DEPARTMENT OF MICROBIOLOGY

M.Sc. DEGREE (SEMESTER) COURSE UNDER CBCS SCHEME

SCHEME OF TEACHING AND EXAMINATION

(**Effective from the academic year 2023-24 and onwards**)

PAPER	**Teaching**	**Examination**			**Credits**
	Hours/week	**Hours**	**Marks**	**IA**	
4.1 HC Fermentation Technology and Bioprocess Engineering	4	3	75	25	4
4.2 HC Medical Microbiology and Diagnostics	4	3	75	25	4
4.3 HC Industrial Internship/Project – Dissertation	4	3	75	25	4
4.4 SC Agricultural Microbiology	4	3	75	25	4
4.5 Practical Based on paper 4.1	4	3	35	35	2
4.6 Practical Based on paper 4.2	4	3	35	35	2
4.7 Project colloquium and Viva	4	3	35	35	2
4.8 Practical Based on paper 4.4	4	3	35	35	2

HC – Hard core, SC – Soft core, OE – Open Elective

Department: **Microbiology** Course: **M.Sc Microbiology**

MICHCT4.1	Fermentation Technology and Bioprocess Engineering	4	4	3	25	75	100
MICHCT4.2	Medical Microbiology and Diagnostics	4	4	3	25	75	100
	Internship/Project – Dissertation	4	4	3	25	75	100
MICSCT4.1	Agricultural Microbiology	4	4	3	25	75	100
	Practical Based on paper 4.1	2	4	3	15	35	50
	Practical Based on paper 4.2	2	4	3	15	35	50
	Project colloquium and Viva	2	4	3	15	35	50
	Practical Based on paper 4.4	2	4	3	15	35	50

Paper-4.1 HC: Fermentation Technology and Bioprocess Engineering

1.	Fermentation: Origin, concept and historical development of fermentation. Types of Fermentations- Surface, Submerged, Solid -State, Batch, Continuous, Dual and Fed batch fermentations Industrially important Microorganisms: Isolation, Screening of metabolites (Primary and Secondary metabolites) and Preservation. Strain development- Mutation, Recombination and Protoplast fusion technique. Inoculum development for industrial fermentation. Media for industrial fermentations: Criteria, Media formulation, Media ingredients - Water, Carbon sources, Nitrogen sources, Minerals and Vitamin sources. Buffers, Precursors and Growth factors. Oxygen requirement, Chelaters and Antifoaming agents. Nutrients recycling.	**12 h**
2.	Fermentor: Construction and Design of a typical fermentor. Parts and functions of a fermentor. Manual and automatic control systems. Types of fermentors- Tower, Jet, Loop, Airlift, Bubble, Column, Packed bed, Fluidized bed. Sterilization of media and fermentors - Design of sterilization process for batch and continuous fermentation. Sterilization of Fermentor and Media, Air and Exhaust air. Filter sterilization. Kinetics of microbial growth: Phases of cell growth in batch culture. Simple unstructured kinetic models for microbial growth-Monod model. Growth of filamentous organisms. Growth associated (primary) and non - growth associated (secondary) product formation Kinetics.	**12 h**
3.	Bioprocess Engineering: Origin, Concept and Principles of Bioprocess Engineering. Basic components of bioprocess engineering. Upstream bioprocess: Major process variables. Optimization of process variables. Strategies for the enhanced production - Immobilization and Response surface methodology. Downstream bioprocess: Filtration-Micro, Cross-flow and Ultra. Centrifugation-High speed, Continuous and Ultra. Cell disruption. Precipitation, Coagulation and Flocculation. Solvent /Aqueous 2-phase extractions, Dialysis and Electro-dialysis. Reverse osmosis. SDS-PAGE, Ion Exchange chromatography and HPLC. Gel Filtration. Drying. Crystallization.	**16 h**
4.	Production and purification of microbial products: Enzymes-(Amylase, Proteases), Organic acids (Lactic acid, Citric acid and Vinegar), Amino acids (L-lysine and L-glutamic acid), Antibiotics (Penicillin and Streptomycin), Solvents-(Ethyl alcohol, Acetone- and butanol) Alcoholic beverages-(Beer, Wine, Brandy and Rum). Vitamins B12, Antitumours and Anticholesterol agent. An overview of bioenergy.	**12 h**
5.	Single cell protein and Single cell oil – Concept, production and uses. Intellectual property rights and patents	**8 h**

After successful completion of this course students are expected to be able to:

CO-1: Understand the origin and historical development of fermentation and its various types such as surface, submerged, solid-state, batch, continuous, dual and fed-batch fermentations.

