26-Dec-2023 10:30 am - 01:30 pm 1T00537 - B.E.(Chemical Engineering)(SEM-VII) (Choice Base Credit Grading System) (R- 19) (C Scheme) / 41971 - Instrumentation Process Dynamics and Control QP CODE : 10042333

Time: 3 Hrs **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) Write short note on classification of variables in process control [05]

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

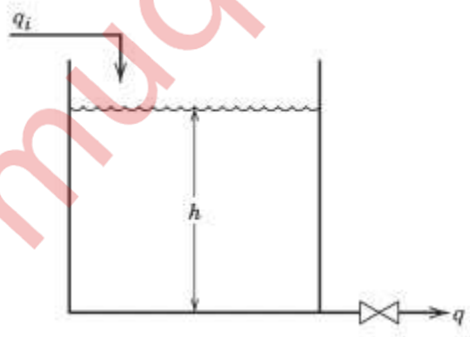
Q.1.c) Explain overshoot, decay ratio, rise time and response time for a second order underdamped system [05]

Q.1.d) Describe in detail Zeigler Nichols controller tuning method [05]

Q.2.a) Develop a dynamic model for a blending process where a pure stream with flow rate w_1, composition $x_1=1$ is blended with other stream with flow rate w_2 and composition x_2, to get a single output stream with flow rate w and composition x. Note that the volume of liquid in the tank V can vary with time, and the exit flow rate is not necessarily equal to the sum of the inlet flow rates. Assume perfect mixing and constant density. Also carry out degree of freedom analysis. [10]

Q.2.b) A stirred-tank heating system is used to preheat a reactant containing a suspended solid catalyst at a constant flow rate of 1000 kg/h. The volume in the tank is 2 m^3, and the density and specific heat of the suspended mixture are, respectively, 900 kg/m^3 and 1 cal/g °C. The process initially is operating with inlet and outlet temperatures of 100 and 130 °C.
(i) What is the heater input at the initial steady state and the values of K and τ ?
(ii) Assume the tank is at its initial steady state. If the inlet temperature is increased suddenly from 100°C to 120 °C, how long will it take before the outlet temperature changes from 130°C to 135 °C? [10]

Q.3.a) A simple surge tank with a valve on the exit line is illustrated in Figure.

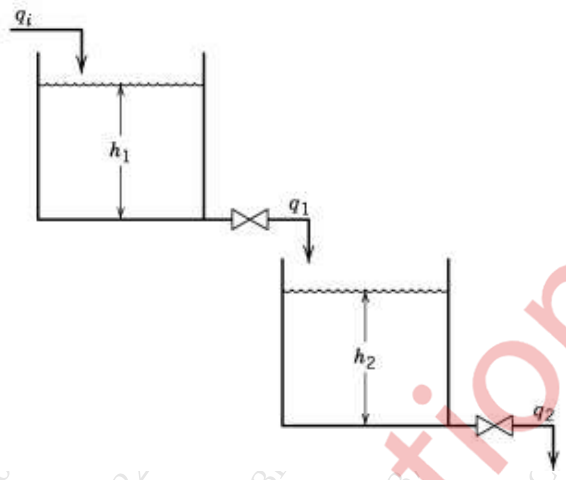


If the exit flow rate is proportional to the square root of the liquid level, an unsteady-state model for the level in the tank is given by

$$A\frac{dh}{dt} = q_i - C_v h^{1/2}$$

By assuming that the process initially is at steady state, Find the transfer function H(s)/Qi(s). Put the transfer function in standard gain/time constant form. [10]

Q.3.b) Two liquid surge tanks are placed in series so that the outflow from the first tank is the inflow to the second tank, as shown in Fig. If the outlet flow rate from each tank is proportional to the height of the liquid (head) in that tank, find the transfer function relating changes in flow rate from the second tank, $Q_2(s)$, to changes in flow rate into the first tank, $Q_i(s)$.
Assume that the two tanks have different cross-sectional areas A_1 and A_2, and that the valve resistances are R_1 and R_2. [10]



Q.4.a) Discuss P, PI and PID controller. Also write their transfer functions [05]

Q.4. b) Calculate the offset for the control loop with transfer function $\frac{C(s)}{R(s)} = \frac{8}{2s^2+3s+9}$ for a step change of 0.1 unit. [05]

Q.4.c) Determine the stability that has characteristic equation $s^5+s^4+2s^3+2s^2+3s+15=0$ using Routh's criterion [10]

Q.5.a) Derive the expression for transient response of proportional control for set point change (Servo problem). Show how response varies with Kc. [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) Explain performance characteristics of instruments [10]

Q.6.b) Explain in detail ultrasonic level measurement [10]