
Unit II	Ecosystem structure & function – Concept of ecosystem, types of ecosystem structure – biotic & abiotic components, Macro & micro ecosystem Function – a) Food chain – Grazing, detritus b) Food web & ecosystem stability, Trophic levels c) Ecological energetics – Energy input / Energy flow (Single channel & Y shaped models) d) Productivity of ecosystem – Primary production (GPP & NPP), Secondary production, Standing crop (biomass) e) Ecological pyramids – Number, biomass & energy.	15
Unit III	Biogeochemical cycles – • Nutrient cycling – a) Gaseous cycle - Hydrological, Carbon, nitrogen, Oxygen b) Sedimentary cycle – Phosphorus, sulphur, Calcium & Magnesium • Ecosystem nutrient cycling modes – Intra – system cycling & extra system transfer – Nutrient inputs, biotic accumulation of nutrients, nutrient outputs	**10**
Unit IV	• Population ecology – Introduction, basic concept, population characteristics – size & density, dispersion (random, aggregate & uniform) nativity (potential & realized), fecundity, mortality (potential & realized), survival curve, age & sex structure, life table & viability analysis, concept of carrying capacity • Population growth – a) Growth curves exponential &logistic b) Population fluctuation c) Biotic potential & environmental resistance	**10**
Unit V	• Community ecology – Characteristics of commonly – Spices diversity, growth forms & structure, Dominance, succession, trophic structure, ecological Niche, ecotone & edge effect • Characters in community structure – Analytic (Qualitative& Quantitative) & synthetic • Inter – specific & intra – specific relationships • Concept of succession, causes of succession, basic types – primary, secondary, autogenic, allogeneic etc. • Mechanism of succession – Nudation, invasion, competition, Co-action & reaction, stabilisation (climax), models & succession – Hydrosere & lithosere	10
Unit VI	Threats to the environment & ecosystem	5

Practical P207: Ecology, Ecosystem & Geosciences

30 hrs

Sr. No.	Practical	Hours
1	Study of ecosystem (Aquatic, forest, river etc.)	4 h
2	Community sampling by quadrate methods for plants – Percentage of frequency, density, abundance, frequency class diagram & comparison with Raunkiaer's frequency chart, Simpson's index & dominance, Shannon diversity index	6 h
3	Measurement of primary productivity of grassland by harvest method	4 h
4	Determination of frequency, abundance (Line) & density (Belt) of spices across terrestrial – aquatic transitional zones	5 h
5	Case studies on ecological succession	3 h
6	Study of natural resources Forest / Mineral / Food / Water / Land	2 h
7	Study of ecological pyramids	2 h
8	Study of different food chains	2 h
9	Field visits	2 h

B. Sc. Part I Semester II

UG HM- T208 Basics of Environmental Pollution and Applied Microbiology & Biotechnology

Unit	Topics	Hours
Unit I	**Environmental Pollution & control**: Introduction, definitions, sources & types of pollution	**4**
Unit II	**Water pollution & microbiology:** Sources & classification of water pollution, different types of aquatic environments, water pollution parameters & their biological significance: ▪ Physical – Colour, odour, temperature, turbidity & density ▪ Chemical – Solids (suspended, total & dissolved, volatile), Hardness, acidity, alkalinity, pH, DO, ions (Fe, Cu, Mn, Na, K, Ca, N, P, F, Cl) ▪ Pollutants – Chemicals, pesticides & detergents ▪ Biological coliforms (faecal, streptococci), Organic matter (BOD, COD) & their significance as pollution indicators ▪ Thermal pollutants – Waste heat & it's uses, cooling ponds & towers, effect of thermal pollution on light & atmosphere ▪ Normal flora of water, sources of microorganisms in water, faecal pollution, most prominent waterborne pathogens, indicators of faecal pollution ▪ Water quality assays – routine bacteriological examination of water (SPC) test for coliforms ▪ Qualitative (preventive, confirmed & completed tests), IMViC test, Eijkman test, Quantitative – MPN, Membrane filter technique ▪ Treatment & purification (primary-physical, secondary-biological & tertiary-chemical) of municipal drinking water supply ▪ Eutrophication ▪ Groundwater & marine pollution.	**20**
Unit III	**Air pollution & aeromicrobiology** Compassion of air, types & classification of air pollutants, gaseous inorganic air pollutants – NO_x, SO_x, CO, CO_2, H_2S, NH_3 , O_3, CFC. ▪ Organic air pollutants – aliphatic & aromatic organic compounds, particulate matters, types & effects ▪ microbial pollutants – number & types of microorganisms in air, sources, infectious dust –droplets & droplets nuclei, microbiological examination of air – air samplers & samplings methods – solid impaction (sieve device) & liquid impingement – (bead bubbler device). ▪ Acid rain, photochemical SMOGs, London & LA SMOGs (mechanisms of formation) decrease of ozone layer (role of CFC's & control). ▪ Green house effects, instrumental analysis of SOx, NO_x,	**15**

	economic impact of air pollutant ▪ Effect of air pollution of human, plants, animals & atmospheric health	
Unit IV	Soil pollution & Microbiology: Definition, sources, role of pesticides in soil pollution. Soil types, types of microbes found in soil, role of microorganisms in soil fertility, soil pollution control measures.	**6**
Unit V	Noise pollution – Sources & types of noise, sonic boom, measurements of noise effects & control measures	4
Unit VI	Radiation pollution – Introduction, atomic radiations, effect of radiation, radioactive waste & disposal, radiation protection	4
Unit VII	Environmental toxicology – Definition, classification & concept. Pesticide toxicity (organic & inorganic), mode of action of toxicants of metals – arsenic, mercury, cadmium, lead, Nickel, Asbestos, chromium, organo phosphate, carbamates, etc., mutagens & carcinogens, Cyanide, Peroxy Acetyl Nitrate (PAN), dioxins. Bioconcentration, bioaccumulation, Biomagnification, potentiation & Synergism Control of toxic effect, biotransformation & excretion	4
Unit VIII	Energy – Renewable & Non-renewable energy sources, fossil fuels, CNG, Crude oil, Coal, fractional distillations of crude oil, bioethanol from sugary & starchy crops, petrocrops – rubber, Biodiesel (production, advantages & limitations)	3

Practical P208 Basics of Environmental Pollution and Applied Microbiology & Biotechnology

30 hrs

Sr. No.	Practical	Hours
1	Determination of temporary & permanent hardness of water	**2**
2	Estimation of COD & DO, BOD of polluted water samples	**2**
3	Determination of solid content of polluted water samples (SS, TS, DS, VS)	**2**
4	Routine bacteriological analysis of water – preventive, confirmed & completed test, MPN, Eijeckmen's Test	**2**
5	Bacteriological analysis of water - IMViC test	**2**
6	Study of degradation of pesticides using microorganisms	**2**
7	Enumeration of microorganisms from air by solid impaction & liquid impingement techniques	**2**
8	Study of effect of pesticides on azotobacter population by viable count method	**2**
9	Study of effect of heavy metals on growth of microorganisms	**2**
10	Estimation of noise by dB meter (L_{eq})	**2**
11	Determination of nitrate & phosphate content in polluted water	**2**
12	Determination of PM concentration using High Volume Air Sampler (HVS)	**2**
13	Determination of organic matter and carbon from given soil sample	**2**
14	Determination of chlorine demand for the potable water	**2**
15	Detection of radioactive material in fruits & vegetables	**2**

UG HM- T209 Spoken English II

Unit	Topics	Hours
Unit I	**Communication as part of science:** Language – a means of Communication; Communication – Meaning of Communication, Definitions; Principles of communications; Communication – Situation for and need of communication, Importance of communication Features, objectives and functions of communication, Communication cycle, Elements of Communication, Communication process, stages in Communication process	**5**
Unit II	**Types of Communications:** Formal **–** Informal, Verbal – Nonverbal, Vertical – Horizontal Diagonal	**2**
Unit III	**Principles of effective communication** Definitions of effective communication; Communication barriers and ways to overcome them; Developing effective messages – Knowledge about the audience, purpose of communication, structure of message, selecting the proper channel, avoiding barriers in communication, facilitating feedback.	**4**
Unit IV	**Non -Verbal Communication** Non – verbal codes: Body Language, chronemics and Artifacts	**1**
Unit V	**Illustrating with visuals**: Photographs, tables, graphs, flow charts, figures, maps, picture diagrams, pie diagrams, family tree.	1
Unit VI	**Formal written skills** i. Report writing: Seminar report, Conference report, Progress report, Investigative report, Accident report, Fall/rise in the Production, Joining report ii. Applications: Job Application with resume (C.V.), Sick leave application, Application for getting particular information (eg. prospectus / prescribed admission / scholarship form). iii. Business correspondence: Enquiry letter, Order letter, Complaint letter, Adjustment Letter iv. Office drafting: Circular, Notice, Memo, Defining and Describing object and Giving Instructions	2

UG HM- T210 Personality Development

Unit	Topics	Hours
Unit I	**Planning and Goal setting:** Five skills needed to achieve carrier goals: Human perceptions, Understanding people, types of soft skills, Types of soft skills, Need for achievement and Spiritual Intelligence, Developing potential and self actualization	**5**
Unit II	**Conflicts and stress:** Types of conflicts, conflict resolution skills, Types of stress, causes of stress, effects of stress and regulating the stress; Habits – Good and bad habits, Forming Habits of success, breaking bad habits.	**3**
Unit III	**Communication skills** Communication cycle advanced and essentials, Basic telephonic skills. Communication barriers- Interpersonal transactions, miscommunication Technology and Communication - Email- Principle, Netiquettes, E-mail etiquettes	**4**
Unit IV	**Presentation skills:** Overcoming fear, Becoming a professional, the role of body language, effective reading and using visuals.	**3**

UG HM – T211VAC: Introduction to Research Methodology – II

Unit- I	**Scientific Writing-** 1) Language as means of communication – English language 2) Scientific writing verses unscientific writing- Scientific writing in English language 3) Good English and grammar in scientific writing - Basic grammar, Tenses, Voices, Prepositions and Conjunctions, conditional sentences, count and non count nouns, concord and punctuations, use and misuse of words, jargons and avoiding jargons, use of abbreviations, accepted abbreviations and symbols, common error in the style and in spellings. 4) Scientific methods – Concept, hypothesis, theory, law, design of experiment, inductive & deductive reasoning. 5) General structure of scientific reports (types of scientific documents) – Journal articles, books, posters, conference, papers, thesis, review papers, books reviews, project & conference reports. 6) Writing a scientific papers – IMRAD/IRDAM acronym/ system, literature search, title, listening of authors & addresses, abstract, key words, introduction, material –method, result & discussion, summary & conclusion, references, stating the acknowledgement, tables/graphs/diagrams & illustrations 7) Structure of project – Title, author & their institution, abstract/ summary, certificates (students undertaking, guide certificate, plagiarism checker certificate, ethical clearance), acknowledgements, list of content, abbreviations, introduction, literature survey, aim & objectives, material & methods, results & discussion, conclusion/ recommendation, bibliography, annexure (list of chemicals, glasswares, reagents, media used with composition, paper publication etc.).	**15 hrs**

UG HM – P211VAC: Practical course Research methodology

30 hrs.

