

MAHATMA GANDHI UNIVERSITY, KOTTAYAM
Undergraduate Programme in Microbiology
Scheme & Syllabus

Department of Microbiology Program Outcomes:

The graduation in Microbiology a student should have:

1. Acquired knowledge of facts and figures related to various subjects in pure sciences such as Microbiology, Physics, Chemistry, Botany, Zoology, Mathematics, etc.
2. Understood the basic concepts, fundamental principles, and scientific theories related to various scientific phenomena and their relevancies in day-to-day life.
3. Acquired skills in handling scientific instruments, planning and performing in laboratory experiments.
4. The skills of observations and drawing logical inferences from scientific experiments. Analyzed the given scientific data critically and systematically and the ability to draw objective conclusions.
5. Be able to think creatively (divergently and convergent) to propose novel ideas in explaining facts and figures or providing new solutions to problems.
6. Realized how developments in any science subject help in the development of other science subjects and vice-versa and how an interdisciplinary approach helps in providing better solutions and new ideas for sustainable developments.
7. Developed scientific outlook not only concerning science subjects but also in all aspects related to life.
8. Realized that knowledge of subjects in other faculties such as humanities, performing arts, social sciences etc. can have a great and effective influence which inspires evolving new scientific theories and inventions.
9. Imbued ethical, moral and social values in personal and social life leading to a highly cultured and civilized personality.
10. Developed various communication skills such as reading, listening, speaking, etc., which will help in expressing ideas and views clearly and effectively. Realized that the pursuit of knowledge is a lifelong activity and in combination with untiring efforts and positive attitude and other necessary qualities leads towards a successful life.
11. Developed flair by participating in various social and cultural activities voluntarily, to spread knowledge, creating awareness about social evils, blind faith, etc

Program Specific Outcome

Microbiology is a branch of science that studies microscopic life forms such as bacteria, protozoa, algae, fungi, bacteria, viruses, etc. These studies are inclusive of cytology, physiology, ecology, genetics and molecular biology, evolution, taxonomy and systematics with a focus on microorganisms.

The relevance and applications of these microorganisms to the surrounding environment including human life become part of this branch. Since the inception of this branch of science, microbiology has remained a field of active research and ever-expanding in all possible directions; broadly categorized as pure and applied science. Different branches of pure microbiology based on taxonomy are bacteriology, mycology, protozoology and parasitology, phycology and virology; with considerable overlap between these specific branches over each other and also with other disciplines of life sciences, like biochemistry, botany, zoology, cell biology, biotechnology, nanotechnology, bioinformatics, etc. Areas in the applied microbial sciences can be identified as

medical, pharmaceutical, industrial (fermentation, pollution control), air, water, food and dairy, agriculture (plant pathology and soil microbiology), veterinary, environmental (ecology, geomicrobiology); and the technological aspects of these areas. Knowledge of different aspects of microbiology has become crucial and indispensable to everyone in society. The study of microbes has become an integral part of education and human progress.

Building a foundation and a sound knowledge base of microbiological principles among the future citizens of the country will lead to an educated, intellectual and scientifically advanced society. Microbiological tools have been extensively used to study different life processes and are cutting-edge technologies. There is a continual demand for microbiologists in the workforce – education, industry and research. Career opportunities for graduate students are available in the manufacturing industry and research institutes at a technical level

Eligibility criteria for admission to B. Sc. Microbiology programme

Pass in plus two or equivalent with biology as a subject or vocational higher secondary in any biological/paramedical/agricultural /related branch.

DURATION OF COURSE

- The duration of U.G. programme in Microbiology shall be **6 semesters**.
- There shall be two Semesters in an academic year, the ‘ODD’ semester commences in June and on completion, the ‘EVEN’ Semester commences after a semester-break of three days with two months vacation during April and May. (The commencement of first semester may be delayed owing to the finalization of the admission processes.)

A student may be permitted to complete the Programme, on valid reasons, within a period of 12 continuous semesters from the date of commencement of the first semester of the programme.

EVALUATION OF PROJECT, OJT, ASSIGNMENT, SEMINAR, VIVA, INTERNAL ASSESSMENT, TEST PAPERS

- **Assignments-** Assignments are to be done from 1st to 4th Semesters. At least one assignment should be done in each semester for all papers.
- **Seminar/Viva-** A student shall present a seminar in the 5th semester for each paper and appear for Viva-voce in the 6th semester for each paper.
- **Internal Assessment, Test Papers-**At least one internal test-paper is to be attended in each semester for each paper. The evaluations of all components are to be published and are to be acknowledged by the candidates. All documents of internal assessments are to be kept in the college for two years and shall be made available for verification by the University. The

responsibility of evaluating the internal assessment is vested on the teacher(s), who teach the paper.

- **Project-** All students are to do a **project in the area of core course**. This project can be done individually or in groups (not more than five students) for all subjects which may be carried out in or outside the campus. The projects are to be identified during the II semester of the programme with the help of the supervising teacher. The report of the project in duplicate is to be submitted to the department at the sixth semester and are to be produced before the examiners appointed by the University. External Project evaluation and Viva / Presentation is compulsory for all subjects and will be conducted at the end of the programme. Along with project report, a report of visit to a research institute/industry must be submitted during the viva.

CONDUCT OF PRACTICAL EXAMINATIONS

Practical examinations will be conducted at the end of Even Semesters by a team consisting of an external examiner and internal examiner

Mahatma Gandhi University

B.Sc. Course in Microbiology under Choice Based Credit System

Consolidated scheme for all semesters

(modified scheme –theory papers)

Theory papers and project work

Semester	Title with Course Code	Course Category	Hours/ week	Credit	Total Credit	Marks %	
						Intl	Extl
First Semester	English I	Common	5	4	16	20	80
	MB1CRT01 Fundamentals of Microbiology	Core 1	4	4		20	80
	MB1CRT02 Microbial Physiology & Metabolism	Core 2	4	4		20	80
	First complementary course I Biochemistry -1	Complementary	2	2		20	80
	Second complementary course I Biotechnology -1	Complementary	2	2		20	80
Second Semester	English II	Common	5	4	16	20	80

	MB2CRT03 Immunology	Core 3	4	4		20	80
	MB2CRT04 Microbial Genetics	Core 4	4	4		20	80
	First complementary course II Biochemistry -2	complem entary	2	2		20	80
	Second complementary course II Biotechnology -2	complem entary	2	2		20	80
Third Semester	MB3CRT06 Bioinstrumentation and Techniques	Core 6	4	4	16	20	80
	MB3CRT07 Industrial Microbiology	Core 7	4	4		20	80
	MB3CRT08 Food Microbiology	Core 8	4	4		20	80
	First complementary course III Biochemistry -3	complem entary	2	2		20	80
	Second complementary course III Biotechnology -3	complem entary	2	2		20	80
Fourth Semester	MB4CRT09 Fundamentals of Biostatistics, Bioinformatics & Research Methodology	Core 9	4	4	16	20	80
	MB4CRT10 Aquatic Microbiology	Core 10	4	4		20	80
	MB4CRT11 Agricultural Microbiology	Core 11	4	4		20	80
	First complementary course IV Biochemistry -4	complem entary	2	2		20	80
	Second complementary course IV Biotechnology -4	complem entary	2	2		20	80
Fifth Semester	MB5CRT13 Medical Bacteriology - I	Core 13	4	4	18	20	80
	MB5CRT14 Medical Mycology	Core 14	4	4		20	80
	MB5CRT15 Medical Parasitology	Core 15	3	3		20	80
	MB5CRT16- Environmental Biochemistry and human rights	Core 16	4	4		20	80
	Open course: (Two options for the College to choose from) MB5OPT01 Human Physiology MB5OPT02 Nutrition and Health MB5OPT03 Ecology and Evolution	Core	4	3		20	80
Sixth Semester	MB6CRT17 Medical Virology	Core 17	4	4	18	20	80
	MB6CRT18 Diagnostic Microbiology	Core 18	4	4		20	80
	MB5CRT14 Medical Bacteriology - II	Core 19	2	2		20	80
	Choice based paper I (One among the Three papers students can choose from) MB6CBT01- Microbioprocess MB6CBT02- Sanitation Microbiology MB6CBT03- Medical Entomology	Core	4	4		20	80

	MB6PRP01-Project work	Core	5 (P)	4		20	80
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Project work is a single course spread over fifth and sixth semesters having both internal and external evaluation which will be conducted at the end of the programme.

Note: Along with project report, a report of visit to a research institute/industry must be submitted during the viva.

