M.TECH DEGREE EXAMINATIONS: NOV/DEC 2023

(Regulation 2018)

First Semester

BIOTECHNOLOGY

P18BTI1202: Bioprocess Modelling and simulation

COURSE OUTCOMES

CO1: Conceptualize mathematical and engineering concepts in bioprocess modeling and simulation.

CO2:   Identify and analyze mathematical model in biochemical engineering systems.

CO3: Select the appropriate components of SuperPro Design software.

CO4: Apply the concepts of MATLAB and SIMULINK in bioprocess systems.

CO5: Ability to solve and analyze data using MATLAB.

CO6: Apply, design and interpret process flowsheeting using SuperPro Design software.

Time: Three Hours   **Maximum Marks: 100**

Answer all the Questions:-
PART A (10 x 1 = 10 Marks)

1. Choose the correct order from the options below: CO1   [K$_2$]

    a) Model hypothesis, Experimental design, Perform experiments, Evaluation of experiments

    b) Experimental design, Perform experiments, Evaluation of experiments, Model hypothesis

    c) Perform experiments, Experimental design, Model hypothesis, Evaluation of experiments

    d) Model hypothesis, Evaluation of experiments, Perform experiments, Experimental design

2. Which term describes a state in which no changes occur over time, indicating a balanced condition in a bioprocess system?   CO1   [K$_2$]

    a) Steady State

    b) Transient State

    c) Dynamic State

    d) Equilibrium State

3. What is the main objective of utilizing flowsheets in chemical engineering processes?   CO2   [K$_2$]

    a) Scheduling

    b) Throughput analysis

    c) Economic evaluation

    d) Equipment utilization analysis

4. Match list I (Organism) with list II and select the correct answer (carbon content)   CO3   [K$_3$]
        using the codes given below the list:

	List 1 (Type of Organism)		List II Carbon content(% dry weight)
A.	Bacteria	1.	40-63
B.	Yeast	2.	50-53
C.	fungi	3.	45-50
D.	*Bacillus subtillus*	4.	53

a) A-I, B-II,C-III, D-IV   b) A-II, B-III,C-I, D-IV

c) A-I, B-IV,C-III, D-II   d) A-III, B-II,C-I, D-IV

5. Which type of vessel is associated with the boiling of a single component liquid in biochemical engineering, where the system is not isolated from the surroundings?   CO2   [K2]

   a) Open vessel   b) Batch distillation

   c) Continuous flow tank   d) Enclosed vessel

6. Process Optimization is a mathematical discipline that focuses on finding: CO3   [K2]

   a) Maxima points of a process   b) Minima points of a process

   c) Maxima and minima points of a process   d) Optima of the process

7. **Assertion (A):** In continuous flow tanks used in biochemical engineering, maintaining a steady flow rate is essential for consistent product quality.   CO5   [K3]

   Reasoning (R): Continuous flow tanks enable continuous processing, and variations in flow rates can affect reaction kinetics and overall process efficiency

   a) Both A and R are true and R is the correct explanation of A   b) A is true and but R is false

   c) Both A and R are true but R is not a correct explanation of A   d) Both are false

8. What are the two primary modes of operation in SuperPro Designer for carrying out material and energy balance?   CO4   [K2]

   a) Manual and automatic   b) Open and closed

   c) Batch and continuous   d) Preliminary and detailed

9. In SuperPro Designer, what factors are typically considered when selecting unit operations for a process?   CO4   [K2]

   a) Aesthetic appeal   b) Component library size

   c) Energy consumption   d) Software compatibility

10. Why are numerical integration methods like Euler and Runge Kutta employed in   CO6   [K3]

MATLAB for problem-solving?

a) Symbolic computation   b) Matrix factorization

c) Approximating solutions   d) Geometric transformations

PART B (10 x 2 = 20 Marks)