1	Writing suitable title of research papers, search of instruction s to authors from website of scientific journal (its analysis and comparison)	02 hrs.
2	Writing abstract for research paper	02 hrs.
3	Writing summary and conclusion for given scientific paper	
4	Writing a bibliography for given research paper	02 hrs.
5	Preparation of research paper for publication (may be on their research project)	08hrs.
6	Prepare a plagiarized and non plagiarized document (use of plagiarism checker)	03 hrs.

B. Sc. Part II Semester III

UGMBT – 301-CC Genetics Paper I (Prokaryotic & Eukaryotic and Environmental aspects)

3 Credits 60 hrs

Unit	Topics	Hours
Unit I	**1) Inheritance of characters & invariability (overview)** – Definitions – gene, genome, genotype, Pseudo genes, clusters, prototroph & auxotroph, phenotype, muton, recon, cistron, split genes (introns & exons), overlapping genes, mutagen, phenotypic & genotypic changes, allele, homozygous & heterozygous conditions. **2) Evolutionary genetics** – Theories of evolution – pre Darwinian theory of evolution, Darwin theory of evolution & modern evolutionary synthesis, Hardy Weinberg's law, genetic equilibrium, Changes in allelic frequencies – Mutation, migration, genetic drift, natural selection, coevolution, cooperation, speciation and molecular evolution	**4**
Unit II	**1) Mechanism of inheritance** – Mendelism – Mendel's experiments – Mendel's laws, law of segregation, independent assortment, concept of dominance, deviation from Mendel's law, partial or incomplete dominance, Codominance, epistasis, penetration & pleiotropism, expressivity, concept of alleles, multiple alleles, monohybrid, dihybrid ratio modifiers and suppressors (variety of gene expression) & trihybrid alleles ratio, test cross & backcross, dominant & recessive traits, Chi^2 analysis for monohybrid, dihybrid ratios, punnet's square (checker board) & branch diagram for determining ratios of genotypes & phenotypes, Gene linkage & recombination, discovery- linkage, partial linkage, interference & coincidence, mitotic crossing over in Drosophila, complementary & duplicate genes, tetrad analysis **2) Mechanism of sex determination** – sex linked inheritance – X chromosome inactivation (dosage compensation, Barr body) – X linkage in haemophilia, Y linkage – Holandric genes. **3) Concept of karyotype** **4)** Prenatal & parental diagnosis, pedigree analysis & norms of genetic counselling, Mitochondrial & Chloroplast horizontal gene transfer.	6
Unit III	**Genetic material** a) Evidences for nucleic acid as genetic materials – Miescher's work, Discovery of transforming material (Griffith's experiment). Avery – MacLeoid, Gieren–Shramn experiments, Fraenkel – Conrat & Singer experiment (TIUV), M. Hershey & Chase experiment Maternal effect (pigmentation in flour moth), inheritance of coiling in some snails, Maternal effects in human b) Structure of DNA – Nitrogenous bases, Nucleosides & nucleotides, Polynucleoide chain, bonds involved in DNA structure (Watson & Crick Model), different forms of DNA (A,B,C,D,Z), Chargaff's rule	**5**
Unit IV	**Genetic Organization:** 1) Gene as unit of heredity (organisation of chromosomes) 2) Folded fiber modes of prokaryotic genome – *E.Coli.* 3) Eukaryotic genome - Nucleus, nucleosome organization, chromosome organisation (Euchromatin & Heterochromatin) and properties, Types, giant chromosomes, folded fiber model of euchtomatic chromosome (DuPraw's model), Histone & Non histone	**6**

	proteins in prokaryotes & eukaryotes, C – value & C – value paradox 4) Genome organization in viruses – Packaging of DNA, Genes within genes (overlapping genes), Alternate splicing, terminal redundancy. Plasmids – Extra chromosomal genetic material, – Types, natural & artificial properties, Artificial plasmids e.g. PBR 322 series, PUC series, structure & applications – replication, incompatibility, curing & amplification. 5) Cytoplasmic inheritance in eukaryotes, mitochondria, plastids, kappa particles, Rules, other examples (chloroplast in four o clock plant & corn), streptomycin resistance in respiratory deficiencies (petites) Saccharomyces cerevisiae, Poky mutants (*Neurospora crassa*), Human genetic diseases & mitochondrial defects, infectious heredity (killer yeast & paramoecium) 6) Sequence complexicity – unique sequences, repeated sequences & satellite DNA. 7) Mobile genetic elements – Discovery, Overview, transposable elements in bacteria (IS elements, composite & non-composite transposons) , Transposable elements in eukaryotes (AC/DS elements in maize), transposable elements in humans (LINES, SINES), Evolutionary significance, J. shapirds model of replicative transposition.	
Unit V	**Replication of genetic material:** A) DNA replication – • Models of DNA replication (conservative, semiconservative & dispersive), Meselson & Stalh's experiment, six basic rules of DNA replication (conservation, Uni/Bidirectional, specific origin, 5' to 3', direction, discontinuous, primer requirement), Enzymes, proteins (Primase, helicase topoisomerases, SSB, DNA polymerase, Ligases, Ter & TuS proteins) & other factors involved in DNA replication oriC • Modes of DNA replications – rolling circle(σ), θ & linear DNA replication(T7) • Chromosome duplication in eukaryotes. • Folded Fiber model (DuPraw's model) • Six basic rules, Organelle DNA replication (Mitochondrial & chloroplast) • Viral DNA replication – Single stranded, double stranded, Linear & circular, Fidelity of DNA replication, Telomerase activity B) RNA replication – Single & double stranded in viruses, retroviral RNA replication	5
Unit VI	**Gene Expression and environmental aspects:** A) **Genetic code** – Establishment of genetic code, One gene one polypeptide hypothesis, Cis trans test, Milestones in deciphering the genetic code, dictionery of genetic code, features (degenerate, almost universal, triplet, almost non overlapping, commaless, almost continuous), Initiation & termination codons, Wobble hypothesis, split & overlapping genes. B) **Flow of genetic information** – Central dogma in molecular biology, modified central dogma (Reverse transcription) C) a) **Transcription in Prokaryotes** – RNA synthesis, RNA pol for prokaryotes, promoters & enhancers, initiation of transcription of promoter, elongation & termination of RNA chain, post transcriptional modifications, types of RNAs. b) **Transcription in Eukaryotes –** Eukaryotic RNA polymerases, promoters,	7

	transcription proteins, transcription of protein coding genes by RNA polymerase II, Eukaryotic m- RNA & t- RNA & r – RNA, post transcriptional modifications, self splicing of introns, RNA editing. c) **Translation in prokaryotes & eukaryotes –** Initiation of translation, charging of t-RNAs, Amino acid loading, formation of initiation complex with small & large subunits of ribosomes, Binding of t-RNA, m-RNA & ribosomes, Peptide bond formation, translocation, elongation of polypeptide chain, termination of translation, post transnational modification, Protein sorting and protein secretion. D) **Regulation of gene expression in prokaryotes** – Operon concept 1) Lactose operon – Induction, repression, allolactose, role of c– AMP, positive & negative regulation, Lac mutants. 2) Arabinose operon – Structure, induction & repression, doubly sensitive repression & it's double regulation by repression, positive & negative regulation. 3) Tryptophan operon - Regulation of biosynthetic pathway, structure of operon, regulation of tryptophan operon at different concentration of tryptophan, autoregulation, repression vs attenuation, antitermination, riboswitches. E) **Regulation of gene expression in eukaryotes** - Operon in Eukaryotes (Britten & Davidson's model), Control of transcriptional initiation, gene silencing & genomic imprinting, post transcriptional control, RNA interference (riboswitches) F) **Regulation in viruses** – Lytic & lysogenic regulations.	
Unit VII	Variation in inheritance – (Damage) A) Mutations – • Terminology – allels, homozymogen, phenotypes, genotypes somatic mutations, germline mutations, gene mutation, chromosomal mutation, phenotypic lag, hotopots & mutator genes. • Nature of mutations – Spontenous & induced, fluctuation test • Detection of mutation – Replica plate technique, selection & isolation of mutants, mutation rate estimation, phenotypic expression of gene, Mutation phenotypic lag • Types of mutations – Poin mutations, reverse mutation, suppressor mutation, frameshift mutation, conditional leathal mutation, base pair, substitution – transitions & transversions, Missense & non-sence mutation, silent & occult mutations neutral & pleuiotrophic mutations. • Causesof mutations – Natural / spontenous mutations – mutator gene replication error, depurination & deamination, induced mutations – molecular mechanism for (mutagens) i) Chemical mutagen – Base analogues - 5 bromouracil, 2 – aminopuri---- nitrus acid & hydroxylamine, intercalating agents (DNA distorting agents) acrydine dyes (acrydine oragen acryflavin, proflavin, oxyflavin & perflavin), EtBr, alkylating agents, Nitrogen mcostards (NTG, β- propyolactone, EMS, DES, ECH), Mutation in phages (plaque morphology, kosit range & conditional leather mutants). ii) Physical mutagens – Radiations, lionizing – X –rays, ϒ – rays, Cathod rays, nonionizing (DNA disto-----) – UV iii) Biological mutagens – transposable elements, Viral DNA insertion (site	6

	directed mutagenesis) B) Chromosomal abbrdions & mutations – • Numerical variations – Types, dosage compensation & Barr bodies (human), aneuploidy in human & polyploidy in plants. • Structural variations – Detection, duplication, inversion, translocation. • Relets human diseases – Klinfelter, Turner, Cri-du-Chat syndrome, Philadeal Phia Syndrome, (Myeloid leukaemia), Trisomy 21, Trisomy 18, Trisomy 13, SCA, Down syndrome, Frigale X – chromosome.	
Unit VIII	Repair damaged DNA in prokaryotes, eukaryotes & viruses • Ways of DNA damage, (hydrolysis, ----------, alkylation, oxidation, radiation, -----) • Repair mechanisms – Photoreactivation light repair, nucleotide excision repair (dark repair), Base Excision Repair (BER), mismatch repair, post replication recombination repair, repair of alkylation damage, SOS repair (trans dimer synthesis), (error prone repair) , AIMS test, non homologues end joining repair.	5
Unit IX	Gene transfer & recombination in microorganisms, plants & animals A) In bacteria – Natural (transformation, transduction, conjugation, cell fusion), artificial transfection method (used in genetic engineering), transformation definition & discovery, natural transformation system, *Streptococcus pneumonae, Bacillus, Haemophilic influenza*, exogenote & endogenote, factors affecting transformation, competence ste----, size of foreign DNA, homologous / heterologous DNA, concentration of DNA , fate of exogenote, artificial transformation (transfection) uses & evolutionary significance. Conjugation in bacteria – Definition & discovery, physiology of conjugation – F / sex factor, F^+ cells, F^- cells, HFR $^+$ cells, conjugation between F^+ X F^+, F^+ X F^-, F^- X F^-, HFR X F^- , Lethal zygosis & zygotic induction, F' plasmid (sex duction / F duction). • Conjugation in *E.Coli* system a) Transform F factor from donor to recipient. b) F mediated conjugation of chromosomal genes from donor to recipient. c) F duction / sex duction • Conjugation in *Streptococcus feacalius* system • F factor – structure & properties, transgene (transfer of multiple drug resistance fate of excogenote & evolutionary significance. • Transduction – Definition & discovery generalized transduction & specialized transduction with example. • Specialized transduction λ phage, θ 80 phage mediated, λ dg & λ dbio, θ 80dt & θ 80 diac • Generalized P1 & P2 phage mediated • Transduction / sex duction & phage conversion • Uses take of excogenote & evolutionary significance • Cell fusion / natural method B) In Eukaryote & recombination (animals & plants) - Mitosis & meosis, overview Yeast & molds, hybridization in yeast. Parasexual cycle in molds , protozova – cell fusion algae conjugation - overview Artificial introduction of genes by different methods like transfection in microorganisms, plants & animals. C) In gene transfer & recombination viruses – Host cell infection, super infection &	10

	recombination • Recombination – In bacteria General / homologus recombination, molecular bases of recombination, holiday model of recombination (single strand DNA break only), Enzymes required for recombination, Site specific & illegitanicte recombination, Gene conversion. • Restriction & Modification -	
Unit X	Introduction to gene mapping – Gene linkage & concept of genetic recombination, recombination mapping – map unit, recombination frequency, mapping of gene by cotransformation, cotransduction intertied mapping techniques & numerical problem recombination on genetic mapping. Genetic mapping by tetried analysis in *Neurospora crassa* Genetic mapping by paraseual cycle in *Aspergillus nidulans* Mapping of human genes by somatic cell hybridization Model organisms in genetical studies *E. Coli, Sacchyamyces cereviece, Arabidopsis thaliana, Caenorhabditis elegans, Drosophila melanogaster & mice*	6

