मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
प्रयागराज–211004 भारत,

Motilal Nehru National Institute of Technology Allahabad
Prayagraj-211004 [India]

Chemical Engineering Department
Mid Semester (Even) Examination 2023-24

Programme Name: B.Tech. Semester: IV

Course Code: CHN14109 Course Name: Process Dynamics and Control

Branch: Chemical Engineering Student Reg. No.:

Duration: 90 Minutes Max. Marks: 25

Instructions: (Related to Questions)

1. *Figures to the right indicate the full marks. 2.Answer the questions sequentially. 3. Assume suitable data wherever necessary.*

		Marks	Mapped to CO number
Q 1	A process given by $$G(s) = \frac{2}{(5s+1)}$$ is subjected to a ramp change having a slope of 2. Determine the output y for this processes at 30 min.	5	CO1
Q 2	A chemical process is represented by a transfer function $$Y(s) = \frac{s+5}{s^2+5s+4)}$$ Find out the value of an output y at 15 min.	5	CO1
Q3	Dynamics of a chemical process is exhibited by the following transfer function: $$G(s) = \frac{Y(s)}{U(s)} = \frac{30}{60s+6}$$ i. What is the steady state gain and time constant? ii. For a step change of magnitude 2, what is the value of the y(t) when time tends to infinity.	5	CO1/CO2

Q 4 A mixed tank reactor is represented by a following equation: 10 CO2

$$V\frac{dC}{dt} = q(C_i - C) - Vk_0\, e^{\frac{-E}{RT}}C$$

Determine the concentration at 2 min and 5 min. considering the following data.

Data:

Initial concentration of A in feed (C_i) is 0.2 mol/cum.

Flow rate (q) is 20 cum/min.

V is 10 cum (constant).

K_o is 500 min^{-1}

E is 20.5 kJ/mol.

T is 325 K

R is universal gas constant (8.314 J/mol.K)

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प्रयागराज-211004 [इंडिया]

Motilal Nehru National Institute of Technology Allahabad
Prayagraj-211004 [India]

End Semester Examination 2023-24

Programme Name: B.Tech.
Course Code: CH14109
Semester: IV
Course Name: Process Dynamics and Control

Branch: Chemical
Student Reg. No.: 2 0 2 2 2 0 6 8

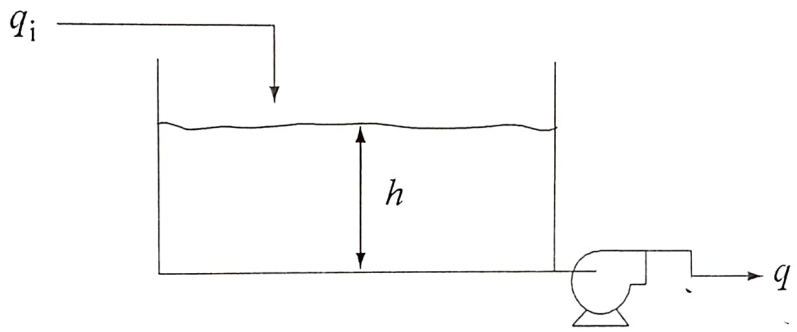
Duration: 150 min
Max. Marks: 40

Instructions:
1. *Answer the questions sequentially; 2. Use of non-programmable scientific calculator is permitted.*

Marks

Part A

Q 1 Consider a liquid storage system given below and determine transfer function between outlet flowrate (h) and inlet flowrate (q_i). Make suitable assumptions, as necessary. 6 (CO 1)



Q 2 A process output y shows a time delay of θ min for the change in inout x such that; 6 (CO 2)

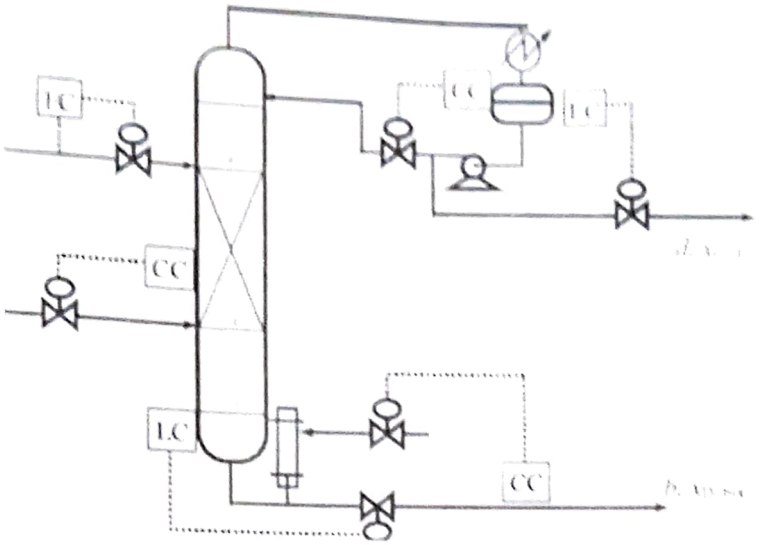
$y(t) = 0$ for $t < 0$ and

$y(t) = x(t-\theta)$ for $0 \leq t$

Determine the transfer function G(s) for the above case.

Q 3 Derive position and velocity forms of the PID controller. Also, state their 2 merits as compared to conventional PID controller. 6 (CO 4)

Q4 In the distillation process given below, composition of the bottom product is being controlled by manipulating the steam (flowrate) to the reboiler using PID controller [CC]. The sensor/transducer is direct acting, while the control valve is air-to-open type. Explain if the controller is direct-acting or reverse-action with suitable justification. 6 (CO 4)



Part B (Solve any TWO)

Q 5 The dynamic response of the stirred tank bioreactor can be represented as 8

$$\frac{C'(s)}{C'_F(s)} = \frac{8}{4s+2}$$ (CO 3)

Where, C′ is the exit substrate concentration (mol/L) and C'_F is feed substrate concentration (mol/L)

(a) Derive an expression for c'(t) if $C'_F(t)$ is a rectangular pulse as

$$C'_F(t) = \begin{cases} 0 & t < 0 \\ 2 & 0 \le t < 2 \\ 0 & 2 \le t < \infty \end{cases}$$

(b) What is the maximum value of c'(t)?

(c) When does the maximum value occur?

(d) What is the final value of c'(t)?

Q 6 Consider a feedback control system that has the open-loop transfer function. 8

$$G(s) = \frac{4\,Kc\,(1 + 0.25s)e^{-2s}}{(s+4)(2s+1)}$$ (CO 4)

Find out using Bode plot if the feedback control system is stable for controller gain of *10. Vary frequency* from 0 to 20 to generate Bode plot. *[Given:* $e^{-2s} = \cos(2w) - j\sin(2w)$*]*.

Q 7 A heat transfer process has the following transfer function between a temperature T and an inlet flow rate q where the time constants have units of minutes: 8

$$T'(s)/Q'(s) = 3(1-s)/s(2s+1)$$ (CO 4, CO 5)

If the flow rate varies sinusoidally with an amplitude of 2 L/min and a period of 0.5 min, what is the amplitude of the temperature signal after the transients have died out?

All the Best