

**B.SC ZOOLOGY & INDUSTRIAL
MICROBIOLOGY**

BOARD OF STUDIES IN ZOOLOGY & INDUSTRIAL MICRO BIOLOGY
(UG)

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DEFINITIONS

'Semester' means a term consisting of a minimum of **450** contact hours distributed over **90** working days, inclusive of examination days, within **18** five-day academic weeks.

'Academic Week' is a unit of five working days in which distribution of work is organized from Monday to Friday, with five contact hours of one hour duration on each day.

'Programme' means a three year programme of study and examinations spread over six semesters, according to the regulations of the respective programme, the successful completion of which would lead to the award of a degree.

'Course' means a complete unit of learning which will be taught and evaluated within a semester.

'Common Course I' means a course that comes under the category of courses for English

'Core course' means a course in the subject of specialization within a degree programme.

'Complementary Course' means a course which would enrich the study of core courses.

'Open course' means a course outside the field of his/her specialization, which can be opted by a student.

'Credit' is the numerical value assigned to a course according to the relative importance of the content of the syllabus of the programme.

'Parent Department' means the department which offers core courses within a degree programme.

'Grade' means a letter symbol (A, B, C, etc.), which indicates the broad level of performance of a student in a course/ semester/programme.

'Grade point'(GP) is the numerical indicator of the percentage of marks awarded to a student in a course.

Words and expressions used and not defined in this regulation shall have the same meaning assigned to them in the Act and Statutes.

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COURSE STRUCTURE OF BSc INDUSTRIAL MICROBIOLOGY AND ZOOLOGY (DOUBLE CORE) PROGRAMME

The U.G.programme includes

I. Common Course

English

II. Core Courses

1. Industrial Microbiology
2. Zoology- Approved syllabus of Zoology Board of studies

III. Complementary Courses

1. Biochemistry- Approved syllabus of Biochemistry Board of studies
2. Computer Science- Approved syllabus of Computer Science Board of studies

IV. Open Course –Dairy Microbiology

V. On- The – Job Training

VI. Investigatory Project

Double Core programme is exempted from Core choice Board Courses (Electives) that is designed for single core courses (VI Semester).

However they have open courses in V Semester as other programmes.

Programme Duration	6 Semesters
Total Credits required for successful completion of the programme	120
Minimum credits required from Core courses + Complementary + Project	79
Minimum credits required from Open course	3
Minimum attendance required	75%

- No course shall carry more than 4 credits.
- Student shall have the option to choose Open courses offered by any other Department.

CONTENT OUTLINE OF THE COURSE

Semester	Code	Title of the Paper
I	CEN101	Common Course Communication skills in English
	BMB101	Fundamentals of Microbiology
	BMB102	Microbial Diversity
	BMB103	Biodiversity and Biosystematics
	DBZ101	Biochemistry Course I
	DCS101	Computer science course I
II	CEN202	Common Course in English II
	BMB204	Microbial physiology
	BMB205	Immunology
	DBC202	Evolutionary Biology and zoogeography
	DBZ202	Biochemistry Course II
DCS202	Computer science II	
III	BMB306	Microbial Genetics and Recombinant DNA Technology
	BMB307	Medical Microbiology
		On the Job training
	BMB308	Animal diversity –Non Chordata
		Biochemistry Course III
	Computer science III	

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IV	BMB409	Basics of Industrial microbiology
	BMB410	Fermentation Technology
	BMB411	Animal Diversity- Chordata
	BMB412	Research Methodology & Biostatistics
		Biochemistry Course IV
		Computer science IV
V	BMB513	- Food Microbiology
		On the Job training
	BMB514	Diary Microbiology
	BMB515	Cell biology and Molecular Biology
	BMB516	Perspectives in Ecology
	BMB517	Animal Physiology
VI	BMB618	Agricultural microbiology and Biofertilizers
	BMB619	Microbial waste Management
	BMB620	Genetics, Biotechnology and Bioinformatics
	BMB621	Developmental Biology
	BMB622	- Endocrinology, Reproductive Biology and Ethology
		Field Visit/ Study Tour, Visit to research institutes
		PROJECT - (Either From Core I or Core II)

EXAMINATIONS

The evaluation of each course shall contain two parts:

- (i) In-Semester Assessment (ISA)
- (ii) End-Semester Assessment (ESA)

The in-semester to end-semester assessment ratio shall be 1:4, for both courses with or without practical. There shall be a maximum of **80** marks for end-semester evaluation and maximum of **20** marks for in-semester evaluation. For all courses (theory & practical), grades are given on a 07-point scale based on the total percentage of marks. (*ISA+ESA*) as given below

Percentage of Marks	Grade	Grade Point
90 and above	A+ - Outstanding	10
80-89	A - Excellent	9
70-79	B - Very Good	8
60-69	C - Good	7

50-59	D - Satisfactory	6
40-49	E - Adequate	5
Below 40	F - Failure	4

Note: Decimal are to be rounded to the next whole number

CREDIT POINT AND CREDIT POINT AVERAGE

Credit Point (CP) of a course is calculated using the formula

$$CP = C \times GP, \text{ where } C = \text{Credit}; GP = \text{Grade point}$$

Credit Point Average (CPA) of a Semester/Programme is calculated using the formula

$$CPA = TCP/TC, \text{ where } TCP = \text{Total Credit Point}; TC = \text{Total Credit}$$

Grades for the different semesters and overall programme are given based on the corresponding CPA as shown below:

CPA	Grade
Above 9	A+ - Outstanding
Above 8, but below or equal to 9	A - Excellent
Above 7, but below or equal to 8	B -Very Good
Above 6, but below or equal to 7	C – Good
Above 5, but below or equal to 6	D – Satisfactory
Above 4, but below or equal to 5	E – Adequate
4 or below	F – Failure

Note: A separate minimum of 30% marks each for in-semester and end-semester (for both theory and practical) and aggregate minimum of 40% are required for a pass for a course. For a pass in a programme, a separate minimum of Grade **E** is required for all the individual courses. If a candidate secures **F** Grade for any one of the courses offered in a Semester/Programme only **F** grade will be awarded for that Semester/Programme until he/she improves this to **E** grade or above within the permitted period. Candidate who secures **E** grade and above will be eligible for higher studies.

MARKS DISTRIBUTION FOR END-SEMESTER EXAMINATION AND IN-SEMESTER EVALUATION

The end-semester examination of all semesters shall be conducted by the College at the end of each semester. In-semester evaluation is to be done by continuous assessment. Marks distribution for end-semester and in-semester assessments and the components for in-semester evaluation with their marks are shown below:

Components of the in-semester evaluation and their marks are as below.

1) For all courses without practical

- a) Marks of end-semester Examination: 80
- b) Marks of in-semester evaluation: 20

All the three components of the in-semester assessment are mandatory.

Components of In- semester Evaluation	Marks
Attendance	5
Assignment /Seminar/Viva	5
Test paper(s) (1 or 2) (1x10=10; 2x5=10)	10
Total	20

2) For all courses with practical

- a) Marks of theory –End-semester Examination: 60
- b) Marks of theory –In-semester Evaluation: 10

Components of Theory: In-semester Evaluation	Marks
Attendance	3
Assignment/Seminar/Viva	2
Test paper(s) (1 or 2) (1x5=5; 2x2.5=5)	5
Total	10

- a) Marks of Practical: End-semester Examination: 40
(Only in even semesters)
- b) Marks of Practical: In-semester Evaluation: 20
(Odd and even semesters combined annually)

Components of Practical: In-semester evaluation	Marks
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Attendance	4
Record	10
Lab involvement	6
Total	20

Practical- End semester evaluation

There will be two examiners for each lab course external examination, of whom one will be internal. There will be combined evaluation of the students by the two examiners. Each lab course examination will include a viva-voce component, the marks for which should not exceed 20% of the marks allotted. A student has to obtain at least 40% in the internal plus external aggregate to pass the theory or lab course component.

PROJECT EVALUATION

Components of Project Evaluation	Max. Marks
In-semester Evaluation	20
Dissertation (End-semester)	50
Viva-Voce (End-semester)	30
Total	100

EVALUATION OF OJT

A system of continuous evaluation will be followed during the OJT programme. The Mentor at the training organization/institute and the tutor will jointly assess the OJT programme of the student.

Mentor Assessment of OJT

The mentor at the training organization will assess the performance of the student for 50% of the total marks and according to the following scheme.

Attendance and punctuality	5 marks
Observation of Etiquette	5 marks
Technical Competence	5 marks
Responsibility/ Dependability	5 marks
Group –interpersonal skill	5 marks
Total	25 marks

Tutor Assessment of OJT

The tutor will assess the performance of the candidate for the rest 50% of the total marks on the basis of the consolidated OJT assignment report signed by the students class mentor and according to the following scheme.

Methodology	5 marks
Content	5 marks
Presentation style	5 marks
Technical exposure	5 marks
Language of the report	5 marks
Total	25 marks

ASSIGNMENTS

Assignments are to be done from 1st to 4th Semesters. At least one assignment should be done in each semester.

SEMINAR/VIVA

A student shall present a seminar in the 5th semester and appear for Viva-voce in the 6th semester.

ATTENDANCE EVALUATION

1) For all courses without practical

Percentage of attendance	Marks
90 and above	5
85 – 89	4
80-84	3
76-79	2
75	1

(Decimals are to be rounded to the next higher whole number)

2) For all courses with practical

% of Attendance	Marks for theory	% of Attendance	Marks for practical
90 and above	3	90 and above	4
80--89	2	85--89	3
75--79	1	80--84	2
		75--79	1

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(Decimals are to be rounded to the next higher whole number)

IN-SEMESTER ASSESSMENT TEST PAPERS

At least one in-semester test-paper is to be attended in each semester for each course. The evaluations of all components are to be published and are to be acknowledged by the candidates. All documents of in-semester assessments are to be kept in the college for two years. The responsibility of evaluating the in-semester assessment is vested on the teacher(s), who teach the course.

