Ref. No. : EX/PG/BPE/T/122A/2018

M.E. BIO-PROCESS ENGINEERING FIRST YEAR SECOND SEMESTER - 2018

BIOPROCESS DYNAMICS AND CONTROL

Time: three hour | Full marks: 100

Answer any FIVE questions
Assume any missing data
All questions carry equal marks
Symbols have usual significance

1. Explain steady state multiplicity of exothermic liquid phase reacting system taking place in a CSTR. Equation: A → B

2. Using Laplace transform method solve the following differential equations.

(a)

$$\frac{d^3x}{dt^3} + 4\frac{d^2x}{dt^2} + 5\frac{dx}{dt} + 2x = 2$$

$$x(0) = \frac{dx(0)}{dt} = \frac{d^2x(0)}{dt^2} = 0$$

(b) $$\frac{d^2x}{dt^2} + x = \sin t$$

(c) What are the characteristics of a first order system? Explain the significance of time constant. Why deviation variables are used for mathematical modeling of the system?

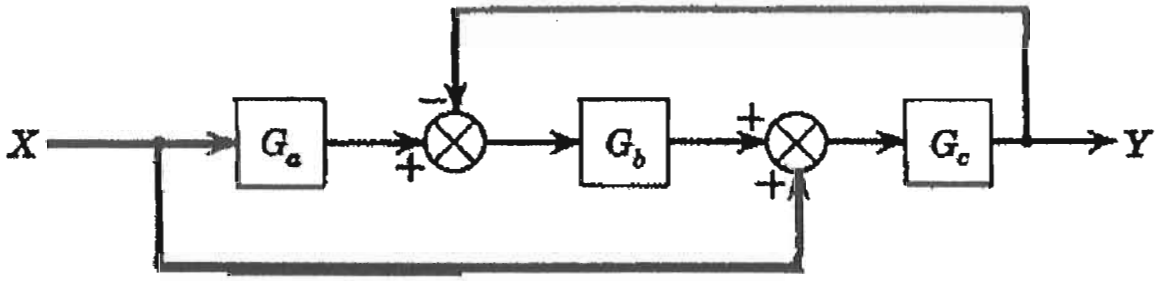
3. Draw a schematic of mercury-in- glass thermometer and derive required differential equation to predict the thermal dynamics of a system. Using Laplace transformation method solve the dynamics in case of unit step function.

4. Draw a schematic of continuous flow stirred tank heater. Derive the unsteady state differential equation for the system. Draw and explain the block diagram for feedback control loop of such a system.

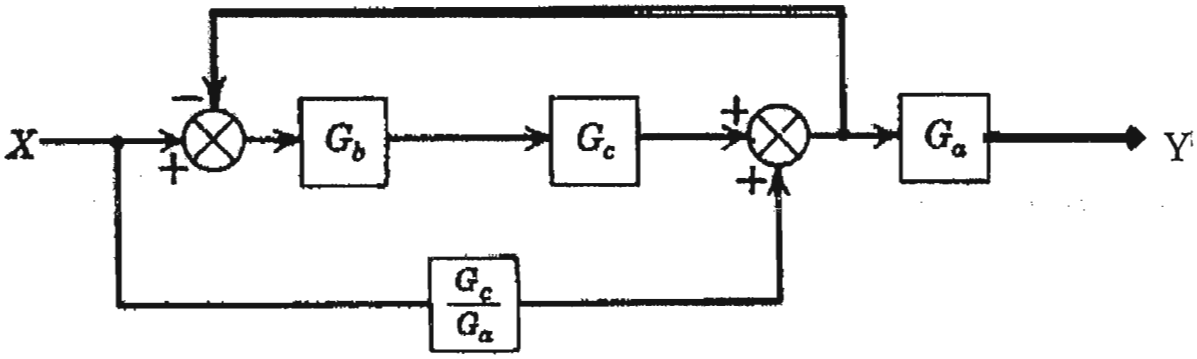
5. With suitable schematics derive the transfer function between liquid height and outflow rate for (a) two non-interacting tanks and (b) two interacting tanks.

