Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

IISEMESTER M.TECH (INDUSTRIAL BIOTECHNOLOGY)
END SEMESTER EXAMINATIONS, JUNE 2022 (REGULAR)

BIO5254: BIOREACTOR DESIGN AND ANALYSIS

REVISED CREDIT SYSTEM
ANSWER ALL QUESTIONS

Time: 3 Hours **MAX. MARKS: 50**

SL NO	Question	CO	BTL	M
1A.	How do you define the reaction rate in heterogeneous reaction system? Explain various parameters affecting the reaction rate in heterogeneous reaction system.	**1**	**3**	**4**
1B.	Write on the various dimensionless parameters that are used in estimating (i) External Mass transfer effects (ii) Internal mass transfer effects	**1**	**3**	**3**
1C	Hydrolysis of palm oil is carried out in a CSTR with free lipase enzyme. The substrate sucrose (S0=4M) is pumped at 0.1 L/h.Find the volume of the reactor to achieve 45% conversion at steady state for (a) Michaelis-Menten Kinetics (b) Substrate Inhibition Kinetics. Kinetics data: V_m=0.028 M/min, K_m=0.23 M, K_I=0.2 M	**2**	**3**	**3**
2A.	What do you mean by constant feed rate policy in the operation of immobilized enzyme reactor system? Develop a suitable model for predicting the time course profiles of conversion due to enzyme deactivation for first order kinetics, no pore diffusion effects in PFR with immobilized enzyme.	**2**	**3**	**4**
2B.	Consider a 1000 L CSTR in which biomass is being produced with glucose as the substrate. The microbial system follows a Monod relationship with μ_m = 0.4 h^{-1}, K_S = 1.5 g/l and the yield factor $Y_{X/S}$ = 0.5 g biomass/g substrate consumed. If the normal operation is with a sterile feed containing 10 g/l glucose at a rate of 100 L/h: i. What is the specific biomass production rate (g/L-h) at steady state? **ii.** If recycle is used with a recycle stream of 10 L/h and a recycle biomass concentration five times as large as that in the reactor exit, what would be the new specific biomass production rate?	**2**	**3**	**4**
2C	When do you prefer the Fed-batch reactor? Explain how quasi steady state is justified in Fed-batch reactor.	**2**	**3**	**2**
3A.	Differentiate between controllability and stabilizability of the bioprocess? Explain various steps involved in designing of controller for bioprocess.	**4**	**3**	**4**
3B	Consider that you have been working with Chemostat system where cell growth follows the substrate inhibition kinetics. Write the conditions for obtaining positive and negative real parts of Eigen values.	**3**	**3**	**2**