PATTERN OF QUESTIONS

Questions shall be set to assess knowledge acquired, standard application of knowledge, application of knowledge in new situations, critical evaluation of knowledge and the ability to synthesize knowledge. The question setter shall ensure that questions covering all skills are set and should be equally distributed from every module. She/he shall also submit a detailed scheme of evaluation along with the question paper.

A question paper shall be a judicious mix of objective type, short answer type, short essay type /problem solving type and long essay type questions.

Pattern of questions for end-semester examination for theory paper without practical

	Total no. of questions	Number of questions to be answered	Marks of each question	Total marks
	10	10	1	10
	12	8	2	16
	9	6	4	24
	4	2	15	30
TOTAL	35	26	x	80

Pattern of questions for end-semester examination for theory papers with practical

	Total no. of questions	Number of questions to be answered	Marks of each question	Total marks
	8	8	1	8
	10	6	2	12
	6	4	4	16
	4	2	12	24
TOTAL	28	20	x	60

INVESTIGATORY PROJECT, ON- THE –JOB TRAINING, FIELD COURSE, FIELD VISIT, STUDY TOUR & VISIT TO RESEARCH INSTITUTES

Investigatory Project

Each student is expected to complete one investigatory project during the programme either in core 1 or core 2, and the project dissertation shall be submitted for evaluation at the end of 6th semester. The projects are to be identified during the 4th semester of the programme with the help of the supervising teacher. Project presentation and viva- voce will be conducted along with the 6th semester practical examinations.

On The Job Training programme (Core 1- Industrial Microbiology)

The On the Job training (OJT) programme is intended to bring the curriculum to the reality of the world of work. This programme enables the students to apply their classroom knowledge to live situations under the joint supervision of the tutor and a mentor. The OJT has two components namely OJT-1 and OJT -2, each of one week (36 Hrs.) duration, implemented during the semester III and Semester V respectively. At the end of each OJT programme students are expected to produce an attendance certificate and a detailed report of the OJT assignments. (Internal Evaluation only)

Field visit to biodiversity rich area (Core 2- Zoology)

As a part of core 2 Zoology, a Field visit to a biodiversity rich area should be conducted during the 1st semester. The visit is intended to study the biodiversity and conservation status of the area and forms a part of the practical course during Semester 1. Each student is required to prepare a report of the visit which will be evaluated during the practical examination at the end of the semester.

Study Tour & Visit to Research Institutes (Core 2 –Zoology)

Study tour and visit to research institutes should be conducted preferably during the 5th semester. During the study tour, students are expected to visit different habitats, zoos, aquaria and other places of zoological importance. They must also visit research institutes to familiarize themselves with the process of research in biological sciences.

PROGRAMME OBJECTIVES

The programme is designed to help the students to:

1. Impart basic knowledge in Microbiology, Zoology and related subjects meant both for a graduate terminal course and for higher studies.
2. Acquire basic knowledge and skills for employment in the field of Microbiology especially Industrial Microbiology.
3. Inculcate interest in and love of nature with its myriad living creatures.
4. Understand the unity of life with the rich diversity of microorganisms and their ecological significance.
5. Acquire basic skills for the utilization of microbes for human welfare.
6. Acquire basic skills in the observation and study of nature, biological techniques, experimental skills and scientific investigation.
7. Acquire basic knowledge and skills in applied branches to enable them for self-employment.
8. Impart awareness about the conservation of the biosphere.

SCHEME OF INSTRUCTIONAL HOURS AND CREDITS

SEMESTER I

Total Credits 20

SL NO	Course Title	No of hrs/ Week	Number of Credits	Total Credits
1	Common Course Communication skills in English [Board of studies English]	5	4	4
2	Core I Industrial Microbiology Course I B MB1 01-Fundamentals of Microbiology	2	2	2
	Fundamentals of Microbiology Practical I-B MB 1P 01	2	1	1
3	Core I Industrial Microbiology Course II B MB102- Microbial Diversity	2	2	2
	Microbial Diversity Practical II-BMB1P02	2	2	2
4	Core II Zoology Course I BZO101-Biodiversity and Biosystematics	2	2	2
	Biodiversity and Biosystematics Practical- BZO1P01	2	1	1
5	Complementary I DBC101-Biochemistry Course I, Biophysical Chemistry	2	2	2
	Biochemistry-Practical- DBC1P 01	2	1	1
6	Complementary II DCS101-Computer science course I	2	2	2
	Computer science Practical-DCS1P01	2	1	1
	TOTAL	25 Hrs.	20 Credit	20 Credit

SEMESTER II**Total Credits 20**

SL NO	Course Title	No of hrs/ Week	Number of Credits	Total Credits
1	Common Course in English II Critical Thinking, Academic writing & Presentation.	5	4	4
2	Core I Industrial Microbiology Course III BMB203 -Microbial physiology	2	2	2
	Microbial physiology Practical III - BMB2P03	2	2	2
3	Core I Industrial Microbiology Course IV BMB204- Immunology	2	2	2
	Immunology Practical IV - BMB2P04	2	1	1
4	Core II Zoology Course II- BZO202 Evolutionary Biology and zoogeography	2	2	2
	Evolutionary Biology and zoogeography Practical II- BZO2P02	2	1	1
5	Complementary IBiochemistry Course II DBC202 -Biomolecules	2	2	2
	Biochemistry II- PracticalDBC2P02	2	1	1
6	Complementary II-DCS202 Computer science II	2	2	2
	Computer science II-PracticalDCS2P02	2	1	1
	TOTAL	25 Hrs.	20 Credit	20 Credit

SEMESTER III**Total Credits 20**

SL.NO	Course Title	No of hrs./ Week	Number of Credits	Total Credits
1	Core I Industrial Microbiology Course V BMB305-Microbial Genetics and Recombinant DNA Technology	3	3	3
	Microbial Genetics and Recombinant DNA Technology Practicals V - BMB3P05	2	1	1
2	Core I Industrial Microbiology Course VI BMB306 - Medical Microbiology	2	2	2
	Medical Microbiology Practicals VI -BMB3P06	2	1	1
3	OJT –I	1	1	1
4	Core II Zoology Course III BZO303-Animal diversity –Non Chordata	3	3	3
	Animal diversity –Non chordate Practicals- BZO3P03	2	1	1
5	Complementary I- Biochemistry Course III DBC303 – Enzymology and Biological Techniques	3	3	3
	Biochemistry Course III- PracticalDBC3P03	2	1	1
6	Complementary II DCS303 Computer science III	3	3	3
	Computer science III PracticalDCS3P03	2	1	1
	TOTAL	25 Hrs	20 Credit	20 Credit

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SEMESTER IV**Total Credits 20**

SL N O	Course Title	No of hours/week	Number of Credits	Total Credits
1	Core I Industrial Microbiology Course VII BMB407 -Basics of Industrial microbiology	2	2	2
	Basics of Industrial microbiology Practicals VII– BMB4P07	2	1	1
2	Core I Industrial Microbiology Course VIII BMB408 - Fermentation Technology.	2	2	2
	Fermentation Technology Practicals VIII - BMB4P08	2	1	1
3	Core II Zoology Course IV BZO404 - Animal Diversity- Chordata	3	3	3
	Animal Diversity- Chordata Practical IV - BZO4P04	2	1	1
4	Core II Zoology Course V Research Methodology & Biostatistics	2	2	2
5	Complementary I-Biochemistry Course IV DBC404 – Metabolism	3	3	3
	Biochemistry Course IV Practicals DBC4P04	2	1	1
6	Complementary II DCS404 Computer science IV	3	3	3
	Computer science IV Practicals DCS4P04	2	1	1
	TOTAL	25 Hrs.	20 Credit	20 Credit

SEMESTER V**Total Credits 20**

SL. NO	Course Title	No of hours/ Week	Number of Credits	Total Credits
1	Core I Industrial Microbiology Course IX B MB509- Food Microbiology.	3	3	3
	Food Microbiology. Practical IX- BMB5P09	2	1	1
2	OJT -2	1	1	1
3.	EMB501- Dairy Microbiology OPEN COURSE	4	3	3
4.	Core II Zoology Course V I- BZO506 -Cell biology and Molecular Biology	3	3	3
	Cell biology and Molecular Biology Practical VI- BZO5P06	2	1	1
5	Core II Zoology Course VII- BZO507- Perspectives in Ecology	3	3	3
	Perspectives in Ecology Practical VII - BZO5P07	2	1	1
6	Core II Zoology Course VIII- BZO508 Animal Physiology	3	3	3
	Animal Physiology Practical VIII- B ZO5P08	2	1	1
	TOTAL	25Hrs	20Credit	20 Credit

SEMESTER VI**Total Credits 20**

SL. NO	Course Title	No of hrs/ Week	Number of Credits	Total Credits
1	Core I Industrial Microbiology Course X- BMB610-Agricultural microbiology	2	2	2
	Agricultural microbiology Practical X -- BMB6P10	2	1	1
2	Core I Industrial Microbiology Course XI- BMB611- Microbial waste Management	2	2	2
	Microbial waste Management Practical 11- BMB6P11	2	1	1
3	Core II Zoology Course IX – BZO609 Genetics, Biotechnology and Bioinformatics	3	3	3
	Genetics, Biotechnology and Bioinformatics Practical IX - BZO6P09	2	1	1
4	Core II Zoology Course X BZO611 -Developmental Biology	3	3	3
	Developmental Biology Practical X – BZO6P11	2	1	1
5	Core II Zoology Course XI BZO612- Endocrinology , Reproductive Biology and Ethology	3	3	3
	Endocrinology, Reproductive Biology and Ethology Practical XI - BZO6P12	2	1	1
6	Core II Zoology Field Visit/ Study Tour, Visit to research institutes	1	1	1
7	PROJECT - (Either From Core I or Core II)	1	1	1
	TOTAL	25 Hrs.	20 Credit	20 Credit

TOTAL CREDITS - 120

	Common Course	Complementary		Core I	Core II		
SEME-STER	ENGLISH	BIO-CHEMISTRY	COMPUTER SCIENCE	INDUS-TRIAL MICRO-BIOLOGY	ZOOLOGY	OPEN COURSE	PROJECT
I	4	3	3	7	3		
II	4	3	3	7	3		
III		4	4	8	4		
IV		4	4	6	6		
V				5	12	3	
VI				6	13		1
TOTAL	8	14	14	39	41	3	1

SEMESTER I

FUNDAMENTALS OF MICROBIOLOGY

Total hours: 36 Hrs.