Choice based open course offered to students of other Departments (Vth Semester)

MB5OPT01 Human Physiology - 3 Credits

MB5OPT02 Nutrition and Health - 3 Credits

MB5OPT03 Ecology and Evolution - 3 Credits

Choice based core course offered to students of Department of Biochemistry (VIth Semester)

MB6CBT01- Microbioprocess - 3 credits

MB6CBT02- Sanitation Microbiology - 3 credits

MB6CBT03- Medical Entomology - 3 credits

Practical papers

Semester	Title with Course Code	Course Category	Hours/week	Credit	Total Credit	Marks %	
						Intl	Ext I
First and Second Semester	MB2CRP05 Microbiology Practical-I	Core 5	4	4	8	20	80
	First complementary practical I Practical Biochemistry-1	complementary	2	2		20	80
	Second complementary practical I Practical Biotechnology-1	complementary	2	2		20	80
Third and Fourth Semester	MB4CRP12 Microbiology Practical-2	Core 12	5	4	8	20	80
	First complementary practical II Practical Biochemistry-2	complementary	2	2		20	80
	Second complementary practical II Practical Biotechnology-2	complementary	2	2		20	80
Fifth and Sixth Semester	MB6CRP20 Microbiology Practical -3	Core 20	6	4	4	20	80

Consolidated scheme for courses (Model I, II & III) having Microbiology as a complementary subject

Theory papers

Semester	Title with Course Code	Course Category	Hours/week	Credit	Total Credit	Marks %	
						Intl	Extl

First	MB1CMT01 Fundamentals of Microbiology-1	Complementary	2	2	8	20	80
Second	MB2CMT02 Fundamentals of Microbiology-II	Complementary	2	2		20	80
Third	MB3CMT04 Applied Microbiology	Complementary	2	2		20	80
Fourth	MB4CMT05 Medical Microbiology	Complementary	2	2		20	80

Practical papers

Semester	Title with Course Code	Course Category	Hours/week	Credit	Total Credit	Marks %	
						Intl	Extl
First and Second	MB2CMP03 Microbiology Practical-I	Complementary	2	2	4	20	80
Third and Fourth	MB4CMP06 Microbiology Practical-II	Complementary	2	2		20	80

Syllabus for B. Sc. Microbiology- Core

FIRST SEMESTER

Core Course I: BC1CRT01- MB1CRT01 Fundamentals of Microbiology

Total hours of instruction: 72 Hours/week: 4 Credit: 4

CO No.	Expected Course Outcome	Learning Domains *
CO1	Introduce the philosophy of Science	U
CO2	Explain The Scope, History and Beneficial and harmful role of microbes	U
CO3	Describe the ultrastructure of prokaryotic cells.	U
CO4	Demonstrate fundamental techniques used for the identification and culturing of aerobic and anaerobic bacteria.	U
CO5	Apply the physical, chemical and chemotherapeutic methods used in the control of microorganisms.	A
CO6	Understand Growth, Growth requirements, Preservation and enumeration of bacteria	U
CO7		U
CO8	Overview of information technology	U

COURSE CONTENT

Content for Classroom transactions (Units)

Module	Course description	PSO	CO No.
1	Introduction to Philosophy of Science	8	
1.1 1.2	Relationship between History and Philosophy of Science.	1	CO1
1.3	What is Science; laws of science, Formulation of hypothesis; hypothetico-deductive model, inductive model.	1,2,9	CO1
1.4	Access to microbiological literature-monographs and series, reference works and handbooks, literature searches, internet as an information resource, documentation of practical work.	1,2,11	CO2
2	Definition, Scope and history of microbiology and future prospects..		
2.1	Diversity of microbial world. Beneficial and harmful microbes. Five kingdom classification. Principles of classification, Groups of bacteria as per Bergey's manual		
2.2	Differentiate between eukaryote and prokaryote. Principles of classification- classification of bacteria. Differences between archaebacteria and eubacteria.		
2.3	Ultrastructure of prokaryotic cell.		
2.4	Bacteriological techniques- Staining and Culture methods	13	
2.5	Microscopes, Culture media	4	CO2
2.6	Staining techniques,	4	CO3

2,7	culture methods (including anaerobic bacteria) Isolation of pure cultures.	5	CO4
3	Control of microorganisms	12	
3.1	Sterilization and disinfection physical and chemical methods.	4	CO5
3.2	Antimicrobial agents ♦ mode of action	4	CO5
Unit 4	Growth, Growth requirements, Preservation and enumeration of bacteria		
4.1	Nutrition, nutritional types,	12	CO6
4.2	growth requirements and conditions influencing growth, growth curve, growth kinetics, phases of growth, cell division, sporulation, germination.	6	CO6
4.3	Preservation and transport of bacteria.	3	CO6
4.4	Enumeration & quantitation of bacteria and microbes.	2	C)6
Unit 5	Overview of information technology: Features of modern personal computer and peripherals computer networks and Internet -Overview of operating system and major applications of software. Academic search techniques –, plagiarism - Introduction to use of IT in teaching and learning. Power point features and slide preparation.	1,8,11	

References:

- Biochemical methods by Pingoud A, Urbanke C, Hoggett J and Jeltsch A, Chapter 1
- Microbiology by Daniel Lim
- Microbiology: Principles and Explorations by Jacquelyn G. Black
- Prescott/Harley/Klein's Microbiology by Joanne Willey, Linda Sherwood, and Chris Woolverton
- Microbiology Pelczar, Chan and Krieg.
- General microbiology Vol 1 Powar & Daginawala
- Microbiology Pelczar, Chan and Krieg.
- Ananthanarayan and Paniker's Textbook of Microbiology R. Ananthanarayan, C.K Jayaram Panikar

Core Course 2: MB1CRT02 Microbial Physiology & Metabolism**Total hours of instruction: 72****Hours/week: 4****Credit: 4**

Co No	Expected Outcome	Learning Domain
CO1	Understand Nutrition ,Nutritional types	R
CO2	Describe different preservation methods and Transport Of bacteria	R
CO3	Explain bacterial photosynthesis	Apl
CO4	understand growth requirements and different conditions influencing bacterial growth.	U
CO5	Evaluate growth curve and growth kinetics	Evaluate
CO6	Recognise cell division , Sporulation and germination,	R
CO7	Distinguish Enumeration and Quantification Of bacteria and microbes.	An
CO8	Identify Enzymes and factors affecting enzyme activity	U
CO9	Explain transition state in enzyme catalysed reactions	Appl
CO10	Summarise High energy compounds- ATP, GTP ,role of reducing power of NAD, NADPH.	U
CO11	Describe Carbohydrate metabolism- glycolysis, Alcoholic fermentation,, electron transport chain, TCA cycle, Glyoxylate cycle	U

CO12	Demonstrate Electron transport chain, substrate level and oxidative phosphorylation.,Pentose Phosphate Pathway, Transamination and Nitrogen Fixation.	
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COURSE CONTENT

Content for Classroom transactions (Units)

Module	Course description	CO No.
1	Nutrition	1
1.1	Nutritional types	1
1.2	Preservation and transport of bacteria	2
1.3	Microbial Photosynthesis.	3
1.4	Microbial life in extreme environments.	4
2	Growth	4
2.1	Growth requirements and conditions influencing growth	4
2.3	Growth curve	5
2.4	Growth kinetics	5
2.5	Cell division	6

2.6	Sporulation and germination	6
2.7	Enumeration & quantification of bacteria and microbes.	7
3	Enzymes	8
3.1	Factors affecting enzyme activity	8
3.2	Transition state in enzyme catalysed reactions	9
3.3	High energy compounds- ATP, GTP ,role of reducing power of NAD, NADPH.	10
4	Bacterial metabolism	11
4.1	Carbohydrate metabolism- glycolysis	11
4.2	Alcoholic fermentation,, electron transport chain,	11
4.3	TCA cycle	11
4.4	Glyoxylate cycle	11
4.5	Electron transport chain, substrate level and oxidative phosphorylation,	12
4.6	Pentose phosphate pathway.	12
4.7	Transamination and Nitrogen fixation	12

References:

1. General microbiology Vol 1 Powar & Daginawala
2. General microbiology Vol 2 Powar & Daginawala
3. Microbiology Pelczar, Chan and Krieg
4. Prescott/Harley/Klein's Microbiology by Joanne Willey, Linda Sherwood, and Chris Woolverton

SECOND SEMESTER

Core Course 3: MB1CRT03 Immunology

Total hours of instruction: 72

Hours/week: 4

Credit: 4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No	Rubric level
CO1	Acquire a fundamental understanding of the Immune System	U	PO1 PO2	2 3
CO2 CO3 CO4 CO5	Illustrate the structure and functions of components involved in the immune response – Ag, Ab, Complement System, Major histocompatibility complex Ag – Ab Reactions	U	PO1 PO2	3 3
CO6 CO7	Explain the basic mechanisms of immune response – HMI Monoclonal Antibody CMI	U	PO1 PO2	3 3

CO8				
CO9	Analyse the role of immune response in health and disease Immunohaematology- Blood groups. Blood transfusion- Rh incompatibilities, Hypersensitivity Reactions- Type I, II, III, & IV. Brief of Transplantation Immunology- Types of grafts. Autoimmunity.	An	PO1	3
			PO2	3
CO9			PO6	2
			PO10	3
CO10				
CO11				
CO12				
<i>*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)</i>				

COURSE CONTENT

Content for Classroom transactions (Units)

