

UNIVERSITY OF MUMBAI



**Revised Syllabus for S.Y.B.Sc.
Program: B.Sc.
Course : Microbiology(USMB)**

(Credit Based Semester and Grading System with
effect from the academic year 2015–2016)

PREAMBLE

With the introduction of credit based semester & grading system (CBSGS) and continuous evaluation consisting of components of Internal Assessment & External Assessment by the esteemed University from the academic year 2011-12 at F.Y.B.Sc.level, the earlier existing syllabus of F.Y.B.Sc.microbiology was restructured according to the CBSGS pattern for its implementation from 2011-12. Likewise S.Y.B.Sc.microbiology existing syllabus was restructured as per the CBSGS pattern for its implementation from 2012-13.

The existing syllabus of F.Y.B.Sc.microbiology was due for revision and for its implementation from the academic year 2014-15. Now it is the existing syllabus of S.Y.B.Sc.microbiology which was due for its revision as per the CBSGS pattern and for its implementation from the academic year 2015-16.

Keeping in tune with the revised syllabus of F.Y.B.Sc., the sub-committee has taken utmost care to maintain the continuity in the flow of information of higher level at S.Y.B.Sc. Hence some of the modules of the earlier syllabus of S.Y.B.Sc. have been upgraded with the new modules viz: immunology has been combined with epidemiology of infectious diseases plus diagnostic & clinical microbiology in order to make the learners aware about the spread of infection by different routes, sources of infection and functioning of the clinical microbiology laboratory. Earlier module of microbial biochemistry has been updated as per the recent developments in molecular biology & enzymology with an objective to raise the students awareness in interdisciplinary courses such as biophysics, bioinformatics and computational biochemistry.

A course on environmental microbiology has been introduced in order to make students familiar with the biodiversity of microorganisms in different habitats/ecological niches including extreme environments and applications of these microorganisms in bioremediation, pollution control, agriculture, pharmaceuticals & biotechnology.

I am thankful to all the members of the sub-committee for their great efforts and for timely submission of the draft syllabus.

S.Y.B.Sc. Microbiology Syllabus (General Outline)
Credit Based Semester and Grading System
To be implemented from the Academic year 2015-2016

SEMESTER III

Course Code	UNIT	TITLE	Credits	Lec. / Week
USMB301		Microbial Diversity, Microbial Taxonomy & Instrumentation	02	03
	I	Biodiversity In Extreme Environments		1
	II	Microbial Taxonomy		1
	III	Instrumentation In Microbiology		1
USMB302		Environmental Microbiology	02	03
	I	Air & Fresh Water Microbiology		1
	II	Marine & Sewage Microbiology		1
	III	Soil & Geo Microbiology		1
USMB303		Metabolism & Biology Of Macromolecules	02	03
	I	Introduction To Metabolism & Enzymes		1
	II	Principles Of Bioenergetics		1
	III	Estimation Of Biomolecules		1
USMBP3		Practicals based on above three courses	03	09

Course Code	UNIT	TITLE	Credits	Lec / Week
USMB401		Medical Microbiology & Immunology	02	03
	I	Innate Immunity & Immune System		1
	II	Epidemiology Of Infectious Diseases		1
	III	Diagnostic & Clinical Microbiology		1
USMB402		Industrial,Food & Dairy Microbiology	02	03

SEMESTER- IV

	I	Industrial Microbiology		1
	II	Food Microbiology		1
	III	Dairy Microbiology		1
USMB403		Molecular Biology & Enzymology	02	03
	I	Nucleic Acid Chemistry & Structure		1
	II	Central Dogma, Genetic Code, Transcription & Translation In Prokaryotes		1
	III	Enzymology		1
USMBP4	Practicals based on above three courses		03	09

S.Y.B.Sc. Microbiology Detail Syllabus
Credit Based Semester and Grading System
To be implemented from the Academic year 2015-2016

