1T00537 - B.E.(Chemical Engineering)(SEM-VII)(Choice Base Credit Grading System) (R- 19-20) (C Scheme) / 41971 - Instrumentation Process Dynamics and Control

QP CODE: 10028862 DATE: 14/06/2023

Time: 3 Hours **Total Marks:-80**

N.B:

1) Question 1 is compulsory. Answer any three questions from the remaining.
2) Assume data if necessary and specify the assumptions clearly
3) Draw neat sketches wherever required
4) Answer to the sub-questions of an individual question should be grouped and written together.

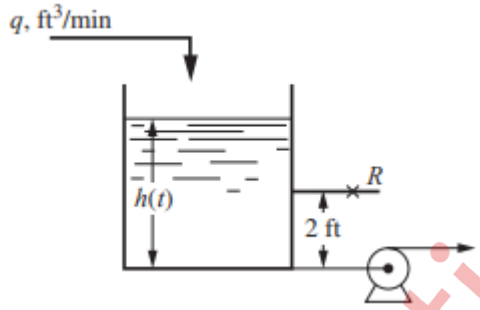
Q.1.a) A process of unknown transfer function is subjected to a unit impulse input. The output of the process is measured accurately and is found to be represented by the function $y(t) = te^{-t}$. Determine the unit step response of this process. [05]

Q.1.b) Explain Phase Margin and Gain Margin? [05]

Q.1.c) A second order system is found to have a peak amplitude ratio of 1.1547 at a frequency of 0.7071 *rad/min*. What are the values of natural period of oscillation and the damping coefficient of the system [05]

Q.1.d) Draw a typical block diagram for a process showing all the elements of the control system and input and output from all the blocks. [05]

Q.2.a) Derive the transfer function H(s)/Q(s) for the liquid level system shown in figure, when :(i) The tank level operates about the steady state values of hs = 1 ft, (ii) The tank level operates about the steady state value of hs = 3 ft The pump removes water at a constant rate of 10 ft^3 /min. The rate is independent of head. The cross sectional area (A) of tank 1 ft^2 and resistance R is 0.5 ft /(ft^3/min). [10]



Q.2.b) Two streams w_1 and w_2 each at a constant density of 900 kg/m^3, and carrying solute of mass fraction x_1 and x_2 respectively, enter a continuous stirred tank of 2m^3 capacity. At steady-state, w_{1s}=500 kg/min, w_{2s}=200 kg/min, x_{1s}=0.4, and x_{2s}=0.75. Suddenly the inlet flow rate w_2 decreases to 100 kg/min and remains there. Determine an expression for the mass fraction of the solute *x(t)*. Assume that liquid hold up is constant. [10]

Q.3.a) A composition sensor is used to continually monitor the contaminant level in a liquid stream. The dynamic behaviour of the sensor can be described by a first-order transfer function with a time constant of 10 s, where C' is the actual contaminant concentration and C'_m is the measured value. Both are expressed as deviation variables (e.g., C' = C- C_s). The nominal concentration is C_s =5 ppm. Both C and C_m have values of 5 ppm initially (i.e., the values at t = 0). An alarm sounds if the measured value exceeds the environmental limit of 7 ppm. Suppose that the contaminant concentration C gradually increases according to the expression $C(t) = 5 + 0.2t$, where t is expressed in seconds. After the actual contaminant concentration exceeds the environmental limit, what is the time interval, Δt until the alarm sounds? [10]

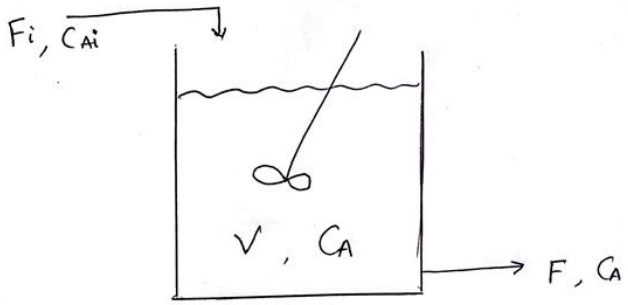
$$\frac{C'_m(s)}{C'(s)} = \frac{1}{10s+1}$$

Q.3.b) Consider the stirred-tank reactor shown in below Figure. The reaction occurring is a first order reaction $A \xrightarrow{k} B$

F_i and F are inlet and outlet volumetric flow rates.

C_{Ai} and C_A are inlet and outlet concentrations.

Assumptions: Well mixed tank, density of liquid and volume are constant. Derive the transfer function relating the concentration in the reactor to the feed-stream concentration. Prepare a block diagram for the reactor. [10]



Q.4.a) Discuss control valve characteristics in detail [10]

Q.4.b) A first order process is controlled with a PI controller. For the system under study assume that $G_p(s) = G_d(s) = \frac{1}{s+3}$ and $G_m(s) = G_f(s) = 1$.Find the values of the controller gain K_c and reset time τ_I that can satisfy, if possible, for the following condition when decay ratio of the closed loop response is equal to 0.25. [10]

Q.5.a) A pneumatic Proportional controller is used in the process to control the stream temperature within the range of 60 °C to 120 °C. The controller gain is adjusted so that the output pressure goes from 3 psig (valve fully closed) to 15 psig (valve fully open) as the measured temperature goes from 70 to 76 °C with the set point held constant. Find the controller gain Kc. [05]

Q.5 b) For the Given characteristic equation $s^4 + 3s^3 + 5s^2 + 4s + 2 = 0$, determine the stability by Routh criterion. [05]

Q.5.c) A unity feedback system has $G(s) = \frac{80}{s(s+2)(s+20)}$

Draw the bode plot. Determine GM, PM, ω_{gc}, ω_{pc},. Comment on stability [10]

Q.6.a) Explain in detail ultrasonic flow measurement [10]

Q.6.b) Explain in detail Bourdon Tube instrument [10]

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