B. Sc. Part II Semester III

UGMBP 301 – CC Practical Genetics I

30 hrs

1	Study of auxotrophic bacteria	1
2	Mendel's law problems- Monohybrid, / dihybrid ratios	**1**
3	Study of sex mutation in Drosophila	1
4	DNA structure -(problems) -	1
5	DNA staining in bacteria / nucleus in yeast / plant / animal cells	2
6	Isolation of plasmid DNA from bacteria – curing & amplification	1
7	Detection of transposable elements in bacteria	1
8	Determination of C- value in *E. coli*	1
9	Model of DNA replication (problem) – θ model	1
10	Genetic code - (problem) -	1
11	Study of flow of genetic information in case of retroviruses (animation)	1
12	Transcription & translation – (problems)	1
13	Study of polytene chromosomes from *Chyronomous larvae*	2
14	Isolation of chromosomes from animal / plant cells	3
15	Study of induction of β galactosidase in *E. coli*	1
16	Study & isolation of tryptophan requiring mutants of *E. coli*	3
17	Study of Hardy Wemberg law - (problems)	1
18	Identification of Drosophila from Lab stock	2
19	Study of modified Dihybrid ratios – (problems)	1
20	Problems on two & three point test – crossing and gene mapping	1

B. Sc. Part II Semester III

Microbiology

UGMPT – 302 CC Introduction to Agricultural Microbiology & Biotechnology

Unit	Topics	Hours
Unit I	Basics of soil microbiology – A) Physical and chemical characteristics of soil. B) Types of microorganisms in soil & rhyzosphere, their role in soil fertility. C) Role of microorganisms in elemental cycles - C, N, S & P cycles.	3
Unit II	Role of microorganisms in reclaimation of soil & composting (recycling of agricultural waste) – a) Role of microbes in reclaimation of soil. b) Manure & compost – Methods of production, green & farmyard manure, city compost – windows & Pit method, vermicomposting, optimal conditions for composting with reference to composition of organic waste, availability of microorganisms, aeration, CNP ratio, moisture content, temperature, pH, time, consortium approaches. c) Biodegradation of pesticides & hydrocarbons. d) Brief account of microbial interaction, symbiosis neutralization, commensalism, ammensalism, synergism, parasitism& predation.	6
Unit III	Microbial plant pathology (plant diseases)- a) Historical background, host -parasitism relationship, plant growth stages in development in disease (with respect to disease resistance & stages in development in disease – infection, invasion, colonization, dissemination of pathogens & penetration). b) Classification of diseases based on symptoms – Canker (Citrus canker), mosaic (TMV), blight (rot) – Pomegranate & tikka of groundnut, downy mildew – Causative agent, symptoms, entry & control measures. c) Epidemiology – Concepts of monocyclic, polycyclic, polyetic diseases with one example of each, disease trangle & forcasting of plant diseases. d) Methods of plant disease, control and eradication - chemical control, biological control (use of bacterial / fungal cultures), (IPM) Integrated Paste Management & genetic engineering for disease resistante plants.	6
Unit IV	Microbial Bio inoculants – Concept of inoculum, carriers, applications, monoculture, co-culture, poly culture (consortium), inoculum formulations. a) Bio fertilizers – definition, mass production (solid & liquid) & field application of i) Nitrogen fixers (Symbiotic Rhizobium Azolla). Non symbiotic Mycorrhiza Azotobactor, Azospirillum Acetobactor, Cyanobacteria. ii) Phosphate solubilizing bacteria & fungi iii) Phytohormones & cytokinin producing bacteria / fungi (ecto & endo). iv) Sidero phore producing, Iron and potassium mobilizers, iron fertilizers. b) Biopesticides – Characteristics, types, physiology, mechanism of action & application of bacterial (*Bacillus thuringiensis*), viral (insect viruses), fungi - (entamopathogenic) & plant origin biopesticides and one example of each.	8

	c) Secondary metabolite uses.	
Unit V	**Methods of crop improvement (overview of PTC).** Introduction, acclimatization, breeding for self-pollinated plants and vegetatively reproducing plants (pure line & mass), Hybridization & mutation, somaclonal variations, haploids, micropropagation, somatic embryogenesis and synseeds .	6
Unit VI	**Microorganisms in sustainable agriculture –** a) Soil microbiome (plant – microbiome), concept, composition, functioning & methods to study microbiome. b) Conservation of soil health. c) Phytonutrient availability by soil microorganisms, mechanism of diazotrophy, phosphate solublization, potassium immobilization and micronutrient availability. d) Biofilming on plant surfaces, biofilm formation, biofilm of microbes in phylosphere & rhyzosphere, examples of plant microbe interactions in biofilms, applications of biofilms.	7
Unit VII	**Microorganisms in plant genetic engineering** a) Concept of GM crops (transgenic crops) – i) Herbicide resistance ii) Bacterial, fungal, viral, insect resistance, disease resistance, stress resistance, improved varieties (improved carbohydrate & protein content & amino acid profile), edible vaccines, improved florstics, molecular farming, GM foods, ethical & social aspects **Tools & techniques –** a) Microbes as tools in plant transgenosis (shuttle vectors). b) Markers in plant breeding (classical & DNA markers) & applications of plant DNA barcoding – barcoding marker methods & applications, Morphological, biochemical & molecular markers (RFLP, RAPD, AFLP, STRS, QTL and SSR)	8
Unit VIII	**Precision agricultural and agricultural system –** a) Green house technology types, Importance, functions & features of green house, design criteria & calculation, construction material, covering material & it's characteristics, growing media, irrigation system, nutrient management, green house heating, cooling & shading, ventilation system, computer control environment. b) Phytotrons, fertigation & roof system. c) Precision cultivation – Tools, sensors for information aquisition.	6
Unit IX	**Plant Stress Biology** a) Abiotic stress - Physiological & molecular responses of plants to water stress, salinity, temperature – heat & cold, phytooxidative stress, perception & stress signalling pathways, ionic & osmotic homeostasis, reactive oxygen species scavenging. b) Biotic stress – Plant interaction with bacterial, viral & fungal pathogen, plant response to pathogen – Biochemical & molecular basis of host parasite resistance, toxins of fungi & bacteria, systemic and induced resistance, pathogen derived resistance & signalling.	5
Unit X	**Animal husbandry in agriculture -**	3

B. Sc. Part II Semester III

Practical

UGMBP – 302 CC Introduction to Agricultural Microbiology & Biotechnology

30 hrs

1	Isolation & identification of etiological agents of citrus canker & blight of pomegranate (*Xanthomonas spp*.)	**1**
2	Isolation of *Aspergillus niger* from black rot of onion	**1**
3	Collection of plant diseases specimen & study of symptoms, project based on digital record of plant diseases (group activity)	**1**
4	Isolation of PGPR with phosphate solubilisation potential/Cyno bacteria / azotobacteria/ VAM – Vesicular Arbuscular Mycorrhiza, preparation of liquid of bioinoculant, Preparation of biofertilizer of mixed flora & stability studies. (consortium)	**2**
5	Validation of commercial formulation of bioinoculant based on BIS standards, pot studies to check effect of bioinoculum on plant growth.	**2**
6	Preparation of biopesticide using *Trichoderma* isolate / *B. thuringienesis* & similar biopesticides	**1**
7	Isolation of pesticide, hydrocarbons degrading microorganism from contaminated soils	**2**
8	Determination of fertility of soil: **physical** (texture, moisture, gravimetric, porosity, water holding capacity) **Chemical** (C:N:P ratio, organic carbon, pH) **Microbial** – SPC of microorganisms	**2**
9	Preparation of compost from agricultural wastes – aerobic composting using consortia approach and vermi composting	**1**
10	Isolation of *Fusarium oxysporum* pathogen from wilted cotton plant	**1**
11	Study of TMV, tikka disease of plant (demo), Downy mildew (demo)	**1**
12	Isolation and study of siderophore producing bacteria	**2**
13	Extraction of pigment from Beet root	**2**
14	Isolation of Actinomyctes on Coconut water agar	**2**
15	Study of Plant Tissue Culture (demo)	**2**
16	Study of effect of abiotic stress on plant (drought, PEG, mannitol, salt)	2
17	Visit to green house facility	2
18	RAPD analysis (demo)	2

B. Sc. Part II Semester III

Microbiology

UGMBT -303 CC Basics of Medical Microbiology & Immunology

Unit	Topics	Hours
Unit I	**A) Medical Microbiology** **Basics of microbial diseases –** 1) Definitions – Host, parasite, commensal, etological agent, infection, toxigenicity, pathogenicity, virulence, invasion, symptoms, disease & syndrome, epidemic, sporadic, endemic & pandemic, incubation period, viability, susceptibility, sequel infections, lab diagnosis, prophylaxis. 2) Infections & diseases- i) Establishing the etiology of disease – Koch's postulates & River's postulates ii) Virulance of pathogenic microorganisms – Factor governing the virulence, enzymes, antiphagocytic factors (cell wall & capsules), adhesion factors (attachment & colonization), Siderophores, toxins (exotoxin, endotoxins). iii) Classification of diseases – On the basis of occurrence (epidemic, endemic, pandemic, sporadic), Severity or duration(acute & chronic), extent of host involvement (infectious or communicable, Non-infectious or non – communicable). iv) Types of infections – Opportunistic, nosocomial, primary infection, reinfection, secondary infection, focal, cross, iatrogenic inapparent, latent, inherited, congenital, overt, overt simple, mixed & pyogenic infections, local & generalized v) Sources of infections – Exogenous & endogenous (patient, carrier, types, animals, insects, soil, water, food, reservoirs of infections, fomites, animal products). vi) Epidemiology – Modes of transmission of disease, Transmission by air, water, food, contact vectors, study of diseases in population, tracking diseases in the population, Epidemiological statistics, frequency of cases, investigative strategies of epidemiologists. vii)Disease process – pathogenesis – spread of pathogens in the body, tissue damage of the host by the pathogen.	**20**
Unit II	**5) Microbial diseases:** Etiology – Epidemiology, pathogenesis, characteristics, signs & symptoms, laboratory diagnosis, prevention & control of diseases caused by: 1) Bacterial - *Staphylococcus aureus,, Streptococcus pyogenes, pneumoniae, , enteropathogenic . E. coli, Corynebacterium diptheriae, Bordetella pertussis*. *salmonella typhi, mycoplasma, pneumoniae* 2) Viral – Influenza virus, Rabies, Bird flue, Lumpy, COVID 19, SARS, Nipah virus 3) Fungal – *Aspergillosis, cryptococcosis, candidiasis* 4) Protozoal – Malaria, Leishmaniasis, Amoebias, Try*Panosomiasis*	10