CO-2: Identify and isolate industrially important microorganisms.

CO-3: Formulate media for industrial fermentations.

CO-4: Understand the construction and design of a typical fermentor.

CO-5: Design a sterilization process for batch and continuous fermentation.

CO-6: Understand the origin, concept and principles of bioprocess engineering along with its basic components.Understand downstream bioprocesses such as filtration (micro, cross-flow and ultra), centrifugation (high speed, continuous and ultra), cell disruption.

CO-7: Understand the concepts of microbial production and purification of various products such as enzymes (amylase, proteases), organic acids (lactic acid, citric acid, and vinegar), amino acids (L-lysine and L-glutamic acid), antibiotics (penicillin and streptomycin), solvents (ethyl alcohol, acetone, and butanol), alcoholic beverages (beer, wine, brandy, and rum).

CO-8: Understand the concept of intellectual property rights and patents. They will learn about the different types of patents, patent filing procedures, patent infringement, and patent litigation.

Reference Books:

1. Cinar, A., Parulekar, S. J., & et al. (2014). Batch Fermentation: Modeling, Monitoring, and Control (3rd ed.). CRC Press.
2. Arnold, D., & Davies, J. E. (2019). Atlas of Industrial Microbiology & Biotechnology (2nd ed.). Taylor & Francis.
3. Crueger, W., &Crueger, A. (2019). Biotechnology: A Text Book of Industrial Microbiology (3rd ed.). Science Publishers.
4. Casida, L. E. (2015). Industrial Microbiology (2nd ed.). Wiley-Blackwell.
5. Demain, A. L., &Adrio, J. L. (2019). Biology of Industrial Microorganisms (3rd ed.). CRC Press.
6. DiLallo, R., &DiLallo, M. (2017). Methods in Food and Dairy Microbiology (2nd ed.). CRC Press.
7. Reisman, H. B. (1988). Economic Analysis of Fermentation Processes (1st ed.). CRC Press.
8. Vogel, A., & Todaro, L. C. (2007). Fermented and Biochemical Engineering Handbook (3rd ed.). Noyes Publications.
9. Harvey, W., Blanch, S., & Clark, D. S. (2019). Biochemical Engineering (2nd ed.). CRC Press.

Practical Based on paper 4.1 Fermentation Technology and Bioprocess Engineering

1. Study of Fermentor and Bioreactor
2. Production Curd, Yoghurt, Paneer, Acidophilus milk, Tempeh and Sauerkraut.
3. Study of alcohol fermentation – alcohol production from different substrates, Lab production of Wine, Estimation of percentage of Alcohol, Total acidity and volatile acidity in wine
4. Estimation of Alcohol by Potassium dichromate method
5. Production and analysis of SCP from *Spirulina and Yeast*
6. Product ion of Citric acid by *Aspergillusniger, Pencilliumcitrannum* and its estimation
7. Production of Pectinase from *Aspergillusniger* by using Wheat bran, Coffee pulp using small scale fermentor and its assay
8. Production of α- Amylase using *Aspergillusoryzae*, *Bacillus licheniformis* using Wheat bran in small scale solid state fermentation and its assay
9. Immobilization of yeast cells by calcium alginate gel entrapment and assay for enzymes Invertase and Catalase
10. Preparation of immobilized cells of *Bacillus licheniformis* for the use in the production of α-amylase
11. Extraction and estimation of vitamins- Thiamine/ Niacin/ Riboflavin/ Vitamin C
12. Mandatory visit to Research Institutes / Industries