Course Code	UNIT	TITLE	Credits	Lectures/ Sem
USMB301		MICROBIAL DIVERSITY, MICROBIAL TAXONOMY & INSTRUMENTATION	02	45 Lectures
	I	<u>Biodiversity In Extreme Environments</u> 1.1 Extreme Environments and their types with respect to the physical conditions which lead to microbial stress. (05L) a) Temperature based environments- Low and high temperature environments b) pH based environments- Acidic and alkaline environments, Acid mine drainage. c) Environments with high salt concentration. 1.2 Microbial Physiology of the extremophiles (05L) a) Examples of extremophiles in each environment with their morphology and cultural characteristics. b) Physiology of the extremophiles in each environment. c) Molecular adaptations of the extremophiles 1.3 Applications of extremophiles (05L) a) Applications of Acidophiles and Alkalophiles b) Applications of halophiles- in biotechnology and medicine c) Applications of psychrophiles in pharmaceuticals and environment. d) Applications of thermophiles and hyperthermophiles in enzymology		15 Lectures
	II	<u>Microbial Taxonomy</u> 2.1 Introduction to microbial Taxonomy (01L) 2.2 Taxonomic ranks (01L) 2.3 Techniques for determining Microbial Taxonomy and Phylogeny (05L) a) Microscopic & macroscopic morphology and biochemical characteristics, (b) Chemical Analysis, (c) Serological analysis, (d) Genetic & molecular analysis:-(i) RNA sequencing and finger printing, (ii) G+C content, (iii) DNA sequencing, (iv) DNA-DNA hybridization 2.4 Phylogenetic Trees (02L) (a) Types, (b) Construction (an overview) 2.5 Numerical Taxonomy (03L) (a) Grouping by numerical methods of taxonomic units, (b) Phylogenetic inferences 2.6 Bergey's Manual of Systematic Bacteriology (03L)		15 Lectures
	III	<u>Instrumentation In Microbiology</u> 3.1 Spectroscopic techniques: (03L) a) Visible and UV spectrophotometry i) Principles ii) Instrumentation iii) Applications 3.2 Electrophoretic techniques: a) General Principles (01L) b) Factors affecting electrophoresis (01L)		15 Lectures

		<p>c) Low voltage thin sheet & high voltage electrophoresis i) Materials (02L) ii) Apparatus and methods</p> <p>d) Gel electrophoresis (01L) i) Materials ii) Apparatus and methods</p> <p>3.3 Chromatographic Techniques: (03L) a) General principles and techniques b) TLC c) Paper chromatography</p> <p>3.4 Centrifugation techniques: (04L) a) Basic principles of sedimentation b) Types of centrifuges and their use (Give an overview) i) Small bench centrifuges ii) Large capacity refrigerated centrifuges iii) Small high speed refrigerated centrifuges iv) Continuous slow refrigerated centrifuges v) Preparative centrifuges vi) Analytical ultracentrifuges</p>		
USMB302	UNIT	ENVIRONMENTAL MICROBIOLOGY	02	45 Lectures
	I	<p>Air & Fresh Water Microbiology</p> <p>1.1 Air Microbiology: (05 L) a) Origin, distribution, number and kinds of microorganisms in air , Factors affecting microbial survival in air b) Enumeration of microorganisms in air : Impingement in liquids ,Impaction on solids ,Filtration, Sedimentation ,Centrifugation ,Electrostatic Precipitation. c) Air borne pathogens and diseases, droplets and droplet nuclei d) Air sanitation- methods and application</p> <p>1.2 Fresh water microbiology: (10 L) a) General: Hydrologic cycle, groups of natural waters, factors affecting kinds of microorganisms found in aquatic environments and nutrient cycles in aquatic environments b) Fresh Water environments and microorganisms found in Lakes , ponds, rivers, marshes, bogs and springs c) Potable water: Definition, water purification and pathogens transmitted through water. d) Microorganisms as indicators of water quality e) Bacteriological examination of water-sampling,routine analysis,SPC,membrane filter technique</p>		15 Lectures

	II	Marine and Sewage Microbiology 2.1 Marine Microbiology: (05 L) a. Characteristics of marine environments b. Marine microbial characteristics and their importance c. Ecosystems of Deep sea Hydrothermal vents and Subterranean Water 2.2 Sewage Microbiology: (10 L) a. Types of waste water b. Characteristics of waste water c. Modern waste water treatment: Primary, Secondary and tertiary treatment. d. Removal of pathogens by sewage treatment Processes e. Sludge Processing f. Oxidation Ponds, Septic tanks g. Disposal of Solid Waste, Modern Sanitary Landfills, Composting		15 Lectures
	III	Soil & Geo Microbiology 3.1 Terrestrial environment: (03 L) a) Soil – Definition, composition, function ,Textural Triangle b) Types Of Soil microorganisms & their activities 3.2 Methods of studying soil microorganisms: (5L) Sampling , Cultural methods , Physiological methods , Immunological methods , NA based methods ,Radioisotope techniques 3.3 Biogeochemical Cycles : (05 L) Carbon cycle, Nitrogen cycle, Sulphur cycle, Phosphorus cycle 3.4 Soil Bioremediation: (02 L)		15 Lectures
USMB303	Unit	METABOLISM & BIOLOGY OF MACROMOLECULES	02	45 Lectures