Total Credit 2

Module 1. **4 Hrs.**

History and Scope of Microbiology

Spontaneous generation theory – conflict –Contributions of Leuwenhoek, Louis Pasteur, Robert Koch, Edward Jenner, Joseph Lister, Alexander Fleming, John Tyndall.

Module 2. **8 Hrs.**

Ultrastructure of Eubacteria- size, shape and arrangements of bacteria. Structure and arrangement of bacterial flagella. pili, capsule, cell wall and its composition- cell wall of gram positive and gram negative cell. Cytoplasmic membrane, protoplasts, spheroplasts, intracellular membrane systems, cytoplasm, vacuoles, nuclear material, spores and cysts, endospores, cell inclusions and mesosomes.

Module 3 **8Hrs.**

Sterilization and disinfections - Different methods of sterilization- physical and chemical methods

Introduction to antibiotics: -Classification of antibiotics, mode of action. Drug resistance, antibiotic sensitivity test.

Evaluation of antimicrobial chemical agents- tube dilution and agar plate techniques- phenol coefficient method, micro dilution method.

Module 4 **8Hrs.**

Culture media -Selective media, Enriched media, Enrichment media, Indicator media, and Differential media, Transport media, anaerobic media.

Plating techniques and isolation of pure colonies- aerobic culture methods

-pour plate , spread plate, streak plate, lawn culture, stab culture. Anaerobic culture methods

Culture preservation techniques -serial sub culturing, refrigeration, freezing, overlaying cultures with mineral oil, liquid nitrogen and lyophilization. Culture collection centers.

Staining techniques- Simple staining, differential staining (Gram stain, acid fast stain), Structural staining (spore, flagella, capsule, granule)

Module 5 **8 Hrs.**

Microscopy-principles and application – Bright field, Dark field, Phase contrast, Fluorescence, SEM & TEMS- Specimen preparation of electron microscopy –ultra sectioning, shadowing, negative staining ,freeze etching.

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BMB1P01 - FUNDAMENTALS OF MICROBIOLOGY

PRACTICAL – I

Total hours: 36 Hrs.

Total Credit 1

1. General rules in microbiology laboratory
2. Instrumentation
 - a. Microscopy
 - b. Incubator
 - c. Hot air oven
 - d. Autoclave
 - e. Quebec colony counter
3. Sterilization of glass wares
4. Preparation of media

Solid media- nutrient agar , Mac Conkey agar, Blood agar , Chocolate agar, SDA, PDA (for fungi)

Liquid media- nutrient broth and glucose broth
5. Isolation methods.
 - a. Serial dilution
 - b. Pour plate
 - c. Spread plate
 - d. Streak plate
 - e. Lawn culture
 - f. Stab culture
6. Measurement of pH by pH meter.
7. Antibiotic sensitivity test.

Reference:

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SEMESTER I
BMB102- MICROBIAL DIVERSITY

Total hours: 36 Hrs.

Total Credit 2

Module 1.

6 Hrs.

Principle of Classification

Outline classification of Bacteria according to Bergy's manual, Principles of classification- classification based on morphological characteristics, based on biochemical characteristics, based on staining reactions, based on genetic and molecular characteristics, principles of bacterial taxonomy.

Module II.

8 Hrs.

- a) Archaeobacteria- a brief account on characteristics and economic importance of archaeobacteria.
- b) Mycoplasma- general properties, structure- Cultural characteristics of mycoplasma. Classification of mycoplasma. Economic importance of mycoplasma
- c) Actinomycetes – General characteristics, classification and economic importance.
- D) Rickettsiae- Classification, Morphology and distinguishing characteristics of Rickettsiae, Economic importance

d) Module III

8 Hrs

Viruses: general properties of virus, structure and replication of Bacteriophages, TMV, HIV. Cultivation of viruses. Virions, viroids and prions

Module IV

6 Hrs

Fungi -morphology and classification of fungi ascomycota, basidiomycota, zygomycota, deuteromycota. reproduction – asexual and sexual. Cultivation of fungi, distinguishing characteristics of *rhizopus*, *mucor*, *aspergillus*, *pencillium* and *fusarium*.

Economic importance of fungi.

Module V

8 Hrs.

Algae- characteristics of algae- morphology and structure of algal cell. Algal pigments, motility, reproduction, classification of algae, economic importance of algae.

Cyanobacteria- distribution, characteristics of cyanobacteria. Ultra structure of cyanobacterial cell. Classification of cyanobacteria. Economic importance of blue green algae.

References

1. Topley, W. W. C., Wilson, G. S., Parker, T. and Collier, L. H. 1990. *Topley and Wilson's*
2. *Principles of Bacteriology, Virology and Immunology*. 8th Edition. Edward Arnold, London.
3. Black, J. G. 2005. *Microbiology, Principles and exploration*. 6th Edition. John Wiley & Sons.
4. Tortora, G. J., Funke, B. R. and Case, C. L. 2012. *Microbiology: An Introduction*. 11th Edition. Pearson education Pvt. Ltd. Singapore.
5. Lim, D. V. 2002. *Microbiology*. Dubuque, IA: Kendall/Hunt.
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9. Stanier, R. Y., Ingraham, J. L., Wheelis, M. L. and Painter, P. R. 2005. *General Microbiology*. 5th Edition. McMillan.
10. Russell A. D., Hugo W. B. and Ayliffe G. A. J. 1999. *Principles and practice of disinfection, preservation, and sterilization*, 3rd Edition. Blackwell Science, Oxford.
11. Tortora G. J., Funke B. R. and Case C. L. 2013. *Microbiology*. 11th Edition. Pearson New International.
12. Madigan, M., Martinko, J., Buckley, D. and Stahl, D. 2014. *Brock Biology of Microorganisms*, 14th Edition. Benjamin Cummings, New York.

SEMESTER I

B MB 1P 02- PRACTICAL – II

Total hours: 36 Hrs.

Total Credit 2

I. Staining techniques

1. Simple staining

2. Differential staining-

- a. Gram's staining,
- b. Acid fast staining

3. Structural staining-

- a. Endospore staining
- b. Granule staining
- c. Capsule staining
- d. Negative staining

4. Fungal staining-

- a) lacto phenol cotton blue mounting
- b) Scotch tape preparation

II. Preparation of permanent slides of bacteria (2 slides / student)

III. Motility of bacteria

- a. Hanging drop technique
- b. Wet mount method

Reference:

1. Lammert , J. M. 2006. *Techniques for Microbiology: A Student Handbook*. Benjamin Cummings.
2. Aneja, K. R. 2003. *Experiments in Microbiology, Plant Pathology and Biotechnology*. 4th Edition. New Age International (P) Limited, New Delhi.
3. Aneja, K. R. 2001. *Experiments in microbiology, plant pathology, tissue culture and mushroom production technology*. 3rd Edition. New Age International (P) Limited.
4. Dubey, R. C. and Maheswari, D. K. 2002. *Practical Microbiology*. 2nd Edition, S. Chand & Co., New Delhi.
5. Kannan, N. 2002. *Laboratory manual in general microbiology*. 2nd Edition, Panima Publishing Co., New Delhi.
6. Gunasekaran, P. 2002. *Laboratory manual in microbiology*. 2nd Edition, New Age International (P) Limited, New Delhi.
7. Kalaichelvan, P. T. 2005. *Microbiology and Biotechnology Laboratory manual*. MJP Publishers, Chennai.

8. Murugalatha, N. *et al.* 2012. *Microbiological techniques*. MJP Publishers, Chennai.
9. Goldman, E. and Green, L. H. 2008. *Practical Handbook of Microbiology*. 2nd Edition. CRP Press.
10. Cappuccino, J. and Sherman, N. 2013. *Microbiology: A Laboratory Manual*. 10th Edition. Benjamin-Cummings Publishing Company, Subs Of Addison Wesley Longman, Inc.

SEMESTER II

BMB203 - MICROBIAL PHYSIOLOGY

Total hours: 36 Hrs.Total Credit 2

Module 1. 4 Hrs.

Microbial Nutrition -Nutritional requirements - C, N, P, S, and minerals, Nutritional classification of bacteria. Uptake of nutrients passive diffusion, facilitated diffusion, Active transport,Group translocation .

Module2 10Hrs

Bacterial Growth- Factors affecting growth- effect of Temperature, pH, Oxygen concentration, Radiation. generation time;

Bacterial growth curve.

