Department of Chemical Engineering
Tutorial Sheet No.1

Subject: Process Control    Semester: 6th, Chemical Engineering

Q1. Solve the differential equation $5\frac{dy}{dt}+4y=2$ , when $y(0)=1$ using Laplace transforms.

Hint: $\frac{dy}{dt}=sY(s)+Y(0)$

Answer: $Y(s)=\frac{5s+2}{s(5s+4)}$

$y(t)=0.5+0.5e^{-0.8t}$

Q2. $Y(s)=\frac{s+1}{s(s^2+4s+4)}=\frac{\alpha 1}{s+2}+\frac{\alpha 2}{(s+2)^2}+\frac{\alpha 3}{s}$, evaluate the unknown coefficients.

Hint: $\alpha 1=-1/4$

$\alpha 2=1/2$

$\alpha 3=1/4$

Q3. Find the inverse Laplace transform of $Y(s)=\frac{s+1}{s^2(s^2+4s+5)}$

Answer: $y(t)=\frac{-0.04s-0.36}{(s+2)^2+1}$

Department of Chemical Engineering
Tutorial Sheet No.2

Subject: Process Control Semester: $6^{th}$, Chemical Engineering

Q1. Consider the simple heterogeneous first-order problem

$$\frac{dx}{dt} + 2x = 4.5 \ ,$$

When $x(0) = 4$. Solve it for time domain.

Q2. Assume that a chemical compound, A is in feed stream entering a mixing tank. Assume that there is no reaction, and that the concentration of A has no effect on the density of the fluid. Also assume that the flow rate is constant and the volume in the tank is constant. The process is operating at steady-state, then concentration is suddenly changed to a new value, Find the tank outlet concentration as a function of time.

Q3. Consider the case where V= 5 $ft^3$, F= 1 $ft^3$/min and the steady state concentration (inlet and outlet) is 1.25 Ibmol/$ft^3$.Consider a step change in inlet concentration from 1.25 to 1.75Ibmol/$ft^3$. Find the c (t) and plot the concentration time profile.

Department of Chemical Engineering
Tutorial Sheet No.3

Subject: Process Control                                    Semester: 6th, Chemical Engineering

Q.1 Consider the following transfer function, subject to a unit step (Δ u=1) input change (assume time units are minutes)

$$G(s) = \frac{4}{4s^2 + 0.8s + 1}$$

Find the (1) rise time, (2) time to first peak, (3) overshoot, (4) decay ratio, (5) period of oscillation, (6) Value of y (t) at the peak time

Q.2 The open loop transfer function of unity feedback control system is given by:

$$G(s) = \frac{k}{s(\tau s + 1)}$$

(i) By what factor should k be multiplied so that damping ratio is increased from 0.2 to 0.8?

(ii) By what factor should $\tau$ be multiplied so that damping ratio is reduced from 0.6 to 0.3?

Q. 3 A second order element is known to be critically damped. Determine the time constant from the following data to the response of the element to a unit step change. Assume the steady sate gain to be unity.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Time | 0 | 2 | 4 | 6 | 10 | 16 | 20 |
| Y(t) minutes | 0 | 0.09 | 0.264 | 0.442 | 0.73 | .908 | .96 |

Department of Chemical Engineering
Tutorial Sheet No.4

Subject: Process Control                                        Semester: 6th, Chemical Engineering

Q1. A P-I controller has a proportional band of 50% and integration time of 2sec. Find the transfer function of the controller.

Q2. The transfer function of a first order plant is $G(s) = \frac{2}{1+2s}$ .It is used in a unity feedback system as shown in Fig. 1 with a proportional controller of proportional band 100%. Find the steady state error for a unit step input, and the time constant of the closed loop system.

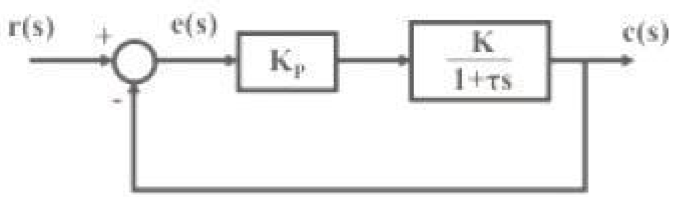


Figure 1

Q3. Repeat problem 2 if proportional band is 50%.

