ST. JOSEPH'S UNIVERSITY

BENGALURU-27

SCHOOL OF LIFESCIENCES

DEPARTMENT OF MICROBIOLOGY

SYLLABUS FOR UNDERGRADUATE PROGRAMME

From 2022 onwards

(NATIONAL EDUCATION POLICY 2020)

SUMMARY OF CREDITS IN MICROBIOLOGY

DEPARTMENT OF MICROBIOLOGY (UG) (2022 onwards)								
Semester 1	**Code Number**	**Title**	**No. of Contact Hours**	**No. of contact Hours per week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	MB-121	Basic Microbiology and Microbiological Techniques	56	04	04	40	60	100
Practical	MB-1P1	Basic Microbiology and Microbiological Techniques	44	04	02	15	35	50
Theory	MBOE1	Microbial Technology for Human Welfare	42	03	03	40	60	100
Total Number of credits:			**09**					
Semester 2	**Code Number**	**Title**	**No. of Contact Hours**	**No. of Contact Hours per week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	MB-221	Microbial Biochemistry and Analytical Techniques	56	04	04	40	60	100
Practical	MB-2P1	Microbial Biochemistry and Analytical Techniques	44	04	02	15	35	50
Theory	MBOE2	Environmental Microbiology and Public Health	42	03	03	40	60	100
Total Number of credits:			**09**					

Semester 3	**Code Number**	**Title**	**No. of Contact Hours**	**No. of Contact Hours**	**No. of Credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	MB-322	Microbial diversity, growth and control of microorganisms	56	04	04	40	60	100
Practical	MB-3P1	Microbial diversity, growth and control of microorganisms	44	04	02	15	35	50
Theory	MBOE3	Microbial Diseases: Causes, Prevention and Cure	42	03	03	40	60	100
Total Number of credits:			**09**					
Semester 4	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of teaching Hrs /week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	MB-422	Microbial Enzymology and Metabolism.	56	04	04	40	60	100
Practical	MB-4P1	Microbial Enzymology and Metabolism.	44	04	02	15	35	50
Theory	MBOE4	Microbes and the Food Industry	42	03	03	40	60	100
Total Number of credits:			**09**					

Semester 5	**Code Number**	**Title**	**No. of Contact Hours**	**No. of Contact Hours per week**	**No. of Credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	MB-5123	Microbial genetics and Molecular biology	42	03	03	40	60	100
Practical	MB-5P1	Microbial genetics and Molecular biology	44	04	02	15	35	50
Theory	MB-5223	Immunology and Medical Microbiology	42	03	03	40	60	100
Practical	MB-5P2	Immunology and Medical Microbiology	44	04	02	15	35	50
Total Number of credits:			**10**					

Semester 6	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of teaching Hrs /week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	MB-6123	Food and Dairy Microbiology	42	03	03	40	60	100
Practical	MB-6P1	Food and Dairy Microbiology	44	04	02	15	35	50
Theory	MB-6223	Industrial Microbiology and Bioprocess Technology	42	03	03	40	60	100
Practical	MB-6P2	Industrial Microbiology and Bioprocess Technology	44	04	02	15	35	50
Total Number of credits:			**10**					

CORE COURSES (CC)	
Course Title	**Code Number**
Basic Microbiology and Microbiological Techniques	MB -121
Microbial Biochemistry and Analytical Techniques	MB - 221
Microbial diversity, growth and control of microorganisms	MB - 322
Microbial Enzymology and Metabolism	MB - 422
Microbial Genetics and Molecular Biology	MB - 5123
Immunology and Medical Microbiology	MB - 5223
Food and Dairy Microbiology	MB - 6123
Industrial Microbiology and Bioprocess Technology	MB - 6223
GENERIC ELECTIVE COURSES (GSE)/ OPEN ELECTIVES OFFERED	
Course Title	**Code Number**
Microbial Technology for Human Welfare	MBOE 1
Environmental Microbiology and Public Health	MBOE 2
Microbial Diseases: Causes, Prevention and Cure	MBOE 3
Microbes and the Food Industry	MBOE 4

VALUE ADDED COURSES (VAC)	
Course Title	**Code Number**
Principles of Genetic Engineering and Protein Purification	MBCC 01
Food Technology	MBCC 02
Principles of Biomedical Techniques and Ethics	MBCC 03
Scientific Writing-Reading, Writing and Critiquing a research paper	MBCC 04

Core Course Content

DEPARTMENT OF MICROBIOLOGY

Semester	I
Course	1
Paper Code	**MB-121**
Paper Title	**Basic Microbiology and Microbiological Techniques**
Number of teaching hours per week	04
Total number of teaching hours per semester	56
Number of credits	04

Objective of the Paper:
This paper introduces the students to the history, contribution of scientists, scope and the diversity of Microorganisms. It gives an overview of the microbial world and the techniques used to visualize and keep microbes in check. This paper acts as the first step to gain insight about the basics of the vast field of Microbiology.

UNIT-I **Historical development, origin of microorganisms, major contributions, and microscopy**	**13**
a. History and Scope of Microbiology: Theories of origin of life Fossil evidences of microorganisms Scope and relevance of Microbiology as a modern science Branches of Microbiology	4
b. Contribution of Scientists to the field of Microbiology: Antony Von Leeuwenhoek, Francisco Redi, Edward Jenner, Louis Pasteur, Joseph Lister, Robert Koch and Alexander Fleming, Dr. Anand Mohan Chakravarthy, Dr. Khurana	2
c. Microscopic examination of Microorganisms Light Microscopy-Bright field, Dark field, Fluorescence and Phase contrast Electron microscopy (TEM and SEM)	**7**