Reproduction and Growth:Modes of cell division- binary fission, budding, Fragmentation, Spore formation.

Continuous culturing of bacteria- chemostat, turbidostat.Synchronous growth.

Enumeration methods of bacteria- SPC, Direct microscopic count, turbidometric estimation

Module3 8 Hrs.

Photosynthesis -Photosynthetic microorganisms.Photosynthetic apparatus in prokaryotes and eukaryotes- photosynthetic pigments, Mechanism of cyclic and non-cyclic photophosphorylation, Calvin cycle. Rhodopsin based phototrophy.

Module4 8 hrs.

Microbial Metabolism-Glycolysis, Krebs's cycle & its significance, Pentose Phosphate Pathway, gluconeogenesis, ED pathway. Substrate level phosphorylation, Electron transport Chain and oxidative Phosphorylation. Fermentation -Alcoholic fermentation, Homo and hetro-lacticacid fermentation, mixed acid fermentations.

Module5 6 Hrs.

Nitrogen metabolism -Nitrogen Cycle, nitrification, denitrification and ammonification.Amino acid metabolism-transamination and deamination reactions.

Nitrogen fixation in symbiotic, associative and free living system, oxygen regulation of nitrogen fixation.

References :

- Doelle, H. W. 1975. *Bacterial Metabolism*. 2nd Edition. Academic Press.
- Moat, A. G. and Foster, J. W. 1988. *Microbial physiology*. 2nd Edition. Springer Verlag.
- White, D. 2000. *Physiology and Biochemistry of Prokaryotes*. 2nd Edition. Oxford University Press, New York.
- Caldwell, D. R. 1995. *Microbial physiology and Metabolism*. Wm. C Brown Publishers, England.
- Madigan, M. T., Martinko, J. M., Stahl, D. A. and Clark, D. P. 2012. *Brock Biology of Microorganisms*, 13th Edition, Benjamin Cummings, San Francisco.
- Lim, D. 1998. *Microbiology*. 2nd Edition; McGraw-Hill Publication.
- Ingraham, J. L. and Ingraham, C. A. 2004. *Introduction to Microbiology: A case history approach*. 3rd Edition. Thomson Brooks/Cole, Pacific Grove, Ca.
- Madigan, M. T. and Martinko, J. M. 2006. *Brock's Biology of Microorganisms*. 11th Edition. Pearson Education Inc.
- Pelczar, M. J. Jr., Chan, E. C. S. and Krieg, N. R. 1993. *Microbiology*, 5th Edition, Tata MacGraw Hill Press.
- Prescott, L. M., Harley, J. P. and Klein, D. A. 2005. *Microbiology*. 6th Edition. MacGraw Hill Companies Inc.
- Prescott, L. M., Harley, J. P. and Klein, D. A. 2006. *Microbiology*. 6th Edition. Edition, McGraw Hill Higher Education.
- Willey, J. M., Sherwood, L. M. and Woolverton, C. J. 2013. *Prescott's Microbiology*. 8th Edition, McGraw-Hill Higher Education.

9. Goldman, E. and Green, L. H. 2008. *Practical Handbook of Microbiology*. 2nd Edition. CRP Press.
10. Cappuccino, J. and Sherman, N. 2013. *Microbiology: A Laboratory Manual*. 10th Edition. Benjamin-Cummings Publishing Company, Subs Of Addison Wesley Longman, Inc.
11. Chakraborty, P. and Chakraborty, G. 2005. *Practical pathology*. Vol. 33. Kolkata: New Central Book Agency (P) Ltd.

SEMESTER II

BMB204- IMMUNOLOGY

Total hours: 36 Hrs.

Total Credit 2

Module 1 Introduction to immunology

5 hrs.

Types of immunity, innate immunity, acquired, passive, active Mechanism of innate immunity (eg. Barriers, Phagocytosis, inflammation.)

Module 2 Antigens and Antibodies

6 hrs.

Types of Antigens, Factors influencing antigenicity (foreignness, molecular size, heterogeneity), Epitopes, haptens. Basic structure of immunoglobulin. Different classes of immunoglobulin's and functions

Module 3 Antigen-antibody reactions:

6 hrs.

Precipitation test, Agglutination Test, Clinical applications of antigen antibody reaction (Eg: Widal , VDRL , HIV test (ELISA) Complement fixation test, Coombs test.

Module 4 Immune Response system

8hrs.

Primary and secondary lymphoid organs. Cells of the immune system. (Leucocytes, Lymphocytes T & B cells, Macrophages, Plasma cells, Memory cells) MHC Antibody synthesis, primary and secondary responses, Cytokines (Interferon's, Interleukins and TNFs), Complement system and its biological importance. Monoclonal antibodies – production and application, Polyclonal antibodies.

Module 5 Immunopathology

8 hrs.

Immune disorders, Different types of hypersensitivity reactions -

Mechanism of allergic reaction, Anaphylaxis and atopy, Mechanism of immune complex disease. (Eg. Arthus reaction, Serum sickness)

Autoimmunity, Delayed hypersensitivity, Autoimmune diseases (A brief account)

Transplantation Immunity - Graft rejection, major histocompatibility, Human leukocyte antigen system - (HLA) immuno-suppression, Graft versus host reaction.

Tumor immunity-Immune responses in malignancy, Immunotherapy, Immuno-haematology, Immunology of blood transfusion, Erythroblastosis foetalis. Immuno-deficiency, AIDS

Module 6 Vaccines

3 hrs.

Brief history of vaccination, principles of vaccines, major types of vaccines (BCG, DPT, Polio vaccine and TAB vaccines) DNA vaccines, toxoids, adjuvants. Recent trends in vaccine preparation

Reference

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1. Ananthanarayan, R. and Panicker, C. K. J. 2008. *Textbook of Microbiology*. Orient Longman Private Ltd.
2. Ananthanarayan, R. and Panicker, C. K. J. 2009. *Ananthanarayan and Paniker's Textbook of Microbiology*. Orient Longman Limited Universities Press (India) Pvt. Ltd.
3. Coleman, R. M. 1992. *Fundamentals of Immunology*. McGraw-Hill Higher Education.
4. Wise, D. J. and Carter, G. R. 2004. *Immunology - A Comprehensive Review*. Iowa State University Press, Blackwell Science Co.
5. Schlegel, H. G. *General Microbiology*. 7th Edition. Cambridge University Press, New York, USA.
6. Hapel, H., Harney, M., Misbah, S., and Snowden, N. 2006. *Essentials of Clinical Immunology* 5th Edition. Blackwell Publishing Company.
7. Heritage, J., Evaus, E. G. V. and Killungten, R. A. 2007. *Introductory Microbiology*. Cambridge University Press.
8. Delves, P. J., Martin, S. J., Burton, D. R. and Roitt, I. M. 2002. *Roitt's Essential Immunology*. 12th Edition. Wiley-Blackwell, John Wiley and Sons Ltd., Publication.
9. Park, K. 2002. *Parks Text Book of Preventive and Social Medicine*. 17th Edition. Jabalpur: M/S BanarsidasBhanot.
10. Kindt, T. J. Goldsby, R. A. and Osborne, B. A. 2007. *Kuby Immunology*. 6th Edition. W. H. Freeman and Co, New York.
11. Frank, S. A. 2002. *Immunology and Evolution of Infectious Disease*. Princeton University Press.
12. Sharma, K. 2009. *Manual of Microbiology: Tools and Techniques*. 2nd Edition. Anes Book's Pvt. Ltd., New Delhi.

PRACTICAL - 4
BMB2P4-IMMUNOLOGY
Total hours: 36 Hrs.Total Credit 1

1. Determination of ABO blood groups and Rh factor (Antigen antibody Reaction)
2. Study through photographs/ illustration, the primary immune (Bone marrow and thymus) and secondary immune (spleen and lymph nodes) organs in Man.
3. ELISA
4. RIA
5. WIDAL Test- slide agglutination test
6. VDRL test for syphilis.

REFERENCE

1. Aneja, K. R. 2001. *Experiments in microbiology, plant pathology, tissue culture and mushroom production technology*. 3rd Edition. New Age International (P) Limited.
2. Dubey, R. C. and Maheswari, D. K. 2002. *Practical Microbiology*. 2nd Edition, S. Chand & Co., New Delhi.
3. Kannan, N. 2002. *Laboratory manual in general microbiology*. 2nd Edition, Panima Publishing Co., New Delhi.
4. Gunasekaran, P. 2002. *Laboratory manual in microbiology*. 2nd Edition, New Age International (P) Limited, New Delhi.
5. Kalaichelvan, P. T. 2005. *Microbiology and Biotechnology Laboratory manual*. MJP Publishers, Chennai.
6. Murugalatha, N. *et al.* 2012. *Microbiological techniques*. MJP Publishers, Chennai.
7. Goldman, E. and Green, L. H. 2008. *Practical Handbook of Microbiology*. 2nd Edition. CRP Press.
8. Cappuccino, J. and Sherman, N. 2013. *Microbiology: A Laboratory Manual*. 10th Edition. Benjamin-Cummings Publishing Company, Subs Of Addison Wesley Longman, Inc.
9. Chakraborty, P. and Chakraborty, G. 2005. *Practical pathology*. Vol. 33. Kolkata: New Central Book Agency (P) Ltd.
10. Hay, F. C. and Westwood, O. M. R. 2002. *Practical Immunology*. 4th Edition. Wiley-Blackwell.

SEMESTER III

BMB305 –MICROBIAL GENETICS AND RECOMBINANT DNA TECHNOLOGY

Total hours: 54Hrs Total Credit 3

Module 1 Bacterial genome

8Hrs.