Module (Units)	Course description	Hrs	CO No.
1	Fundamental Understanding of the Immune System	10 Hours	CO 1
1.1	History of Immunology		CO 1
1.2	Infection and types of infections		CO 1
1.3	Types of Immunity- innate immunity and Acquired immunity		CO 1

1.4	Study of the cells and organs of the immune system		CO 1
2	Structure and functions of components involved in the immune response	12 Hours	CO 2
2.1	Antigens- types, properties, Haptens, Adjuvants		CO 2
2.2	Immunoglobulins- Structure, types and properties.		CO 2
2.3	Complement- functions of complement components and Complement activation pathways,		CO 3
2.4	Major histocompatibility complex		CO4
2.5	Antigen-Antibody Reactions – Precipitation Reaction, Agglutination Reaction, Complement Fixation Test, Neutralisation reactions, Immunofluorescence, ELISA, RIA.		CO5
3	Basic mechanisms of immune responses.	11 Hours	
3.1	Humoral Immune response- B cells, plasma cells and antibody secretion,		CO 6

3.2	Monoclonal Antibodies		CO 7
3.3	Cell-mediated immune response – Cells involved and their mechanism– T Cells, NK Cells, ADCC.		CO 8
4	Role of immune response in health and disease	12 Hours	CO 9
4.1	Immunohaematology- Blood groups. Blood transfusion- Rh incompatibilities		CO 9
4.2	Hypersensitivity Reactions- Type I, II, III, & IV.		CO 10
4.3	Brief of Transplantation Immunology- Types of grafts.		CO 11
4.4	Autoimmunity.		CO12

References

1. Kindt, Thomas J., Richard A. Goldsby, Barbara A. Osborne, and Janis Kuby. *Kuby immunology*. Macmillan, 2007.
2. Ananthanarayan, R. *Ananthanarayan and Paniker's textbook of microbiology*. Orient Blackswan, 2006.
3. Delves, Peter J., Seamus J. Martin, Dennis R. Burton, and Ivan M. Roitt. *Roitt's essential immunology*. John Wiley & Sons, 2017.

4. Latha, Madhavee P. *A Textbook of Immunology*. S. Chand Publishing, 2012.
5. Kannan I. *Immunology*. MJP Publishers, Chennai, 2021
6. Rao, C. Vaman. *Immunology: A textbook*. Alpha Science Int'l Ltd., 2005.

Core Course 4: MB2CRT04 Microbial Genetics

Total hours of instruction: 72
Credit: 4

Hours/week: 4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No	Rubric level
CO1	Understand the basic concepts of genomic organization of bacteria & experiments	U	PO1 PO2	3
CO2	Distinguish the genetic exchange mechanisms in bacteria	An	PO2 PO1	3 3
CO3	Analyse the molecular mechanism involved in bacterial gene expression	An	PO2	3
CO4	Identify the concepts of mutation and repair mechanisms in bacteria	An	PO1 PO2	3 3

COURSE CONTENT for Classroom transaction (Units)

Module	Units	Course description	CO No.
1	1.1	Bacterial Chromosome-structure, function,	CO1
	1.2	Experiments to prove DNA as the genetic material.	CO1
	1.3	DNA replication	CO1
	1.4	Extrachromosomal genetic material in bacteria: Plasmids-Structure, replication, Incompatibility. Transposons-Brief Introduction, Transposition - Cut & Paste Mechanism.	CO1
2	2.1	Genetic exchange- : Experiments and Mechanism- Conjugation transformation,	CO2

		transduction	
	2.2	Mechanism and Spread of Antibiotic Resistance in Bacteria.	CO2
Mod ule	Units	Course description	CO No.
3	3.1	Gene expression in prokaryotes - Central Dogma, Transcription, Translation, Enzymes involved	CO3
	3.2	Control of Gene Expression in Prokaryotes – Induction, Repression, Positive Control, Negative Control – based on Lac Concept	CO3
4	4.1	Mutation - Spontaneous - Induced mutation -Mutagens:- Physical Chemical agents. Types Of Mutation base pair changes,frame shift, deletion, addition.	CO4
	4.2	Useful phenotypes of mutants (Auxotrophs, conditional, lethal, resistant). Reversion Vs Suppression. Ames test.	CO4
	4.3	DNA repair in bacteria- Excision Repair and SOS repair	CO4

References:

1. Microbial Genetics Stanley R. Maloy, Freifelder and Cronan
2. Molecular Genetics of Bacteria Snyder and Charminess.
3. Fundamentals of molecular Biology by Veer Bala Rastogi Ane books India
4. Prescott/Harley/Klein's Microbiology by Joanne Willey, Linda Sherwood, and Chris Woolverton

Core Course 5- MB2CRP05 Microbiology Practical – I**Total hours of instruction: 144****Hours/week: 4****Credit: 4****(72 in Semester I and 72 in Semester II)**

Study the parts and usage of a Compound Microscope

Study the parts and working and uses of

Autoclaves

Hot air oven

Membrane Filter

LAF

Anaerobic Jar

Preparation of culture Media(NB, NA, MA) and dispensing media in test tubes, bottles, petridishes.

Cultivation of Bacteria on nutrient Agar for obtaining isolated colonies; Streak plate method. Study of cultural colony characters- Size, shape, colour etc.

Viable Count of bacteria by pour plate/ spread plate method.

Preparation and examination of Hanging drop mount for studying the motility of bacteria.

Preparation of slide smears for staining.

Staining- Principle & techniques

- Simple staining

- Gram Staining

- Negative Staining.

- Special Staining – endospores

Slide agglutination test - Blood grouping, ASO

Precipitation reaction –RPR

ODD, RID, Dot ELISA-Demonstration

Titration of Antibody – Widal Test.

References:

1. Microbiology – Concepts and Application – Pelzer Jr. Chang Kreig Mac Graw Hill Inc
2. Microbiology – Prescott, Harley and Klein Wim.C.Brown Publishers.
3. Practical Microbiology – R.C Dubey, D.K Maheshwari, S Chand and Company, New Delhi.
4. Microbiology Laboratory Manual – Cappuccino, Sherman, Pearson Education
5. Manual of Microbiology Kanika Sharma Ane Books Pvt. Ltd.
6. Bailey and Scott's Diagnostic Microbiology
7. Practical Medical Microbiology by Mackie & Mc Cartney
8. Hand book of experimental immunology by D.M. Weir
9. Practical Microbiology by Dubey and Maheswari

THIRD SEMESTER

Core Course 6: MB3CRT06 Bioinstrumentation and Techniques

Total hours of instruction: 72

Hours/week: 4

Credit: 4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PSO No	Rubric level
CO1	Distinguish the Principle, working and application of Light, Dark, Phase contrast, fluorescent, Confocal microscope and Electron microscope	An	PSO1 PSO4 PSO	3 2 3

CO2	Understand the Principle and application of Differential centrifugation and density gradient centrifugation.	U	PO1	3
			PO4	2
			PO10	2
CO3	Compare the Principle, application and types of Electrophoresis and Blotting techniques.	An	PO1	3
			PO2	3
			PO4	2
			PO10	3
CO4	Understand Beer Lamberts Law, Principle, instrumentation and application of Colorimetry, Turbidometry, UV & Visible Spectrophotometry	U	PO1	3
			PO4	2
			PO10	2
CO5	Explain the Principle and application of PCR, Molecular markers - RFLP, RAPD, VNTR & DNA fingerprinting.	E	PO1	3
			PO2	3
			PO4	2
			PO10	2
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)				

RUBRICS

MAPPING STRENGTH	RUBRICS LEVEL
>70%	3
40 -69%	2
10-39%	1
<10 %	0

COURSE CONTENT Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	1.1	Microscopic techniques Microscopy- Principle, Instrumentation and application – Introduction- Magnification, Resolution, and Numerical aperture.	5	1
	1.2	Principle, design, working, applications, advantages and disadvantages of Light, Dark, Phase contrast, fluorescent, Confocal microscope.	10	
	1.3	Electron Microscope – SEM and TEM. Chromatic Aberration.	5	
2	2.1	Principles, Instrumentation and application of Differential centrifugation, Density gradient centrifugation.	5	2
	2.2	Electrophoretic Techniques Basic Principle and application of Electrophoresis: AGE, PAGE, SDS PPAGE. Two dimensional electrophoresis	7	3
	2.3	Blotting techniques: Southern, Northern, Western hybridization	3	
	3.1	Spectrophotometric Techniques Beer Lambert’s Law. Basic principles application of colorimetry and turbidometry	7	4

	3.2	Spectrophotometry: Principles, working and application – UV, Visible Spectrophotometry.	8	
	4.1	Introduction to Molecular techniques PCR- Steps and application, Types – Nested PCR, multiplex.	5	5
	4.2	Molecular markers - RFLP, RAPD, VNTR. DNA fingerprinting.	5	

Reference

1. Biophysical Chemistry Principles and Techniques- Upadhyay, Nath.
2. Practical Biochemistry Principles and Techniques - Ed Keith Wilson and John Walker
3. Cambridge University press, Cambridge, U K.
4. Modern Experimental Biochemistry Rodney F Boyer, The Benjamin /Cummings Publishing Company
5. Biochemical Methods- S. Sadasivam and A. Manikam
1. Biotechnology –B D Singh
2. Cell and molecular biology -Gerald Karp