Q4. What would be the steady state error for the plant in problem-2 if the transfer function of the controller is $G(s) = 2(1+\frac{1}{2s})$?

Q5. Incorporation of P-I action may lead to instability in the closed loop performance-justify.

Q6. How does incorporation of derivative action in the controller improve the closed loop performance?

Q7. Why derivative control is not recommended for a flow control process?

Q8. What type of controller would you recommend for control of pH level in a liquid?

Department of Chemical Engineering
Tutorial Sheet No.5

Subject: Process Control Semester: 6th, Chemical Engineering

Q1. The location of a load change in a control loop may affect the system response. In the block diagram shown in Fig1 , a unit step change in load enters at either location 1 and location 2.

(a) What is the frequency of the transient response when the load enters at location 1?
(b) What is the offset when the load enters at 1 & when it enters at 2?
(c) Sketch the transient response to a step change in $U_1$ and to a step change in $U_2$.

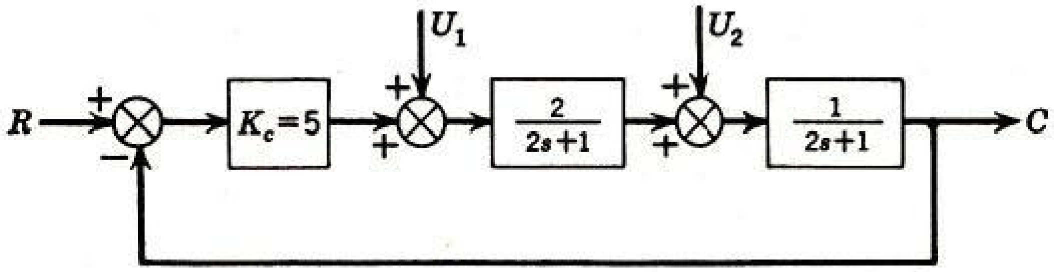


**Figure 1**

Q2. For control system shown in Fig.2 determine **(a)** C(s)/R(s), **(b)** C (∞), **(c)** Offset, (d) C (0.5)
(e) Whether the closed loop response is oscillatory.

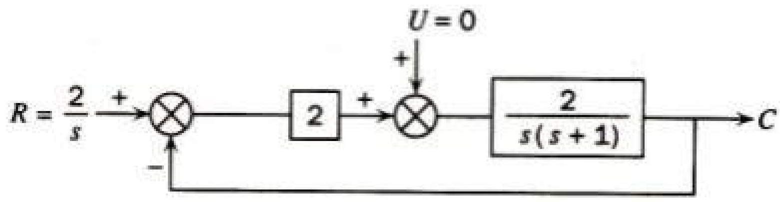


**Figure 2**

Q3. For the control system shown in Fig. 3 determine the transfer function C(s)/R(s).

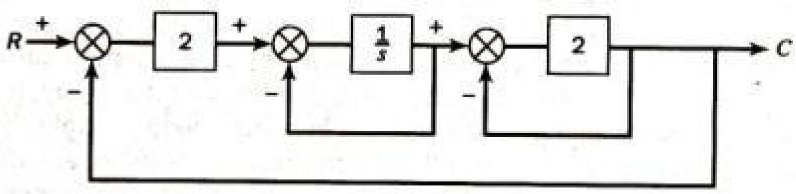


**Figure 3**

Q.4 For the control system shown in Fig. 4 determine the transfer function Y/X

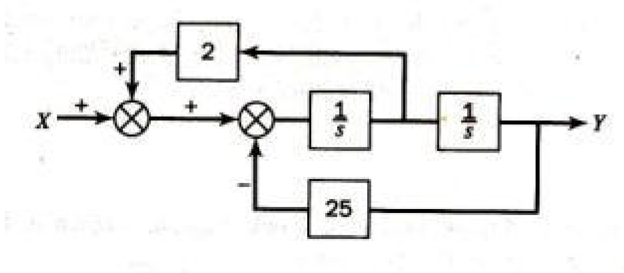


**Figure 4**