Bacterial chromosome, DNA replication in prokaryote. Meselson and Stahl experiment, modes of replication- rolling circle model and theta mode.

Module 2 Mutation

8 Hrs.

Spontaneous and induced mutations, transition, transversion, effects of mutation- silent, missense, non-sense, frame shift and conditional mutations. Forward and reverse mutations. Detection and isolation of mutants.

Module 3 Recombination

8 Hrs.

Recombination methods in bacteria: transformation, transduction and conjugation.

Module 4 Vectors

8 Hrs.

plasmids, pBR 322, pUC 8, phage vectors- M13, lamda,cosmids, phagemids, BAC, YAC, Ti plasmid, SV 40

Module 5 RecombinantDNA Technology

12 Hrs.

Principles, techniques & applications- Isolation of DNA. isolation of vector,enzymes used in recombinant DNA technology- type II restriction endonucleases, ligases, S1 nuclease, alkaline phosphatase, terminal transferase, DNA polymerase I, reverse transcriptase, exonuclease III, bacteriophages I exonuclease.

Production of Recombinant DNA, Transformation, Transduction, Transfection, Electroporation, Biolistic, Microinjection. Selection and analysis of Recombinant Clones

Module 6 Basic molecular biological techniques

10 Hrs.

DNA Sequencing- Maxam and Gilbert method, Sangers chain termination method.

blotting techniques- southern, northern, and western blotting, polymerase chain reaction, finger printing technique, autoradiography.

References:

1. Primrose, S., Twyman, R. and Old, B. 2001. *Principles of Gene Manipulation*, 6th Edition, Blackwell Science Ltd.
2. Chakravarty, A. K. 2013. *Introduction to Biotechnology*. OUP India.
3. Chaudhuri, K. 2012. *Microbial Genetics*. The Energy and Resources Institute, TERI.
4. Sridhar, S. 2005. *Genetics and Microbial Biotechnology*. Dominant Publishers and Distributors.

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5. Nicholl, D. S. T. 1994. *An Introduction to Genetic Engineering*. Cambridge University Press.
6. Old, R. W. and Primrose, S. B. 2008. *Principles of Gene manipulation*, 4th Edition, Blackwell scientific publications, London.
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10. Watson, J. D., Gilman, M., Witkowski, J. and Zoller, M. 1992. *Recombinant DNA*. 2nd Edition, Scientific American Books.
11. Lewin, B. 2000. *Genes VIII*. Oxford University Press. Oxford.
12. Balasubramanian, D., Bryce, C., Dharmalingam, K., Green, J. and Jayaraman, K. 1996. *Concepts in Biotechnology*. University Press, India.
13. Trevan, M. D., Boffey, S., Coulding K. H. and Standury, P. 1990. *Biotechnology. The basic principles*. Tata MC Graw Hill Edition.
14. Freifelder, S. 1987. *Microbial Genetics*. Jones and Bartlett, Boston.
15. Klug, W. S. and Cummings, M. R. 1996. *Essentials of Genetics*. Mentics Hail. New Jersey.
16. Gardner, E. J., Simmons, M. J. and Snustard, D. P. 1991. *Principles of Genetics*. 8th Edition. John Wiley and Sons, NY.
17. Glazer, A. N. and Nikaido, H. 2007. *Microbial Biotechnology: Fundamentals of Applied Microbiology*. 2nd Edition. Cambridge University Press.

SEMESTER III

PRACTICAL 5

BMB3P05 - GENETICS AND MICROBIAL BIOTECHNOLOGY

Total hours: 36 Hrs.

Total Credit 1

1. Isolation of chromosomal DNA from *E.coli*
2. Isolation of plasmid DNA
3. Agarose gel electrophoresis
4. Bacterial transformation
5. Immobilization of yeast cells by sodium alginate method
6. Polymerase chain reaction
7. **Blotting techniques**
 - a. Southern blotting
 - b. Northern blotting
 - c. Western blotting

Reference:

1. Aneja, K. R. 2001. *Experiments in microbiology, plant pathology, tissue culture and mushroom production technology*. 3rd Edition. New Age International (P) Limited.
2. Dubey, R. C. and Maheswari, D. K. 2002. *Practical Microbiology*. 2nd Edition, S. Chand & Co., New Delhi.
3. Kannan, N. 2002. *Laboratory manual in general microbiology*. 2nd Edition, Panima Publishing Co., New Delhi.
4. Gunasekaran, P. 2002. *Laboratory manual in microbiology*. 2nd Edition, New Age International (P) Limited, New Delhi.
5. Kalaichelvan, P. T. 2005. *Microbiology and Biotechnology Laboratory manual*. MJP Publishers, Chennai.
6. Murugalatha, N. *et al.* 2012. *Microbiological techniques*. MJP Publishers, Chennai.
7. Janarthanan, S. and Vincent, S. 2007. *Practical Biotechnology: Methods and Protocols*. Orient BlackSwan/Universities Press.
8. Jane, M., ValanArasu, M. and Duraipandiyam, V. 2012. *Practical Handbook in Microbial Biotechnology*. Lambert Academic Publishing.

SEMESTER III

BMB306 -MEDICAL MICROBIOLOGY

Total hours: 36 Hrs.

Total Credit 2

Module 1.	8Hrs.
Normal microbial flora of Human body, A systematic study of <i>Staphylococcus aureus</i> , <i>Streptococci</i> (<i>Str. pyogenes</i> and <i>Str. Pneumoniae</i>), <i>Escherichia coli</i> , <i>Klebsiella pneumoniae</i> , <i>Pseudomonas aeruginosa</i> , <i>Shigella</i> , <i>Vibrio cholerae</i> .	
Module 2	6Hrs.
Epidemiology, Symptomology, Pathogenesis, Diagnosis and treatment of Tuberculosis, Syphilis, Actinomycosis.	
Module 3	5 Hrs.
Respiratory tract infections -Infections of the upper and lower respiratory tract	
Module 4	6 Hrs.
Urinary tract infections, Genital tract infections, sexually transmitted diseases, and nosocomial infections	
Module 5	8Hrs.
Viral diseases: herpes virus, orthomyxovirus (influenza), paramyxoviruses (mumps, measles) rubella, hepatitis B, Rhabdo viruses, arbovirus, AIDS viruses, polio virus.	
Module 6	3 Hrs.
Fungal diseases:-Superficial and deep mycosis.	

Reference

1. Cann, A. J. 2005. *Principles of Molecular Virology*. 4th Edition. Elsevier Academic Press.
2. Pichare, A. P. and Nagoba, B. S. 2013. *Medical Microbiology: Prep Manual for Undergraduates*. Elsevier India Pvt. Ltd.
3. Carter, J. and Saunders, V. 2007. *Virology: Principles and Applications*. John Wiley and Sons Ltd.
4. Dimmock, N. J., Easton, A. J. and Leppard, K. N. 2007. *Introduction to Modern Virology*, 6th Edition. Blackwell Publishing.
5. Kayser F. H., Bienz, K. A., Eckert, J. and Zinkernagel, R. M. 2004. *Medical Microbiology*. Berlin: Thieme Medical.
6. Baron, S. 1996. *Medical Microbiology*, 4th Edition. Galveston (TX): University of Texas Medical Branch at Galveston
7. Greenwood, D., Slack, R. C. B., Peutherer, J. F. and Barer, M. R. 2007. *Medical Microbiology: A Guide to Microbial Infections: Pathogenesis, Immunity, Laboratory Diagnosis and Control*. 17th Edition. Elsevier Health Sciences UK.
8. Topley, W. W. C., Wilson, G. S., Parker, M. T. and Collier, L. H. 1990. *Topley and Wilson's Principles of Bacteriology, Virology and Immunology*. 8th Edition. London: Edward Arnold.

9. Zinsser, H. and Joklik, W. K. 1992. *Zinsser microbiology*. 20th Edition. Norwalk, CT: Appleton & Lange.
10. Ananthanarayan, R. and Paniker, C. K. J. 2006. *Textbook of microbiology*. 7th Edition. Orient Blackswan.
11. Emmons, C. W., Binford, C. H., Utz, J. P., Kwon-Chung, K. J. 1977. *Medical Mycology*. 3rd Edition. Philadelphia, Lea &Febiger.
12. Rippon, J. W. 1988. *Medical mycology: the pathogenic fungi and the pathogenic actinomycetes*. 3rd Edition. Saunder, Philadelphia.

SEMESTER III

PRACTICAL 6

BMB3P06 -MEDICAL MICROBIOLOGY

Total hours: 36 Hrs.

Total Credit 1

- 1 . Microbiology of laboratory safety, General concept for specimen collection, handling.
2. Study of the morphology, staining characters, cultural characters and identification of medically important bacteria *Staphylococci*, *Streptococci*, *E.coli*, *Klebsiella*, , *Proteus*, *Pseudomonas*,
3. Test for hemolytic property of bacteria.
4. Isolation and identification of bacteria from culture
5. Culture methods for isolation and identification of fungi- KOH mount preparation, Lacto phenol cotton blue staining, Slide culture technique etc.
6. Study of normal microbial flora of human being
7. Estimation of hemoglobin content in blood

Reference:

1. Cheesbrough, M. 2006. *District Laboratory Practice in Tropical countries*. 2nd Edition. Cambridge, University Press.
2. Rowland, S. S., Walsh, S. R., Teel, L. D. and Carnahan, A. M. 1994 *Pathogenic and Clinical Microbiology: A Laboratory Manual*. **Lippincott Williams and Wilkins**.
3. Gradwohl, R. B. H., Sonnenwirth, A. C. and Jarett, L. 1980. *Gradwohl's clinical laboratory methods and diagnosis*. 8th Edition. Mosby, London.
4. Cappuccino, J. G. and Sherman, N. 2008. *Microbiology: A Laboratory Manual*. 9th Edition. Pearson/Benjamin Cummings.
5. Prince, C. P. 2009. *Practical Manual of Medical Microbiology*. Jaypee Brothers Medical Publishers (p) Ltd., New Delhi.
6. Mackie, T. J. 1996. *Mackie and McCartney Practical Medical Microbiology*. Churchill Livingstone.
7. Aneja, K. R. 2001. *Experiments in microbiology, plant pathology, tissue culture and mushroom production technology*. 3rd Edition. New Age International (P) Limited.
8. Kannan, N. 2002. *Laboratory manual in general microbiology*. 2nd Edition, Panima Publishing Co., New Delhi.

