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Motilal Nehru National Institute of Technology Allahabad
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End Semester Examination 2023-24

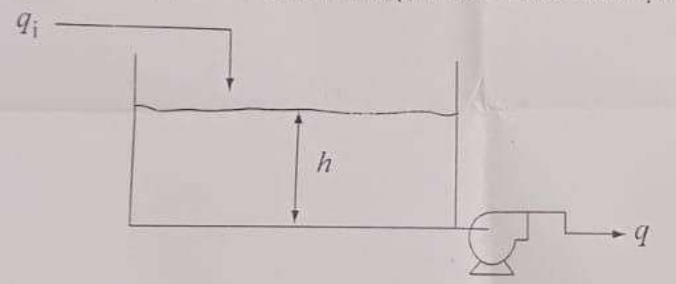
Programme Name: B.Tech. **Semester:** IV
Course Code: CH14109 **Course Name:** Process Dynamics and Control
Branch: Chemical **Student Reg. No**
Duration: 150 min **Max. Marks:** 40

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)

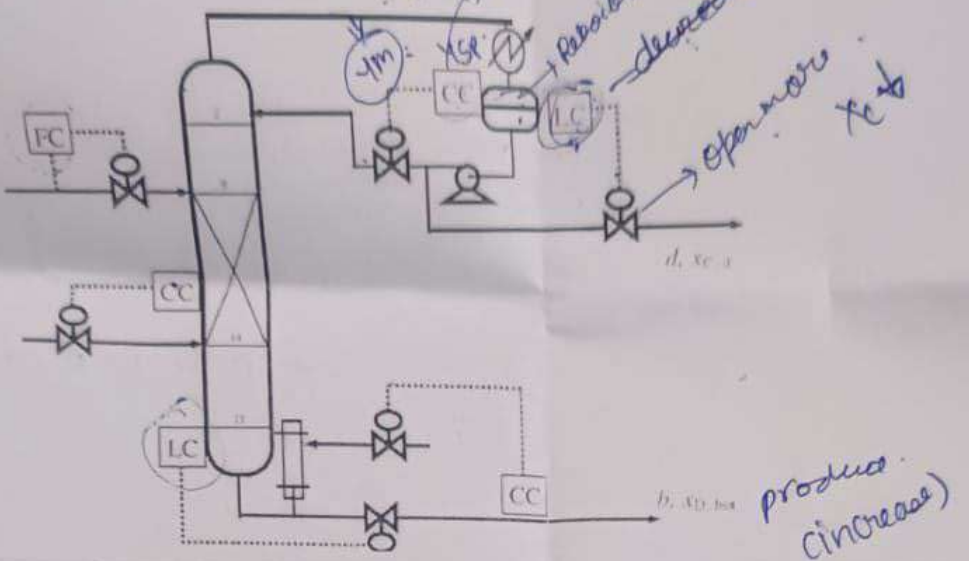
$y(t) = 0$ for $t < 0$ and

$y(t) = x(t-\theta)$ 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