Core Course 7: MB3CRT07 Industrial microbiology

Total hours of instruction: 72

Hours/week: 4

Credit: 4

COURSE OUTCOMES (CO)

Sl No.	Expected Course Outcome	Learning Domains *	CO No	
Module 1				
1	Understand the basic concepts of industrial Microbiology	U	CO1	
Module2				
2	Describe different parts of a fermenter and their functions	U	CO2	
Module 3				
3	Describe the production of different microbial products- Organic acids, Enzymes, Aminoacids, antibiotics	An	CO3	
Module 4				

4	Summarize different methods of Immobilisation.	U	CO4	
5	Define Intellectual Property rights and Explain functions.	U	CO5	
<i>*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)</i>				

COURSE CONTENT

Content for Classroom transactions (Units)

Module	Course description		CO No.
1	General concepts of industrial microbiology.		CO1
1.1	Principles of exploitation of microorganisms for their products.		CO1
1.2	Introduction to fermentation, Types of Fermentation, single, batch, continuous, dual or multiple, solid- state and submerged fermentation.		CO1
1.3	Industrial strains– characteristics		CO1
1.3	Isolation techniques- primary and secondary screening techniques.		CO1
1.4	Strain Improvement-Introduction		CO1

<p>2</p> <p>2.1</p> <p>2.2</p> <p>2.3</p>	<p>Fermenter- parts of stirred tank fermentor</p> <p>Fermentation media formulation strategies</p> <p>sterilization, control of foaming</p> <p>product recovery and purification (outlines only).</p>		<p>CO2</p> <p>CO2</p> <p>CO2</p>
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<p>3</p> <p>3.1</p> <p>3.2</p> <p>3.3</p> <p>3.4</p>	<p>Industrial products derived from microbes</p> <p>organic acid – Citric acid,</p> <p>industrial enzymes- amylase, proteinase.</p> <p>Amino acid production - glutamic acid and lysine</p> <p>. Production of antibiotics- penicillins, streptomycin</p>		<p>CO3</p>
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4	Immobilization methods-		CO4
4.1	Adsorption; covalent linkages, membrane entrapment. Advantages and disadvantages of each method.		
	Applications of immobilized enzymes		
4.2	Brief Study of Intellectual Property Rights (IPR)- Definition and Function.		CO5
			4-2

References

1. Principles of Fermentation Technology by Peter F. Stanbury, Stephen J. Hall, and Allan Whitaker
2. Manual of Industrial Microbiology and Biotechnology by Ronald M. Atlas
3. Prescott and Dunn's Industrial Microbiology by Gerald Reed
4. Industrial Microbiology by Samuel C. Prescott
5. Industrial Microbiology by L.E. Casida

Core Course 8: MB3CRT08 Food Microbiology

Total hours of instruction: 72

Hours/week: 4

Credit: 4

COURSE OUTCOMES (CO)

	Expected Course Outcome	Learnin g Domains	PO	Rubr Level
1	To understand the type of microorganisms involved in food microbiology	U	PO1 PO4	1 2
2	To understand the methods of examination preservation in the food industry	U	PO1 PO2 PO4 PO6 PO1 0	2 2 2 3 2
3	To understand the major fermented food products	U	PO3 PO4 PO6	2 2 2
4	To Analyse the food-borne illness and food safety management.	An	PO2 PO6 PO1 0	3 3 3
<i>Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create Skill (S), Interest (I) and Appreciation (Ap)</i>				

COURSE CONTENT

Content for Classroom transactions (Units)

Module	Units	Course description		CO No.

1.1		History of Food Microbiology.		CO1
1.2		Beneficial role of microbes in food industry; Molds, yeasts and bacteria.		
1.3		Principles of food preservation - High temperature - Low temperature - Drying - Food additives-organic acids & their salts, nitrites & nitrates, sulfur dioxide & sulfites, wood smoke	7	
2		Contamination and spoilage and intoxications		
2.1		Contamination and spoilage - vegetables and fruits, meat and meat products, milk and milk products - fish and sea food - Poultry, Spoilage of canned foods.		CO2
2.2		Food borne infections, poisoning and intoxications.		
2.3		Microbiological examination of food, Milk. HACCP- definition and principles (out line)		
3		Importance of microbes in food industries.	8	

3.1		<p>Fermented food products by microbes – Bread, Vinegar.</p> <p>Alcoholic beverages- wine, beer, cedar.</p> <p>Oriental fermented foods-Shoyu, Miso, Tempeh.</p> <p>Fermented vegetables. Milk and milk products- butter, cheese, Probiotics (brief study)</p>		CO3
4		<input type="checkbox"/> SCP and Edible Mushroom Production <input type="checkbox"/> Foodborne Illness		CO4
4.1		Microbial cells as food-single cell proteins- Baker's yeast	4	CO4
4.2		Edible mushroom- types and production- <i>Agaricus bisporus</i> , <i>Volvariella volvacea</i> , <i>Pleurotus</i>	1 5	CO4
4.3		Food borne disease – Salmonellosis, Botulism and <i>E.coli</i> poisoning, aflatoxin and other toxins.	1 6	

Reference

1. Frazier, W.C. 1978. Food Microbiology. McGraw Hill.
2. Industrial Microbiology by Samuel C. Prescott
3. Parihar and Parihar Dairy Microbiology, Saraswati Purohit, Jodhpur India, 2007
4. Prajapati J. B. (1995), Fundamentals of Dairy Microbiology. 23

FOURTH SEMESTER

Core Course 9: MB4CRT09 Fundamentals of Biostatistics, Bioinformatics & Research Methodology

Total hours of instruction: 72
Credit: 4

Hours/week: 4

CO No.	Expected Course Outcome	Learning Domains *	PO No	RUBRICS level
MODULE 1				
1	To get an insight into the role of statistics in research	U	1 2 5	2
MODULE 2				
2	Understand the steps in research from sampling to reporting	U	1 2	2 2
MODULE 3				
3	Analyse the role of Bioinformatics in research	A	1 2	2 2
MODULE 4				
4	To get an idea of research and the essentials of research	U	2	2
<p><i>*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)</i></p>				

COURSE CONTENT

Content for Classroom transactions (Units)

Module	Units	Course description	Hrs	CO No.
1		<p>Nature and scope of statistical methods and their limitation.</p> <p>Compilation, classification, tabulation, and application in life science.</p> <p>Graphical representation, Measure of average and dispersion mean, median, mode</p>	15	1
2		<p>Proficient Research Practices – Sampling methods – simple random, stratified, systematic and cluster sampling procedures. Sampling distribution, Probability, Tests of significance based on T, Chi-square and F Test Designing and methodology of experiment</p>	15	2
3		<p>Introduction to Bioinformatics</p> <p>Importance and scope of Bioinformatics,</p> <p>Data base types, Data mining and data analysis methods - Computer tools for sequence analysis,</p> <p>Finding and retrieving sequences, Similarity searching</p>	15	3
4		<p>Introduction to research methodology to Documentation</p> <p>Experimentation in science and data handling, design of an experiment; Experimentation; observation; data collection; interpretation and deduction.</p> <p>Documentation of experiments, record keeping</p>		4

References

1. Fundamentals of Biostatistics. Bernard Rosner
2. Biostatistics for medical, nursing and pharmacy students. A. Indrayan and L. Satyanarayana.
3. Statistics for Biologists. Campbell. R.C

4. Bioinformatics: A Beginner's Guide. By Jean- Michel Claverie and Cedric Noterdame; Wiley Publishing, Inc.2003.
5. Bioinformatics: A practical approach. K. Mani and Vijayaraj, Aparna Publication, 2004
6. Debbie Holmes, Peter Moody, Diana Dine. Research methods for the Biosciences, International Student Ed., Oxford University Press Inc. New York
7. S K Aggarwal. Foundation Course in Biology, Ane's Student Ed., Second Ed.
8. R C Sobti, V L Sharma. Essentials of Modern Biology, Ane's Student Ed.

Core Course 10: MB4CRT10 Aquatic microbiology

Total hours of instruction: 72

Hours/week: 4

Credit: 4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No	RUBRICS LEVEL
1	To Remember the various aquatic ecosystems and familiarize the various organisms	K	PO1 PO2 PO10	2 2 2
2	To understand different techniques for the study of aquatic microorganisms and the role and importance of aquatic microbial ecosystem and microbial consortia	U	PO1 PO2 PO10	2 2 2
3	To recognize the various pollutants in the environment using microorganisms	K	PO1 PO2 PO10	2 2 2
4	To Understand different methods of water purification, potability of water and its importance in the prevention of different water-borne diseases	U An	1 2 7 11	

**Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Content for Classroom transactions (Units)

Module	Units	Course description	Hrs	CO No.
1	1.1	The aquatic environment and distribution of microorganisms in the aquatic environment.	15 hrs	1
	1.2	Aquatic Ecosystem-freshwater (ponds,lakes,stream) marine(estuaries, mangroves,deep sea) Microbial indicators of pollution		
	1.3	.Water zonations-upwelling.Benthic microorganisms.Marine microflora and biofouling.		
2	2.1	Techniques for the study of aquatic microorganisms.	15 hrs	2
	2.2	The role and importance of aquatic microbial ecosystem.		
	2.3	Microbial consortia. Surface attachment and biofilm development.		

