Paper / Subject Code: 41971 / Instrumentation Process Dynamics and Control

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

QP CODE: 10015527 DATE: 08/12/2022

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.

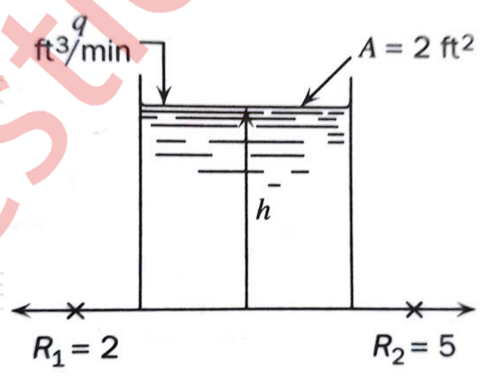
Q.1.a) Discuss degrees of freedom analysis for process (N_F) and degrees of freedom analysis for process control (N_{FC})? Also discuss the relation between them [05]

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

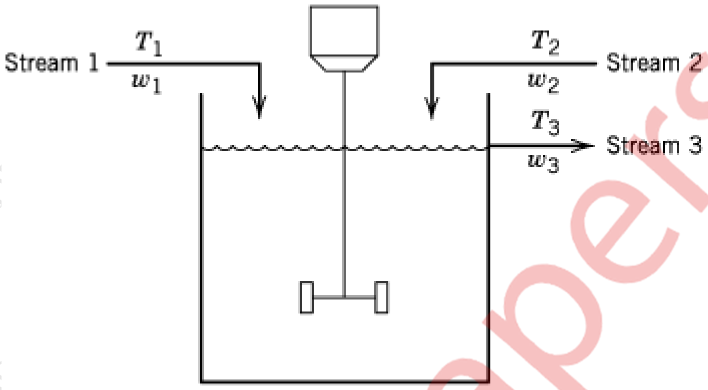
Q.1.c) Define a unit pulse function mathematically and graphically. Also derive the Laplace transform [05]

Q.1.d) Discuss performance criteria for closed loop systems [05]

Q.2.a) Derive the transfer function H/Q for the liquid level system shown in figure. The resistances are linear. H and Q are deviation variables. Show clearly how you derive the transfer function. You are expected to give numerical values in the transfer function [10]



Q.2.b) A perfectly stirred, constant-volume tank has two input streams, both consisting of the same liquid. The temperature and flow rate of each of the streams can vary with time. Derive a dynamic model that will describe transient operation. Also perform degrees of freedom analysis assuming that both Streams 1 and 2 come from upstream units (i.e., their flow rates and temperatures are known functions of time). *Notes: w_i denotes mass flow rate for stream i. Liquid properties are constant (not functions of temperature).* [10]



Q.3.a) consider the following transfer function

$$G(s) = \frac{Y(s)}{U(s)} = \frac{3}{10s+1}$$

Find the steady state gain and time constant?
If $U(s)$= 2/s, what is the value of the output $y(t)$when t $\rightarrow \infty$?
For the same $U(s)$, what is the value of the output when t=10?
If U(s) = $(1-e^{-s})/s$, that is the unit rectangular pulse, what is the output when t $\rightarrow \infty$?
If u(t) = δ(t), that is the unit impulse at t=0, what is the output when t $\rightarrow \infty$? [10]

Q.3.b) The dynamic behavior of the liquid level in each leg of a manometer tube, responding to a change in pressure, is given by where *h(t)* is the level of fluid measured with respect to the initial steady-state value, *p(t)* is the pressure change, and *R,L, g,* ρ, and μare constants. [10]

$$\frac{d^2h}{dt^2} + \frac{6\mu}{R^2\rho}\frac{dh}{dt} + \frac{3}{2}\frac{g}{L}h = \frac{3}{4\rho L}p(t)$$

(i) Rearrange this equation into standard gain-time constant form and find expressions for *K*, τ and ξ in terms of the physical constants.
(ii) For what values of the physical constants does the manometer response oscillate?
(iii) Would changing the manometer fluid so that ρ (density) is larger make its response more oscillatory, or less?

Q.4.a) Explain in detail Turbine Flow meter with neat diagram [10]

Q.4.b) Consider a feedback control system with process transfer function of 5/(10s+1) , disturbance transfer function of -0.5/(10s+1) , measurement dynamics 1/(0.1s+1) and valve dynamics of 1/(s+1) . This process is controlled by a P controller with gain 0.45. What will be the offset if the set point is changed by 2 units? [10]

Q.5.a) For a system with $G(s)H(s) = \frac{K(1+s)^2}{s^3}$ find range of 'K' for system to be stable [10]

Q.5.b) For unity feedback system with $G(s) = \frac{10}{s(s+1)(s+5)}$ sketch the Bode plot. Find Gain margin, Phase margin, Gain cross over frequency, phase cross over frequency and Comment on stability [10]

Q.6.a) Define all performance characteristics of instruments in detail [10]

Q.6.b) Discuss continuous cycling controller tuning method in detail with steps [10]