11.	How do chemical kinetics is utilized to model and predict microbial growth in a bioprocess.	CO1	[K$_3$]
12.	Mention any two role of transport equations in modeling the movement of nutrients and metabolites within a bioprocess system.	CO1	[K$_3$]
13.	Enlist any two advantages and disadvantages of using an enclosed vessel in a biochemical engineering system compared to an open vessel.	CO2	[K$_2$]
14.	Illustrate how a continuous flow tank differs from a steam jacketed vessel in biochemical engineering systems, emphasizing their respective functions and applications.	CO2	[K$_3$]
15.	Enlist any two differences between the batch and continuous modes of operation in SuperPro Designer, emphasizing their applications and advantages in material and energy balance analysis.	CO3	[K$_3$]
16.	How do Gantt charts aid in equipment utilization analysis, illustrating their role in identifying bottlenecks and optimizing process schedules.	CO3	[K$_2$]
17.	A continuous process is set up for treatment of waste water. Each day, 10^5 kg cellulose and 10^3 kg bacteria enter in the feed stream, while 10^4 kg cellulose and 1.5×10^4 kg bacteria leave in the effluent. The rate of cellulose digestion by the bacteria is 7×10^4 kg/ day. The rate of bacterial growth is 2×10^4 kg/ day; the rate of cell death by lysis is 5×10^2 kg/ day. Write balances for cellulose and bacteria in the system.	CO4	[K$_4$]
18.	How does a lower Ks (*Michaelis-Menten* Constant) value reflect a higher affinity of microorganisms for a substrate? Provide an example or scenario to illustrate the significance of Ks in determining the growth behavior of microorganisms	CO4	[K$_3$]
19.	Mention any two advantages and limitations of using numerical integration methods such as Euler and Runge Kutta in MATLAB for solving mathematical problems.	CO5	[K$_2$]
20.	Provide an example of how cost analysis is conducted in bio-chemical engineering flowsheeting, emphasizing the key cost components considered.	CO6	[K$_3$]

PART C (6 x 5 = 30 Marks)

21.	Assess the importance of incorporating chemical kinetics in bioprocess models. Discuss its implications for process optimization and control.	CO1	[K$_3$]
22.	How do the fundamental laws, including the continuity equation, energy equation, and equations of motion, are integrated to create comprehensive models for bioprocess systems. Highlight their interdependence and contributions	CO2	[K$_3$]
23.	In downstream processing of gluconic acid, concentrated fermentation broth containing 20% (w/w) gluconic acid is cooled prior to crystallisation. The concentrated broth leaves an evaporator at a rate of 2000 kg/h and must be cooled from 90ºC to 6ºC. Cooling is achieved by heat exchange with 2700 kg/h water initially at 2ºC. If the final temperature of the cooling water is 50 ºC. what is the rate of heat loss from the gluconic acid solution to the surroundings? Assume the heat capacity of gluconic acid is 0.35 cal/g/ºC.	CO3	[K$_4$]

Data:

h (liquid water at 90 ºC)= 376.9 kJ/kg

h (liquid water at 6 ºC)= 376.9 kJ/kg

h (liquid water at 2 ºC)= 8.4 kJ/kg

h (liquid water at 50 ºC)= 209.3 kJ/kg

The rate of heat input is 4.933103 kJ/h

24.	Examine the merits and demerits associated with various modes of bioreactors employed in biochemical engineering	CO4	[K$_2$]
25.	The synthesis of biomass from glucose (C$_6$H$_{12}$O$_6$) and ammonia (NH$_3$) is represented by the following generalized equation:	CO5	[K$_4$]

$C_6H_{12}O_6 + aO_2 + b\ NH_3 \rightarrow cCH_{1.8}O_{0.5}N_{0.2} + d\ CO_2 + e\ H_2O$

If the Respiratory Quotient (RQ) for this process is found to be 0.90. Determine the stoichiometric coefficients (a,b,c,d&e) for the given equation.

26.	Develop a systematic approach for conducting economic evaluations in biochemical engineering flowsheeting, considering the criteria for assessing project viability.	CO6	[K$_4$]

Answer any FOUR Questions
PART D (4 x 10 = 40 Marks)

27.	Tetracycline produced in *Streptomyces aureus* fermentations is purified by crystallisation. One hundred kg of a supersaturated solution containing 7.7 wt% tetracycline is cooled in a batch fluidised-bed crystalliser. Seed crystals of tetracycline are added at a concentration of 40 ppm to promote crystal growth. At the end of the crystallisation process, the remaining solution contains 2.8% tetracycline.	CO1	[K$_4$]

(a) What is the mass of the residual tetracycline solution?

(b) What mass of tetracycline crystals is produced?

28.	With a suitable assumption, derive the derivation for Fed batch operation	CO2	[K$_2$]
29.	The concentration of salt in a home-made soap maker is given as a function of time by $\frac{dx}{dt} = 3.75 - 3.5x$	CO4	[K$_5$]

At the initial time, $t = 0$, the salt concentration in the tank is 50 g/L Using Runge-Kutta 4th order method and a step size of, $h = 1.5$ min, what is the salt concentration after 3 minutes?

30.	A startup company proposes to use corn stover as a feedstock(39% cellulose, 26 % hemicellulose and 23 % lignin, 12 % ash) to to produce ethanol. The company claims to have discovered a new process that can produce 492 L ethanol/ dry metric ton (130 gal ethanol/dry ton) of feedstock. As a bioprocess engineer, scrutinize the feasibility of the estimates provided by the company .	CO5	[K$_5$]
31.	Using PFD and BFD, Illustrate the complete flowsheet for the production of ethanol from lignocellulosic waste .	CO6	[K$_5$]

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