	5) Nemotods – Ascaris, lumbricoides, Wuchereria bancrofti 6) Others – UTI caused by Proteus vulgaris Nosocomial infections, Sources, control, prevention & surveillance (*Staphylococcus aureus and Pseudomonas aeruginosa)*	
Unit III	**6) Control of diseases** Types of control measures, vaccines & immunization (passive immunization - immunesera), General methods of preparation of vaccines, wholecell vaccines, acellular or subunit vaccines, DNA vaccines, live (attenuated) & killed vaccines, examples of vaccines to prevent viral & bacterial diseases. Disease outbreaks – Sources & reservoirs of pathogens. Epidemic – Common source & person to person epidemic, latest immunization schedule in India.	**7**
Unit IV	**B) Immunology** **Host Defence Mechanism** 1) Immunity – Definition, types(innate & acquired, Active & Passive, Humoral & cell mediated). 2) First line of nonspecific defence – Physical barriers (skin, mucous membrane, fluid flow) , chemical barriers (Lysozyme, interferon, complement, acidity, normal microbial human microbiota, iron binding protein) & cellular mechanisms. 3) Second line of defence (Specific & non-specific) – inflammation & fever, antimicrobial substances present in the blood & tissue fluids, Phagocytic cells & phagocytosis. 4) Third line of defence (Specific defence mechanism) – antibody mediated, humoral response) – Primary & secondary antibody mediated response, antigen presentation & mechanism cell mediated response (activation of resting β – lymphocytes to effector cells, activation of Tc cells & mechanism of killing by CD 8 cells, memory cells.	**10**
Unit V	**Hematology** 1) Formation of blood cells (Haemotoposis) – Myleoid & lymphoid lineages & differentiation process. 2) Immunohaematology - ABO & Rh blood group systems, Bombay blood group, other minor groups, biochemistry of blood group substances, inheritance of ABH antigen, medicolegal applications of blood groups	6
Unit VI	**Hypersensitivity –** Basic concept, Gell coombs classification, Types- anaphylaxis mechanisms, types & hypersensitisation (Type I), antibody dependant cytotoxic (Type II) blood transfusion reactions), immune complex mediated (Type III) (Arthus reaction & serum sickness), Cell mediated (Type IV) (delayed type – allergy of infection, allograft rejection), Stimulatory (Type V),	4
Unit VII	Transplantation – Types of grafts, mechanism of homograft rejection, prevention of graph rejection	3

B. Sc. Part II Semester III Microbiology

UGMBP – 303 – CC Basics of Medical Microbiology and Immunology

30 hrs

1	Study of *Staphylococcus aureus* from wound infections	2
2	Study of Streptococcus (β- haemolytic)species from throat	2
3	Study of Enteropathogenic *Escherichia coli*	2
4	Study of *Candida albicans* and *Aspergillus fumigatus*	2
5	Study of Malarial parasite	2
6	Study of *Ascaris lumbricoides*	2
7	Study of Proteus spp. *Pseudomonas aeruginosa* from UTI	2
8	Preparation of heat killed vaccine of typhoid	2
9	Immunological/serological techniques: a) agglutination test-blood grouping b) Coagulation test c) Latex slide agglutination test d) Precipitation tests LVDRL test e) Radial immune diffusion test f) Immuno electrophoresis	6
10	Phagocytic index, opsonophagic index	2
11	Study of virulence factors like pigment production, capsule, lecithinase production by microbes	3
12	Study of microorganisms from skin, mouth (Teeth), Nasal mucosa and Ear.	3

B. Sc. Part II Semester III Microbiology

UGMBT – 304 - CC Basics of Industrial Microbiology & Biotechnology

Unit	Topics	Hours
Unit I	**Scope of Industrial Microbiology :** Fermentation - Definition, Industrial Microbiology, V/S Biotechnology, History (an art from the past, a skill for the future), multidisciplinary nature, a typical bioprocess (Introduction, Advantages, Limitation), Types of fermentations (Aseptic and Non Aseptic), fermentation types according to the organization of biological system (suspended and support culture), organizational in an industrial Microbiology establishment, upstream processing (USP) and downstream Processing (DSP) and their units, process flow diagram, industrial fermentation products and their producer microorganisms (list), Obsolesence of producers and methods, patents and IPR.	**4**
Unit II	**Industrial Microorganisms-** 1) Taxonomic diversity of industrially useful bacteria, fungi (an overview) 2) Important characteristics of microbes used in industrial microbiology 3) Isolation of suitable producer microorganisms from environment - (approach for enrichment & isolation) 4) Concept and examples of microorganism classified as generally regarded as safe (GRAS) 5) Culture collection of industrially important microorganisms 6) Use of mutants/genetically modified (GMO) as against wildtype isolates for production	4
Unit III	**Manufacturing and environmental safety** WHOs classification of microorganisms on the basis of hazard, safety precautions required for different level of containment.	3
Unit IV	**Development of pharmaceutical product** - overview	2
Unit V	**Biochemistry and physiology of industrially important microorganisms, their growth and metabolism** a) Introduction to metabolism(anabolism, catabolism, fermentation and respiration) b) Catabolic pathaways (overview) 1) Importance pathways of degradation of glucose- EMP, PKP, EDP 2) Fatty acid oxidation 3) Amino acid catabolism 4) Biosynthesis overview - Primary and secondary metabolites • Kinetics of microbial growth and death • Efficiency of microbial growth • Control of metabolic process • Application of metabolic regulation in fermentation industry	5
Unit VI	**Bioprocess Technology** a) **Upstream processing**- Selection of microorganism – screening - primary and secondary-	20

	• lab scale, pilot plant and scale up • Isolation, preservation and maintenance of industrially important microorganism • Strain improvement- introduction, mutation, selection of mutants, recombination, regulation, genetical methods and gene technology • Designing of fermentation media in fermentation industry, statistical methods. • Raw material (principal, substrates), Carbon and Nitrogen sources, nutrients - supplementary inducers, precursors and repressors • Sterilization of fermentation media, fermentor and air in fermentation in industry **b) Fermentation:** • Typical fermentor and it's accessories, measurement and control of bioprocess parameters • Inoculum preparation – steps, critical factor (quantity and reproducibility), detection and control of contamination • Fermentation process- factors controlling fermentation, fermentation operation • Contamination problems in fermentation industry, their control. **c) Downstream processing** Introduction, stages in the isolation and purification products • Solid liquid separation (filtration, centrifugation), pretreatment (release of intracellular components) • Disruption of microbial cells, homogenization of animal/plant tissues, concentration of biological products (evaporation, liquid liquid extraction), membrane filtration, precipitation, use of chromatographic techniques, product formulation and shelf life, monitoring of downstream processing, process integration, waste water management (overview) d) Whole cell immobilization and it's industrial applications, methods of cell immobilization, advantages and applications	
Unit VII	**Production of bioinsecticides** - Introduction, historical background, Candidate microbial insecticides, developmental phases of microbial insecticides, production of bioinsecticides, Bt toxin & Baculo viruses.	8
Unit VIII	**Production of biofertilizers** – Features, bacterial, algae & fungal fertilizers. Production of yeast & yeast derived products – Introduction.	4
Unit IX	**Microbial polysaccharides & single cell oils and biomass & products –** a) **Microbial polysaccharides** – introduction, commercially produced common polysaccharides, Xanthan, alginate curdlan, scleroglucan, polulans & dextrans, biosynthesis & production of xanthan. b) **Single cell oils (SCOs)** – Introduction, nomenclature of fatty acids, functional role of cell lipids, advantages & disadvantages of SCOs. Production of SCOs by fermentations, safety & future prospects. c) Yeast biomass production (bakers yeast) & yeast derived products.	6
Unit X	**Biopolymer & their application** • Polymers & biopolymers, their properties & distinguishing features, types (starch, nucleic acids, proteins, poly alkanoids, synthetic biopolymers, bioplastic, surfactants & emulsifiers).	4

	• Applications of biopolymers.	
Unit XI	**Enzyme biotechnology** – • Introduction, global market for enzymes, development of producer strains – screening from natures diversity, genetic engineering of production strains, common examples, large scale production, surface / submerged cultures, fermentation schemes, recovery & formulation (liquid & solid forms), immobilization of enzymes & their significance, applications of enzymes.	4

B. Sc. Part II Semester III Microbiology

UGMBP – 304 – CC Basics of Industrial Microbiology & Biotechnology

30 hrs

Sr. No.	Practical	Hours
1	Screening of industrially important organisms from soil for production of Antibiotics Organic acids Amino acids and Phosphatase enzyme	2
2	Culturing, characterization of microbes used in dairy industry, agro industry, yeast used in bakery/distillery/ winery, fungi(mold) actinomycetes used in pharmaceutical industry	2
3	Microscopic observation of industrially important microorganisms using light microscopy(compounds microscopy) and phase contrast microscopy (Real time microscopy of yeast)	2
4	Necessity and procedure of writing SOPs for instruments and equipments used in industries/GLP	2
5	Preservation of industrially important strains of microbes - bacteria and fungi by different methods	2
6	Study of bioreactor and its essential parts.	2
7	Production of amylase by solid state fermentative methods(Koji culture)- preparation of inoculum, extraction & purification	2
8	Purification of enzymes – amylase purification by ammonium sulphate precipitation	2
9	Immobilization of enzymes– amylase entrapment in calcium alginate gel.	2
10	Isolation of Azotobacter spp. & Rhizobacterium spp. from soil, plasmids & production of biofertilizer and shelf life study	2
11	Production of bioinsecticides and shelf life	3
12	Production of xanthan gum & application	3
13	Development of inoculum for activated sludge process & testing	2
14	Overview of production of biogas from industrial wastes & efficiency testing.	2