UNIT-II **Introduction to prokaryotic microorganisms**	**12**
a. Overview of a bacterial cell (morphology, ultra-structure and function) **b.** Structure and function of flagella, pili and capsule, cell wall (gram positive and gram negative), cell membrane, mesosomes, ribosomes, and genetic material. Inclusion bodies and reserve food materials. **c.** Endospore – structure, function, sporulation and germination. Reproduction in bacteria: binary fission	**9**
d. Overview of cyanobacterial cell (Ultrastructure and functions)	**1**
e. Bacteria with unusual properties: Mycoplasma Actinomycetes	**2**
UNIT-III **Introduction to eukaryotic microorganisms and infectious particles**	**18**
a. Cellular organization of eukaryotes- General structure and intracellular organelles- cell membrane, cytoskeleton, Membrane bound organelles- Endoplasmic reticulum, Golgi complex, Lysosomes, Vesicles, Nucleus, Mitochondrion and Chloroplast Peroxisomes, Ribosomes.	**4**
b. Phycology General characteristics and importance.	**1**
c. Mycology Overview of fungal cell -ultra structure of Hyphal and yeast form. Reproduction in fungi: asexual and sexual	**3**
d. Protozoology General characters and type study- Paramecium (structure and reproduction).	**1**
e. Introduction to infectious particles Virology Structure, Reproduction, and Significance of: Bacterial viruses - T4, Plant virus- TMV, Animal virus - HIV.	**7**
f. Infectious particles- Prions & Viroids (general characteristics and diseases.) **g. Emergent pathogen relevant at the time - case study**	**2**

UNIT - IV **Microbiological techniques**	**13**
a. Staining Techniques: Simple staining (Negative staining) Differential staining (Grams and Acid fast staining) Structural staining (endospore, cell wall, flagella and capsular staining) and fungal staining **b. Sterilization techniques:** i) Factors affecting antimicrobial activity: - Environment, organisms, physiological status of the organisms, inoculums concentration, intensity of concentration of the antimicrobial agent, temperature and time of action as factors affecting antimicrobial activity. ii) Physical methods: Moist heat (Pasteurization) Moist heat under pressure (Autoclave) Dry heat (incineration, hot air over) Filtration- membrane filter, HEPA filter Radiation (UV- rays, X- rays, ultrasonic rays) iii) Chemicals (alcohols, formaldehyde, phenol, halogens and heavy metals, gaseous agents) Desired characteristics of antimicrobial chemical agents Evaluation of antimicrobial chemical agents- agar plate techniques, Phenol co-efficient methods.	**3** **10**

NOTE: 4 hours of self-study will be assigned from the following topics.

(Contribution of scientists to the field of microbiology, overview of fungal ultrastructure)

REFERENCES:

1.	Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). Prescott's microbiology. New York: McGraw-Hill.
2.	Black, J. G., & Black, L. J. (2008). Microbiology: Principles and explorations. Hoboken, NJ: John Wiley & Sons, Inc.
3.	O.P. Sharma. (1992), Textbook of algae, New Delhi : Tata McGraw-Hill.
4.	Douglas B Murphy;(2012), Fundamentals of light microscopy and electronic imaging; John Wiley and Sons.
5.	Constantine John Alexopoulos; Charles W Mims; Meredith Blackwel, (1996), Introductory mycology, New York : Wiley.

BLUEPRINT:

Code number: MB-121

Title of the Paper: Basic Microbiology and Microbiological Techniques

Chapter number	**Number of Hrs**	**Total marks for which the questions are to be asked (including bonus questions)**
Unit I	13	20
Unit II	12	20
Unit III	18	28
Unit IV	13	20
	56	**88**
Maximum marks for the paper (Excluding bonus question) = 60		

Practical I

MB 1P$_1$ – Basic Microbiology and Microbiological Techniques

(4 hours/11 sessions)

S. No.	Experiment	Units
1	Microbiological laboratory standards and safety protocols.	1
2	Standard aseptic conditions of Microbiological laboratory.	
3	Study of compound microscope.	1/2
4	Study of instruments - Autoclave, hot air oven, LAF, incubator, membrane filter, colony counter. Applications of basic microbiological tools (Pipettes, Micropipette, Bunsen burner, Inoculation loop, Spreader).	1
5	Preparation of media – NB, NA.	1/2
6	Isolation and identification of bacteria.	1
7	Pure culture techniques – pour plate, spread plate and streak plate (Simple, Continuous, Quadrant) methods.	1
8	Aseptic transfer techniques.	1
9	Simple staining, Negative staining	1
10	Differential staining- Gram's staining, Acid-fast staining	1
11	Structural staining- Flagella, Cell wall, Endospore and Capsule Staining.	1
12	Bacterial motility- hanging drop, swarming/ swimming agar	1
13	Staining and identification of fungi.	1
14	Demonstration and observations of microorganisms from natural sources under light microscope (Algae, Yeast and Protozoa).	

Course outcomes (MB-121 and MB $1P_1$)

At the end of the Course, the Student will be able to

CO1	Appreciate contributions of Pioneers in the field of microbial research.
CO2	Get acquainted with different types of microbial life forms and their basic structure and functions.
CO3	Understand the basics of structural organization of a prokaryotic and eukaryotic cell.
CO4	Build a strong foundation in theoretical and practical understanding of growth and control of microorganisms
CO5	Apply the knowledge gained to identify and use various laboratory aids to culture, visualize and control microorganisms.
CO6	Compare and contrast the similarities and differences between different groups of microorganisms.
CO7	Assess the importance of microbes in all realms of life.
CO8	Apply the basic disinfection and sterilization techniques to maintain health and hygiene.

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Semester	II
Course	1
Paper Code	**MB-221**
Paper title	**Microbial Biochemistry and Analytical Techniques**
Number of teaching hours per week	04
Total number of teaching hours per semester	56
Number of Credits	04

Objective of the Paper:
This paper enables students to learn about the structure, classification, and importance of Biomolecules present in microbial cells and the techniques used in their analysis.

UNIT 1 **BIOCHEMICAL CONCEPTS**	**16**
a. Basic Biochemical Concepts: Major elements of life and their primary characteristics, atomic bonds and molecules – bonding properties of carbon, chemical bonds- covalent and non-covalent, Hydrogen bonds and Vander Waal Forces	**3**
b. Biological Solvents: Structure and properties of water molecule, Water as a universal solvent, polarity, hydrophilic and hydrophobic interactions, properties of water	**3**
c. Acids, bases, electrolytes, hydrogen ion concentration, pH, buffers and physiological buffer system, Henderson – Hasselbach equation.	**4**
d. Bioenergetics: Law of thermodynamics, Free energy, Enthalpy, Entropy, Classification of high energy compounds, Oxidation-reduction reactions, equilibrium constant.	**6**
UNIT II **MACROMOLECULES – TYPES, STRUCTURE, AND PROPERTIES**	**22**
a. Carbohydrates: Definition, classification, structure, and properties	**4**
b. Amino acids and proteins: Definition, structure, classification and properties of amino acids, Structure and classification of proteins.	**6**
c. Nucleic acids: Structure, function, forms/types - DNA and RNA	**5**

d. Lipids and Fats: Definition, classification, structure, properties, and importance of lipids. e. Porphyrins and Vitamins: Definition, structure, properties and importance of chlorophyll, cytochrome, and hemoglobin.	**3** **4**
UNIT III **ANALYTICAL TECHNIQUES**	**18**
Principles, Methods, and Applications: a. Chromatography (Thin Layer Chromatography, Ion exchange, Size exclusion, Affinity, and High Performance Liquid Chromatography) b. Centrifugation (Preparative and Analytical) c. Electrophoresis (Agarose Gel Electrophoresis and SDS-PAGE) d. Spectrophotometry (UV-Visible)	 **6** **5** **4** **3**

NOTE: 4 hours of self-study will be assigned from the following topics.