<p>I</p>	<p>Introduction to Metabolism & Enzymes</p> <p>1.1 Nutrition of bacteria: (01 L)</p> <p>1.2 Major & minor bioelements (01 L)</p> <p>1.3 Survey of metabolism: (07 L)</p> <ul style="list-style-type: none"> a) Participation of living organisms in carbon & oxygen cycle b) Nitrogen cycle in the biosphere c) Promotion of metabolic pathways by sequential enzyme systems d) Metabolism- Catabolism & Anabolism e) Catabolic pathways converge to a few end products f) Biosynthetic pathways diverge to yield many products g) Important differences between catabolic & anabolic pathways h) ATP as a carrier of energy from catabolic to anabolic reactions i) NADPH as a carrier of reducing power j) Cell metabolism-an economical tightly regulated process k) Secondary metabolism l) Compartmentalization of metabolic pathways in cells <p>1.4 Introduction to enzymes: (06L)</p> <ul style="list-style-type: none"> a) General properties of enzymes b) How do enzymes accelerate reaction c) Rate law for a simple catalysed reaction, Michaelis-Menten equation and it's derivation d) Classification of enzymes 		<p>15 Lectures</p>
<p>II</p>	<p>Principles of Bioenergetics</p> <p>2.1 Bioenergetics & thermodynamics: (06L) Energy transformations, thermodynamic quantities, standard – free energy, difference between ΔG & ΔG°</p> <p>2.2 Structure of ATP, phosphoryl group transfer and (05L) ATP, Types of energy –rich compounds, multi-roles of ATP, inorganic phosphoryl group donor</p> <p>2.3 Biochemical & chemical reactions, Biological oxidation-reduction reaction (04L)</p>		<p>15 Lectures</p>
<p>III</p>	<p>Estimation Of Biomolecules</p> <p>3.1 Estimation of Biomolecules (15 L)</p> <ul style="list-style-type: none"> a) Macromolecular composition of a microbial cell b) Methods of elemental analysis: Carbon by Slyke's method Nitrogen by Microkjelhdahl method. Phosphorus by Fiske-Subbarow method c) Estimation of Carbohydrates by Phenol and Anthrone method Estimation of Reducing Sugars by DNSA method Detection of Sugars by Aniline-Pthalate method d) Estimation of Proteins by Biuret method Estimation of Amino acids by Ninhydrin method e) Extraction of Lipids by Soxhlet method f) Extraction of Nucleic acids g) Estimation of Nucleic acids by DPA and Orcinol method 		<p>15 Lectures</p>

USMBP3	Practicals based on above three courses	03	
	SECTION-I (Practicals based on USMB301)		45 Lectures
	<ol style="list-style-type: none"> 1) Enrichment and isolation of Thermophiles and Acidophiles from hot water springs of Vajreshwari/Pali 2) Enrichment and isolation of Psychrophiles from refrigerator swabs/ soil obtained from ice factories/cold storages 3) Enrichment and isolation of Halophiles from marine water 4) Construction of phylogenetic tree on the basis of given data 5) Identification of an organism using Bergey's Manual.(Characteristics to be given) 6) Isolating an organism from soil and identifying the same on the basis of "Classical Characteristics"(Bacillus spp.) 7) Paper Chromatography 8) TLC 9) Verification of Beer and Lambert's Law 10) Demonstration of Agarose gel electrophoresis 		
USMBP3	Section –II (Practicals based on USMB302)		45 Lectures
	<ol style="list-style-type: none"> 1.Enumeration of microorganisms in air and study its load after fumigation 2. Routine analysis of water 3. Rapid detection of <i>E.coli</i> by MUG technique-Demo 4. Visit to Sewage treatment plant 5. Microbiological analysis of waste water by SPC 6.Total Viable count of Soil Flora 7. Enrichment and isolation of Cellulose degraders ,Sulphate reducers and Phosphate solubilisers 8 Winogradsky Column 		
USMBP3	Section-III (Practicals based on USMB303)		45 Lectures
	<ol style="list-style-type: none"> 1.Problems on Thermodynamics/ Bioenergetics 2.Qualitative reactions of carbohydrates 3.Estimation of total carbohydrates by anthrone method 4.Estimation of reducing sugars by DNSA method 5.Qualitative reactions of amino acids & proteins 6.Estimation of proteins by biuret, Robinson Hogden method 7.Study of hydrolytic enzymes: Lipase, Casease, Amylase(Isolation) 		