9. Gunasekaran, P. 2002. *Laboratory manual in microbiology*. 2nd Edition, New Age International (P) Limited, New Delhi.
10. Kalaichelvan, P. T. 2005. *Microbiology and Biotechnology Laboratory manual*. MJP Publishers, Chennai.
11. Chakraborty, P. and Chakraborty, G. 2005. *Practical pathology*. Vol. 33. Kolkata: New Central Book Agency (P) Ltd.

SEMESTER IV

BMB407 -BASICS OF INDUSTRIAL MICROBIOLOGY

Total hours: 36 Hrs.

Total Credit 2

Module 1 8 Hrs.

History and development of industrial microbiology - scope of industrial microbiology.
Screening of industrially important microorganisms- Primary Screening and Secondary Screening. Strain Improvement – Mutation, Recombination, and protoplasmic Fusion.

Module 2 8 Hrs.

Preservation and storage of microorganisms. Development of inoculum for industrial fermentation. Fermentation media- formulation of media- saccharine materials, starchy materials, cellulosic materials, nitrogenous materials, enhancers and precursors.
Industrial sterilization- batch and continuous sterilization.

Module 3 8 Hrs.

Structure of a typical Batch fermenter, antifoams.
Type of fermenters: Batch Fermenter , Continuous Stirred Tank Fermenter , Fluidized Bed Fermenter, Solid State Fermenter, Air Lift Fermenter, Tubular Fermenter.

Module 4 4 Hrs.

Fermentation process: Surface, Submerged and Continuous fermentation .Computer control of fermentation process.

Module 5 8 Hrs.

Downstream Processing or Recovery- intra cellular and extra cellular product recovery. Physical and chemical methods. Cell disruption- methods, solvent extraction, and purification. Product recovery by whole broth processing.

References:

1. Whitaker, A., Stanbury, P. F. and Hall, S. J. 2009. *Principles of Fermentation Techniques*. Elsevier.
2. Demain, A. L. and Solomon, N. A. 1986. *Manual of Industrial Microbiology*. Oxford University Press, Oxford.
3. Waites, M. J., Morgan, N. L., Rockey, J. S. and Higton, G. 2001. *Industrial Microbiology: An Introduction*. Blackwell Science Ltd.
4. Prescott, S. C., Dunn, C. G., and Reed, G. 1982. *Prescott and Dunn's Industrial Microbiology*, 4th Edition. AVI Pub. Co., Westport, Conn.
5. Waites, M. J. 2001. *Industrial Microbiology*. Blackwell Science, Oxford.

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6. McNeil, B. and Harvey, L. M. 1990. *Fermentation: A Practical Approach*. Oxford; New York: IRL Press.
7. Enfors, S. O. and Haggström, L. 2000. *Bioprocess Technology: Fundamentals and Applications*. Royal Institute of technology, Stockholm, Sweden.
8. Crueger, W., Crueger, A., and Brock, T. D. 1990. *Biotechnology: A Textbook of Industrial Microbiology*. Sinauer Associates.
9. Casida, L. E. 1968. *Industrial Microbiology*. Wiley, New York; London.
10. Okafor, N. 2007. *Modern Industrial Microbiology and Biotechnology*. CRC Press.

PRACTICAL 7

BMB4P07-- BASICS OF INDUSTRIAL MICROBIOLOGY

Total hours: 36 Hrs.

Total Credit 1

1. Crowded plate technique for screening of industrially important microorganisms- microbes producing enzymes, antibiotics etc.
2. Production of enzymes – amylase and protease
3. Solid state & submerged fermentation
4. **Preservation techniques:**
 - a. Serial sub culturing
 - b. Over laying mineral oil
 - c. Lyophilization
 - d. Liquid nitrogen storage.
 - e. Methods for the storage of Fungi
5. Estimation of lactic acid from milk.

Reference:

1. Aneja, K. R. 2003. *Experiments in Microbiology, Plant Pathology and Biotechnology*. 4th Edition. New Age International (P) Limited, New Delhi.
2. Aneja, K. R. 2001. *Experiments in microbiology, plant pathology, tissue culture and mushroom production technology*. 3rd Edition. New Age International (P) Limited.
3. Dubey, R. C. and Maheswari, D. K. 2002. *Practical Microbiology*. 2nd Edition, S. Chand & Co., New Delhi.
4. Kannan, N. 2002. *Laboratory manual in general microbiology*. 2nd Edition, Panima Publishing Co., New Delhi.
5. Gunasekaran, P. 2002. *Laboratory manual in microbiology*. 2nd Edition, New Age International (P) Limited, New Delhi.
6. Kalaichelvan, P. T. 2005. *Microbiology and Biotechnology Laboratory manual*. MJP Publishers, Chennai.
7. Murugalatha, N. *et al.* 2012. *Microbiological techniques*. MJP Publishers, Chennai.
8. Goldman, E. and Green, L. H. 2008. *Practical Handbook of Microbiology*. 2nd Edition. CRP Press.
9. Baltz, R. H., Davies, J. E. and Demain, A. L. 2012. *Manual of Industrial Microbiology and Biotechnology*. 3rd Edition. Washington DC: American Society of Microbiology.

SEMESTER IV

BMB408-FERMENTATION TECHNOLOGY

Total hours: 36 Hrs.

Total Credit 2

Module 1	7 Hrs.
Fermentative production of industrially important compounds	
Pharmaceuticals: antibiotic fermentations – production of penicillin and streptomycin.	
Production of vitamins & growth stimulants: riboflavin, cyanocobalamines and gibberellins	
Module 2	10 Hrs.
Production of Organic acids: Acetic acid, citric acid, lactic acid	
Amino acid fermentations : Production of Lysine and glutamic acid	
Enzymes as fermentation products: Protease, amylase	
Solvents: Ethanol, Glycerol	
Module 3	7 Hrs.
Production of biofuels - Hydrogen, Methane	
Production of Beverages- Beer- Distilled spirits and Wine	
Production of Single cell Protein- Baker's Yeast and Spirullina	
Module 4	7 Hrs.
Enzyme immobilization - Different methods of enzyme immobilization, applications of enzyme immobilization. Industrial applications of enzymes	
Module 5	5 Hrs.
Microbial recovery of metals- bioleaching of copper, gold & uranium	
microbially enhanced oil recovery (MEOR)	

References:

1. Whitaker, A., Stanbury, P. F. and Hall, S. J. 2009. *Principles of Fermentation Techniques*. Elsevier.
2. Demain, A. L. and Solomon, N. A. 1986. *Manual of Industrial Microbiology*. Oxford University Press, Oxford.
3. Prescott, S. C., Dunn, C. G., and Reed, G. 1982. *Prescott and Dunn's Industrial Microbiology*, 4th Edition. AVI Pub. Co., Westport, Conn.
4. Hui, Y. H., Meunier-Goddik, L., Hansen, A. L., Josephsen, J., Nip, W.-K., Stanfield, P. S. and Toldra, F. 2004. *Handbook of Food and Beverage Fermentation Technology*. New York : Marcel Dekker Incorporated.
5. Waites, M. J. 2001. *Industrial Microbiology*. Blackwell Science, Oxford.
6. McNeil, B. and Harvey, L. M. 1990. *Fermentation: A Practical Approach*. Oxford; New York: IRL Press.

7. Peppler, H. J. 1995. *Microbial Technology: Fermentation technology*. Academic Press.
8. Srivastava, M. 2008. *Fermentation Technology*. Alpha Science International.
9. Enfors, S. O. and Haggström, L. 2000. *Bioprocess Technology: Fundamentals and Applications*. Royal Institute of technology, Stockholm, Sweden.
10. Crueger, W., Crueger, A., and Brock, T. D. 1990. *Biotechnology: A Textbook of Industrial Microbiology*. Sinauer Associates.
11. Casida, L. E. 1968. *Industrial Microbiology*. Wiley, New York; London.

PRACTICAL 8

BMB4P08 - FERMENTATION TECHNOLOGY

Total hours: 36 Hrs. Total Credit 1

1. Study of alcoholic fermentation of fruit juice by yeast.
2. Quantitative estimation of ethanol produced during yeast fermentation.
3. Production of citric acid by *Aspergillus niger*
4. Estimation of citric acid.
5. Production of Penicillin & testing of antimicrobial activity.