(Deficiencies of Vitamins, Applications of Chromatography)

REFERENCES:

1.	Avinash Upadhyay, Kakoli Upadhyay and Nirmalendu Nath (2009), *Biophysical Chemistry (Principles and Techniques)*, Himalayan Publishing House.
2.	David L Nelson, Michael M Cox (7th edition). *Lehninger Principles of Biochemistry*, Worth Publishers, Inc.
3.	Donald Voet, Judith Voet & Charlotte W. Pratt (4th edition). *Voet's Principles of Biochemistry*, John Wiley and Sons.
4.	Garrett, R. H., and Grisham, C. M. *Biochemistry*. 2nd edition. Saunders College Publishing.
5.	J. L. Jain, Sunjay Jain and Nitin Jain (2007). *Fundamentals of Biochemistry*. S. Chand & Company Ltd.
6.	Jeremy M. Berg, Lubert Stryer, John Tymoczko and Gregory Gatto (9th edition). *Biochemistry*, Freeman and Company, New York.
7.	Keith Wilson and John Walker (7th edition). *Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge University Press.
8.	Mary K. Campbell and Shawn O. Farrell (8th edition). *Biochemistry*, Cengage Learning.
9.	Rodney F. Boyer (3rd edition). *Concepts in Biochemistry*. John Wiley and Sons.

BLUEPRINT:

Code number: MB-221
Title of the Paper: Microbial Biochemistry and Analytical Techniques

Chapter Number	Number of Hrs	Total marks for which the questions are to be asked (including bonus questions)
UNIT I	16	25
UNIT II	22	35
UNIT III	18	28
	56	**88**
Maximum marks for the paper (Excluding bonus questions) = 60		

Practical II

MB 2P$_1$: Microbial Biochemistry and Analytical Techniques

(4 hours/11 sessions)

S.No	Experiments	Units
1.	Preparation of Solution: Normal and Molar solutions	1
2.	Calibration of pH meter and determination of pH of natural samples	
3.	Preparation of Buffer Solutions (Phosphate and Citrate buffers)	1/2
4.	Qualitative determination and identification of Carbohydrates	1
5.	Qualitative determination and identification of Proteins	
6.	Qualitative determination and identification of Amino Acids	1
7.	Qualitative determination and identification of Fatty Acids	
8.	Quantitative estimation of Reducing Sugar by DNS method	1
9.	Quantitative estimation of Proteins by Biuret and Lowry's / UV method	1
10.	Quantitative estimation of DNA by Diphenylamine / UV method	1
11.	Quantitative estimation of RNA by Orcinol method	1
12.	Determination of lipid saponification values of fats and iodine number of fatty acids	1
13.	Thin Layer Chromatography of Amino Acids	1
14.	Demonstration – HPLC, Agarose gel electrophoresis, SDS-PAGE	1.5

Course outcomes (MB-221 and MB 2P1):

At the end of the Course, the Student will be able to

CO1	Gain insights into major elements and their chemical interactions required for functioning of living cells.
CO2	Gain knowledge about the structure, classification and functions of biomolecules.
CO3	Understand the principles and the processes of various analytical techniques used to study biomolecules.
CO4	Estimate biomolecules from different samples
CO5	Analyse the data obtained from the experiments.
CO6	Appreciate the importance of biomolecules in living systems

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Semester	**III**
Course	1
Paper Code	**MB-322**
Paper Title	**Microbial diversity, Growth and control of microorganisms**
Number of teaching hours per week	04
Total number of teaching hours per semester	56
Number of credits	04

Objective of the Paper:
This paper enables students to understand the nutritional requirement, growth pattern, diversification and control of microorganisms.

UNIT-I **Microbial Diversity**	**19**
a. Microbial systematics 5 kingdom classification system, 3 domain classification system	**1**
b. Introduction to Microbial Taxonomy Phylogenetic trees, Taxonomic hierarchy and ranks, and binomial nomenclature of microorganisms Differences in concept of 'species' in eukaryotes and prokaryotes Definition of species in prokaryotes.	**2** **1**
Phenetic Approach Phylogenetic Approach Polyphasic approach- Numerical taxonomy, chemotaxonomy and genetic analyses. 1. Bacterial Classification Bergey's manual. 2. Fungal classification – Alexopoulos 3. Viral classification – Baltimore	**6** **1** **1** **1**
c. Microbial associations (Parasitism, symbiosis/ syntrophy, commensalism, antagonism, predation and competition). Co-evolution of hosts and symbionts/parasites	**5** **1**

UNIT-II **Microbial nutrition and growth and maintenance**	**27**
a. Nutritional requirements: Macronutrients, Micronutrients and trace elements. b. Nutritional types c. Influence of Environmental Factors on growth (temperature, pH, oxygen, solute and water activity) d. Oligotrophic environments e. Fungal growth curve f. One step growth curve of bacteriophage g. Laboratory culture of Cellular Microbes: Types of Media Cultivation of Aerobes and Anaerobes Cultivation of cyanobacteria Cultivation of viruses h. Unculturable bacteria i. Enrichment and Isolation of Pure Cultures Enrichment culture, streak plate, spread plate and pour plate. Microbial Growth on solid and liquid media i. Bacterial growth curve and calculation of generation time. j. Measurement of Microbial Population Size - Cell number and cell mass k. Continuous culture system – chemostat and turbidostat. l. Maintenance and preservation of bacterial and fungal cultures.	**2** **1** **2** **1** **1** **1** **2** **1** **1** **1** **3** **3** **3** **2** **3**
UNIT-III **Antimicrobial Chemotherapy**	**10**
a. Definition, Development and classification of antibiotics. b. General Characteristics of Antimicrobial Drugs c. Mode of action of: Penicillins, Cephalosporins, Vancomycin, Streptomycin/Tetracyclines/Erythromycin/Chloramphenicol/ Polymyxin and Bacitracin/ Antifungal – Nystatin, Griseofulvin, Amphotericin B) d. Determining the Level of Antimicrobial Activity e. Development of Resistance to antibiotics.	**1** **1** **4** **2** **2**

NOTE: 4 hours of self-study will be assigned from the following topics. (Fungal classification – Alexopoulos, Co-evolution of hosts and symbionts/parasites, Enrichment and Isolation of Pure Cultures.)