B. Sc. Part II Semester III Microbiology

UGMBT – 305- CC Basics of Pharmaceutical Microbiology

Unit	Topics	Hours
Unit I	Introduction to pharmaceutical Microbiology & Biotechnology – Scope, importance & opportunities in research in India.	**4**
Unit II	Microbes in pharmaceutical industries -	3
Unit III	Drug discovery & development a) **Drug discovery** – Historical aspects, current approaches to drug discovery, conventional process – bioprospecting, principles of extraction, purification & characterization of bioactive molecules from natural sources, Rationale drug design – principles & tools. b) **Drug development** – Pharmagenomics – Introduction, investigative tools & role of pharmacogenomics in selective systems, pharmacogenomics & drug development, pre- clinical development – toxicological evolution of drug – mutagenicity. Carcinogenicity & teratogenicity, clinical development – Clinical trials, aims, objectives & conduct, phase I, II, III & IV. Stability aspects of biotechnological products, methods to improve stability of peptides.	10
Unit IV	**Biotechnologically produced drugs (overview)-** Introduction, biotechnological drugs in market, hormones, monoclonal antibodies, vaccines, thrombolytic factors**,** tumour necrosis factors, DNases, lymphokines, cellular & molecular medicines.	8
Unit V	**Production of Pharmaceuticals** – 1) **Production of antibiotics & drugs** – Antibiotics & synthetic antimicrobial agents – antibacterial, antifungal, antiviral, antiprotozoal & anticancer antibiotics & drugs & their mode of action. Microbial production of antibiotics – Penicillin, streptomycin, chloramphenicol, tetracycline, erythromycin, rifamycin, anthracyclins, amphotericin – B griseefuluvin, Bacitracin, Novobiocin (general views) . 2) **Production of vitamins** – General view, vitamin B_2 (riboflavin), Biotin, Vit. C and Vit. B_{12}. 3) **Production of amino acids** – General views, L- lysine, L-glutamic acid, L- leucine, L-isoleucine, L-threonic, L - tryptophan & L- aspartic acid	15
Unit VI	**Microbiological assays** – Antibiotics, vitamins & amino acids, assays and graphical analysis, sterility testing of pharmaceutical products. • **Production of ergot alkaloids** – Introduction, microorganisms used, physiology of alkaloid formation, commercial production in bioreactors. • **Production of microbial enzymes by fermentation** – General overview, oxidoreductases, oxidases, hydrolases, transferases, kinases & isomerases. • **Production of Probiotics and Prebiotics** – *Lactobacillus acidophilus, Lactobacillus casei*, prebiotics	20

	• **Biotransformation & steroid production –** Introduction, methods used in biotransformation process with special reference to hydroxylation, dehydrogenation, hydrogenation, epoxidation, aromatization & synthetic rope. • **Production of secondary plant metabolites –** Production, stages, uses of tissue culture techniques, applications of new culture method, hairy root culture, elicitation of product accumulation, production of recombinant DNA technology products (overview) insulin, human growth hormones, interferon, monoclonal antibodies & vaccines. • **Production of mammalian cell –** General overview, introduction, mammalian cell line & their characteristics, commercial products, protein glycolsates media for cultivation of mammalian cell metabolism, Large scale cultivation of mammalian cells, Genetic engineering of mammalian cells, Xenograft mic and their applications. • **Synthesis of lycopene, SCP & indigo by microbial rDNA technology:** Regulatory aspects, introduction to pharmacopoeia, FDA, regulation of Indian pharmacopoeia (IP), British pharmacopoeia (BP), US pharmacopoeia (USP). Good Laboratory Practices (GLP), Good Manufacturing Practices (GMP),, current, GMP, validation, QA & QC and regulatory affairs, reimbursement of bilogicals & drugs, Patents WTO regulations & proprietary rights, GILSP, GMM	

B. Sc. Part II Semester III

UGMBP – 305 - CC Basics of Pharmaceutical Microbiology

30 hrs

1	Study of clinical trial problems (case study)	**1**
2	Study of teratogersity (thalidomide episode) (case study)	**1**
3	Study of sterility testing of pharmaceuticals – Tablets, syrups, liquid & ointments	**1**
4	Isolation of DNAse enzyme from microorganisms	**2**
5	Fermentative production and Chemical & microbial assays of Penecillin and preparation of Penicillin derivatives by using Penicillin acylase enzymes	**2**
6	Fermentative productions of – Amphotericins & B Riphamycin antibiotics	**1**
7	Fermentative production of L-lysine, L- glutamic acid and assay	**2**
8	Microbial production of isomerases & kinases	**2**
9	Production of probiotics using *Lactobacillus acidophilus, Lactobacillus casei* and production of prebiotics	**1**
10	Study of transformation of any one sterol to steroid using microorganisms	**1**
11	Study of secondary metabolite production in plants using hairy root culture technique	**1**
12	Microbiological production and assay of vitamin C & biotin	**2**
13	Study of assay of amino acid – Leucine & glutamic acid	**2**
14	Cultivation of mammalian cells & maintenance of cell lines	**2**
15	Production & assays for tyrosinase using cell line	**2**
16	Microbial production of Indigo using *E. coli* & *Pseudomonas aeruginosa* enzymes	**2**
17	Isolation of licopene from microotganisms	**2**
18	Study & preparation of draft of GLP, GMP, cGMP for pharmaceuticals.	**2**

B. Sc. Part II Semester III

UGMBT – 306 - CC Biodiversity Natural Sources Conservation Management

Unit	Topics	Hours
Unit I	**Biological Diversity-** Biodiversity The Concept, Definition and Levels - Ecosystem, Species & Genetic. Methods of assessment of Biological diversity Ecosystem Diversity	3
Unit II	**Ecosystem Diversity** Classification of Ecosystem-a) Udvardy's Classification. b) Bailey's Classification. c) Olsen's Classification. d) Holdridge's Classification. Major Ecosystem types of India with their physical & biological characteristics. Major Ecosystem types of the World with their physical & biological characteristics. Importance of Ecosystem in maintaining Ecological balance	5
Unit III	**Species Diversity** a) Species Diversity at Local, National and International Level b) Special features and Latest estimates for major groups of Plants, Animals & Microbes. Measuring Species Diversity - Species Richness, Species Abundance and Species Evenness Factors affecting global distribution of Species Richness-Latitudinal, Altitudinal, Rainfall gradients, temperature...etc. **Endemism-** a) the Concept b) Types with Examples c) Endemism in India Centers of Diversity -a) the concept b)Types with examples: Analyses at global level. **Concept of hotspot** i) Myer's Hot-spots. ii) Mega-diversity Centers/Countries. c) Western Ghat as a Hot spot. d) India as a Mega-diversity Country.	10
Unit IV	**Genetic Diversity** Meaning & Introduction to Genetic Variations in Species. Nature & Origin of Genetic Variations. Factors affecting Genetic Diversity Darwin's theory of Evolution and Lamarck's theory of Natural Selection Measurement of Genetic Diversity - a) Based on DNA & Chromosomes. b) Molecular Marker Techniques. Transgenic Organisms. **Diversity in Domesticated Species** - a) Variations since the first domestication to the present. Land Races, Advanced Cultivars, Wild Relatives of Cultivated Plants & Feral Plants. Biodiversity – Significance Ecological Significances Contribution of Biodiversity to various Eco- Services. Non Ecological Significances - Nutritional, Medicinal, Aesthetic, Cultural, Commercial Values, etc. Optional Values, Use of microorganism in remediation of pollution **Threat to Biodiversity** Development Threats with suitable Examples- a) Large Scale. Dev. Projects - Habitat Destruction & Fragmentation. b) Changing Agri, & Forestry Practices.	17

	c) Invasion by Introduced Species. d) Over-exploitation. e) Environment Pollution. f) Global Climate Change. g) Loss of Traditional Knowledge. h) Nature of Legal & Mgmt. System - Human Wildlife Conflict. i) Genetically Modified Organisms, etc. mangers **Biodiversity Conservation** Conservation Methods-In-situ & Ex-situ methods with Example. National Conservation Efforts - a) The laws - Environment Protection Act, Forest Act, Wildlife Act, Biodiversity Act 2002 b) Involving People's Participation -NBSAP, PBR c) Involving Community Participation-JFM, EDP d) People's Movement - Silent Valley Movement, Beej Bachao Andolan International Conservation Efforts-a) IUCN-The World Conservation Union. b) CBD. c) CITES Traditional Methods of Conservation - Sacred Groves/Ponds/Species, Periodic restrictions on resource harvesting, etc. Biodiversity conservation-value addition through biotechnology Need & Awareness.	
Unit V	**Environmental Resource Management** Air Quality Parameters and Monitoring Air Quality Monitoring National standards for ambient air quality by WHO Site and Parameter selection, Air Sampling Techniques Monitoring of important ambient air components such as Particulate matter (PM) of 10 micron or less in size and 2.5 micron and less in size, Oxides of Sulfur, Nitrogen, Carbon monoxide Methods of analysis of SOx, NOx Monitoring tools/instruments used for the same and its work principle, Stack gases monitoring technique Plume behaviour	3
Unit VI	**Water Quality Monitoring** Purpose/ objectives of monitoring Water Quality Monitoring Protocol Collection of sample (types of sample, chain of custody, sampling method, number of samples, sample containers, sample volume, etc.) Sample preservation, handling & storage guidelines/criteria Water quality monitoring on field test parameters, off field test parameters Waste Water Treatment: a) Primary Treatment - Screening, Grit removal, Sedimentation b) Secondary Treatment Aerobic Method-i) Activated Sludge Process. ii) Trickling Filter. iii) Rotating Contractor iv) Oxidation Pond Anaerobic Method. d) Tertiary Treatment - Disinfection (Chlorination), e) Biogas-one stage and second stage digester, Principle	5
Unit VII	**Soil Quality Monitoring** Objectives of soil monitoring/testing Sampling and sample units, sample number, frequency and timing: Sampling methodology a Site selection b. Infield sampling technique c. Describing the soil profile d. Site description e. Setting a transect instruments/Equipment used Guidelines for handling and storage of samples Physiochemical and Biological parameters Biological methods to control soil pollution Biological Method to control soil pollution- a) To reduce dependency on chemicals - Use of Bio fertilizers & Bio pesticides, Conservational Tillage, Mixed Cropping, Crop rotation, Biological Pest Mgmt., Organic Farming b) Bio/Phyto-remediation of contaminated sites. Soil carbon Flux	6
Unit VIII	Forest Monitoring Classification of forests Measurement of individual trees: a. Measurement of diameter and girth of trees b. Measurement of heights of trees c. Measurement of	6

	form of trees d. Measurement of volume of felled trees e. Measurement of volume of standing trees f. Determination of age of trees Forest inventory Kinds of sampling, sampling units, sampling intensity	
Unit IX	**Noise Quality Parameters** Noise and Vibration Monitoring The Basic Noise Unit; Lmax, SEL, Leq(h), Ldn, 24-Hour Exposure from All DYCH Noise Control Techniques- Sound Insulation, Sound Absorption, Vibration Damping and Isolation Noise Control at Source- a) Selection & Maintenance of machines. b) Control over vibrations. c) Installation of barriers / enclosures. d) Using protective equipment e) Noise proof walls	5

B. Sc. Part II Semester III

UGMBP – 306 - CC Biodiversity Natural Sources Conservation Management

30 hrs

1	Texture analysis of soil	**1**
2	Relationship between productivity & biomass measurement	**1**
3	Preparation of ecological pyramids	**1**
4	Study of zooplankton, phytoplankton fresh water / marine water	**2**
5	Wetland study (productivity of lake)	**2**
6	Study of vegetation & birds by LINE, Belt, quadract – methods	**1**
7	Population density, mortality, natality, dispersion, age structure, age pyramid of population, wing data provided	**2**
8	Population growth – logistic & exponential curve	**2**
9	Calculation of species diversity index – Simpson, Shannon, Pilues, evenness from line, Belt & quadract data	**1**
10	Study of Ecological interactions – **Positive** – proto cooperation, syntrophism, synergism, mutualism, commensalism, symbiosis **Negative** – Parasitism, ammensalism, competition, predation and antagonism	**1**
11	Preparation of PBR (Public Biodiversity Register)	**1**
12	Case studies on climate change	**2**
13	Estimation of greenhouse gases	**2**
14	Estimation of Carbon footprint	**2**
15	Determination of living planet index	**2**
16	Determination of Optimum Dose of Alum (Coagulant) required for water	**2**
17	Determination of Turbidity of water (Turbidimeter/ Nephelometer)	**1**
18	Estimation of productivity of lake using DO method	**1**
19	Determination of available nitrogen from soil (Kjeldahl method)	**2**