6. Give an example of second order system. Derive unsteady state differential equation for such a system. Neatly draw response curves for different cases of a second order system and explain important parameters involved in the dynamics of second order systems.

7. Find transfer functions Y(s)/X(s) of the following block diagrams.

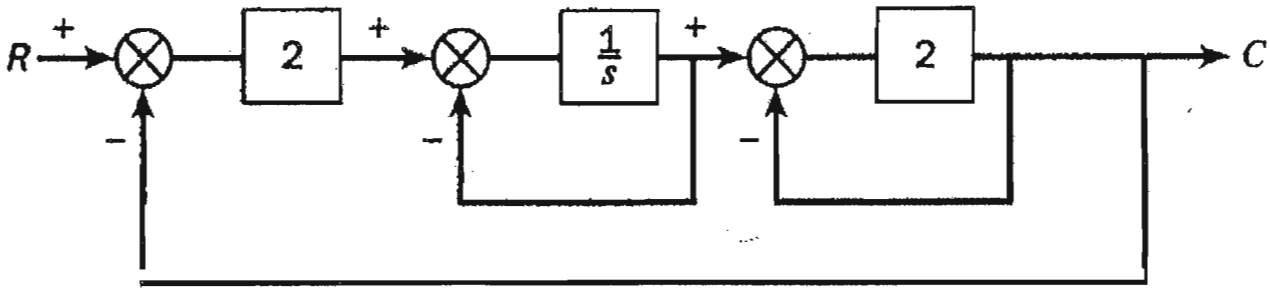


(a)

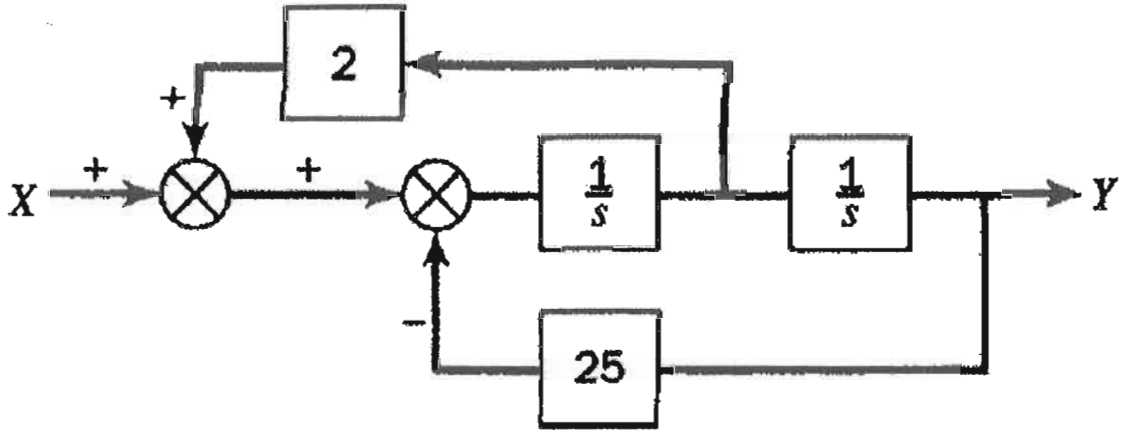


(b)

(c) Find the closed loop transfer functions C(s)/R(s)



(d) Find Y(s)/X(s)



8. What is meant by stability of a dynamic process? Explain Routh's criterion.

From the following characteristic equation determine whether the system is stable or not.

(a) $s^5 + 2s^4 + s^3 + 3s^2 + 4s + 5 = 0$

(b) $(10s+1)(5s+1)(2s+1) = 0$

9. For a unit step change in set point, find the response y for the system given below and represent graphically the dynamics of the system.