REFERENCES:

1.	Atlas, R. M., & Bartha, R. (1993). *Microbial ecology: Fundamentals and applications*. Redwood City, Calif: Benjamin/Cummings Pub. Co
2.	Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). *Prescott's microbiology*. New York: McGraw-Hill.
3.	Constantine John Alexopoulos; Charles W Mims; Meredith Blackwel, (1996), *Introductory mycology,* New York : Wiley.
4.	Perry, J. J., Staley, J. T., & Lory, S. (2002). *Microbial life*. Sunderland, Mass: Sinauer Associates.

BLUEPRINT:

Code number: MB-322

Title of the Paper: Microbial diversity, Growth and control of microorganisms

Chapter number	**Number of Hrs**	**Total marks for which the questions are to be asked (including bonus questions)**
Unit I	19	30
Unit II	27	42
Unit III	10	16
	56	88
Maximum marks for the paper (Excluding bonus question) = 60		

Practical III

MB 3P1- Microbial diversity, Growth and control of microorganisms

(4hours/11 sessions)

S.No	Experiment	Units
1	Preparation of different media: Synthetic media - Minimal Agar, complex media- Nutrient agar and Selective media McConkey agar, EMB agar	1
2	Isolation and enumeration of bacteria from various samples on different media : by spread plate method/pour plate method.	1
3	Nutritional requirement – Growth of bacteria on various carbon and nitrogen sources.	1
4	Bacterial growth curve (Spectrophotometric method) and generation time.	1
5	Linear growth of fungi	1
6	Counting of yeast cells by using a haemocytometer	1
7	Use of Micrometer and calibration, measurement of yeasts/ fungal spores	1
8	Preservation of bacterial cultures (Agar slant and Ultra low temperature)	1
9	Evaluation of antibiotic sensitivity test (disc diffusion method)	1
10	Effect of temperature and pH on growth of *E.coli*	1
11	Study of microbial interaction- Antagonism	1

Course outcomes (MB322 and MB 3P1)

At the end of the Course, the Student will be able to

CO1	Develop an understanding of growth requirements of various microorganisms for their subsequent cultivation and control.
CO2	Identify the physical factors affecting the growth characteristics of the microorganisms under different environmental conditions such as nutrition, temperature, pH, oxygen, solute and water activity.
CO3	Gain knowledge about the diversification of microorganisms and learn about interactions of microorganisms with other organisms.
CO4	Perform basic experiments to culture, identify, classify and preserve microorganisms in the laboratory.
CO5	Carry out comparative analysis of growth requirements of various kinds of microorganisms.

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Semester	**IV**
Course	1
Paper Code	**MB-422**
Paper title	**Microbial Enzymology and Metabolism**
Number of teaching hours per week	04
Total number of teaching hours per semester	56
Number of Credits	04

Objective of the Paper:
This paper enables a student to understand the concepts of enzymes and their relevance in different fields. Students also gain knowledge about aerobic and anaerobic respiration and how these are manifested in the form of different metabolic pathways in microorganisms.

UNIT 1 **MICROBIAL ENZYMOLOGY**	**16**
a. Structure of enzyme, Apoenzyme, Holoenzymes, cofactors, prosthetic group-TPP, coenzyme -NAD, metal cofactors. b. Classification and nomenclature of enzymes c. Mechanism of action of enzymes: active site, transition state complex and activation energy, allosteric site. d. Lock and key hypothesis, and Induced Fit hypothesis. e. Significance of hyperbolic (Michaelis-Menten equation), double reciprocal plots (Lineweaver-Burk equation) of enzyme activity f. Definitions of terms – enzyme unit, specific activity and turnover number, g. Effect of pH and temperature on enzyme activity. h. Enzyme inhibition: competitive- sulfa drugs; non-competitive-heavy metal salts.	**2** **2** **2** **1** **3** **2** **1** **3**
UNIT II	
Microbial Enzymes and their Relevance in Industries, Medicine, and Beyond - Broader overview	**4**

UNIT III **CHEMOHETEROTROPHIC METABOLISM - AEROBIC RESPIRATION**	**16**
a. Concept of aerobic respiration, anaerobic respiration and fermentation. b. Sugar degradation pathways: Glycolysis, Entner–Doudoroff pathway, Pentose phosphate pathway, Tricarboxylic acid cycle. Electron transport chain: components of respiratory chain, comparison of mitochondrial and bacterial ETC, oxidative phosphorylation.	**4** **12**
UNIT IV **CHEMOHETEROTROPHIC METABOLISM- ANAEROBIC RESPIRATION AND FERMENTATION**	**8**
a. Anaerobic respiration with special reference to dissimilatory nitrate reduction (Denitrification; nitrate /nitrite and nitrate/ammonia respiration). b. Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative and heterofermentative pathways), mixed acid fermentation.	**4** **4**
UNIT V **CHEMOLITHOTROPHIC AND PHOTOTROPHIC METABOLISM**	**8**
a. Introduction to aerobic and anaerobic chemolithotrophy with an example each. Hydrogen oxidation (definition and reaction) and methanogenesis (definition and b. c. reaction). d. Introduction to phototrophic metabolism – groups of phototrophic microorganisms, oxygenic vs. anoxygenic photosynthesis with reference to photosynthesis in green bacteria, purple bacteria and cyanobacteria.	**4** **4**
UNIT VI **NITROGEN METABOLISM**	**4**
An overview a. Introduction to biological nitrogen fixation b. Ammonia assimilation c. Assimilatory nitrate reduction	**2** **1** **1**