	2.4	Antibacterial and bioactive compounds from aquatic microorganisms.		
3	3.1	Water pollution, microbial changes induced by inorganic and organic pollutants. Metals as pollutants.	15 hrs	3
	3.2	Algal blooms. Biological and chemical control of algal blooms		

4	4.1	Potability of water. Purification and disinfection..	30 hrs	
	4.2	Indicator organisms		
	4.3	Microbiological examination of drinking water.		
	4.4	Water borne diseases and control measures.		

References

1. Aquatic microbiology-Rheinheiner
2. Marine pollution-Clark
3. Elements of microbiology- Pelczar, Reid and chan
4. Aquatic microbiology-Rheinheiner
5. Fundamentals of bacteriology-A.J.Salle
6. Ecological aspect of waste water treatment vol 2 biological activities and treatment process-Cruds C.R and hawkes
7. Microbiology-Prescott, M.J, Harley, J. P. and Klein, D. A.

Core Course 11: MB4CRT11 Agricultural microbiology

Total hours of instruction: 72

Hours/week: 4

Credit: 4

COURSE OUTCOMES (CO)

SL No.	Expected Course Outcome	Learning Domains *	CO NO	RUBRIC LEVEL
1	Understand about Microbial interactions , interactions among themselves & plants	U	CO1	3
2	Explain bacterial, fungal & viral plant pathogens, transmission & its control	U	CO2	3
2	Understand rhizosphere, phyllosphere & endophytic microflora & its importance	U	CO3	3
3	Develop knowledge on retting, silage & tobacco curing	S	CO5	3
8	Build knowledge on IPM	U	CO5	3
9	Create knowledge on production of biofertilizers	C	CO6	3
<p><i>*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)</i></p>				

COURSE CONTENT

Content for Classroom transactions (Units)

Mod ule	Course description	CO No.
1	Soil microbes & their interactions	CO1

1.1	A brief account of microbial interactions (symbiosis)- commensalism, synergism, mutualism, amensalism, parasitism, predation.	CO1
1.3	Plant-microbe interactions- Mycorrhiza- ecto, endo & ectendomycorrhiza, Actinomycetes	CO1
2	Microbial diseases of plants- pathogens, transmission & control measures. Common bacterial- crown gall disease, potato scab, soft rot disease, Bacterial Wilt Of Potato. citrus canker, fungal- club root disease, wart disease, ergot of cereals & viral- TMV, bunchy top of banana, tomato spotted wilt, sugar cane mosaic- diseases.	CO2
3	Rhizosphere, Phyllosphere and Endophytic Microflora	CO3
3.1	Role Of Microbe in Retting	CO4
3.2	Microbiology of silage, tobacco curing. Role of microbes in retting	CO5
4.1	Biopesticides- bacterial, viral & fungal pesticides. Biological control of plant diseases. Integrated pest management	CO5
4.2	Production of biofertilizers	CO6

References

1. Microbiology Fundamentals and applications-Ronald M. Atlas
2. Soil microorganisms and plant growth-N.S. Subba Rao
3. Agricultural microbiology- G. Rangaswamy and D.J. Bagyaraj
4. Microbial ecology-Atlas and Bartha
5. General microbiology-Pelczar, Reid and Chan
6. Microbiology-Prescott, M.J.; Harley, J.P. and Klein, D.A

Core Course 12- MB4CRP12 Microbiology Practical – II

Total hours of instruction: 180 Hours/week: 5 Credit: 4
(90 in Semester III and 90 in Semester IV)

Enumeration of soil microbes by Plate culture method and isolation of
Microorganisms from soil sample – Bacteria, Fungi, Actinomycetes and Azotobacteria.
Wine Production from grapes
Immobilization of yeast cells
Study of Microbial contamination in food products
Analysis of food samples- Vegetables, Fruits, Fish and Meat
Milk analysis by MBRT
Isolation of Lactobacillus from curd
Mushroom cultivation
Enumeration and isolation of microorganism from water.
Microbial investigation of drinking water samples, total bacteria count, coliform test – MPN.
Estimation of BOD.
Study of common Plant pathogen – Citrus canker
Estimation of rhizosphere microbial population and calculation of R: S ratio.
Isolation of nitrogen fixing bacteria – Rhizobium

References

1. Experiments in Microbiology, Plant Pathology and Biotechnology by K.R. Aneja
2. Practical Microbiology – R.C Dubey, D.K Maheshwari, S Chand and Company, New Delhi.
3. Microbiology Laboratory Manual – Cappuccino, Sherman, Pearson Education
4. Manual of Microbiology Kanika Sharma Ane Books Pvt. Ltd.
5. Experiments in Microbiology, Plant Pathology and Biotechnology by K.R. Aneja

FIFTH SEMESTER

Core Course 13: MB5CRT13 Medical Bacteriology- I

Total hours of instruction: 72 Hours/week: 4 Credit: 4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No	Rubric level
CO1	To understand the systematic identification of bacteria using morphology, cultural Characteristics and biochemical reactions.	U	PO1	3
			PO10	2
CO2	To explain the pathogenesis, laboratory diagnosis and treatment of medically important Gram-positive and Gram-negative cocci	A	PO1	3
			PO2	3
			PO10	2
CO3	To explain the pathogenesis, laboratory diagnosis and treatment of medically important Gram-positive bacilli	A	PO1	3
			PO2	3
			PO10	2
CO4	To explain the pathogenesis, laboratory diagnosis and treatment of medically important Gram-negative bacilli	A	PO1	3
			PO2	3
			PO10	2
CO5	To explain the pathogenesis, laboratory diagnosis and treatment of medically important Acid - fast bacteria		PO1	3
			PO2	3
			PO10	2
<i>*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)</i>				

RUBRICS

MAPPING STRENGTH	RUBRICS LEVEL
>70%	3
40 -69%	2

10-39%	1
<10 %	0

COURSE CONTENT Content for Classroom transaction (Units)

Module	Units	Course description	Hrs	CO No.
1	1.1	Identification of Bacteria Systematic study of Bacteria Morphology, Colony characteristics	3	1
	1.2	Biochemical reactions Carbohydrate fermentations, IMViC, TSI, H ₂ S production, Urease, Nitrate reduction, Catalase and Oxidase	7	
2	2.1	Detailed study of Morphology, Cultural characteristics, Biochemical reactions, Epidemiology, Pathogenesis, Laboratory diagnosis, Prophylaxis and Treatment of GRAM-POSITIVE COCCI <i>Staphylococcus aureus, Streptococcus pyogenes, Pneumococcus</i>	10	2
	2.2	GRAM-NEGATIVE COCCI <i>Neisseria meningitides, N.gonorrhoeae</i>	5	
3	2.3	GRAM POSITIVE BACILLI <i>Corynebacterium sp.</i>	4	3

	2.4	<i>Bacillus anthracis, B.cereus.</i>	4	
	2.5	<i>Clostridium perfringens, Clostridium tetani, Clostridium botulinum.</i>	7	
4	3.1	GRAM NEGATIVE BACILLI - Enterobacteriaceae I <i>Coliforms – Escherichia coli, Klebsiella, Proteus mirabilis,</i>	6	4
	3.2	Enterobacteriaceae II - <i>Shigella dysentriae</i> Enterobacteriaceae III - <i>Salmonella typhi & Salmonella paratyphi.</i>	7	
	3.3	<i>Vibrio cholerae,</i> <i>Pseudomonas.</i>	7	
4	4.1	<i>Mycobacterium tuberculosis,</i>		
	4.2	<i>Mycobacterium leprae</i>		

References

1. Mackie and Mc Carteny Practical Medical Microbiology – 13th Edition, Churchill Livingstone.
2. Ronald M. Atlas (1989) Microbiology, Fundamentals and Applications. II edition. Maxwell Macmillan International editions.
3. David Greenwood, Richard C.B. Stack and John Forrest Peutherer (1992). Medical Microbiology. 14th edition. ELBS with Churchill Livingstone.
4. Ananthanarayan and Paniker's Textbook of Microbiology R. Ananthanarayan, C.K. Jayaram Panikar

Core Course 14: MB5CRT14 Medical Mycology

Total hours of instruction: 72

Hours/week: 4

Credit: 4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	CO No	Rubric level
MODULE 1				
1	To understand the general characteristics, cell structure, growth and nutrition of yeast and mould, staining methods,	U	CO1	
MODULE 2				
1	To understand the reproduction in yeast and mould, fungal classification,	U	CO2	
2	To understand the mode of action and uses of antifungal agents.	U	CO3	
MODULE 3				
1	To understand in detail the etiological agents, clinical manifestations, laboratory diagnosis, and treatment of superficial mycoses and Sub cutaneous mycoses	U	CO4	
<i>*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)</i>				