B. Sc. Part II Semester III Microbiology

UGMBT – 308- CC SECC Leadership Development

Unit	Topics	Hours
Unit I	• Introduction to leadership, functions of leadership, theories.	**3**
Unit II	• Leadership types- Effective leadership, successful management, leadership behaviors- Emergence, leadership and trust, Transformation leadership.	5
Unit III	• Leadership Skills- leadership and management, competencies and skills of leaders, leaders in action.	4
Unit IV	• Institution Building in framework and issues Institution building.	3

B. Sc. Part II Semester IV Biotechnology/ Microbiology

UGMBT – 401 - CC Basics of Enzymology

Unit I	Enzymes and introduction, types of enzymes(proteins & RNA), classes of enzymes, IUB classification concept of active site activation energy, binding energy, allostery, enzyme activity and enzyme specifity, transition state, hypothesis Protein nature enzymes, Non protein enzymes – Ribozymes & DNAzymes, metallo enzymes & metal activated enzymes.	5
Unit II	Structure of enzymes a) Methods to determine amino acid residues at active site(physical methods e.g. X ray crystallography and chemical methods such as trapping of ES complex, Use of inhibitors, Use of psudo substrate, change of pH) b) Role of vitamins and coenzymes and Cofactors- Introduction, occurance, structure and biological functions of following Vitamin A, D, K, E & C, B1 deffiency diseases	7
Unit III	Enzyme catalysis – Mechanism, acid base catalysis covalent, metalion catalysis, proximity & orientation effect mechanism of action of serive protease & Mechanism of enzyme action- lock and key, induced fit hypothesis	6
Unit IV	Enzyme assays a) Principles of enzyme assays and calculation of enzyme unit , specific activity. b) Enzyme assays with examples by spectrophotometric methods, radioisotopes assay.	4
Unit V	Principles and methods of enzyme purifications a) Methods of cell fractionation b) Principles and methods of enzymes purification on the basis of molecular size, change, solublity differences and specific binding property and selective adsorption c) Construction of enzyme purification ---------	8
Unit VI	Enzyme kinetics a) Concept use of initial velocity, order of reactions(up to second order) b) Mickelis Mendel equation initial velocity of single substrate enzyme catalysed reaction, MM plot, Line-weavier burke plot, Eadie- Hofstee plot, Briggs- Hodne plot, definition with significance of Km, Ks and Umax, turn over number inhibition types, competitive, Non-competitive and uncompetitive, factors affecting enzyme activity- pH temperature and substrate concentration	10
Unit VII	Metabolic regulationEnzyme compartmentalization of cellular level,allosteric enzymes, feedback mechanisms, covalenty modified regulatory, isozymes - enzymes,(Glycogen phosptolase), prpteiolytol activation of zymogenes,Isozymes concept and examples) multienzymes complex pyruvate, dehydrogenase complex pyruvate, dehydrogenase complex (PDH) fatty acid synthase complex. Enzyme copartrantation, mechanism of qe----------	10
Unit VIII	Immobilization of enzymes Concept, methods of immobilization Introduction to Enzymes: • Properties of enzymes; definition of active sites, enzyme units, specific activity; purity of enzyme. • Protein nature of enzymes and Non-protein enzymesRibozymes and DNAzymes • Metalloenzymes and metal activated enzymes. Enzyme Catalysis: • Mechanism of enzyme catalysis: Acid base catalysis, Covalent Catalysis, Metal ion catalysis, Proximity and orientation effect • Mechanism of action of Serine proteases: Chymotrypsin Enzyme Kinetics: • Factors affecting the enzyme activity- Enzyme & Substrate Concentration, pH and Temperature. • Kinetics of Single substrate enzyme catalysed reaction. • Michealis- Menten equation, Km, Vmax, Lineweaver-Burk plot, Turnover number, Kcat 6 IV Enzyme Regulation: • Regulation on the basis of Activity: Feedback Regulation,	10

	Allosteric Regulation, Covalent modification and Proteolytic activation of Zymogens • Multienzyme complexes and Isoenzymes • Organization of enzymes in Cells: Compartmentation of metabolic pathways for eg Fatty acid Catabolism & Anabolism, Enzymes in Membrane with suitable examples. • Mechanism of enzyme Degradation: Lysosomal and nonlysosomal pathways. 8 V Immobilization of Enzymes • Carrier matrices & its properties. • Methods of enzyme immobilization. • Whole Enzyme/cells immobilization. • Applications of immobilized enzymes. 3 VI Industrial and clinical applications of enzymes • Industrial Enzymes: Thermophilic enzymes (Reverse transcriptase), Amylases, Lipases, Proteolytic enzymes in Meat and leather industry, cellulose degrading enzymes, Metals degrading enzymes. 6 • Clinical Enzymes: Enzymes as thrombolytic agent, Antiinflammatroy agents, Streptokinase, Asparginase, LDH, Transaminases (AST), Amylases, Phosphatases, Cholinesterases. • Biosensor: Components of enzyme biosensor: eg. Glucose, Oxydase	

B. Sc. Part II Sem IV Biotechnology/ Microbiology

UGMBP – 401 - CC Basics of Enzymology

1	Enzyme production, purification, quantification & immobilization – a) Lab scale production of α/β amylase, lipase & protease using suitable sources. b) Precipitation of amylase from fermentation broth (salt/solvent). c) Determination of enzymes activity – Preparation of standard graph of maltose, calculation of specific activity of crude & purified amylase, preparation of standard curve of protein (albumin) by Folin – Lawry method. Determination of purity of enzyme. d) Effect of following parameters on enzyme activity. pH, temperature, time, substrate determination of Km curve & it's modification, Km & V max.
2	Enzyme immobilization (amylase) using calcium alginate gel entrapment method & stability studies.
3	Detection & quantification of serum enzymes – SGOP, SGPT / alkaline phosphatase
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B. Sc. Part II Semester IV Microbiology

UGMBT – 402 - CC Introduction to Food Microbiology & Biotechnology

A) Food Microbiology & Biotechnology

Unit	Topics	Hours
Unit I	**Microbes in food –** **a) Evolution of food Microbiology** b) **Microorganisms & food materials** – Principles that influence microbial growth, sources of contamination, survival & death of microbes in food, intrinsic factors (pH), water activity, OR potential, nutrients containts, biological structure of food, inhibitory substances in food), Extrinsic factors (temperature of storage, relative humity, concentration of gases) c) **Processing of food** – Asepsis, heat processing (pasteurization, appertization & sterilization), high pressure processing, irradiation (traditional method, UV & ionizing radiation), role of FDA. d) **Importance of microbes in food** – Food born infections & intoxicative – gram -ve bacteria (Salmonellios food infection), gram +ve bacteria (Staphylococcal food poisoning). **Beneficial activities of microbes in food -** i) Microbial metabolism of food components ii) Fermented food – General methods of production, starter cultures 7 enzymes, traditional fermented foods & Microbiology of process – Dairy products, cheese, yogurt, Indian dairy products, butter & curd, Indian foods – Idli, dosa, gelibi, bakery products – breads. iii) Non-alcoholic breaverages - Definition, currency – trends (use in health benefits, stress reliever & immunesystem booster), Juice based breaverages – Coconut water, sweet – loddy, sugarcane juice, coconut milk, flavoured syrups, fruit breverages, Tea(combucha), coffee, cocoa, spices & ------- extracts.basics of extruded foods, breaverges (feen, brandy & wine), (wine – white, red, sherry & cha-----) fermented pickle, Indian pickles, sauerkraut, cucumber pickles, concept of genetically modified foods, Soy products. **E) Spoilage of food –** a) **Basics** – i) Classification of foods – Perisable, semiperisable & non-perisable foods (stable), sensory / organoleptic factors of food – appearance factors (size, shape, colour, gloss, consistency & woleness), Textural factors (texture changes) (Open/ close to close), flavour factors (taste, smell, mouth felt temperature), Types of spoilage – Physical, chemical & biological . ii) General principles (auto, microbial) understanding spoilage – Sources of contaminations, asepsis, killing & removal of microorganisms. iii) Important food spoilage bacteria. iv) Sequence of event in spoilage. v) Factors governing spoilage of food (number & type of microbial load), type of food, suspension, storage conditions – temperature & humidity.	**60**

b) Spoilage of food comodities –

i) Meat (fresh) & products, fish & fish products –structure, composition, primary processing & spoilage, egg & poultry products – Plant products, fruits & vegetables, cereals & cereal products – sugar & sugar products, salted dressing, splies & condiments, spoilage of canned food, spoilage of fermented foods.

F) Preservation & storage of foods – Principles of food preservation .

i) Low temperature storage, chilling, freezing.

ii) Use of high (refrigeration) temperature – Blanching, pasteurization, sterilization, boiling & canning, importance of TDP, TDT, D, F, Z values, V 12 – D concept.

iii) Preservation by drying – sun drying, air consection dryer fluidized bed drier, roller drier, vaccume dryer & spray dryer.

iv) Preservation by freeze dryer.

v) Preservation by concentration – Methods of concentration, types of evaporators.

vi) Preservation of chemical preservatives – GRAS chemicals, salts (Nacl, Sodium benzoate) food addaties & other preservatives, organic acids & natural antimicrobials, sugars, SO_2 , antibiotics.

vii) Food preservation by food grade preservatives.

Viii) Preservation by radiation – Types of radiations, factors determining. Status of irradiated food in India, microwave & ovenic heating.

ix) Heardle technology – Aseptic packaging (Tetra pack technology), Use of biodegradable plastic, edible bio plastic, edible packaging & bio composites, food packaging laws & regulations, barcodes & other marking. Modified atmosphere & control atmosphere packaging.

x) Detection of microbes in food, indicator microorganisms & microbiological criteria. Background history, controversy over risks, applications multidisciplinary perspectives, regulations.

- Concept of prebiotic & probiotic foods, definition, health effects, quality assurance, side effects, potential applications.
- Industrial awareness – QA & QC, concept of good manufacturing practices (Hazard analysis – HACCP), regulatory authorities, ISO, WHO, FDA (19000 & other series). Indian food laws & standards.
- SCP & mushroom production & it's use in food & feed – Introduction, production, quality & safety, economics & energy considerations.
- Process development in food industry with & without mathematical modelling.
- Methods of microbial examination of food –
  a) Homogenization of food samples.
  b) Methods – SPC, spiral plater, membrane filter, dry films, surface examination – Swab -------- and contact plate methods.
  c) Enlist the following methods giving their applications only - ---------- ,microcalometry, thermostable nucleus,LAC test, PCR, ATP,whole animal assay,ligate loop technique

  Food sanitation-

  a) Food sanitation and hygiene- water, potable water, sources of contamination of water, treatment of water pesticide residues.
  b) Food, food handling, food contamination, equipment, control of insects and rodents, practical rules for good sanitation.
  c) Food borne diseases (poisoning & infections by microbes).
  d) Toxins from plants & animals, mycotoxins, toxic agricultural residues,

	chemical poisoning. e) Food laws & food adulteration. f) Consumer protection & consumer guidance society.	