NOTE: 4 hours of self-study will be assigned from the following topics.
(Microbial Enzymes and their Relevance)

REFERENCES:

1.	Atlas Ronald M., *Principles of Microbiology,* St. Louis: Mosby.
2.	David L Nelson, Michael M Cox (7th edition). *Lehninger Principles of Biochemistry*, Worth Publishers, Inc.
3.	Donald Voet, Judith Voet & Charlotte W. Pratt (4th edition). *Voet's Principles of Biochemistry*, John Wiley and Sons.
4.	Gottschalk G. (1986). *Bacterial Metabolism*. 2nd edition. Springer Verlag.
5.	J. L. Jain, Sunjay Jain and Nitin Jain (2007). *Fundamentals of Biochemistry*. S. Chand & Company Ltd.
6.	Madigan MT, and Martinko JM (2014). *Brock Biology of Microorganisms*. 14th edition. Prentice Hall International Inc.
7.	Moat AG and Foster JW. (2002). *Microbial Physiology*. 4th edition. John Wiley & Sons.
8.	Mary K. Campbell and Shawn O. Farrell (8th edition). *Biochemistry*, Cengage Learning.
9.	Garrett, R. H., and Grisham, C. M. *Biochemistry*. 2nd edition. Saunders College Publishing.
10.	Reddy SR and Reddy SM. (2008). *Microbial Physiology*. Scientific Publishers India.
11.	Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. (1987). *General Microbiology*. 5th edition, McMillan Press.
12.	Willey JM, Sherwood LM, and Woolverton CJ. (2013). *Prescott's Microbiology*. 9th edition. McGraw Hill Higher Education.
13.	Jeremy M. Berg, John L. Tymoczko, and Lubert Stryer. *Biochemistry*, Wiley

BLUEPRINT:
Code number: MB422
Title of the Paper: Microbial Enzymology and Metabolism

Chapter Number	Number of Hrs	Total marks for which the questions are to be asked (including bonus questions)
UNIT I	16	25
UNIT II	4	6
UNIT III	16	25
UNIT IV	8	13
UNIT V	8	13
UNIT VI	4	6
	56	**88**
Maximum marks for the paper (Excluding bonus questions) = 60		

PRACTICAL IV

MB4P1: Microbial Enzymology and Metabolism

(4 hours/ 11 sessions)

S.No	Experiments	Unit
1.	Buffer preparations for enzymatic activity and Numerical problems to explain the concepts	1
2.	Production of microbial enzymes (amylase) and estimation of its activity.	2
3.	Study of enzyme kinetics – calculation of Km and Vmax.	1
4.	Study the effect of temperature on enzyme activity	1
5.	Study the effect of pH on enzyme activity.	1
6.	Study the effect of heavy metals on enzyme activity	1
7.	Biochemical tests used for the identification of bacteria - IMViC, fermentation of carbohydrates (any three), starch hydrolysis, TSI, Gelatin liquefaction, catalase and oxidase Test.	4

Course outcomes (MB422 and MB 4P1)

At the end of the Course, the Student will be able to

CO1	Describe the multifarious function of enzymes; calculate enzyme activity and other quantitative and qualitative parameters of enzyme kinetics.
CO2	Understand the differentiating concepts of aerobic and anaerobic respiration.
CO3	Summarize the different metabolic pathways in microorganisms.
CO4	Critique the role of enzymes, coenzymes, and cofactors involved in different pathways

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Semester	**V**
Course	1
Paper Code	**MB-5123**
Paper Title	**Microbial Genetics and Molecular Biology**
Number of teaching hours per week	03
Total number of teaching hours per semester	42
Number of credits	03

Objective of the Paper
This paper helps student understand the basic genetics and molecular biology in Microbial system.

UNIT-I – Microbial Genetics – Concepts	**12**
a. History and Scope of Genetics	2
b. Origin of bacterial genetics and molecular biology, the transforming principle, Genes as carriers of heredity, early models of DNA structure, salient features of DNA double helix, denaturation and Renaturation.	3
c. DNA topology	2
d. Genome organization in prokaryotes, viruses and eukaryotes.	3
e. Plasmids: Property and function of plasmids, Types of natural plasmids.	2
UNIT-II – Mechanisms	**17**
a. DNA replication in prokaryotes: Messelson and Stahl's experiment, Models of DNA replication (Theta and Rolling circle) and mechanism of DNA replication.	4
b. Mutations: Types of mutations, physical and chemical mutagens, Spontaneous and induced mutations, Site directed mutagenesis. Mutations for economic benefit of mankind.	4
c. DNA repair: Photo reactivation repair, nucleotide excision repair and mutHLS repair.	2
d. Prokaryotic transposable elements – Insertion Sequences, composite and non-composite transposons, Replicative and Non replicative transposition, Uses of transposons.	2
e. Mechanism of Genetic Exchange and its significance: Transformation: Discovery and mechanism of natural competency Conjugation: Discovery and mechanism. Hfr and F' strains Transduction: Mechanism of generalized transduction and specialized transduction	5

UNIT-III – Molecular Biology		13
a.	Central dogma of Molecular biology	1
b.	Gene Expression in prokaryotes:	
i)	Transcription - Definition, promoter - concept and strength of promoter. Transcriptional Machinery and Mechanism of transcription.	3
ii)	Types and structure of RNA	2
iii)	Translation - Genetic code, Translational machinery, charging of tRNA, aminoacyl tRNA synthetases, Mechanisms of initiation, elongation and termination of polypeptides.	3
c.	Regulation of gene expression in prokaryotes: Operon concept, Principles of transcriptional regulation, regulation initiation with examples: *lac* and *trp* operons	4

NOTE: 4 hours of self-study will be assigned from the following topics.
(History, Scope of Genetics, Types and structure of RNA)

REFERENCES:

1.	David L. Nelson, Michael M. Cox; Lehninger, *Principles of Biochemistry*, 8th edition, W.H. Freeman and Co., New York.
2.	David Freifelder (2000); *Molecular Biology*, 2nd edition, Narosa Publishing House, New Delhi.
3.	M.W. Strickberger (2008), *Genetics*, 3rd edition, 2008, Prentice-Hall, India
4.	Daniel Hartl (2002), *Essential Genetics*: A genomics perspective, Jones & Bartlett 6th edition.
5.	James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levin and Richard Losick (2004); Molecular Biology of the Gene, 5th edition., Pearson, Benjamin Cummings and CSHL press.
6.	Gardner E J, Simmons M J and Snupstad DP (2006), *Principles of genetics*, 8th edition John Wiley & Sons,.
7.	Larry Snyder, Wendy Champness, *Molecular Genetics of Bacteria*, ASM Press; (2007).
8.	Benjamin Lewin, *Gene XI*, Oxford University Press, (2000).