COURSE CONTENT

Content for Classroom transactions (Units)

MODULE	UNITS		CO
1	1.1	Introduction to mycology. General characteristics of fungi – yeast and mould, Cell structure, vegetative structure (yeast and mould). Growth and nutrition in fungi. (yeast and mould)	CO1
	1.2	Reproduction in fungi – asexual and sexual (yeast and mould). Classification of fungi principles and approaches.	CO2
2.	2.1	Isolation and identification of fungi. Cultivation of fungi – culture media and cultural characters.	CO2
	2.2	Routine mycological techniques- Germ tube test, hair perforation test, hair bait technique, slide culture technique, LPCB mount.	
	2.3	Staining methods used in mycology- wet mount and differential stain.	
	2.4	Antifungal agents – mechanism of action and uses.	C03
3	3.1	Fungal diseases Fungal Diseases: Causative Fungi, Clinical Manifestations, Laboratory Diagnosis and treatment of following diseases-Superficial mycoses. Pityriasis versicolor, Dermatophytoses, Piedra.	CO4

	3.2	Subcutaneous mycoses – Mycetoma, Rhinosporidiosis, Phycomycosis, Sporotrichosis.	CO4
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References

1. Text book of Medical Mycology - Jagdish Chander, Interprint, New Delhi.
2. Mycology and Virology – Topley and Wilson. Volume 4
3. Medical Mycology by Rippon .W B Saunders. Co
4. Manual of Clinical Mycology by Conant, Smith, Baker, Callaway & Mertics

Core Course 15: MB5CRT15 Medical Parasitology

Total hours of instruction: 54

Hours/week: 3

Credit: 3

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No	Rubric level
CO 1	Understand general concepts of parasitology	U	P01 P09 P010	2 2 2
CO 2	Explain Pathogenic mechanisms, disease transmissions, their life cycles and Lab Diagnosis of the mentioned protozoans	A	P01 P02 PO6 P010	2 2 3 3

CO 3	Point out the classification, life cycle, Transmission, pathogenicity and Lab diagnosis of mentioned helminths.	An	P01	2
			P02	
			PO6	2
			P010	3
				3

4	Identify the laboratory techniques in parasitology	A	PO1	2
			PO2	
			PO6	3
			PO10	2
				3
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)				

COURSE CONTENT

Content for Classroom transactions (Units)

MoUdule	Course description	Hrs	CO No.
1.	Title: General concepts in parasitology		
	General Concepts – Introduction to Parasitology, Classification – Host parasite relationship. Laboratory techniques in parasitology-Blood –Thick and thin smear, Faeces –Examination for ova and cyst.	8	C01
2	Title: Clinical characterisation of protozoans		

	Protozoology: Pathogenic mechanisms, Disease transmissions, their life cycles and Lab Diagnosis of the following- <i>Entamoeba histolytica, Plasmodium vivax, Plasmodium falciparum, Leishmania donovani, Giardia lamblia, Trichomonas vaginalis, Balantidium coli, Toxoplasma gondii</i> and <i>Cryptosporidium parvum</i> .	22	CO2
3	Title: Clinical Characterisation of Helminths		
	Helminthology: Classification, Cestodes – <i>Taenia solium, T. saginata, T. echinococcus</i> , trematodes – <i>Schistosoma haematobium, Fasciola hepatica</i> , Nematodes – <i>Ascaris, Anchylostoma, Trichuris, Enterobius</i> and <i>Wuchereria</i> - their life cycle , Transmission, pathogenicity and Lab Diagnosis.	20	CO 3

References

1. Text Book of Medical Parasitology by P. Chakraborty
2. Text Book of Parasitology By Jayaram Panicker
3. Text Book of Medical Parasitology by Parija S.C.
4. Parasitology by K.D. Chatterjee

Core Course 16: MB5CRT16 -Environmental Microbiology and Human Rights

Total hours of instruction: 72

Hours/week: 4

Credit: 4

CO No.	Expected Course Outcome	Learning Domains *
CO1	To understand the Multidisciplinary nature of environmental studies and natural resources	U
CO2	To distinguish Natural Resources: Renewable and non-renewable resources	U

CO3	To describe Forest resources	U
CO4	To explain Water Resources	U
CO5	To explain Mineral Resources	U
CO6	To explain Food Resources	U
CO7	To explain Energy Resources	U
CO8	To explain Land Resources	U
CO9	To generalise the role of individuals in the conservation of natural resources.	A
CO10	To evaluate the Equitable use of resources for sustainable lifestyles.	E
CO11	To recall the Concept, structure and functions of an Ecosystem	R
CO12	To explain the Forest Ecosystem	U
CO13	To understand Biodiversity and its conservation -	U
CO14	To analyse the Threats to biodiversity	An
CO15	To describe different types of environmental pollution – such as air, water, soil, noise, marine etc	R
CO16	To understand Solid Waste Management: Causes, effects and Control measures	U
CO17	To generalize the Role of an individual in pollution prevention, Pollution case studies, and Disaster management: floods, earthquakes, cyclones and landslides.	A

CO18	To explain Social Issues and the Environment related to energy and Water conservation, rainwater harvesting, watershed management Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and the holocaust, Case studies.	U
CO19	To understand Waste water management and sewage treatment.	U
CO20	To distinguish Bioremediation and strategies for bioremediation.	U
CO21	To explain Biostimulation and Bioaugmentation.	U
CO22	To explain the Bioremediation Of Soil	A
CO23	To understand Environmental mutagenesis and toxicity testing.	U
CO24	To give an outline of Human Rights, Meaning, concept and development, History	U
CO25	To Understand Human Rights and the United Nations	U
CO26	To determine Human Rights in the Indian Constitution	E

**Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

RUBRICS

MAPPING STRENGTH	RUBRICS LEVEL
>70%	3
40-69 %	2

10-39%	1
Below 10	0

COURSE CONTENT

Content for Classroom transactions (Units)

Module (Units)	Course description	Hrs	CO No.
1	Multidisciplinary nature of environmental studies and natural resources	12 Hours	CO 1
1.1	Definition, scope and importance. Need for public awareness.		CO 1
1.2	- Natural Resources: Renewable and non-renewable resources, Natural resources and associated problems.		CO 2

<p>1.3</p>	<p>Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.</p> <p>b. Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams -benefits and problems.</p> <p>c. Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.</p> <p>d. Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies.</p> <p>e. Energy resources: Growing energy needs, renewable and non-renewable energy sources, alternate energy sources, Case studies.</p> <p>f. Land resources: Land as a resource, land degradation, man-induced landslides, soil erosion and desertification</p>		<p>CO 3</p> <p>CO4</p> <p>CO5</p> <p>CO6</p> <p>CO7</p> <p>CO8</p>
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1.4	<ul style="list-style-type: none"> • Role of individual in the conservation of natural resources. • Equitable use of resources for sustainable lifestyles. 		<p>CO 9</p> <p>CO10</p>
1.5	- Ecosystems: Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumers and decomposers, Energy flow in the ecosystem, Ecological succession, Food chains, food webs and ecological pyramids.		CO11
1.6	- Forest ecosystem - Introduction, types, characteristic features, structure and function of the given ecosystem		CO12
2	Biodiversity and its conservation -	26 Hours	
2.1	Biodiversity and its conservation - Introduction, Biogeographical classification of India, Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values. India is a mega-diversity nation, and sports of biodiversity		CO 13
2.2	Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts, Endangered and endemic species of India		CO 14
2.3	Environmental Pollution Definition, Causes, effects and control measures of - Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards		CO 15

2.4	- Solid waste Management: Causes, effects and control measures of urban and industrial wastes.		CO 16
2.5	- Role of an individual in pollution prevention, Pollution case studies, Disaster management: floods, earthquakes, cyclones and landslides.		CO17
2.5	<p>Social Issues and the Environment</p> <ol style="list-style-type: none"> 1. Urban problems related to energy 2. Water conservation, rainwater harvesting, watershed management 3. Resettlement and rehabilitation of people: its problems and concerns, Case studies 4. Environmental ethics: Issues and possible solutions 5. Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust, Case studies 6. Consumerism and waste products 7. Environment Protection Ac 8. Air (Prevention and Control of Pollution) Act 9. Water (Prevention and Control of Pollution) Act 10. Wildlife Protection Act 11. Forest Conservation Act 12. Issues involved in the enforcement of environmental legislation 13. Public awareness 		CO18

3		10 Hours	
3.1	- Waste water management and sewage treatment.		CO 19
3.2	- Bioremediation and strategies for bioremediation. Phytoremediation Microbial degradation of petroleum and petroleum products, Pesticide degradation.		CO 20
3.3	Biostimulation and bioaugmentation.		CO 21
4	BIOREMEDIATION OF SOIL	10 Hours	
4.1	Bioremediation of contaminated soils and wastelands - solid waste - sources and management (composting, vermiculture and methane production),		CO 22
4.2	Environmental mutagenesis and toxicity testing.		CO 23
5	HUMAN RIGHTS	8 HOURS	
5.1	An Introduction to Human Rights, Meaning, concept and development, History of Human Rights, Different Generations of Human Rights, Universality of Human Rights, Basic International Human Rights Documents – UDHR, ICCPR, ICESCR – Value Dimensions of Human Rights		CO 24

