KATHMANDU UNIVERSITY
End Semester Examination
January/February, 2024

Level : B.E.
Year : III
Time : 2 hrs. 30 mins.

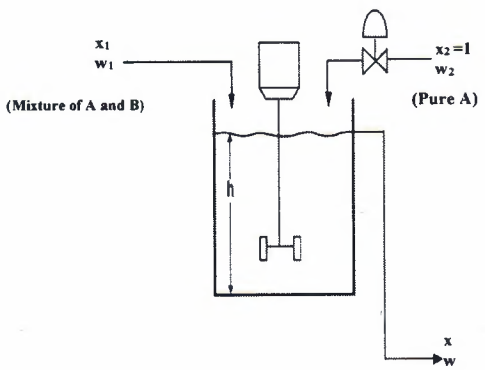
26 JAN 2024

Course : CHEG 302
Semester : I
F.M. : 40

SECTION "B"
[5Q × 8 = 40 marks]

Attempt *All* questions.

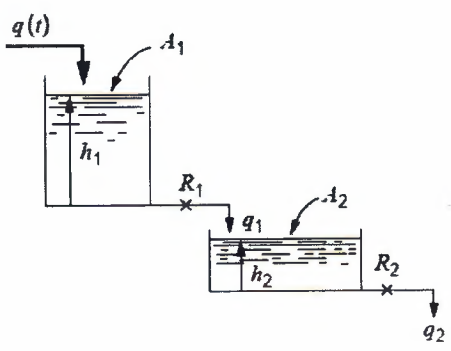
1. a. Considering the blending system described in figure with the control strategies, propose a specific scenario or condition change and discuss which control strategy would be most effective in maintaining the desired set point (SP). Justify your choice based on the characteristics of each method and their potential effectiveness in handling transient conditions. [5]



b. Solve

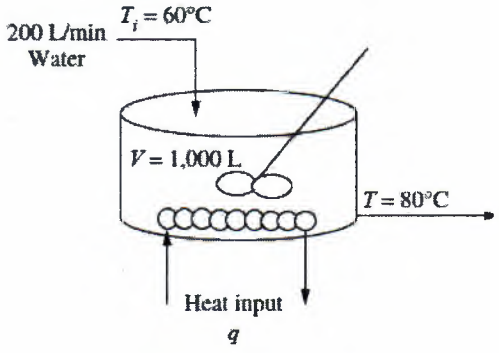
$$\frac{d^3x}{dt^3}+2\frac{d^2x}{dt^2}-\frac{dx}{dt}-2x=4+e^{2t}, \text{ where, } x(0)=1,\ x'(0)=0, x''(0)=0$$ [3]

2. a. What are the key differences between noninteracting and interacting systems in the context of first-order systems in series, and show that response of two first-order noninteracting tank systems in series is dependent on the resistance of the second tank (See figure)? [5]



b. Discuss in detail the mechanism of control valve. A valve with a C_v rating of 4.0 is used to throttle the flow of glycerine for which sg = 1.26. Determine the maximum flow through the valve for a pressure drop of 100 psi. [3]

3. a. Stirred-tank heater model. Please consider the stirred-tank heater as shown in figure. [5]



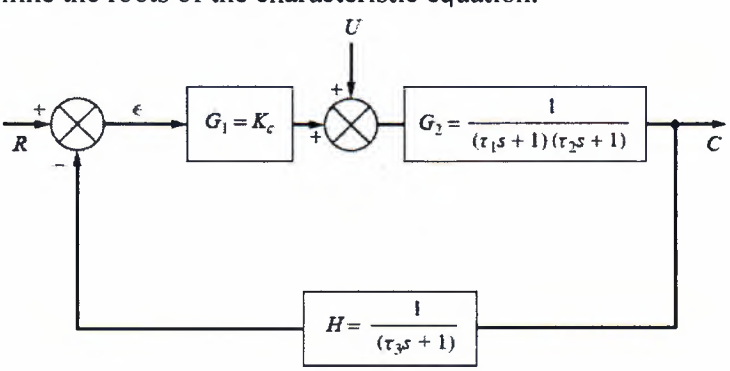
i. Determine the response of the outlet temperature of the tank to a step change in the inlet temperature from 60 °C to 70 °C.
ii. Determine the response of the outlet temperature of the tank to a step increase in the heat input of 42 kW.
iii. Determine the response of the outlet temperature of the tank to a simultaneous step change in the inlet temperature from 60 °C to 70 °C and a step increase in the heat input of 42 kW.

b. Calculate the overall transfer function of a single-loop system, taking into account both (i) variations in setpoint and (ii) changes in load [3]

4. a. Explain the key principles and steps involved in the Routh test for assessing the stability of a control system. Additionally, discuss the limitations of the Routh test. [4]

b.

i. Using $\tau_1=1$, $\tau_2=\frac{1}{2}$, $\tau_2=\frac{1}{3}$ determine the values of K_c for which the control system Figure is stable. [2]
ii. For the value of K_c for which the system is on the threshold of instability, determine the roots of the characteristic equation. [2]



5. Discuss on *ANY FOUR* [2+2+2+2]

a. Location of typical roots of characteristic equation.
b. Step response and impulse response.
c. Transportation lag
d. Bode diagram for first order system
e. Amplitude ratio, ultimate period

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SECTION "A"
[20Q. × 0.5 =10 marks]

Choose and encircle the most appropriate option from each set of choices.