BLUEPRINT:

Code number: MB-5123
Title of the Paper: Microbial Genetics and Molecular Biology

Chapter Number	Number of Hrs.	Total marks for which the questions are to be asked (including bonus questions)
Unit I	12	25
Unit II	17	36
Unit III	13	27
	42	**88**
Maximum marks for the paper (Excluding bonus question) = 60		

Practical V

MB $5P_1$ – Microbial Genetics and Molecular Biology

(4 hours/11 sessions)

S.No	Experiment	Units
1.	Study the effect of physical (UV) mutagens on bacterial cells.	1
2.	Study the effect of chemical (Ethidium Bromide)) mutagens on bacterial cells.	1
3.	Determination of mutagenicity of chemicals by AMES test.	2
4.	Study of Bacterial Conjugation.	2
5.	Isolation of bacterial genomic DNA.	1
6.	Estimation of DNA by UV spectrophotometer (A260measurement)	1
7.	Agarose gel electrophoresis of Genomic DNA.	1
8.	Isolation of Plasmid DNA	1
9.	Agarose gel electrophoresis of Plasmid DNA and studying the conformation of plasmid DNA.	1

Course outcomes (MB5123 and MB 5P1)

At the end of the course, the students will be able to

CO1	Acquire knowledge of genes, their structure, expression and their regulation.
CO2	Acquire fairly good understanding of genetic mechanisms
CO3	Develop practical skills for isolation of bacterial/plasmid DNA and its visualization in gel after separation by electrophoresis, genetic exchange mechanisms and mutational analysis.
CO4	Analyse and summarise the experimental work carried out.
CO5	Identify and distinguish genetic mechanisms in different species
CO6	Design basic experiments in microbial genetics and molecular biology.

DEPARTMENT OF MICROBIOLOGY

Semester	**V**
Course	1
Paper Code	**MB-5223**
Paper Title	**Immunology and Medical Microbiology**
Number of teaching hours per week	03
Total number of teaching hours per semester	42
Number of credits	03

Objective of the Paper:

To acquire fundamental knowledge of the basic principles of immunology and to understand how these principles apply to the process of immune function.
The course also provides the conceptual basis for understanding pathogenic microorganisms and the mechanisms by which they cause diseases in the human body.

UNIT-I **Basic concepts of Immunology**	**14**
a. Immunity: Definitions, types (natural, acquired, active and passive)	**2**
b. Antigens: Definition, types of antigens, factors influencing antigenicity.	**2**
c. Immunoglobulins: Definition, structure, types, properties and functions of immunoglobulins.	**3**
d. Principle and Production of monoclonal antibodies and their applications.	**2**
e. Cells and organs of the immune system: Structure, function and properties. Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell, Dendritic cell. Immune Organs –Bone Marrow, Thymus, Lymph Node, Spleen, GALT, MALT, CALT.	**5**

UNIT-II Immune Responses and Techniques.	14
a. Immune response: AMI and CMI	1
b. Complement system: Properties, components, pathways and functions.	1
c. Hypersensitivity: Types (I, II, III, IV), mediators of hypersensitivity reactions, mechanism of mast cell degranulation and detection of Type I hypersensitivity.	2
d. Major histocompatibility complex (MHC): Structure and function.	1
e. Transplantation immunology: Types, graft acceptance, genetic basis of graft rejection. Mechanism and manifestations of graft rejection.	2
f. Vaccines: Definition, types and examples.	2
g. Immunological techniques: Precipitation, agglutinations, complement fixation, ELISA.	5
UNIT-III **Medical Microbiology**	**14**
a. Infection: Definition, primary, nosocomial, inapparent, atypical. Sources of infection, methods of transmission of infection. Factors or mechanisms of microbial pathogenesis. Types of infectious diseases.	4
b. Normal human flora.	1
c. Important groups of pathogenic microorganisms: (signs, symptoms, antigenic structure, pathogenesis, diagnosis, epidemiology, prophylaxis and chemotherapy).	9
Bacterial **a**. Enterobacteriaceae (*Salmonella*). **b**. Gram +ve cocci (*Staphylococcus.* **c.** *Mycobacterium tuberculosis.* **Protozoan** **a**. *Plasmodium.* **b**. *Entamoeba.* **Fungal** **a**. *Candida.* **b**. Systemic Mycoses-Aspergillosis. **Viral** **a.** Hepatitis B. **b**. Emerging pathogen - (Corona)	

NOTE: 3 hours of self-study will be assigned from the following topics. (Application of monoclonal antibodies, CALT, Candida)

REFERENCES:

1.	Ananthanarayan and Paniker (2006). *Text book of Microbiology.* 8th Edition. Hyderabad. Orient Longman publication.
2.	David Greenwood, Richard C.B. Slack and John. F. Peutherer (2008). *Medical Microbiology*. 7th Edition, New Delhi. Elsevier India Private Ltd.
3.	Jawetz, Melnickand Adelbergs (2010). *Medical Microbiology*. 25th Edition. USA. McGraw Hill Companies.
4.	Jenni Punt, Sharon A stranford, Patricia P Jones, Judith A Owen, Janis Kuby (2019). I*mmunology*, 8th Edition; New York. W.H. Freeman and Company.
5.	Kenneth Murphy, Caesar Weaver, Charles Janeway (2017). *Janeway's Immunobiology*. 9th Edition. New York. Garland Science.
6.	Michael Barer ,W L Irving (2018). *Medical Microbiology* 19thh Edition.
7.	Peter J. Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt (2017). *Roitts Essential Immunology,*13th Edition, Oxford. Wiley Blackwell.
8.	Linda Sherwood, Christopher J. Woolverton, Lansing M. Prescott, and Joanne M. Willey (2011). *Prescott's Microbiology*.7th Edition. New York: McGraw-Hill.