References

Course: USMB301

1. Environmental Microbiology ,R. M. Maier,I.L.Pepper & C.P.Gerba (2010),Academic Press
2. A Textbook of Microbiology by RC Dubey and DK Maheshwari,Revised Edition(2013).
3. Prescott's Microbiology,8th edition,J.M.Willey,L.M.Sherwood & C.J.Woolverton,McGraw-Hill International Edition
4. General Microbiology,Stanier,4th edition

5. A biologist's guide to Principles and techniques of practical Biochemistry, 3rd edition, Wilson and Goulding
6. Practical Biochemistry (Principles & Techniques), Ed. Keith Wilson & John Walkar, 5th Edition, Cambridge University Publication

Course: USMB302

1. Fundamental Principles of Bacteriology By A.H.Salle 7th edn, McGRAW-Hill Book Company
2. Prescott, Harley and Klein's Microbiology : 7th Edition ; Willey, Sherwood and Woolverton ,Mc Graw Hill International Edition
3. Microbiology, Michael J. Pelczar Jr., E.C.S. Chan ,Noel R. Krieg, 5th Edition, McGraw Hill Education (India) Pvt.Ltd.
4. Microbiology: Application Based Approach, Michael J. Pelczar Jr., E.C.S. Chan, Noel R. Krieg, 1st Edition (2010), Tata McGraw Hill
5. Methods of studying soil microbial diversity, Journal of Microbiological Methods 58 (2004) 169 – 188 Jennifer L et al.
6. Introduction to Environmental Microbiology-By Barbara Kolawzan, Adamiak et al (2006)
7. Environmental Microbiology by R.M.Maier. I.L. Pepper & C.P. Gerba (2010), Academic Press

Course: USMB303

1. Methods In Microbiology, Vol.5B, Ed. Norris & Ribbon, Academic Press
2. Lehninger: Principles Of Biochemistry, 4th Ed., D.Nelson & M.Cox, W.H. Freeman & Co., New York 2005
3. Outlines Of Biochemistry, 5/E, Conn P. Stumpf, G. Bruening & R. Doi, John Wiley & Sons, New York 1995
4. Enzymes: Biochemistry, Biotechnology & Clinical Chemistry, T. Palmer, East West Press Ltd., New Delhi 2004
5. An Introduction to Practical Biochemistry, David Plummer, 3rd Edition (2003), Tata McGraw-Hill Publishing Co.Ltd.
6. Biochemical Methods, S.Sadasivam & A.Manickam, 2nd Edition (1996), New Age International (P) Ltd.
7. Laboratory Manual in Biochemistry, J.Jayaraman

SEMESTER IV

Course Code	UNIT	TITLE	Credits	Lectures/ Sem.
USMB 401		MEDICAL MICROBIOLOGY AND IMMUNOLOGY	02	45 Lectures
	I	Innate Immunity & Immune System 1.1 Basic concepts in Immunology-Introduction (01L) 1.2 Principals of Innate & adaptive immunity-Primary, Secondary & Tertiary Barriers (02L) 1.3 Components of the immune system-Cells and organs of the immune system (03L) 1.4 Phagocytosis and inflammation-Mechanisms and link to immunity (03L) 1.5 Pattern recognition in innate immune system-PAMPs, PRRs, TLRs (03L) 1.6 The Complement System-Alternative and Lectin Pathways, evolution of Classical Pathway (03L)		15 Lectures
	II	The Epidemiology of Infectious Disease: 2.1 Epidemiological Terminology : Epidemiology, sporadic disease, endemic disease, hyper endemic disease, epidemic disease, index case, pandemic disease, outbreak (01L) 2.2 Development of Disease (02L) 2.3 Epidemiological Methods (02L) 2.4 Patterns of infectious disease in a population (02L) 2.5 The spread of infection: a) Reservoirs of infection –human reservoirs, animal reservoirs, non-living reservoirs (01L) b) Transmission of disease- Contact transmission, Vehicle transmission, Vectors (01L) 2.6 Nosocomial Infections: Microorganisms in the hospital, compromised host, chain of transmission , control of nosocomial infections (02L) 2.7 Public Health Measures for the Control of Disease: Controls directed against the Reservoir, Controls Directed against Transmission of the Pathogen, Immunization, Quarantine, Surveillance, Pathogen Eradication (02L) 2.8 Emerging and Re-emerging Infectious Diseases (02L)		15 Lectures
	III	Diagnostic And Clinical Microbiology 3.1 Overview of the Clinical Microbiology Laboratory: (01L) 3.2 Isolation of Pathogens from clinical specimens: (04L) a) Growth media and Culture b) Collection of specimens, handling and transport c) Types of specimens and their culture --- Blood, Urine, Faeces, sputum, Cerebrospinal fluid, pus, genital and culture of Anaerobes. 3.3 Identification of microorganisms from specimens: (02L) a) Microscopy b)Growth-Dependent Identification Methods 3.4 Rapid Methods of Identification: (02L)		15 Lectures