Reference:

1. Aneja, K. R. 2003. *Experiments in Microbiology, Plant Pathology and Biotechnology*. 4th Edition. New Age International (P) Limited, New Delhi.
2. Aneja, K. R. 2001. *Experiments in microbiology, plant pathology, tissue culture and mushroom production technology*. 3rd Edition. New Age International (P) Limited.
3. Dubey, R. C. and Maheswari, D. K. 2002. *Practical Microbiology*. 2nd Edition, S. Chand & Co., New Delhi.
4. Kannan, N. 2002. *Laboratory manual in general microbiology*. 2nd Edition, Panima Publishing Co., New Delhi.
5. Gunasekaran, P. 2002. *Laboratory manual in microbiology*. 2nd Edition, New Age International (P) Limited, New Delhi.
6. Kalaichelvan, P. T. 2005. *Microbiology and Biotechnology Laboratory manual*. MJP Publishers, Chennai.
7. Murugalatha, N. et al. 2012. *Microbiological techniques*. MJP Publishers, Chennai.
8. McNeil, B. and Harvey, L. M. 2008. *Practical Fermentation Technology*. John Wiley & Sons, Ltd, Chichester.
9. Kulandaivelu, S. and Janarthanan, S. 2012. *Practical Manual on Fermentation Technology*. International Publishing House Pvt. Limited.

SEMESTER V

BMB509 - FOOD MICROBIOLOGY

Total hours: 54Hrs Total Credit 3

Module 1

10 Hrs.

Food as a substrate for microorganisms, micro-organisms important in food microbiology- molds, yeasts and bacteria; brief account of each group; general characteristics and importance. Factors affecting growth- pH, moisture, temperature, water activity, oxygen.

Module 2

12 Hrs.

Principles of food preservation - asepsis, removal of microorganisms, anaerobic conditions, high and low temperatures, drying, radiation. chemical preservatives - food additives. Principles of canning.

Module 3

12 Hrs.

General principles underlying food spoilage and contamination; vegetables, fruits, egg, meat, fish.

Microbial role in production of Bread, vinegar, sauerkraut, beer, and wine.

Cultivation of mushrooms.

Module 4

12 Hrs.

Bacteriological examination of milk. Preservation of milk, pasteurization - different methods and advantages, sterilization, dehydration, bacteriological standards and grading of milk. Fermented dairy products- cheese, cultured buttermilk, bulgarian butter milk, ice cream, lassi, condensed and dry milk products, yoghurt; low lactose milk, kefir and kumiss.

Module 5

8 Hrs.

Food borne Diseases- Food poisonings and food born infections and intoxication. Mycotoxins in food with reference to *Aspergillus*.

Microbiology of food sanitation- Hazard Analysis Critical Control Points (HACCP), Microbiological criteria for food.

References

1. Casida, L. E. 1968. *Industrial Microbiology*. Wiley, New York; London.
2. Doyle, M. P., Beuchat, L. R. and Montville, T. J. 2001. *Food Microbiology: Fundamentals and Frontiers*. 2nd Edition. ASM Press, Washington, D.C.
3. Frazier, W. C. and Westhoff, D. C. 2004. *Food Microbiology*. Tata McGraw Hills Publishing Company Limited.
4. Rose, A. H. 1983. *Food microbiology*. Academic Press, London.
5. Garbutt, J. H. 1997. *Essentials of food microbiology*. Arnold, London.
6. Wood, B. J. B. 1998. *Microbiology of fermented foods*. 2nd Edition. Blackie Academic and Professional, London.

7. Ayres, J. C., Mundt, J. O. and Sandine, W. E. 1980. *Microbiology of foods*. Freeman, San Francisco.
8. Robinson, R. K. 1990. *Dairy Microbiology*. 2nd Edition. Elsevier Science Pub. Co., London; New York.
9. Adams, M. R. and Moss, M. O. 2008. *Food Microbiology*, 3rd Edition. RSC Publishers.
10. Ray, B. 2003. *Fundamentals of Food Microbiology*. Boca Raton, FL: CRC Press.
11. Prescott, S. C., Dunn, C. G. and Reed, G. 1982. *Prescott and Dunn's Industrial Microbiology*. 4th Edition. AVI Pub. Co., Westport, Conn.
12. Waites, M. J. 2001. *Industrial Microbiology*. Blackwell Science, Oxford.
13. McNeil, B. and Harvey, L. M. 1990. *Fermentation: A Practical Approach*. Oxford; New York: IRL Press.
14. Jay, J. M., Loessner, M. J. and Golden, D. A. 2005. *Modern Food Microbiology*. Springer Science & Business Media.

SEMESTER V

PRACTICAL -9

BMB5P09- FOOD MICROBIOLOGY

Total hours: 36 Hrs.Total Credit 1

1. Microbiological examination of food
2. Isolation of bacteria from idli batter & curd.
3. Microbiological examination of soft drinks.
4. Standard plate count of milk.
5. Determination of quality of milk sample by methylene blue reductase test.
6. Detection of number of bacteria in milk by breed count.
7. Quality testing of milk by resazurin test.
8. Determination of phosphatase activity of milk.
9. Detection of mastitis through milk test.
10. Detection of calcium & phosphorous in milk.
11. Cultivation of Edible mushroom

Reference:

1. Aneja, K. R. 2003. *Experiments in Microbiology, Plant Pathology and Biotechnology*. 4th Edition. New Age International (P) Limited, New Delhi.
2. Aneja, K. R. 2001. *Experiments in microbiology, plant pathology, tissue culture and mushroom production technology*. 3rd Edition. New Age International (P) Limited.
3. Dubey, R. C. and Maheswari, D. K. 2002. *Practical Microbiology*. 2nd Edition, S. Chand & Co., New Delhi.

Board of Studies in Zoology & Industrial Microbiology (UG), SB College, Changanacherry

4. Kannan, N. 2002. *Laboratory manual in general microbiology*. 2nd Edition, Panima Publishing Co., New Delhi.
5. Gunasekaran, P. 2002. *Laboratory manual in microbiology*. 2nd Edition, New Age International (P) Limited, New Delhi.
6. Kalaichelvan, P. T. 2005. *Microbiology and Biotechnology Laboratory manual*. MJP Publishers, Chennai.
7. Murugalatha, N. *et al.* 2012. *Microbiological techniques*. MJP Publishers, Chennai.
8. Harrigan, W. F. 1998. *Laboratory Methods in Food Microbiology*. 3rd Edition. Gulf Professional Publishing.
9. Yousef, A. E. and Carlstrom, C. 2003. *Food Microbiology: A Laboratory Manual*, John Wiley and Sons.
10. Roberts, D. and Greenwood, M. 2003. *Practical Food Microbiology*. 3rd Edition, Blackwell publishers.

SEMESTER V
EMB 501-DAIRY MICROBIOLOGY
(OPEN COURSE)

Total hours:72 Hrs. Credits-3

- Module I** **18 Hrs.**
Milk –introduction, composition, microorganisms in milk- bacteria, yeast, mold. Nutritive value of milk. Starter cultures and their biochemical activities- *Streptococcus thermophiles* and *Lactobacillus bulgaricus*. starter culture preparation. dairy processing unit operations- clarification, separation, standardization, toning of milk, homogenization.
- Module II** **14 Hrs.**
Bacteriological examination of milk. Preservation of milk, pasteurization - different methods and advantages, sterilization, dehydration, bacteriological standards and grading of milk.
- Module III** **16 Hrs.**
General principles underlying spoilage of milk and milk products, sources for contamination of milk, milk borne diseases, antimicrobial systems in milk.
- Module IV** **12 Hrs.**
Fermented dairy products- cheese ,cultured buttermilk, bulgarian butter milk, ice cream, lassi, condensed and dry milk products, yoghurt; low lactose milk, kefir and kumiss.
- Module V** **12 Hrs.**
Hygiene in manufacturing milk products, cleaning of dairy equipment's, dairy processing plant sanitation, probiotic role of lactic acid bacteria and fermented milk products, utilization and disposal of dairy byproduct- whey

References

1. Prajapati, J. B. 1995. *Fundamentals of Dairy Microbiology*. AktaPrakashalNadiad, Gujarat.
2. Robinson, R. K. 1990. *Dairy Microbiology*. Volume II and I. Elsevier Applied Science, London.
3. Marth, E. H. and Steele, J. *Applied dairy microbiology*. 2nd Edition. CRC Press.
4. *Milk and Milk Products* - Fourth edition - clarence henry eckles, Tata McGraw Hill publishing company Limited, New Delhi, 1957
5. Dey, S. 1994. *Outlines of Dairy Technology*. Oxford Univ. Press, New Delhi.
6. Robinson, R. K. 1986. *Modern Dairy Technology*. (2 vol. set). Elsevier AppliedScience, UK.
7. Rosenthal, I. 1991. *Milk and Milk Products*. VCH, New York.

8. Warner, J. M. 1976. *Principles of Dairy Processing*. Wiley Eastern Ltd. New Delhi.
9. Yarpar, W. J. and Hall, C. W. 1975. *Dairy Technology and Engineering*. AVI, Westport.
10. Rheinhermer, G. 1986. *Aquatic Microbiology*. John Wiley and Sons, NY.
11. Robinson, R. K. 1981. *Dairy Microbiology: The microbiology of milk products*. Applied Science Publishers.
12. Law, B. A. 1997. *Microbiology and Biochemistry of Cheese and Fermented Milk*. 2nd edition. Blackie Academic & Professional, London.

SEMESTER VI

BMB610 -AGRICULTURAL MICROBIOLOGY

Total hours-36

Credits 2

Module 1

12 Hrs.

soil microorganisms and microbial interactions

mutualism, synergism (proto cooperation) commensalisms.

Amensalism, competition, parasitism, predation, neutralism

Plant –microbe Interaction-Microorganisms of rhizosphere, rhizoplane, phylloplane and mycorrhizae-ectomycorrhizae, endomycorrhizae and vesicular arbuscular mycorrhizae

Module 2

5 Hrs.

Biogeochemical cycles - nitrogen, carbon, sulfur, phosphorus cycles

Biochemistry and physiology of nitrogen fixation, *nif* genes.

