Semester	**VI**
Course	**Major-3**
Paper Title	**BIOPROCESS TECHNOLOGY + INDUSTRIAL VISIT**
Paper Code	
No of Credits	**4**
Theory /Practical /Composite	**Full Theory**
Minimum No. of preparatory hours per week a student has to devote	**4**
Number of Modules	**2**
Syllabus	**MODULE A [35 Marks]** **(2 classes per week)** **UNIT I: Introduction to Bioprocess Technology:** Introduction to bioprocess technology; industrial fermentation; concept of high-yielding strain; important producer microorganisms; range of bioprocess technology and its chronological development; components of fermentation technology (upstream processing, main fermentation including submerged and surface processes, downstream processing); principles of operation of batch, fed-batch and continuous bioreactors; growth kinetics in batch, fed-batch and continuous cultures (including turbidostat and chemostat); fermentation kinetics in batch, fed-batch and continuous cultures. **UNIT II: Bioreactor designs:** Definition of bioreactors; different types of bioreactor vessels - laboratory, pilot-scale and production bioreactors, basic bioreactor design (STR model); introduction to oxygen requirement in bioprocess - significance of spargers, impellers, baffles; different types of culture/production vessels – air-lift, cyclone-column, bubble-column, packed-tower, membrane bioreactor, photo bioreactor, perfusion bioreactor, plug flow reactor, upflow anaerobic sludge blanket reactor. **UNIT III: Liquid waste management:** Treatment of municipal drinking water supplies; large-scale treatment of waste water by municipalities. **UNIT IV: Bioethanol production:** Large-scale microbial production of bioethanol. **MODULE B [35 Marks]** **(2 classes per week)** **Unit V: Engineering principles in Bioprocess Technology:** Mass Balance and Energy Balance, Biomass yield, Theoretical oxygen demand; Fluid flow characteristics and mixing in bioreactors; Newtonian and Non-Newtonian fluids, Reynold's number; Froude's number, Agitation and Power number. **Unit VI: Mass transfer and scale up in bioprocessing:** Types of mass transfer in bioprocessing; Cellular Oxygen Demand; Measurement of

	Mass Transfer Coefficient; Scale up – criteria of scale up, problems related to scale-up. **Unit VII: Upstream processing in fermentation**: Screening of producer microorganisms, strain improvement and preservation of industrial microorganisms, fermentation media preparation and optimization (Plackett-Burman design), Inoculum development and sterilization. **Unit VIII: Downstream processing in fermentation:** Product recovery and purification. **Unit IX: Solid-State Fermentation and Single Cell Protein production:** Factors influencing SSF, Bioreactors used for SSF; Microbial SCP production. **[Both the modules include a COMPULSORY Industrial Visit]**
Learning Outcomes	The course aims to: 1. Acquaint the students with an overall idea of the techniques and methodologies that industries employ for the large-scale fermentative production of socio-economically beneficial products using microbes, and growth and fermentation kinetics. 2. Provide students with information about different types of bioreactors. 3. Outline the basic principles and steps of liquid waste management and bioethanol production. 4. Familiarize students with the concepts of mass and energy balance principles for designing and optimizing large-scale bioprocesses used in industrial biotechnology. 5. Illustrate the fluid dynamics, mixing behavior and mass transfer in bioreactors for efficient scale-up and process control. 6. Develop strong understanding of the steps of upstream and downstream processing for industrial fermentation processes. 7. Introduce the applications of solid-state fermentation and single-cell protein production processes relevant to industrial biotechnology applications.
Reading / Reference List	1. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited. 2. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi. 3. Das HK. (2005). Text Book of Biotechnology. 2nd edition. Wiley Dreamtech India (P) Ltd. 4. Dubey RC. (2010 Reprint Edition). A Text Book of Biotechnology. S. Chand & Company Ltd. 5. Madigan MT, Martinko JM and Parker J. (2003). Brock Biology of Microorganisms.10th edition. Pearson / Benjamin Cummings. 6. Patel AH. (1996). Industrial Microbiology. 1st edition, Macmillan

	India Limited. 7. Salle AJ. (1974). Fundamental Principles of Bacteriology. 7th edition, 2005 27th Reprint. Tata McGraw-Hill. 8. Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd. 9. Waites MJ, Morgan NL, Rockey JS, Higton G. (2001). Industrial Microbiology - An Introduction. 2002 Indian Reprint Edition. Blackwell Publishing. 10. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education. 11. P. M. Doran, "Bioprocess Engineering Principles," 2nd Edition, Academic Press, Waltham, 2013.
Evaluation	**Theory** • CIA- 20 marks • Assignment – 05 marks [1. On Curriculum - 03 2. On Industrial Visit – 02] • Attendance – 05 marks • Semester Exam- 70 marks
Paper Structure for Theory Semester Exam	**Module A (35 marks)** • 1 Compulsory Question (objective type) – 5 marks • Any 3 out of 5 questions; each of 10 marks, with sub-parts (not less than 1, not more than 5) - 3×10 = 30 marks **Module B (35 Marks)** • Any 2 out of 3 Questions of 10 marks each with sub-parts (not less than 1, not more than 5). 2×10 = 20 marks. • Any 3 out of 5 questions; each of 5 marks, with subparts (not less than 1, not more than 5). 3×5 = 15 marks.