		3.5 Bacteriophage Typing (02L) 3.6 Molecular Methods and Analysis of Metabolic Products: (04L) a) Nucleic Acid –Based Detection Methods b) Gas liquid Chromatography c) Plasmid Fingerprinting		
USMB 402		INDUSTRIAL,FOOD & DAIRY MICROBIOLOGY	02	45 Lectures
	I	Industrial Microbiology : 1.1 Strains of industrially important microorganisms: (04L) a. Desirable characteristics of industrial strain b. Principles and methods of primary and secondary screening. 1.2 Types of fermentations: (02L) a).Aerobic, b) Anaerobic and c) Solid state fermentations. 1.3 Types of fermentation processes: (02L) a.Surface and Submerged, b.Batch, continuous, fed-batch fermentation process 1.4 Media for industrial fermentations: (05L) a. Production and Inoculum media b. Media components :- Carbon source, nitrogen source, amino acids and vitamins, minerals, water, buffers, antifoam agents, precursors, inhibitors and inducers.[crude media-from Patel] 1.5 Inoculum development: (02L)		15 Lectures
	II	Food Microbiology 2.1 Introduction: Significance, food as a substrate and sources: (01 L) 2.2 Microbial growth in foods: (02L) 2.3 Intrinsic and extrinsic factors: (01L) 2.4 General Principles of spoilage: Spoilage of fresh foods: fruits and vegetables, eggs, meat, poultry and seafood: (04L) 2.5 General principles of food preservation (principle of each method and example of foods only): High temperature, low temperature, drying, radiations and food additives and preservatives (tabular representation), Asepsis with introduction to HACCP. Food borne diseases and intoxications: (04L) 2.6 Methods of detection of microorganisms in food: overview of cultural, microscopic, physical, chemical and bioassay methods: (03L)		15 Lectures
	III	Dairy Microbiology 3.1 Milk- Definition , composition, Sources of contamination of milk: (02L) 3.2 Pasteurization of milk-LTLT, HTST method: (03L) 3.3. Milk products:- production and spoilage of a Yoghurt (02L) b Butter (02L) c Cheese-Cheddar and Cottage cheese (02L) d Fermented milks (01L) 3.4. Quality control of milk s(03L) a. Rapid platform test b. Microbiological analysis of milk.:- SPC,		15 Lectures

		Coliform count, LPC, Psychrophiles, Thermophilic count, DRT		
USMB 403		MOLECULAR BIOLOGY & ENZYMOLOGY	02	45 Lectures
	I	Nucleic acid chemistry & structure: (15L) (F.Y.BSc: Revision of nucleic acid) 1.1 DNA can occur in different 3D forms,DNA sequences adopt unusual structures 1.2 Many RNAs have complex 3D structures 1.3 Nucleic acid chemistry 1.4 Denaturation of double helical DNA and RNA 1.5 Nucleic acid from different species can form hybrids 1.6 Nucleotides and nucleic acids undergo non enzymatic transformations,DNA methylation 1.7 Functions of nucleotides 1.8 Structures of chromosomes		15 Lectures
	II	Central Dogma,Genetic Code,Transcription & Translation In Prokaryotes 2.1 Pathways for transfer of genetic information: a) RNA biosynthesis, prokaryotic transcription apparatus, prokaryotic promoters, Initiation, elongation and termination of transcription (07 L) b) Translation: components of protein synthesis apparatus Genetic code, mRNA, Ribosomes, Protein synthesis (08 L)		15 Lectures
	III	Enzymology: (Kinetics and purification of enzymes) 3.1 Enzymatically catalysed reactions exhibit saturation kinetics Effect of temperature and pH (07L) Effect of Inhibitors- Reversible and irreversible, competitive, Non competitive and uncompetitive inhibitors Allosteric effects in enzyme catalysed reactions Multisubstrate reactions- Ordered, Random and pingpong reactions Koshland-Nemethy and Filmer model Monod, wyman and Cahngux model 3.2 Coenzymes: Different types and reactions catalyzed by coenzymes (in tabular form), (04L) Water soluble coenzymes (NAD, Nicotinic acid) Fat soluble vitamins and their examples. 3.3 Working with proteins: (04L) Separation and purification of proteins Separation and characterization of proteins by electrophoresis Quantification of unseparated proteins		15 Lectures
USMB P4	Practicals based on above three courses		03	.