Module 3

8 Hrs.

Microbial diseases of plants

Bacterial diseases: Bacterial leaf blight of rice, Citrus canker

Fungal diseases: Root rot of pepper, Downy mildew of grapes, and Tikka disease of groundnut.

Mycoplasmal diseases - Sandal spike, Grassy shoot disease of sugar cane

Actinomycetes diseases- Potato scab disease

Viral Disease – TMV, Bunchy top disease of banana

Module 4

7 Hrs.

Bio fertilizers: production and quality control: *Rhizobium*, *Azotobacter*, *Azospirillum* Cyanobacteria, mycorrhizae :vesicular arbuscular mycorrhizae. phosphatesolubilizing bacillus

Module 5

4 Hrs.

BioPesticides: bacterial, viral and fungal biopesticides. biological control of plant pathogens. microbial warfare on plants.

References

1. Agrios, G. 2005. *Plant Pathology*. 5th Edition, Academic Press.
2. Hull, R. 2002. *Matthew's Plant Virology*. 4th Edition, Academic Press.
3. Atlas, R. N. and Bartha, R. 1998. *Microbial Ecology: Fundamentals & Applications*. 4th Edition. Benjamin & Cummings Science Publishing, California.
4. Subba Rao, M. S. 1995. *Soil microorganisms and plant growth*. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
5. Bagyaraj, D. J. and Rangaswami, G. 2005. *Agricultural microbiology*. 2nd Edition, Prentice Hall of India.
6. Mitchell, R. 1974. *Introduction to environmental microbiology*. Prentice-Hall, Englewood Cliffs, N. J.
7. Campbell, R. E. 1983. *Microbial ecology*. 2nd Edition, Blackwell Scientific Publications, Oxford; Boston.
8. Rheinheimer, G. 1991. *Aquatic microbiology*, 4th Edition, John Wiley and Sons.
9. Ahmad, I., Ahmad, F. and Pichtel, J. 2011. *Microbes and Microbial Technology: Agricultural and Environmental Applications*. Springer, New York.
10. Dart, R. K. 1980 *Microbiological aspects of pollution control*. 2nd Edition. Elsevier Scientific, Amsterdam.
11. Jan Dirk van Elsas. 1997. *Modern Soil Microbiology*. Taylor and Francis.
12. Rajvaidya, N. and Markandey, D. K. 2006. *Agricultural Applications of Microbiology*. APH Publishers.

SEMESTER VI

PRACTICAL 10

BMB6P10 -AGRICULTURAL MICROBIOLOGY

Total hours -36

Credits 1

1. Isolation & enumeration of microorganism from soil.
2. Isolation & Cultivation of rhizobium
3. Morphological observation of rhizobium from root nodules
4. Isolation of *Azospirillum* spp. From soil
5. Isolation of microorganism from rhizosphere, and calculation of R: S Ratio
6. Study of antagonism between soil microorganisms.
7. Study of soil bacteria for denitrification.
8. Study of symptoms of various plant diseases
 - a. Downy mildew of grapes.
 - b. Potato scab disease
 - c. Citrus canker.
 - d. Bacterial leaf blight of rice.
 - e. Bunchy top disease of banana
 - f. Phytophthora root rot of pepper

Reference:

1. Aneja, K. R. 2003. *Experiments in Microbiology, Plant Pathology and Biotechnology*. 4th Edition. New Age International (P) Limited, New Delhi.
2. Aneja, K. R. 2001. *Experiments in microbiology, plant pathology, tissue culture and mushroom production technology*. 3rd Edition. New Age International (P) Limited.
3. Dubey, R. C. and Maheswari, D. K. 2002. *Practical Microbiology*. 2nd Edition, S. Chand & Co., New Delhi.
4. Kannan, N. 2002. *Laboratory manual in general microbiology*. 2nd Edition, Panima Publishing Co., New Delhi.
5. Gunasekaran, P. 2002. *Laboratory manual in microbiology*. 2nd Edition, New Age International (P) Limited, New Delhi.
6. Kalaichelvan, P. T. 2005. *Microbiology and Biotechnology Laboratory manual*. MJP Publishers, Chennai.
7. Murugalatha, N. *et al.* 2012. *Microbiological techniques*. MJP Publishers, Chennai.
8. Schmidt, E. L. 1967. *A Practical Manual of Soil Microbiology Laboratory Methods*. Food and Agriculture Organization of the United Nations.
9. Rozar, A. 2002. *Practical Methods for Environmental Microbiology and Biotechnology*. Krishna Prakashan Media Ltd., Meerut.

SEMESTER VI

B MB 6 11 -MICROBIAL WASTE MANAGEMENT

36 HoursCredit 2

Module 1

8 Hrs.

Solid waste- types and sources of solid waste,

Solid waste disposal; sanitary landfills, composting; static pile, aerated pile, and feed reactor, role of microorganisms in composting.

Vermicomposting–biomethanation.

Module 2

8 Hrs.

Liquid waste- sources of liquid waste, components of industrial waste water, treatment of liquid waste; microbiology of municipal sewage;

Sewage treatment - primary treatment- screening, sedimentation, floatation, coagulation and flocculation, secondary treatment - trickling filter, activated sludge, oxidation pond and tertiary treatments;

Anaerobic sludge digestion process

Module 3

4 Hrs.

Disinfections- chlorination – methods of chlorination- break point chlorination, super chlorination, chloramines, and chlorine dioxide. UV and Ozone treatment.

Disposal of treated sewage

Module 4

6 Hrs.

Microbiology of water pollution

Microbial indicators of water pollution, BOD, COD, eutrophication. Microbiological water quality standards,

Aspects of water pollution- biofilm, bio corrosion, bio augmentation.

Bacteriological techniques for the examination of water – total count, most probable number, membrane filter technique.

Water borne diseases

Module 5

10 Hrs.

Biodegradation - biodegradation of xenobiotic compounds; stimulating biodegradation, hospital waste management, bioremediation- in situ and ex situ techniques, bio sorption

Bioremediation of hazardous waste, dyes, oil, pesticides;

Biodegradation of lignin, cellulose and plastics.

References:

1. Odum, E. P. and Barrett, G. W. 2005. *Fundamentals of Ecology*. 5th Edition. Thomson Brooks/Cole, Belmont, CA.
2. J. C. Daniel, 1999. *Environment Aspects of Microbiology*. 1st Edition, Bright Sun Publications, Chennai.
3. Rajendran, P. and Gunasekaran, P. 2006. *Microbial Bioremediation*. MJP Publishers, Chennai.
4. Rangaswam, G. and Bagyaraj, D. J. 1992. *Agricultural Microbiology*, Asia Publishing House, New Delhi.
5. Atlas, R. M., Bartha, R. and Cummings, B. 1998. *Microbial Ecology*. 4th Edition. Publishing Co, Redwood City, CA.
6. Varnam, A. H. and Evans, M. G. 2000. *Environmental Microbiology*. Manson Publishing Ltd.
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8. Grant, W. D. and Long, P. E. 1981. *Environmental Microbiology*. Kluwer Academic Publishers.
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10. Edmonds, P. 1978. *Microbiology: An environmental Perspective*. Macmillan, New York.
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12. Jjemba, P. K. 2004. *Environmental Microbiology: Principles and Applications*. Science Publishing Inc.
13. Schaechter, M. 2009. *Encyclopedia of Microbiology*. Six-Volume Set, 1-6. Academic press.
14. Kuhad R. C. and Singh, A. 2007. *Lignocellulose Biotechnology: Future Prospects*. I. K. International.
15. Singh, A. and Ward, O. P. 2004. *Applied Bioremediation and Phytoremediation*. Springer.
16. Eriksson, K-E. L., Blanchettee, R. A. and Ander, P. 1990. *Microbial and Enzymatic Degradation of Wood and Wood components*. Springer.
17. Singh, A., Kuhad R. C. and Ward, O. P. 2009. *Advances in Applied Bioremediation*. Springer.

SEMESTER VI
BMB6P11- MICROBIAL WASTE MANAGEMENT
PRACTICAL -11
36 HoursCredit 1

1. Bacterial examination of water by MPN technique and IMVIC test
2. Bacterial examination of water by membrane filter technique
3. Analysis of water by standard plate count
4. Determination of dissolved oxygen
5. Estimation of BOD water, raw / treated sewage
6. Estimation of COD from water, raw / sewage
7. Oligodynamic action of heavy metals.
8. Determination of total alkalinity of water
9. Determination of chlorine in water.
10. Central pollution control board standards for discharge of treated waste water
11. Indian standard Institute specification for Drinking water.

Reference:

1. Aneja, K. R. 2003. *Experiments in Microbiology, Plant Pathology and Biotechnology*. 4th Edition. New Age International (P) Limited, New Delhi.
2. Aneja, K. R. 2001. *Experiments in microbiology, plant pathology, tissue culture and mushroom production technology*. 3rd Edition. New Age International (P) Limited.
3. Dubey, R. C. and Maheswari, D. K. 2002. *Practical Microbiology*. 2nd Edition, S. Chand & Co., New Delhi.
4. Kannan, N. 2002. *Laboratory manual in general microbiology*. 2nd Edition, Panima Publishing Co., New Delhi.
5. Gunasekaran, P. 2002. *Laboratory manual in microbiology*. 2nd Edition, New Age International (P) Limited, New Delhi.
6. Kalaichelvan, P. T. 2005. *Microbiology and Biotechnology Laboratory manual*. MJP Publishers, Chennai.
7. Murugalatha, N. *et al.* 2012. *Microbiological techniques*. MJP Publishers, Chennai.