5.2	Human Rights and United Nations – Human Rights Co-ordination within the U.N.System – Role of U.N Secretariat – The Economic & Social Council – The Commission of Human Rights – The Security Council & Human Rights – The Committee on the Elimination of Racial Discrimination – The Committee on the elimination of discrimination against women – The Committee on Economic, Social & Cultural Rights – The Human Right Committee, Critical Appraisal of U.N Human Rights Regime		CO 25
5.3	Human Rights – National Perspective – Human Rights in Indian Constitution – Fundamental Rights – The Constitutional Context of Human Rights – Directive Principles of State Policy & Human Rights – Human Rights of Women – Children – Minorities – Prisoners – Science Technology & Human Rights – National Human Rights Commission – State Human Rights Commission – Human Rights Awareness in Education		CO26

References

- Bharucha Erach, Text Book of Environmental Studies for undergraduate Courses. University Press, IInd Edition 2013 (TB)
- Clark.R.S., Marine Pollution, Clanderson Press Oxford (Ref)
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- Down to Earth, Centre for Science and Environment (Ref)
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- Odum.E.P 1971. Fundamentals of Ecology. W.B. Saunders Co. USA 574p (Ref)
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- Rajagopalan. R, Environmental Studies from crisis and cure, Oxford University Press, Published: 2016 (TB)
- Sharma B.K., 2001. Environmental Chemistry. Geol Publ. House, Meerut (Ref)
- Townsend C., Harper J, and Michael Begon, Essentials of Ecology, Blackwell Science (Ref)
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- Trivedi R. K. and P.K. Goel, Introduction to air pollution, Techno-Science Publication (Ref)
- Wanger K.D., 1998 Environmental Management. W.B. Saunders Co. Philadelphia, USA 499p
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- Shireesh Pal Singh, Human Rights Education in 21st Century, Discovery Publishing House Pvt. Ltd, New Delhi,
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- United Nations Development Programme, Human Development Report 2004: Cultural Liberty in Today's Diverse World, New Delhi: Oxford University Press, 2004.

SIXTH SEMESTER

Core Course 17: MB6CRT17 Medical Virology

Total hours of instruction: 72

Hours/week: 4

Credit: 4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No	Mapping score
CO1	Describe the basics of Virology	U	PO1	2
			PO2	3
			PO10	3
CO2	List out different types of Animal DNA viruses	An	PO1	1
			PO2	1
			PO6	2
			PO10	3

CO3	Analyse the different types of Animal RNA viruses:	An	PO1	1
			PO2	1
			PO6	2
			PO10	3
CO4	Apply the knowledge for the prevention of emerging and reemerging viral diseases	A	PO1	1
			PO2	1
			PO6	2
			PO10	3
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)				

Module	Units	Course description	Hrs	CO No.
1	1.1	General characters of viruses.	5	CO1
	1.2	Structure, classification- Baltimore, cultivation	5	CO1
	1.3	Structure and replication of bacteriophages.	5	CO1
	1.4	Replication of animal viruses.		
2		Characters and pathogenic significance of Viruses	8	CO2
	2.1	pox viruses, herpes viruses, picorna viruses &	7	CO2

	2.2	myxoviruses –Influenza, Mumps, Measles.		
3	3.1	Characters and pathogenic significance of arboviruses –Bunya virus, Togavirus, Flavivirus.	8	CO3
	3.2	Rhabdoviruses, hepatitis viruses, oncogenic viruses & HIV.	7	CO3
4		Diagnosis of viral infections. Immunoprophylaxis and chemoprophylaxis of viral infections	7	CO4

References

1. Ananthanarayan and Paniker's Textbook of Microbiology R. Ananthanarayan, C.K. Jayaram Panikar
2. Belshe RB Textbook of Human Virology St. Louis: Mosby Year Book.
3. Dimock & Primrose Introduction to modern virology Oxford: Blackwell
4. White & Fenner Medical Virology New York : Academic Press
5. Collier & Oxford Human Virology London Oxford University Press
6. Fields et al Virology Philadelphia: Lippincott – Raven
7. Zuckerman Clinical Virology Chichester : JohnWiley.
8. Topley & Wilson.Principles of Bacteriology, Virology and Immunity, VIII edition, Vol.III Bacterial Diseases, Edward Arnold, London.

Core Course 18: MB6 CRT18 Diagnostic Microbiology

Total hours of instruction: 72

Hours/week: 4

Credit: 4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PSO No	Rubrics
CO1	To Apply the microbiology laboratory safety mechanisms.	A	PO 2 PO6 PO8 PO10	2 3 2 1
CO2	To choose the appropriate methods of specimen, collection, transport and processing.	A	PO2 PO6 PO9 PO10	3 2 1 1
CO3	To apply techniques in diagnostic microbiology.	A	PO2 PO10	3 1
CO4	To demonstrate the pathogenicity and antibiotic sensitivity of microorganisms and animal inoculation studies	A	PO4 PO10	3 3
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)				

COURSE CONTENT**Content for Classroom transactions (Units)**

Module	Course description	Hrs	CO No.
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1.1	Laboratory associated infections. Disinfection and decontamination of laboratory wastes.		CO1
1.2	Biological safety cabinets, bio-safety levels, and classification of biological agents based on hazards.	3	CO1
1.3	Laboratory-associated infections, Nosocomial infections.	3	CO1
2	<p>Collection, Transport and Examination of specimens.</p> <p>Scheme for the microbiological examination of sputum, throat and mouth specimens, wound aspirates, CSF, blood and bone marrow.</p> <p>Scheme for the Microbiological examination of stool specimens, urine, urogenital specimens, skin specimens.</p>	10	CO 2
3.1	<p>Techniques in Diagnostics. Serological diagnosis: Applications of serological techniques such as agglutination reactions-Widal (typhoid fever), precipitation reactions RPR (syphilis), complement fixation tests, and enzyme immunoassay for the diagnosis of Bacterial viral and immunological diseases.</p>	10	CO 3
3.2	<p>Molecular techniques in Microbiology- principles and applications Hybridisation, PCR, RFLP.</p>		

4.1	Antibiotic sensitivity tests. Disc diffusion and dilution methods, Determination of MIC and MBC.		CO4
4.2	Animal inoculation in clinical studies. Egg inoculation.		

Unit I

References

1. Medical Laboratory Manual For Tropical Countries Vol. II Microbiology. Monica Cheesbrough ELBS
2. Bailely & Scott □ Diagnostic Micribiology. E.J. Baron, L.R. Peterson and S.M. Finegold. Mosby

References

1. Medical Laboratory Manual For Tropical Countries Vol. II Microbiology. Monica Cheesbrough ELBS
2. Ananthanarayanan and Paniker Textbook of Microbiology Orient Longman
3. Mackie& McCartney Practical Medical Microbiology J.G.Collee, A.G.Fraser,B.P.Marmion and A.Simmons (Eds.) Churchill Livingstone
- 4.Manual of Clinical Microbiology P.R. Murray,E.J.Baron, J.H.Joorgenson M.A.Pfaller and Yolken R.H. ASM Press Washington DC

Core Course 19: MB6CRT19 Medical Bacteriology II

Total hours of instruction: 36

Hours/week: 2

Credit: 2

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PSO No	Rubrics
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CO1	Distinguish Gram-negative, non-sporing, coccobacilli	An	PO1 PO2 PO10	3 3 3
CO2	Identify the organisms such as Spirochetes	An	PO1 PO2 PO10	3 3 3
CO3	Differentiate the obligate intracellular, gram-negative, nonmotile bacteria	An	PO1 PO2 PO10	3 3 3
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)				

COURSE CONTENT

Content for Classroom transactions (Units)

Module	Course description	Hrs	CO No.
1	Detailed study of Morphology, Cultural characteristics, Biochemical, Pathogenicity, Epidemiology, laboratory diagnosis, prophylaxis and treatment of the following bacteria		
1.1	Haemophilus	8hrs	CO2
1.2	Bordetella	5hrs	CO2
1.3	Brucella	4hrs	CO2
1.4	Yersinia		

2	Detailed study of Morphology, Cultural characteristics, Biochemical, Pathogenicity, Epidemiology, laboratory diagnosis, prophylaxis and treatment of the following bacteria		
2.1	Spirochetes-Treponema	4hrs	CO1
2.2	Leptospira	3hrs	CO1
2.3	Mycoplasma pneumoniae	1hr	CO1
3	Detailed study of Morphology, Cultural characteristics, Biochemical, Pathogenicity, Epidemiology, laboratory diagnosis, prophylaxis and treatment of the following bacteria		
3.1	Rickettsiaceae- Genus Rickettsia	4hrs	CO3
3.2	<i>Chlamydiae pneumonia</i> and <i>C. trachomatis</i>	4hrs	CO3

References

1. Ananthanarayan and Paniker's Textbook of Microbiology R. Ananthanarayan, C.K. Jayaram Panikar
2. Mackie and Mc Carteny Practical Medical Microbiology – 13th Edition, Churchill Livingstone.
3. Ronald M. Atlas (1989). Microbiology, Fundamentals and Applications. II edition. Maxwell Macmillan International editions.
4. David Greenwood, Richard C.B. Stack and John Forrest Peutherer. (1992). Medical Microbiology. 14th edition. ELBS with Churchill Livingstone.
5. Topley / Wilson's (1990). Principles of Bacteriology, Virology and Immunity, VIII edition, Vol. III Bacterial Diseases, Edward Arnold, London.