	<p>Section-I (Practicals based on USMB401)</p> <ol style="list-style-type: none"> Differential staining of Blood by the Field's staining method Isolation of organisms from fomites: Table Tops, Finger Tips, Mobile Phones Use of Selective and Differential Solid Media: Mac Conkeys agar, SS agar, XLD agar, TCBS agar, SIBA, Salt Mannitol agar, CLED agar, Hoyle's tellurite agar Use of Biochemical Media/Tests for Identification of Pathogens: Carbohydrate fermentation, Indole test, Methyl Red test, Vogues Proskauer test, Citrate Utilization, Lysine Decarboxylase, Gelatin Liquefaction, Nitrate Reduction, Phenylalanine deaminase test, Urease test, TSI agar, Oxidase test, Catalase test, Bile solubility test, Coagulase test, Optochin test and Bacitracin test. Rapid Identification of a Pathogen using a Kit: eg. The API 20 E system, Enterotube Multitest system (Demonstration) 		<p>45 Lectures</p>
	<p>Section –II (Practicals based on USMB402)</p> <ol style="list-style-type: none"> Isolation of antibiotic producers from soil. Auxanography Isolation of food spoilage agent Determination of TDT and TDP Determination of Salt and sugar tolerance Determination of MIC of a preservative Visit to Food/Dairy industry Rapid platform tests of raw and pasteurized milk. Microbiological analysis of raw and pasteurized Milk. Microbiological analysis of Butter, Cheese 		<p>45 Lectures</p>
	<p>Section-III (Practicals based on USMB403)</p>		<p>45 Lectures</p>
	<ol style="list-style-type: none"> Isolation of DNA from onion Estimation of DNA by DPA method Estimation of RNA by Orcinol method. Enzyme production (Invertase) Purification of enzyme: salt precipitation and desalting proteins by Dialysis Determination of Km of Invertase (Lineweaver-Burke plot, Michaelis-Menten graph) Effect of variables on enzyme activity (Temp, pH, Enzyme concentration) 		

References

Course : USMB401

- Foundations in Microbiology, Seventh Edition, Talaro. Mcgraw-Hill International Edition
- The Elements of Immunology, Fahim Khan. Pearson Education
- Immunology Essential and Fundamental, Third Edition, Pathak and Palan. Capitol Publishers.
- Prescott's Microbiology: 8th Edition ; Joanne M. Willey, Linda M. Sherwood , Christopher J. Woolverton , Mc Graw Hill International Edition
- Prescott, Harley and Klein's Microbiology : 7th Edition ; Willey, Sherwood and Woolverton ,Mc Graw Hill International Edition
- Brock Biology of Microorganisms: 12th Edition; Madigan Martinko Dunlap Clark

Course : USMB402

1. Casida L. E., "Industrial Microbiology" 2009 Reprint, New Age International (P) Ltd, Publishers, New Delhi
2. Stanbury P. F., Whitaker A. & Hall-S. J., 1997, "Principles of Fermentation, Technology", 2nd Edition, Aditya Books Pvt. Ltd, New Delhi.
3. Prescott and Dunn's "Industrial Microbiology". 1982 4th Edition, MacMillan Publishers
4. H. A. Modi, 2009. "Fermentation Technology" Vol 2, Pointer Publications, India
5. Industrial Microbiology. A.H. Patel. MacMillan. New Delhi. 1984.
6. Modern Food Microbiology. James Jay. 5th Ed,
7. Frazier and Westhoff, Food Microbiology, Tata McGraw Hill, 4th Edition
8. Microbiology By Prescott, Harley, Klein's 7th Edn
9. Outlines Of Dairy Technology, Sukumar De, Oxford University Press