Paper-4.2 HC: Medical Microbiology and Diagnostics

1	Introduction: Historical developments - Major milestones and significant contributions. Human Anatomy and physiology: An overview of human anatomy and physiology. Important terms/concepts of human anatomy and physiology with special reference to microbial infections. Diseases caused by microorganisms: Concept and illustrations; Communicable diseases; normal flora of human body; opportunistic pathogens. Fungal diseases: Types of diseases - superficial and deep mycosis; Causative agents; Diagnosis and Treatment of diseases. Protozoan diseases: Causative agents, symptoms, diagnosis and treatment of Amoebiasis, Giardiasis, Filariasis, Leishmaniasis, Toxoplasmosis and Malaria.	**12 h**
2.	Microbial pathogenicity and pathogenesis: Attributes of pathogenicity and pathogenesis. Mechanism of disease process and prognosis. Host and microbial factors influencing susceptibility. Microbial infections: Concept and types of microbial infections; Modes of transmission of pathogens, Portal of entry and exit; Types of infections; Nosocomial infections. Chemotherapy: Antimicrobial agents and antibiotics; Classification of antibiotics based on chemical structure, mode of action and range of effectiveness; Drug resistance - recent trends and its consequences; Antibiogram and Antibiotic policy; NCCLS (CLSI) guidelines and standards; WHO Guidelines.	**12 h**
3.	Systematic study of important pathogenic bacteria with reference to etiology, symptoms, diagnosis, treatment and epidemiology; Enterobacteriaceae (Salmonella, Shigella, *E.coli*, *Klebsiella*); *Mycobacterium tuberculosis*, *M.leprae*, Staphylococci, Streptococci, *Vibriocholerae*, *Brucella pertusis*, *Clostridium welchi*, *C. tetani* and *Treponema pallidum*	**12 h**
4.	Etiology, epidemiology, symptoms, diagnosis and treatment of diseases caused by Chlamydia, Mycoplasma and Rickettsia. Pathogenicity, symptoms, diagnosis, treatment and preventive measures of viral diseases caused by important viruses - Pox, Herpes, Adeno, PapovoPicarno, myxo, retro, arbo, hepatitis, Rabies, SARS, Chikungunya, Ebola and H_1N_1 viruses.	**12 h**

5.	Advances in Molecular Diagnosis of infections: RT-PCR (HCV, Corona, Mycobacteria), RAT (Rapid Antigen Test), TrueNat (TB and Covid-19), Feluda test Based on CRISPR (Clustered Regularly Interspaced Short Palindromic), Cartridge Based Nucleic Acid Amplification Test (CBNAAT), for TB, MDR-TB. Diagnostics: Collection and transport of clinical samples; Processing of clinical samples for direct and indirect diagnostics tests. Conventional, Serological and Molecular methods and techniques for the diagnosis of Urinary tract infections, Sexually transmitted diseases, Acute diarrheal and gastrointestinal infections, Cholera, Dysentery, Tuberculosis, Leprosy, Pyogenic infections, Dental caries and Central nervous system infections.	**12 h**

After successful completion of this course students are expected to be able to:

CO-1: Demonstrate advanced knowledge and understanding of the nature of pathogenic microorganisms (predominantly viruses and bacteria).

CO-2: Explain the modes of transmission of pathogenic microorganisms.

CO-3: Demonstrate knowledge and understanding of the mechanisms of microbial pathogenesis and the outcomes of infections, including chronic microbial infections.

CO-4: Distinguish between and critically assess the classical and modern approaches to the development of therapeutic agents and vaccines for the prevention of human microbial diseases.

CO-5: Demonstrate knowledge of the laboratory diagnosis of microbial diseases and practical skills, including the isolation and characterization of specific microbes in clinical specimens.

Reference Books:

1. Topley, W. W. C., Wilson, G. S., & Collier, L. H. (1990). Principles of bacteriology, virology, and immunity (8th ed.). Edward Arnold.
2. Greenwood, D., Slack, R. C. B., &Peutherer, J. F. (2007). Medical microbiology: A guide to microbial infections: Pathogenesis, immunity, laboratory diagnosis and control (17th ed.). Churchill Livingstone/Elsevier.
3. Bhatia, R. R., & Kashyap, S. K. (2019). Essentials of medical microbiology (2nd ed.). Jaypee Brothers Medical Publishers.
4. Jawetz, E., Adelberg, E. A., & Brooks, G. F. (2019). Medical microbiology (28th ed.). McGraw-Hill Education.
5. Stokes, J., &Rideway, W. (2018). Clinical microbiology: A laboratory manual (3rd ed.). Wiley-Blackwell.
6. Forbes, B. A., Sahm, D. F., &Weissfeld, A. S. (2007). Bailey & Scott's diagnostic microbiology (12th ed.). Mosby/Elsevier.
7. Murray, P. R., Rosenthal, K. S., &Pfaller, M. A. (2015). Medical microbiology (8th ed.). Elsevier/Mosby.
8. Wilson, B., &Moffet, H. L. (2015). Clinical microbiology: An introduction for healthcare professionals (2nd ed.). Elsevier.

