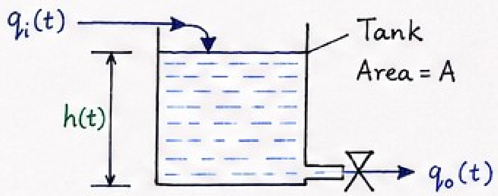
Assignment – Industrial Control (Practical Questions)

Solve any FOUR questions. Show all steps clearly.

Q1. Industrial Control Example & Mathematical Model

Consider a level control system of a single tank as shown in the figure.



$q_i(t)$: Inlet flow rate

$q_o(t)$: Outlet flow rate

$h(t)$: Liquid level

Assume linear relation $q_o(t) = (1/R)\,h(t)$, R – flow resistance.

Derive the mathematical model relating $H(s)$ and $Q_i(s)$.

Hence, obtain the transfer function

$$\boxed{G_p(s) = \frac{H(s)}{Q_i(s)} = \frac{R}{ARs + 1}}$$

Q2. Control Hardware & Their Models

(a) Draw the symbol and give the mathematical model of the following control hardware.

i) DC Servo Motor ii) Tachogenerator iii) Potentiometer

(b) A DC servo motor has the following specifications :

$J = 0.01\ \text{kg}\cdot\text{m}^2$, $B = 0.1\ \text{N}\cdot\text{m}\cdot\text{s/rad}$, $K_t = 0.01\ \text{N}\cdot\text{m/A}$,

$R_a = 1\ \Omega$, $L_a = 0.5\ \text{H}$, $K_b = 0.01\ \text{V}\cdot\text{s/rad}$.

Derive the transfer function $\frac{\Omega(s)}{V_a(s)}$ for the motor.

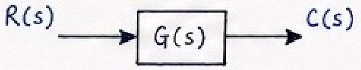
(c) What is the function of each hardware in a control system? Write any two practical applications of each.

Note: Assume zero initial conditions.

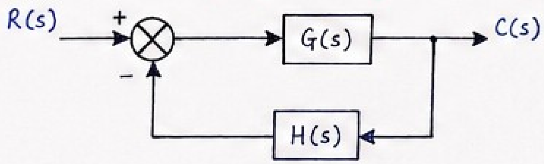
Q3. Feedback Control: Open-Loop & Closed-Loop Systems

The position control system of a motor in open-loop and closed-loop forms are shown below.

Open-Loop System



Closed-Loop System (Negative Feedback)



(a) Derive the closed-loop transfer function $\frac{C(s)}{R(s)}$.

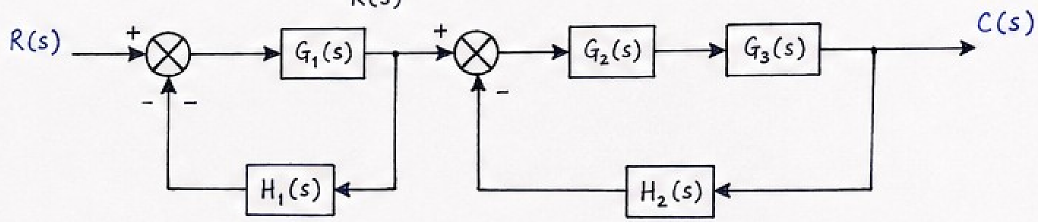
(b) List any FOUR benefits of feedback control over open-loop control.

(c) For unity feedback $(H(s) = 1)$ and $G(s) = \frac{10}{s(s+2)}$, determine the steady-state error for a unit step input.

Note: Assume stable system.

Q4. Block Diagram Algebra

Reduce the following block diagram to a single equivalent transfer function $\frac{C(s)}{R(s)}$.



Given :

$G_1(s) = \frac{2}{s+1}$, $G_2(s) = \frac{5}{s}$, $G_3(s) = \frac{1}{s+2}$

$H_1(s) = 0.5$, $H_2(s) = \frac{1}{s+3}$

Find $\frac{C(s)}{R(s)}$ and hence comment on the type of system.