1. The Laplace transformation of ramp function

$$f(t)=\begin{cases}0 & t<0\\ 1 & t>0\end{cases}=tu(t)$$

is

a. $\frac{1}{s^3}$ b. $\frac{1}{s^2}$ c. $\frac{1}{s^4}$ d. $\frac{1}{s^5}$

2. If the time constant and steady-state gain of a first order process are τ_p and K_p, respectively, then the process is equal to

a. $\frac{K_p}{\tau_p s+1}$ b. $\frac{K_p}{\tau_p s+1}$ c. $\frac{\tau_p}{s+K_p}$ d. $\frac{K_p}{s+\tau_p}$

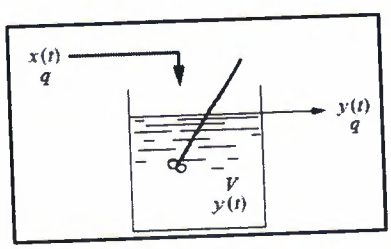
3. A rectangular tank is fitted with a valve at the bottom and is used for storing a liquid. The area of cross section of the tank is 12 m^2 and the flow resistance of the valve (assumed constant) is 0.1 s/m^2. The time constant of the tank will be

a. 1 s b. 1.1 s c. 1.2 s d. 1.4 s

4. The transfer function of mixing process (shown in figure) is

a. $\frac{Y(s)}{X(s)}=\frac{1}{(q/V)s+1}$ b. $\frac{Y(s)}{X(s)}=\frac{1}{(V/q)s+1}$

c. $\frac{Y(s)}{X(s)}=\frac{1}{(q/V)s-1}$ d. $\frac{Y(s)}{X(s)}=\frac{1}{(V/q)s+1}$



5. In the generalization for several noninteracting systems in series $\left(\frac{X_n(s)}{X_0(s)}=\prod_{i=1}^{n}\frac{k_i}{\tau_i s+1}\right)$, what does "n" represent?

a. Number of interacting tanks in series b. Number of noninteracting tanks in series
c. Time constant for each tank d. Cross-sectional area for each tank

6. The transfer function of a process is $\frac{1}{16s^2+8s+4}$. If a step change is introduced into the system, then the response will be

a. Underdamped b. Critically damped c. Overdamped d. Undamped

7. In the servomechanism (or "servo") control
   a. The set-point signal is changed and the manipulated variable is adjusted appropriately.
   b. The set-point signal is not changed and the manipulated variable is adjusted appropriately.
   c. The set-point signal is not changed and the manipulated variable is not adjusted appropriately.
   d. The set-point signal is changed and the manipulated variable is adjusted appropriately

8. If T and T_s are the unsteady and steady state temperature variables then the deviation variable is
   a. $T-T_s$ b. T_s-T c. $1-T_s$ d. 1-T

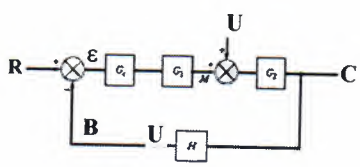
9. For a pneumatic proportional controller, the value of controller gain (K_c) using the pressure range (3 to 15 psig) for a temperature change from 71 to 75 °F, with a constant set point is
   a. 3.5 psi/°F b. 2.5 psi/°F c. 3 psi/°F d. 4 psi/°F

10. According to the Ziegler-Nichols rules, the proportional gain (K_c) in proportional-integral control is equal to
   a. $0.5K_u$ b. $0.45K_u$ c. $0.4K_u$ d. $0.1K_u$

11. For the given sample line with a transportation lag represented by the transfer function $e^{-\tau_d s}$, what does the parameter τd represent?
   a. Real reaction time b. Decay time
   c. No delay d. Time delay

12. The electronic current signal from the output of the controller is
   a. 3 to 15 mA b. 2 to 40 mA c. 1 to 20 mA d. 4 to 40 mA

13. For a closed loop control system (refer to figure), set point change has
   a. $U = 0$ b. $R = 0$
   c. $c = 0$ d. $\varepsilon = 0$



14. A proportional controller with a gain K_c is used to control a first-order process. The offset will increase if
   a. K_c is reduced b. K_c is increased
   c. Integral control action is reduced d. Derivative control action is reduced

15. How does the control performance relate to the measurement lag in a control system?
   a. Control performance improves with a larger measurement lag.
   b. Control performance remains constant regardless of the measurement lag.
   c. Control performance degrades with a larger measurement lag.
   d. Measurement lag has no impact on control performance.

16. What limitation does the Routh test have in terms of testing system stability?
   a. It cannot determine stability for systems with excessive time delays.
   b. It is not applicable to systems with transportation lag.
   c. It is limited to systems with linear characteristics.
   d. The test is ineffective for non-polynomial characteristic equations.

17. Bode diagrams are generated from output response of the system subjected to which of the following input?
   a. Impulse b. Step c. Ramp d. Sinusoidal

18. How is instability determined in a control system based on the open-loop frequency response?
   a. Unstable systems have a phase lead exceeding 180°.
   b. Unstable systems exhibit an amplitude ratio (AR) exceeding unity at 180° phase lag.
   c. Stable systems have an AR exceeding unity at 180° phase lag.
   d. Instability is indicated by a phase lag below 180°.

19. For the transfer function $G(s)=\frac{K(1+\tau_3 S)}{(1+\tau_1 s)(1+\tau_2 s)}$, the system has fast response if
   a. $\tau_3 < 0$ b. $\tau_3 > 0$ c. $K < 0$ d. $K > 0$

20. The On-off controllers have limited use due to
   a. Oscillation of measured variable b. Cycling of measured variable
   c. Oscillation of controlled variable d. Cycling of controlled