Digital References/ Study material:

https://archive.nptel.ac.in/course.html

https://archive.nptel.ac.in/courses/102/103/102103015/

https://onlinecourses.swayam2.ac.in/cec19_bt11/preview

Practical Based on paper 4.2 Medical Microbiology and Diagnostics

1. Preparation of culture media for the culture of different pathogenic microorganisms.
2. Anaerobic culture method for anaerobes of clinical importance.
3. Presumptive identification of pathogenic microorganisms using colony morphology on selective/differential/selective-differential/enrichment media.
4. Isolation and characterization of clinical significant species of *Staphylococcus, Streptococcus, Candida, Cryptococcus, Cornybacterium, Bacillus, Nocordia, Neisseria, Enterobacteriaceae, Vibrio, Pseudomonas, Aeromonas.*
5. Microscopic observation of important human pathogens.
6. Study of commensal microbial flora of human body (mouth/skin/hands/nose/ear).
7. Isolation, characterization and identification of bacterial pathogen from clinical specimen (Urine sample/Pus sample/Blood sample).
8. Demonstration of the diagnosis of HIV by Dot-ELISA (Viral infection).
9. Detection of malarial parasite from human blood sample (Parasitic infection).
10. Study of antibiotic sensitivity test by paper disc method.
11. Determination of MIC value for selected antibiotics by Kirby-Bauer method.
12. Lymphocyte viability test (Trypan blue exclusion test of cell viability)

Paper-4.4 SC: Agricultural Microbiology

1.	Introduction: Origin, Concept and Development of Agricultural Microbiology. Role of microorganisms in soil formation and soil fertility. Factors affecting soil microorganisms. Microbes and biogeochemical cycles - Nitrogen, Carbon, Sulfur and Phosphorous cycles. Plant - Microbe Interactions: Types - Mutualism, Commensalism, parasitism, amensalism and synergism. Concepts of Rhizosphere, Phyllosphere and Spermosphere. Rhizosphere effect and R/S ratio. Factors influencing rhizosphere microorganisms. Plant growth promoting rhizobacteria. Mycorrhizae.	**12 h**
2.	Biological nitrogen fixation: General chemistry, mechanism and genetics of biological nitrogen fixation. Nitrogen fixation by diazotrophs-Rhizobium, Azotobacter, Azospirillum, Frankia and Blue Green Algae. Phosphate solubilizing microorganisms and Mycorrhizae: Types of phosphate solubilizing microorganisms – Bacteria and Fungi, Mechanism of phosphate solubilization. Types, significance and role of mycorrhizae.	**12 h**
3.	Biofertilizers: Concept and types of microbial biofertilizers - Bacterial (Rhizobium, Azotobacter and Azospirillum), Fungal and Algal. Screening and selection of potential strains for biofertilizer. Production and quality control of biofertilizers. Phosphate solubilizing microbial biofertilizers. Methods of application and evaluation of biofertilizers.	**12 h**
	Green manure, Organic matter, Compost and Composting	
4.	Plant diseases: Etiology, pathogenesis, Symptoms and control measures of plant diseases. Bacterial diseases - Wilt and Citrus canker; Fungal diseases – Wilt, Downy mildew, Rust and Smuts); Viral diseases -Tobacco mosaic and Bunchy top of Banana; Mycoplasmal diseases - Grassy shoot of sugar cane and Coconut yellowing disease	**12 h**
	Biological control: Origin and concept. Various microorganisms as biocontrol agents. Isolation, screening, cultivation and mode of action of microbial biocontrol agents. Merits and demerits of biological control	
5.	Biopesticides: Origin and concept. Types, mass production and applications of microbial biopesticides. Bacterial - *Bacillus thuringiensis* and *Pseudomonas fluroscence*; Fungal - *Trichoderma viridae* and Coelomomyces; Viral - NPV and CPV. Integrated pest and plant diseases management Genetically modified crops: Origin and concept. Role and significance of microbial genes. Construction, evaluation and field application of BT cotton, FlavrSavr tomato and Golden Rice. Advantages and disadvantages of GM crop plants.	**12 h**

After successful completion of this course students are expected to be able to:

CO-1: Understand the origin, concept, and development of agricultural microbiology.