<table>
<tr>
<td>3C</td>
<td>Certain bio-product is produced using Bacillus species in a cascade fermentation system of three chemostats in series with volume, V1=167 L, V2=40 L, V3=67 L. The feed flow rate is 100 L/h. Graphically determine the steady state biomass concentration in above all three chemostats. The growth kinetic data for Bacillus species is as follows:
<table>
<tr><td>X, g/l</td><td>0</td><td>0.2</td><td>0.3</td><td>0.4</td><td>0.55</td><td>0.60</td><td>0.70</td><td>0.80</td><td>0.90</td></tr>
<tr><td>dX/dt, g/l-h</td><td>0</td><td>0.1</td><td>0.2</td><td>0.3</td><td>0.38</td><td>0.36</td><td>0.3</td><td>0.2</td><td>0.05</td></tr>
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<td>4A.</td>
<td>Lactic acid is produced using Lactobacillus in a Chemostat under sterile environment with glucose as the substrate, S_0=4 g/l at dilution rate of D=0.18 h^{-1}. Steady state substrate and biomass concentrations are 1.5 and 1.0 g/l respectively. Assume that growth follows the Substrate inhibition kinetics given by the following equation with, μ_m=0.53 h^{-1}, K_s=0.12 g/l, Ki=0.8 g/l and Y=0.4
$$\mu = \frac{\mu m.S}{(Ks + S + \frac{S^2}{KI})}$$
i. Find the elements of A matrix
ii. Find the Eigen values and comment on the stability of the system</td>
<td>3</td><td>4</td><td>4</td>
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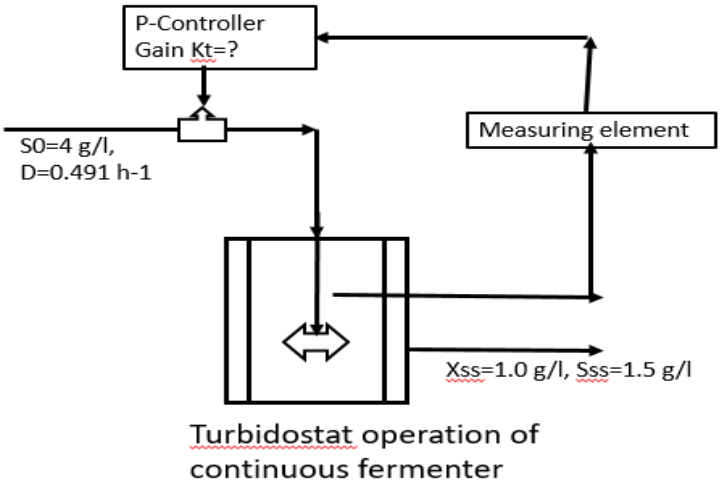
<td>4B.</td>
<td>Proponoic acid is produced using Bacillus licheniformis in a Chemostat under sterile environment with glucose as the substrate ,S_0=4 g/l at dilution rate of D=0.49 h^{-1}. Steady state substrate and biomass concentrations are 1.5 and 1.0 g/l respectively. Assume that growth follows the Monod’s kinetics with, μ_m=0.53 h^{-1}, K_s=0.12 g/l and Y=0.4. It is desired to control the biomass at steady state value by manipulating the dilution rate of feed.


Turbidostat operation of continuous fermenter
i. Find the [A-BK_t] matrix for the above process
ii. Find the suitable K_t value that stabilizes the process in the case of disturbances</td>
<td>4</td><td>4</td><td>4</td>
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<td>4C</td>
<td>Name the Input, output and manipulated variable in Activated sludge process.</td>
<td>4</td><td>3</td><td>2</td>
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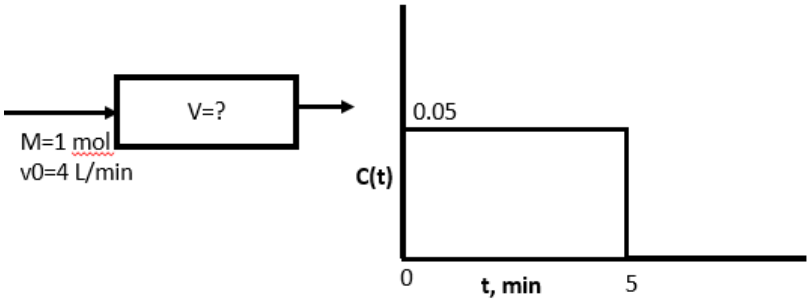
<td>5A.</td>
<td>RTD results for the non-ideal bioreactor are shown in the following table for pulse input. Find the conversion for macro fluid with kinetics (-rA)=k, k=0.5, CA0=10 M</td>
<td>5</td><td>3</td><td>3</td>
</tr>
</table>

Time, min	0	5	10	15	20	25	30	35
E (t)	0	0.03	0.05	0.05	0.04	0.02	0.01	0

5B.	A pulse input to a non-ideal bioreactor gives the results shown in the following fig. (a) Check the material balance with the tracer curve to see whether the results are consistent. (b) If the result is consistent, determine space time (τ), Volume of bioreactor (V) and sketch the E curve. 	**5**	**3**	**4**
5C	Write on the adverse effects of Foaming in the operation of bioreactor. Explain how foaming is controlled in Industrial fermenters.	**2**	**3**	**3**