BLUEPRINT:

Code number: MB 5223

Title of the paper: immunology & medical microbiology

Chapter Number	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
I	14	29
II	14	29
III	14	30
Total	**42**	**88**
Maximum marks excluding bonus questions=60		

Practical V

MB 5P2 – Immunology and Medical Microbiology

(4 hours/11 sessions)

S.No	Experiment	Units
1.	Blood grouping.	1
2.	WIDAL and VDRL.	1
3.	Pregnancy (hCG) test and Coagulase test.	1
4.	ODD (Ouchterlony Double Diffusion).	1
5.	RID (Radial Immuno Diffusion).	1
6.	ELISA.	1
7.	Study of bacterial flora of skin by swab method .Identify bacteria (any three of E. coli, Salmonella, Staphylococcus,) using laboratory strains on the basis of cultural, morphological and biochemical characteristics: IMViC, TSI, nitrate reduction, urease production and catalase tests. Gram's staining and motility.	3
8.	Perform antibacterial sensitivity by Kirby-Bauer method	1
9.	Spotters: AFB, *Staphylococcus, Plasmodium, Entamoeba, Candida, Aspergillus*& HIV.	1

Course outcomes (MB5223 and MB 5P2)

At the end of the Course, the Student will be able to

CO1	a. Understand the basic concepts of the protective role of the immune system in the host against pathogens. b. Introduce and describe the importance of pathogenic microorganisms in human diseases and the various parameters of assessment of their severity and methods of diagnosis.
CO2	a. Explain and distinguish the basic components and mechanism underlying the immune system and its response against pathogens. b. Gain knowledge of the pathogenic mechanisms in establishing diseases
CO3	compare and contrast the similarities and differences between different pathogens.
CO4	a. Apply the immunological techniques learnt in research and industry. b. Apply the knowledge gained to use various laboratory methods to culture, identify and control pathogens.
CO5	a. Develop skills in developing vaccines, diagnostic kits and therapeutics. b. Assess and interpret strategies for prevention and protection against diseases.

DEPARTMENT OF MICROBIOLOGY

Semester	**VI**
Course	1
Paper Code	**MB-6123**
Paper Title	**Food and Dairy Microbiology**
Number of teaching hours per week	03
Total number of teaching hours per semester	42
Number of credits	03

Objective of the Paper:
Food and Dairy Microbiology paper deals with the role of microorganisms in food preparation and dairy products, its processing, control of microbial activity which causes spoilage of food and dairy products and infections in humans.

UNIT – I **Food Microbiology**	**7**
a. Food as a substrate for microorganisms and factors influencing microbial growth in food. b.. Food spoilage: Chemical and physical properties of food affecting microbial growth – pH, water activity, redox potential, nutrients, antimicrobial compounds. c. Sources of spoilage and spoilage of cereals, meat, fruits, vegetables and canned foods d.Change in colour and flavor, degradation of carbohydrates, proteins and fats, change in organoleptic properties.	
UNIT-II	**7**
a. Fermented foods: pickled cucumber, sauerkraut, bread, vinegar. Tea and coffee b. Microbial cells as food- SCP, SCO.	

UNIT-III	**7**
Food preservation: Principles of food preservation a. Use of chemical preservatives – Salt, Sugar, Organic acid (Benzoic acid, Sorbic acid, Propionates, Acetic acid & Lactic acid), Nitrites, Nitrates, Sulphur dioxide, Ethylene dioxide, Propylene acid, Wood Smoke and Antibiotics approved with permissible limits. Canning, Freezing and Dehydration, Use of Radiations. b. Food sanitation and control agencies-HACCP	
UNIT-IV	**7**
a.Microbial food infection and food poisoning a. *Staphylococcus aureus* b. *Clostridium botulinum* c. *Bacillus cereus* d. *Clostridium perfringens* e. *Salmonella* Organisms causing food infection, their sources and prevention. b. Mycotoxins – Aflatoxin B1, G1 – structure, detection, mode of action and detoxification. c. Algal food toxins: Toxic syndromes associated with Marine Algal Toxins d. Food packaging	
UNIT-V **Dairy Microbiology**	**7**
a. Definition, composition and types of milk – skimmed, toned and whole b. Sources of microbial contamination of milk, microflora in raw milk Microbiological analysis of milk: Rapid Platform Tests, Dye reduction tests – MBRT and Resazurin Test. Total bacterial count, Brucella ring test and Test for Mastitis c. Spoilage of milk Succession of microorganisms in milk Colour and flavour defects, sweet curdling, Stormy fermentation, Ropiness, Biochemical Fermentation d. Pasteurization of milk: Methods of pasteurization – LHT, HTST, UHT. Tests for determination of efficiency of pasteurization- Alkaline Phosphatase and Lactoperoxidase tests	

UNIT-VI	7
a. Microbiology of Starter cultures in Dairy Fermentation: role of starter cultures, ecology, classification and types of starter cultures. b. Enzymes of lactic acid bacteria. Use of microbial enzymes in foods c.Milk product: long term preservation of milk (preparation of milk powder, condensed, sweetened milk, sterilized [tetra pack] milk. Butter – Types and production Cheese – Types and production (Cheddar and Cottage) Yoghurt – Types and production d. Prebiotics, Probiotics, Synbiotics and Postbiotics: concept, definition, types, sources, significance on gut microflora. e. Other traditional fermented milk products – names and organisms associated (tabulation only)	

NOTE: 3 hours of self-study will be assigned from the following topics.
(Asepsis, fermented foods-pickled cucumber and use of microbial enzymes in foods)

REFERENCES:

1.	Adams, M.R and Moss, MO. (1995). *Food Microbiology*. The Royal Society of Chemistry,Cambridge.
2.	Dairy Microbiology, Parihar and Parihar
3.	James. M. Jay, (1992), *Modern food microbiology* 4ed.
4.	Dubey. R.C. and Maheswari. D.K. (1999) *A Textbook of Microbiology*, 1 ed.
5.	Frazier, W. C. and Westhoff D.C. (2013) *Food Microbiology* 5th ed.