B. Sc. Part II Semester IV Microbiology

Practical

UGMBP – 402 - CC Introduction to Food Microbiology & Biotechnology

30 hrs

1	Detection of alpha toxin in food	**1**
2	Detection of TDP & TDD value	**1**
3	Detection of TDR & D – value	**1**
4	HACCP guidelines for food industry (activity based)	**2**
5	Standard plate count of food products.	**2**
6	Microbiological examination of foods - Detection of enteric pathogens	**1**
7	Detection of food adulteration	**2**
8	Role of UV radiation in food preservation	**2**
9	Production of cheese, curd (natural starter, use of fruits & flowers)	**1**
10	Alcoholometry - A) Estimation of alcohol in a beverage by colorimetric method B) To study kinetics of oxidation of alcohol by dichromate method C) Distinguish ethanol from methanol by using iodoform test.	**1**
11	Separation of crude Caffeine from tea leaves / leaf powder	**1**
12	Industrial visit – Visit to food & food processing industry, alcohol / non alcoholic beverages industry	**2**
13	Isolation & identification of probiotic microflora from natural sources or any commercial formulation	**2**
14	Isolation & bacteria from spoiled food a) Food leafy vagetables – Physical / microscopic & pectinotytic agent b) Meat – Proteolytic, liptotytic & Saccharolytic microbes	**2**
15	Study of physical, chemical, microbiological & sensory properties of fermented food samples.	**1**
16	Saurkraut / Cucumber / Idli / batter fermentation	**2**
17	Detection of salt & sugar tolerance by spoilage causing microorganisms.	**1**
18	Determination of MIC of chemical causing preservatives	**1**
19	Wine & bread making	**1**
20	Isolation of Staph. aureus from sweets & demonstrating its virulence	**2**

B. Sc. Part II Semester IV

Microbiology & Biotechnology

UGMBT – 403 – CC Dairy Technology

Unit	Topics	Hours
Unit I	Definition, Types, microflora & pathogens – a) Definition of milk, composition & physicochemical properties of milk for different animals, food nutritive value, market milk industries in India & Abroads, difference between colostrum & milk. b) Types of milk – whole, toned, double toned, homogenized, skimmed & dehydrates. c) Microorganisms associated with milk – sources of contamination, associative action microorganisms in raw milk, international standards of milk, importance of microbes in milk & their role in influencing, quality of milk during collection, transportation, storage & dissemination of diseases (milk borne).	10
Unit II	Processing techniques & naturally occurring preservatives in milk. a) Processing techniques with respect to preservation bactofugation thermisation, pasteurization (definition, types, LTH, HTST & UTH) & it's efficiency (phosphatase test), Sterilization & boiling. b) Naturally occurring preservation system in milk - LP system, immunoglobulins, lysozymes, lactoferrin. c) Preservation by physical method, chemical agents, food grade bio preservation (grass) & bacteriocins of lab.	7
Unit III	Spoilage of milk & milk products – a) Spoilage of milk b) Sucction of microorganisms in milk leading to spoilage. c) Stormy fermentation, ropyness & sweet curdling. d) Colour & flavour defects – spoilage of raw milk, pasteurizing of milk, ice-cream, khoya, butter & cheese.	7
Unit IV	Grading & examination of raw milk – Microbiological grading direct & indirect tests. a) Direct tests – Microscopic count, SPC, MPN, LPC, thermophilic, psycrophilic count breeds, smear count – CRRS, MBRT, DMC, RTP tests. b) Indirect tests – Dye reduction test, MBRT & Resazurine. c) Chemical tests for grading (platform tests), acidity tests – clot on boiling test, alcohol test, fat test (Gerber test), fat & solid non fat (SNF) test, adulteration test (starch, urea, sugar, skimmed milk)	10
Unit V	Technology of dairy products – A) • Production of cheese, cheddar, cottage, processed cheese, cheese defect, enlist different types of cheeses & associated microorganisms. • Butter - Microorganisms involved Istarter), butter making process, yield, defects, applications. • Probiotic products – (curd whey) • Yogurt – cultured buttermilk, kefir, kumis, Skyer & Taette, Paneer. B) Microbiology of fermented milk products- • Starter lactic acid bacteric, mesophilic & thermophilic.	8

	• Secondary fcore of fermented dairy products . • Bacteria, molds, yeasts examples, acidification, texture development & flavour contribution by startup lactic acid bacteria • Significance of secondary flora. • Therapeutic significance.	
Unit VI	Microbiology of special milk - sterilized milk, homogenized milk, soft curd milk.	4
Unit VII	Process, development in dairy industry – Process development with & without mathematical modelling. Quality control in dairy industry (GMP, QA, QC, HASCP, ISO, FDA & WHO regulations)	4

B. Sc. Part II Semester IV

Microbiology & Biotechnology

Practical

UGMBP – 403 – CC Dairy Technology

1	Grading of milk – Chemical & microbiological methods (COB test, alcohol test, SPC, MPN, DMC, MBRT, Resazurin tests)	2
2	Microbiological quality control of milk as per BIS / FSSAI	2
3	Analysis of cheese, paneer, butter, yogurt, curd as per BIS / FSSAI (group experiment)	2
4	Microbial analysis of pasteurized milk – DMC, SPC & phosphatase test quantitative to determine efficiency of pasteurization	4
5	Mastitis & somatic cell count test of raw milk	2
6	Microbial quality of indigenous dairy products – Khoa, Kulfi, Shrikhand, Paneer, Curd, buttermilk	2
7	Differentiate between colostrum & milk	2
8	Differentiate whole, tonned & skimmed milk samples.	2
9	Study associative action (succession of microorganisms in raw milk)	2
10	Detection of antibiotics in raw & pasteurized milk	2
11	Chemical analysis of milk – Fat, protein, sugar content of milk, water & solid not fat.	3
12	Preparation of probiotic wine/curd/cheese/yogurt	3

B. Sc. Part II Semester IV Microbiology

UGMBT – 404 - CC Genetics (Prokaryotic, Eukaryotic & Environmental aspects)

Unit	Topics	Hours
Unit I	Variation in inheritance – (Damage) C) Mutations – • Terminology – allels, homozymogen, phenotypes, genotypes somatic mutations, germline mutations, gene mutation, chromosomal mutation, phenotypic lag, hotopots & mutator genes. • Nature of mutations – Spontenous & induced, fluctuation test • Detection of mutation – Replica plate technique, selection & isolation of mutants, mutation rate estimation, phenotypic expression of gene, Mutation phenotypic lag • Types of mutations – Poin mutations, reverse mutation, suppressor mutation, frameshift mutation, conditional leathal mutation, base pair, substitution – transitions & transversions, Missense & non-sence mutation, silent & occult mutations neutral & pleuiotrophic mutations. • Causesof mutations – Natural / spontenous mutations – mutator gene replication error, depurination & deamination, induced mutations – molecular mechanism for (mutagens) iv) Chemical mutagen – Base analogues - 5 bromouracil, 2 – aminopuri---- nitrus acid & hydroxylamine, intercalating agents (DNA distorting agents) acrydine dyes (acrydine oragen acryflavin, proflavin, oxyflavin & perflavin), EtBr, alkylating agents, Nitrogen mcostards (NTG, β- propyolactone, EMS, DES, ECH), Mutation in phages (plaque morphology, kosit range & conditional leather mutants). v) Physical mutagens – Radiations, lionizing – X –rays, ΄Y – rays, Cathod rays, nonionizing (DNA disto-----) – UV vi) Biological mutagens – transposable elements, Viral DNA insertion (site directed mutagenesis) D) Chromosomal abbrdions & mutations – • Numerical variations – Types, dosage compensation & Barr bodies (human), aneuploidy in human & polyploidy in plants. • Structural variations – Detection, duplication, inversion, translocation. • Relets human diseases – Klinfelter, Turner, Cri-du-Chat syndrome, Philadeal Phia Syndrome, (Myeloid leukaemia), Trisomy 21, Trisomy 18, Trisomy 13, SCA, Down syndrome, Frigale X – chromosome.	**20**
Unit II	Repair damaged DNA in prokaryotes, eukaryotes & viruses • Ways of DNA damage, (hydrolysis, ----------, alkylation, oxidation, radiation,) • Repair mechanisms – Photoreactivation light repair, nucleotide excision repair (dark repair), Base Excision Repair (BER), mismatch repair, post replication recombination repair, repair of alkylation damage, SOS repair (trans dimer synthesis), (error prone repair) , AIMS test, non homologues end joining repair.	10

Unit III	Gene transfer & recombination in microorganisms, plants & animals D) In bacteria – Natural (transformation, transduction, conjugation, cell fusion), artificial transfection method (used in genetic engineering), transformation definition & discovery, natural transformation system, *Streptococcus pneumonae, Bacillus, Haemophilic influenza,* exogenote & endogenote, factors affecting transformation, competence ste----, size of foreign DNA, homologous / heterologous DNA, concentration of DNA , fate of exogenote, artificial transformation (transfection) uses & evolutionary significance. Conjugation in bacteria – Definition & discovery, physiology of conjugation – F / sex factor, F^+ cells, F^- cells, HFR $^+$ cells, conjugation between F^+ X F^+, F^+ X F^-, F^- X F^-, HFR X F^- , Lethal zygosis & zygotic induction, F' plasmid (sex duction / F duction). • Conjugation in *E.Coli* system d) Transform F factor from donor to recipient. e) F mediated conjugation of chromosomal genes from donor to recipient. f) F duction / sex duction • Conjugation in *Streptococcus feacalius* system • F factor – structure & properties, transgene (transfer of multiple drug resistance fate of excogenote & evolutionary significance. • Transduction – Definition & discovery generalized transduction & specialized transduction with example. • Specialized transduction λ phage, θ 80 phage mediated, λ dg & λ dbio, θ 80dt & θ 80 diac • Generalized P1 & P2 phage mediated • Transduction / sex duction & phage conversion • Uses take of excogenote & evolutionary significance • Cell fusion / natural method E) In Eukaryote & recombination (animals & plants) - Mitosis & meosis, overview Yeast & molds, hybridization in yeast. Parasexual cycle in molds , protozova – cell fusion algae conjugation - overview Artificial introduction of genes by different methods like transfection in microorganisms, plants & animals. F) In gene transfer & recombination viruses – Host cell infection, super infection & recombination • Recombination – In bacteria General / homologus recombination, molecular bases of recombination, holiday model of recombination (single strand DNA break only), Enzymes required for recombination, Site specific & illegitanicte recombination, Gene conversion. • Restriction & Modification -	**20**
Unit IV	Introduction to gene mapping – Gene linkage & concept of genetic recombination, recombination mapping – map unit, recombination frequency, mapping of gene by cotransformation, cotransduction intertied mapping techniques & numerical problem recombination on genetic mapping. Genetic mapping by tetried analysis in *Neurospora crassa* Genetic mapping by paraseual cycle in *Aspergillus nidulans* Mapping of human genes by somatic cell hybridization Model organisms in genetical studies *E. Coli, Sacchyamyces cereviece, Arabidopsis thaliana, Caenorhabditis elegans, Drosophila melanogaster & mice*	**10**