Core Course 20: MB6CRP20 Microbiology Practical - III

Total hours of instruction: 216 Hours/week: 6 Credit: 4
(108 in Semester V and 108 in Semester VI)

General procedure for the systematic study of Bacteria – Morphology, Staining, Colony Characteristics on BA, MA, other selective Media.

Biochemical reactions of Bacteria: Sugar Fermentation, IMVIC, H₂S production, urease, Catalase, Oxidase, TSI

Identification of Bacteria- *Staphylococcus*, *E. coli*, *Klebsiella*, *Pseudomonas*, *Proteus*

Antimicrobial activity – Disc diffusion

Cultivation of Fungi- Study of colony characters of yeasts and Molds.

Microscopic morphology of molds- *Pencillium*, *Aspergillus*, *Mucor*, *Rhizopus*, *Fusarium* by Lactophenol cotton blue mount examination.

Gram staining of yeast.

Examination of Germ tube – *Candida albicans*

Egg inoculation demonstration

Reference

1. Medical Microbiology by Robert Cruickshank
2. Bailey & Scott's Diagnostic Microbiology
3. Practical Medical Microbiology-Mackie & Mc Cartney
4. Microbiology Laboratory Manual – Cappuccino Sherman
5. Text book of Microbiology – Ananthanarayanan and Jayaram – Orient Longman
6. Text book of Medical Mycology – Jagadish Chander . Interprint
7. Manual for identification of Medical Bacteria by. S.T. Cowan 51

Field study: (Internal only)

- Visit to a local area to document environmental grassland/ hill /mountain
- Visit a local polluted site – Urban/Rural/Industrial/Agricultural Study of common plants, insects, birds etc
- Study of simple ecosystem-pond, river, hill slopes, etc

**Choice Based Open Course Offered to
Students of Other Departments (5th Semester)**

Open course III: MB5OPT03- Ecology and Evolution

Total hours of instruction: 72 Hours/week: 4 Credit: 3

Unit I

Ecology –Definition and Principle, Ecosystem, Biomes-Major Terrestrial Biomes

References

1. Geographical realms Fundamentals of ecology-Odum
2. Modern concepts in ecology-Kumar.H.D
3. Ecology and environment-Sharma P.D
4. Ecology principles and application-Chapman and Reiss
5. Environmental biology-Jobes A.M
6. Essential Environmental Studies S.P. Misra, S.N. Pande Ane Books Pvt. Ltd.
7. Environmental Science V.K. Ahluwalia, Sunita Malhotra Ane Books Pvt. Ltd.

Unit II

Common rhythms in nature-diurnal rhythm, Circadian rhythm, Lunar rhythm. Photoperiodism, Hibernation, Aestivation, Pheromones

References

1. Geographical realms Fundamentals of ecology-Odum
2. Modern concepts in ecology-Kumar.H.D
3. Ecology and environment-Sharma P.D
4. Ecology principles and application-Chapman and Reiss
5. Environmental biology-Jobes A.M
6. Essential Environmental Studies S.P. Misra, S.N. Pande Ane Books Pvt. Ltd.
7. Environmental Science V.K. Ahluwalia, Sunita Malhotra Ane Books Pvt. Ltd.

Unit III

Food chain—Food web, Ecological pyramids, Biogeochemical Cycles-Carbon, Nitrogen, Phosphorous

References

1. Geographical realms Fundamentals of ecology-Odum
2. Modern concepts in ecology-Kumar.H.D
3. Ecology and environment-Sharma P.D
4. Ecology principles and application-Chapman and Reiss
5. Environmental biology-Jobes A.M
6. Essential Environmental Studies S.P. Misra, S.N. Pande Ane Books Pvt. Ltd.
7. Environmental Science V.K. Ahluwalia, Sunita Malhotra Ane Books Pvt. Ltd.

Unit IV

Origin of Life –Lamarckism, Darwinism, Evidences of Evolution

References

1. Geographical realms Fundamentals of ecology-Odum
2. Modern concepts in ecology-Kumar.H.D
3. Ecology and environment-Sharma P.D
4. Ecology principles and application-Chapman and Reiss
5. Environmental biology-Jobes A.M
6. Essential Environmental Studies S.P. Misra, S.N. Pande Ane Books Pvt. Ltd.
7. Environmental Science V.K. Ahluwalia, Sunita Malhotra Ane Books Pvt. Ltd.

Choice based course II: MB6CBT02 Sanitation Microbiology

Total hours of instruction: 72 Hours/week: 4 Credit: 3

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No	RUBRIC S level
MODULE 1				
1	To remember concepts of sanitation and disinfection. General concept of sanitation and disinfection .Sanitation of industrial and food processing units Safe location of animal houses, hospitals, industrial fermentation units etc. Biosafety Biosafety in hospitals and laboratories. Regulations and measures	R	PO1 PO2 PO6 PO10	3 3 3 3
			PO1	3

2	To understand sanitation and safety precautions in industrial, food processing, animal housing, hospitals and laboratories	U	PO 2 PO 6 PO10	3 3 3
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MODULE 2- Airborne diseases and preventive measures. Methods of sampling air. Quantification of air microflora Air sanitation – techniques and applications Biological weapons, their regulation and precaution

3	To analyse methods of air sampling and quantification of air microflora	An	PO1 PO2 PO6 PO10	3 3 3 3
4	To understand airborne diseases, preventive measures and air sanitation techniques	U	PO1 PO2 PO6 PO10	3 3 3 3

MODULE 3- Microbiology of municipal sewage and sewage treatment. BOD and COD Concept. Treatment of Industrial effluent- Waste water treatment-Mechanical and biological. Aerobic and anaerobic treatments. Domestic septic tank. Treatment of municipal water supplies. Water borne diseases.

5	To explain the microbiology of sewage treatment and wastewater treatment	U	PO1 PO 2 PO 4 PO6	3 3 3 3
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			PO10	3
6	To understand waterborne diseases and preventive measures	U	PO1 PO2 PO6 PO10	3 3 3 3
MODULE 4 - Solid waste disposal-sanitary land fills, composting, vermicompost. Disposal of animal and agricultural waste. Methanogenesis and biogas production				
7	To implement solid waste disposal, sanitary landfill, composting, methanogenesis and biogas production	A	PO1 PO2 PO4 PO6 PO10	3 3 3 3 3
<i>*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)</i>				

COURSE CONTENT

Content for Classroom transactions (Units)

Module	Units	Course description	Hrs	CO No.
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1	<p>General concept of sanitation and disinfection.</p> <p>Sanitation and Safety precautions in animal houses, industrial fermentation units, food processing units, hospitals and laboratories.</p>	1 5	C O 1 C O 2
2	<p>Aeromicrobiology</p> <p>Airborne diseases(common cold Influenza, Chickenpox, Mumps, Measles, Whooping cough (pertussis), Tuberculosis (TB), Diphtheria, Covid 19) and preventive measures.</p> <p>Methods of sampling air- I. settling under gravity,</p> <p>2. centrifugal action, 3. filtration</p> <p>4. impingement and</p> <p>5: electrostatic forces.</p> <p>Air sanitation – techniques and applications.</p>	1 5	C O 3 C O 4 C O 5

3	<p>Water microbiology</p> <p>Microbiology of municipal sewage and sewage treatment.</p> <p>Detailed study of Wastewater treatment-Preliminary, Primary, Secondary and Tertiary treatments with special reference to aerobic and anaerobic methods.</p> <p>Waterborne diseases (Cholera, diarrhoea, Hepatitis A, Typhoid, Polio, Leptospirosis, Cryptosporidiasis, Otitis media)and preventive measures.</p>	1 5	C O 6 C O 7
4	<p>Solid waste disposal-sanitary landfills, composting – types of composting, vermicompost.</p> <p>Disposal of animal and agricultural waste.</p> <p>Methanogenesis and biogas production</p>	1 5	C O 8

References

1. Fundamentals of bacteriology-A.J.Salle
2. Microbiology-Prescott,M.J;harley,j.p.and klein,D.A
3. Biology of microorganisms-T.D.Brock
4. Environmental aspects of microbiology-Joseph C. Danie
5. Microbiology essentials and applications-Larry Mckane and Judy Kandel
6. Environmental Microbiology Vijay Ramesh
7. Industrial microbiology-Casida,L.E