BLUEPRINT:
Code number: MB-6123
Title of the Paper: Food and Dairy Microbiology

Chapter Number	Number of Hrs	Total marks for which the questions are to be asked (including bonus questions)
Unit I	7	15
Unit II	7	14
Unit III	7	15
Unit IV	7	15
Unit V	7	15
Unit VI	7	14
	42	**88**
Maximum marks for the paper (Excluding bonus question)= 60		

Practical VI

MB $6P_1$ – FOOD AND DAIRY MICROBIOLOGY

(4 hours/11 sessions)

S.No	Experiment	Units
1.	Enumeration of bacteria by SPC and DMC	2
2.	Dye reduction tests-MBRT and Resazurin tests	1
3.	Estimation of lactic acid and fat content in the milk	1
4.	Estimation of lactose in milk whey	1
5	Production and detection of Aflatoxins from fungi Spotters - aflatoxin and food borne pathogens	1
6.	Isolation and identification of bacteria and fungi from fruits and vegetables	1
7.	Isolation and identification of bacteria and fungi from fermented and stored foods.	1
8.	Enumeration and Isolation of *Salmonella* from processed meat/chicken and Enumeration and Isolation of *Staphylococci* from ready to eat street foods.	1
9.	Isolation and determination of food spoilage psychrotrophs from refrigerated food.	1
10.	Inhibitory effect of spices on microbial load in fish and flesh foods	2

Course outcomes (MB 6123 and MB 6P1)

At the end of the Course, the Student will be able to

CO1	Gains insight into an understanding the role of microbes in food and dairy industry
CO2	Have an understanding of the spoilage and preservation of food.
CO3	Apply the different techniques to prevent the spoilage of foods.
CO4	Compare the effects of microorganisms in food related illness.
CO5	Evaluate the role of different microorganisms for beneficial and harmful effects.
CO6	Develop strategies for beneficial product development for human consumption.

DEPARTMENT OF MICROBIOLOGY

Semester	VI
Course	1
Paper Code	**MB-6223**
Paper Title	**Industrial Microbiology and Bioprocess Technology**
Number of teaching hours per week	03
Total number of teaching hours per semester	42
Number of credits	03

Objective of the Paper:
This paper deals with the use of microbes in the production of various industrial products. The study of bioreactors, their process control parameters, downstream processing and quality assurance.

UNIT-1	**10**
a. Introduction and scope of Industrial fermentation process.	**1**
b. Isolation, screening and maintenance of industrially important microorganisms. Strain improvement methods: Mutation, Recombination and r-DNA technology.	**6**
c. Culture collection and Types of culture collection centres	**1**
d. Development of inoculum for industrial fermentations.	**2**
UNIT-II	**10**
a. Media for industrial fermentation process: Fermentation media: Natural media; synthetic media. Medium formulation- Carbon sources, Nitrogen sources, minerals, growth factors, buffers, precursors, inducers and inhibitors. Antifoaming agents.	**3**

b. Types of industrial fermentation process: batch culture, continuous culture, Fed-batch culture. Surface and submerged fermentation process	**2**
c. Design of a fermenter: Basic features, design and components of a typical fermenter. Specialized bioreactors: stirred, airlift and fluidized bed bioreactor. Sterilization of fermenter, medium, air supply; aseptic inoculation and sampling methods.	**3**
d. Control of process parameters – temperature, pH, O-R potential, aeration, agitation, contamination.	**2**
UNIT-III	**10**
a. Upstream Bioprocess technology: Fermentative production of alcohol and alcoholic beverages (wine), organic acids (citric acid), organic solvents (acetone/butanol), vitamins (B12), antibiotics (penicillin) and enzymes (amylase).	**7**
b. Production of yeast biomass and their applications	**1**
c. Immobilization of enzymes and cells: methods, advantages and applications	**2**
UNIT-IV	**12**
a. Downstream Bioprocess technology: Removal of microbial cell and other solid matter, Foam separation. The recovery and purification of fermentation products through Precipitation, filtration, centrifugation, cell disruption, chromatography, solvent extraction	**8**
b. Quality control assurance	**2**
c. Intellectual Property Rights (IPR): Patent, Copyrights, Trademarks, Trade secret, Geographical indications, Industrial designs. International Regime Relating to IPR:TRIPS and other Treaties (WIPO,WTO, GATT)	**2**

NOTE: 3 hours of self-study will be assigned from the following topics.

(Isolation, screening and maintenance of industrially important microorganisms, culture collection centres)

REFERENCES:

1.	Stanbury P.F, Whitaker A and S. J. Hall (2013). *Principles of Fermentation Technology*, Elsevier Science Ltd, Burlington.
2.	Peppler H.J and D. Perlman (2008). *Microbial Technology fermentation technology*, Academic Press, New York.
3.	Crueger W and Anneliese Crueger (2005). *Biotechnology: A text book of Industrial Microbiology*, Panima Publishing Corporation, New Delhi.
4.	Casida, Lester Earl Casida. *Industrial Microbiology*, Wiley Eastern Ltd., New Delhi.

BLUEPRINT:

Code number: MB-6223

Title of the Paper: Industrial Microbiology and Bioprocess Technology

Chapter Number	**Number of Hrs**	**Total marks for which the questions are to be asked (including bonus questions)**
Unit I	10	21
Unit II	10	21
Unit III	10	21
Unit IV	12	25
	42	**88**
Maximum marks for the paper (Excluding bonus question)= 60		

Practical VI

MB 6P2- Industrial Microbiology and Bioprocess Technology

(4 hours/11 sessions)

S.No.	Experiment	Units
1.	Screening and isolation of Protease producing microorganisms and their preservation	2 units
2.	Production and assaying of microbial proteases	2 units
3.	Production of wine using different substrates by *Saccharomyces cerevisiae*	1 unit
4.	Estimation of total and volatile acidity from wine	1 unit
5.	Batch production and estimation of citric acid	2 units
6.	Immobilization of yeast cells by sodium alginate method	1 unit
7.	Alcohol estimation by specific gravity method	1 unit
8.	Spotters: - study of different types of fermenters	1 unit
9.	Industrial visit	1 unit

Course outcomes (MB6223 and MB 6P2)

At the end of the Course, the student will be able to

CO1	Understand the importance of microorganisms in various industries
CO2	Identify various strategies to improve the ability of industrially important microbes
CO3	Produce industrial products using microbes
CO4	Analyse the microbial products and interpret the results
CO5	Compare the process control strategies to improve the yield
CO6	Design and develop industrial process for the production of microbial products