CO-2: Explain the role of microorganisms in soil formation and soil fertility. Identify the factors that affect soil microorganisms.

CO-3: Describe the Nitrogen, Carbon, Sulfur, and Phosphorous cycles and the role of microbes in these biogeochemical cycles.

CO-4: Explain the different types of plant-microbe interactions such as mutualism, commensalism, parasitism, amensalism, and synergism.

CO-5: Describe the general chemistry, mechanism, and genetics of biological nitrogen fixation. Explain nitrogen fixation by diazotrophs such as Rhizobium, Azotobacter, Azospirillum, Frankia, and Blue Green Algae.

CO-6: Describe the types of phosphate solubilizing microorganisms such as bacteria and fungi. Explain the mechanism of phosphate solubilization. Understand the types, significance, and role of mycorrhizae.

CO-7: Understand the concept and types of microbial biofertilizers. Understand production and quality control of biofertilizers. Describe phosphate solubilizing microbial biofertilizers. Understand methods of application and evaluation of biofertilizers.

CO-8: Understand etiology, pathogenesis, symptoms, and control measures of plant diseases such as bacterial diseases (Wilt and Citrus canker), fungal diseases (Wilt, Downy mildew, Rust, and Smuts), viral diseases.

Reference Books:

1. Subba Rao, N. S. (2019). Soil microbiology (5th ed.). Oxford & IBH.
2. Subba Rao, N. S. (2019). Biofertilizers in agriculture and forestry (3rd ed.). CBS Publishers & Distributors.
3. Subba Rao, N. S. (2019). Recent advances in biological nitrogen fixation (2nd ed.). Cambridge University Press.
4. Rangaswamy, G., &Bagyaraj, D. J. (2007). Agricultural microbiology (2nd ed.). Prentice-Hall of India.
5. Swaminathan, M. S. (2016). Biotechnology in agriculture (2nd ed.). McMillan.
6. Steinhaus, E. A. (1963). Insect pathology: An advanced treatise (Vol I & II). Academic Press.
7. Burges, H. D. (Ed.). (1981). Microbial control of pests and plant diseases 1970-1980 (Vol 1-2). Academic Press.
8. Agrios, G. N. (2005). Plant pathology (5th ed.). Elsevier Academic Press.
9. Atlas, R., & Bartha, R. (1998). Microbial ecology: Fundamentals and applications (4th ed.). Benjamin/Cummings Science Publisher.

Digital References/ Study material:

https://onlinecourses.swayam2.ac.in/cec23_ag03/preview

https://archive.nptel.ac.in/courses/102/103/102103015/

https://onlinecourses.swayam2.ac.in/cec19_bt11/preview

Practical Based on paper 4.3 Agricultural Microbiology

1. Isolation and study of Rhizosphere, Spermosphere and phyllosphere microorganisms.
2. Isolation, enumeration and characterization of nitrogen fixing bacteria.
3. Measurement of nitrogen fixation – the tube culture, Leonard Jar and Pot culture methods.
4. Isolation, enumeration and characterization of phosphate solubilizing bacteria and fungi.
5. Assessment of Vesicular Arbuscular mycorrhiza association with plants and isolation spores.
6. Observation of wet mount of NPV.
7. Isolation of Cellulose, Hemicellulose, Starch, Lignin, Pectin degrading microorganisms.
8. Demonstration of Biogas production using different substrates like cattle dung, water hyacinth, sewage.
9. Organic matter decomposition - CO_2 evolution.
10. Evaluation of seed germination and vigor - Grow on test.
11. Quantitative skills for biotic and abiotic disease stress evaluation and data analysis.
12. Laboratory scale production of bacterial and fungal biofertilizers.