B. Sc. Part II Semester IV Microbiology

UGMBP – 404- CC

30 hrs

1	Study of fluctuation test	**1**
2	Estimation of mutation role in *E. coli.*	**1**
3	Replica plate technique & detection and isolation of drug resistant & auxotrophic mutants in bacteria	**1**
4	Study of phenotypic lag in mutagenesis	**2**
5	Study of leuotrophic mutations in streptococcus.	**2**
6	Study of induction of mutations (plaque morphology & host range) using UV & NTG	**1**
7	Study of UV survival curve & UV mutagenesis	**1**
8	Study of photo reactivation in bacteria	**1**
9	Screening of chemicals for mutagenicity using AME's test	**1**
10	Study of transformation in bacteria	**1**
11	Study of conjugation in bacteria (drug resistance plasmid & chromosomal markers)	**1**
12	Study of zygotic induction & lethal zygosis in *E. coli*	**2**
13	Study of conjugation *Streptococcus fecaulis* system	**2**
14	Study of transduction in *E.coli.*	**2**
15	Study of stages of mycosis / Meiosis in plant & animals cells	**1**
16	Study of cell fusion in protozoa	**2**
17	Study of gene mapping & tetraid analysis problems	**1**
18	Comparative study of suitable as organism for genetical studies in case of E. coli, Saccharomyces cereviceae, Arabidopsis thaliana, Caenorhabditis elegans, drosophila melanogaster & Mice	**1**
19	Role of environment in inheritance of phenotypic characteristics in living being	**1**
20	Study of meiotic abnormalities in Roheo plant	**2**
21	Study of Karyotype by using photograph	**2**

B. Sc. Part II Semester IV Microbiology

UGMBT – 405 - CC Introduction to Clinical Microbiology & Pathology

A) Clinical Microbiology

Unit	Topics	Hours
Unit I	Introduction to clinical Microbiology – Basic microbiology – overview- types of microorganisms, morphology, culture methods	4
Unit II	**Common infectious diseases – Epidemiology & public health awareness** a) 1) Skin infections (Pseudomonas), Acne & measles 2) Infections of nervous system (tetanus & rabies). 3) Infections of respiratory systems (terms, pharyngitis, Laryngitis, sinusitis, diphtheria & common cold). 4) Infections of digestive system – Typhoid, E. coli. Gastroenteritis, Hepatitis A, Rotavirus, amoebiasis . **b) Epidemiology & public health awareness –** 1) Epidemiology of infectious diseases & their control, terms, epidemic, pandemic diseases, index case & outbreak. 2) Sprade of infection – Reservoirs (human, animal & non-living), transmission - Contact, vehicle, vectors. 3) Public health measures for control of diseases – Control directed against reservoirs, transmission of pathogen, immunization, quantitive, surveillance & pathogen eradication.	16
Unit III	**Control of microorganisms & safety in clinical microbiology –** 1) Sterilization & disinfection (overview). 2) Disinfections – Disinfections of surfaces & spoilages, safety cabinets, jars, rooms & skins, testing of disinfectants. 3) Safety in clinical microbiology – Chemical, fire, electrical safety handling of compressed gases, exposure control plan (employ education & orientation), disposal of hazardous waste & standard precautions, engineering controls (laboratory environment), biological safety cabinets, PPE – Personal Protecting Equipment, Poet exposure control, classification of biological agents based on hazard.	10
	B) Clinical Pathology	
Unit IV	1) Specimen collection & processing – Collection of blood by vein puncture with syringe, evacuates tube & puncture of skin & artery, anticoagulants, plasma & serum, collection of urine (time & preservatives), respiratory swabs & sputum, stool sample & processing of samples / specimens. 2) Haematology – a) **Blood analysis** - Haemogram, total & differential count, Cytology & significance of eosinophills, basophiles, neutrophils, macrophages & NK cells, clinical significance of packed RBCj, platelets & erythrocytes, sedimentation rate, blood groups (matching & cross-matching), plasma electrolytes & importance, significance of haemoglobin.	30

b) **Blood conjugation** – Clotting factors, anticoagulants used in labs & as therapeutic agents, nomenclature of procoagulants, formation of platelet plug, intrinsic & entrinsic pathway for blood coagulation, Coagulation tests – clotting time & prothombin time, diseases associated with blood clotting lysis.

c) **Carbohydrates pathophysiology** – regulation of blood sugar, insulin, diabetes, mellitus – regulation of blood glucose, insulin, glucose, prediabetes, Types of dibetes, glucose tolerance text, clinical presentation, diabetic keto acetosis & chronic complications.

d) **Protein pathophysiology** – Determination of Hb_1 glycosylated hb (Hb1C), definition of anaemia, types of anaemia, (iron deficiency) , Pernishius, haemolytic, aplastic, sickle cell anaemia & thalassemia.

3) Liquid & clinical pathology – Metabolism of adipose tissue, hormone sensitive lipase, obesity, fatty liver, leupotrophic factors, Ketone bodies, plasma cholesterol, athero sclerosis, coronary artery disease.
Lipid profile – Determination of triglyceride, cholesterol, VLDL, HDL & their diagnostic significance, docosa – hexnoic acid & its clinical significance, lipid hypothesis of hschizopheria.

4) Clinical relevance of haepatic system – Structure & functions of civer, metabolism of RBC, Bilirubin, free & conjugates bilirubin, Types of jaundice, over productive, obstructive, hepatocellular, congenital,(neonatal), genetic origin of juindice, haemolytic hypatic & post hypatic jaundice.
Liver function test – SGOT, SGPT, total serum bilirubin, Van Den Bergh test & bromosusphalin excretion test.

5) Kidney profile – Structure & functions of kidney, abnormal constituents of urine & their significance.
Glucose, acetone bodies, Urea, creatinine, uric acid, bilirubin, protein, $sodium^+$, K^+ & calcium oxalate.
Reneal function test, Creatin clearance test, Urea clearance test & Phenol sulphonaphalin (PSP) test.

6) Heart function test – Lactate dehydrogenases.

7) Significance of enzymes in diagnosis – Assay & significance & enzyme levels in heart, Liver, kidney & pancreatic disorders, SGPT, SGOT, alkaline phosphatase, lactate dehydrogenases, creatin phosphokinase, alpha amylase.

8) Acid-base balance, acid / bases & buffers, normal pH of the body fluids, regulation of blood pH, acidosis & alkalosis, aniogap .

9) Radioisotopes in medicine – Concept of radioactivity, use of radioisotopes in medicine, radiation hazards, radiation health safety & protection.

10) Community health services & measures – Blood grouping – A, B, O & Rh, methods of blood grouping, blood banking, Rh in compatibility (HDN).

11) Clinical significance of biochemical tests – Concept of health & disease, factors causing diseases, clinical significance of biochemical tests & their role in diagnosis, monitoring & therapy of disease.

B. Sc. Part II Semester IV Microbiology

Practicals

UGMBP – 405 - CC Introduction to Clinical Microbiology & Pathology

30 hrs

1	Isolation & identification of pathogenic *Staphylococcus Coagulant* & DNAse test	**2**
2	Isolation & identification of gram-ve intestinal pathogen – E. coli., Salmonellas	**2**
3	Isolation & identification of urinary tract infection Pseudomonas & proteus.	**2**
4	Peripheral blood smear for total & differential count	**2**
5	Haemoglobin estimation using haematic credit	**2**
6	Slide agglutination test –serological typing. -Blood grouping – A, B, O & Rh - Tube agglutination test – Widal test. - Rapid plasma reagin test (for diagnosis of Cephalisis)	**4**
7	Estimation of glucose of ketone bodies in blood & urine	**2**
8	Glucose tolerance test	**2**
9	Determination of li[id profile	**2**
10	Kidney function test by estimation of urea – creatinine & protein from urine	**2**
11	Liver function test by SGOT / SGPT analysis	**2**
12	Urine analysis	**2**
13	CSF analysis	**2**
14	Separation of serum protein by electrophoresis	**2**

B. Sc. Part II Semester IV Microbiology

UGHM – 407 - CC Ability Enhancement Compulsory Course (AECC) – Environmental Studies II

Unit	Topics	Hours
Unit I	**Environmental Pollution** • Environmental pollution : types, causes, effects and controls; Air, water, soil and noise pollution • Nuclear hazards and human health risks • Solid waste management : Control measures of urban and industrial waste. • Pollution case studies	**2**
Unit II	**Environmental Policies & Practices** • Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture 2/2 • Environment Laws: Environment Protection Act; Air (Prevention & Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act. International agreements: Montreal and Kyoto protocols and Convention on Biological Diversity (CBD). • Nature reserves, tribal populations and rights, and human wildlife conflicts in Indian context.	**5**
Unit III	**Human Communities and the Environment** • Human population growth: Impacts on environment, human health and welfare. • Resettlement and rehabilitation of project affected persons; case studies. • Disaster management: floods, earthquake, cyclones and landslides. • Environmental movements: Chipko, Silent valley, Bishnois of Rajasthan. • Environmental ethics: Role of Indian and other religions and cultures in environmental conservation. • Environmental communication and public awareness, case studies (e.g., CNG vehicles in Delhi).	**5**
Unit IV	**Field work** • Visit to an area to document environmental assets: river/ forest/ flora/fauna, etc. • Visit to a local polluted site-Urban/Rural/Industrial/Agricultural. • Study of common plants, insects, birds and basic principles of identification. • Study of simple ecosystems-pond, river, Delhi Ridge, etc.	**3**

B. Sc. Part II Semester IV Microbiology

UGHM – 408 - CC Skill Enhancement Compulsory Course (SECC) –

Indian Constitution

Unit	Topics	Hours
Unit I	**PHILOSOPHY OF THE INDIAN CONSTITUTION** a) Constitutional History of India b) Role of Dr. B.R. Ambedkar in Constituent Assembly c) Preamble - Source and Objects d) Sovereign and Republic e) Socialist and Secular f) Democratic - Social and Economic Democracy g) Justice - Social, Economic and Political h) Liberty - Thought, Expression, Belief, Faith and 'vVorship i) Equality - Status and Opportunity j) Fraternity, Human Dignity, Unity and Integrity of the Nation	**2**
Unit II	**FUNDAMENTAL RIGHTS** a) Right to equality b) Right to freedoms c) Right against exploitation d) Right to freedom of religion e) Cultural and educational rights f) Right to property g) Right to constitutional remedies	**5**
Unit III	**DIRECTIVE PRINCIPLES OF STATE POLICY** a) Equal Justice and free legal aid b) Right to work and provisions for just and humane conditions of work c) Provision for early childhood, Right to education and SC,ST, weaker section d) Unifonn Civil Code e) Standard of Living, nutrition and public health f) Protection and improvement of environment g) Separation of Judiciary from executive h) Promotion of International peace and security	**5**
Unit IV	**FUNDAMENTAL DUTIES** a) Duty to abide by the Constitution b) Duty to cherish and follow the noble ideals c) Duty· to defend the country and render national service d) Duty to value and preserve the rich heritage of our composite culture e) Duty to develop scientific temper, humanism ,the spirit of inquiry & reform f) Duty to safeguard public prope1ty and abjure violence g) Duty to strive towards excellence	**3**