Course : USMB403

1. Lehninger: Principles Of Biochemistry, 4th Ed., D. Nelson & M. Cox, W.H. Freeman & Co., New York 2005
2. Outlines Of Biochemistry, 5/E, Conn P. Stumpf, G. Bruening & R. Doi, John Wiley & Sons, New York 1995
3. Enzymes: Biochemistry, Biotechnology & Clinical Chemistry, T. Palmer, East West Press Ltd., New Delhi 2004
4. An Introduction to Practical Biochemistry, David Plummer, 3rd Edition (2003), Tata McGraw-Hill Publishing Co. Ltd.
5. Laboratory Manual in Biochemistry, J. Jayaraman
6. Biochemical Methods, S. Sadasivam & A. Manickam, 2nd Edition (1996), New Age International (P) Ltd.

MODALITY OF ASSESSMENT

Theory Examination Pattern:

A) Internal Assessment - 25% Marks.

Theory :- One Periodical Class Test : 25 Marks

Sr No	Particulars	Marks
1	Match the Columns/Fill in the Blanks/Multiple Choice Questions (1/2 Mark Each)	05 Marks
2	Answer in One or Two Lines (Concept Based Questions) (1 Mark Each)	05 Marks
3	Answer in Brief (Attempt Any Two Of The Three)	10 Marks
4	Active participation in routine class instructional deliveries and overall conduct as a responsible learner, mannerism and articulation and exhibit of leadership qualities in organizing related academic activities	05 Marks

B) External examination - 75 % Marks

Semester End Theory Assessment - 75%

75 Marks

- i. Duration - These examinations shall be of **2.5 Hours** duration.
- ii. Theory question paper pattern :-
 1. There shall be **four questions**. On each unit there will be one question with **20 marks each** & fourth one will be based on all the three units with **15 marks**.
 2. All questions shall be compulsory with internal choice within the questions. Question 1 (Unit-I), Question 2 (Unit-II) & Question 3 (Unit-III) will be of **40 marks** with internal options. Question 4 will be of **30 marks** with internal options.
 3. Questions 1,2 & 3 may be sub-divided into two sub-questions such as (a):- (i),(ii),(iii) & (iv) each carrying **06 marks** (subjective type) **AND** (b):- (i),(ii),(iii),(iv),(v),(vi),(vii) & (viii) each carrying **02 marks** (objective type) and the allocation of marks depends on the weightage of the topic. Question 4 may be subdivided into sub questions a,b,c,d,e & f each carrying **five marks** (subjective type).

Passing standards:

The learners to pass a course shall have to obtain a minimum of 40% marks in aggregate for each course where the course consists of Internal Assessment and Semester End Examination. The learners shall obtain 40% marks (i.e. **10 out of 25**) in the **Internal Assessment** and 40% marks in **Semester End Examination** (i.e. **30 out of 75**) separately, to pass the course and minimum of grade E in each project, wherever applicable, to pass a particular semester. A learner will be said to have passed the course if the learner passes the internal assessment and semester end examination together.

PRACTICAL EXAMINATION PATTERN

(A) Internal Examination:-

There will not be any internal examination/ evaluation for practicals.

(B) External (Semester end practical examination) :- 50 Marks Per Section

(Section-I based on course-1, Section-II based on course-2 & Section-III based on course-3)

Sr.No.	Particulars	Marks	Total
1.	Laboratory work (Section-I + II+III)	40 + 40 +40	= 120
2.	Journal	05 +05 +05	= 15
3.	Viva	05 + 05 +05	= 15

PRACTICAL BOOK/JOURNAL

Semester I:

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head/ Co-ordinator / Incharge of the department ; failing which the student will not be allowed to appear for the practical examination.

Semester II

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head/ Co-ordinator / Incharge of the department ; failing which the student will not be allowed to appear for the practical examination.

Overall Examination and Marks Distribution Pattern

Semester III

Course	USMB-301			USMB-302			USMB-303			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	25	75	100	25	75	100	25	75	100	300
Practicals	-	50	50	-	50	50	-	50	50	150

Semester IV

Course	USMB-401			USMB-402			USMB-403			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	25	75	100	25	75	100	25	75	100	300
Practicals	-	50	50	-	50	50	-	50	50	150