Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

Subject code: 150504

Subject Name: Instrumentation and Process Control

Date: 18 /12 /2010 **Time: 03.00 pm - 05.30 pm**

Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Derive the transfer function of mercury thermometer. Determine the response of mercury thermometer for step function and also mention the important features of step response. **07**

(b) A proportional controller having gain K_C is used to control two non-interacting liquid level tanks having time constants $\tau_1 = 1$ and $\tau 2 = 0.5$, for the unity feedback control system. Determine the stability of the system using Routh criterion. **07**

Q.2 **(a)** The open loop transfer function of a control system is given as, **07**

$$G(s) = \frac{K_C}{S(S+1)(S+2)}$$

Sketch the root locus diagram of the system.

(b) Derive the transfer function of U-tube manometer system. **07**

OR

(b) A step change of magnitude 4 is introduced into a system having transfer function, **07**

$$\frac{Y(S)}{X(S)} = \frac{10}{S^2 + 1.6S + 4}$$

Determine the following,

(1) The response, Y(t)

(2) The ultimate value, Y(∞),

(3) % overshoot

(4) Maximum value of the response

(5) Period of oscillation

(6) Rise time.

Q.3 **(a)** A proportional controller is used to control a process having time constants of 2 minute and 10minute. The controlled variable is sensed by an element having time constant of 10 minute and dead time of 4 minute. The reference variable is fed to the controller summing junction through a pneumatic transmitter having a time constant of 1 minute. Draw the block diagram. Write the transfer function relating, **07**

1) The control variable and the reference variable

(2) The sensor output variable and the reference variable. Also, find the Laplace inverse of the following function

(1) $f(s) = \dfrac{1}{(\tau_1 s + 1)(\tau_2 s + 1)}$

(2) $f(s) = \dfrac{1}{(\tau\ s + 1)^2}$

(b) A control system has time constants of 1 minute and 2 minute and a proportional controller. Obtain the response of the closed loop for a unit step change in set point at a controller gain that gives damping ratio of 0.5. Would a higher or lower gain be advantageous? Why? **07**

OR

Q.3 **(a)** (1) Prove that L $\{\delta(t)\}$=1 **03**

(2) Solve the following by using Laplace transforms: **04**

$\frac{d^2x}{dt^2} + 4x = 2e^{-t}$; given x (0) = x` (0) = 0.

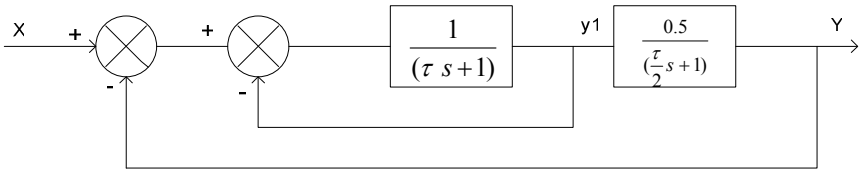
(b) (1) Give merits and demerits of P, PI and PID controller. **03**

(2) Explain Servo and Regulator control with suitable examples **04**

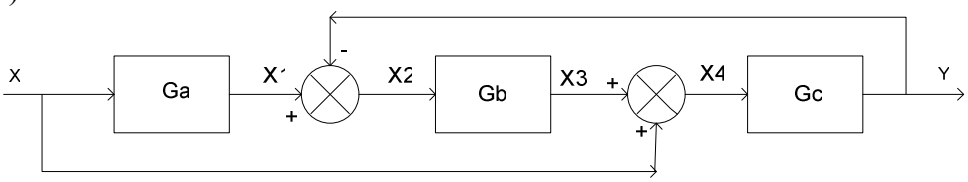
Q.4 **(a)** What is offset? Why it cannot be eliminated when P-controller is used? **07**

(b) Find $\frac{Y}{X}$ of the following closed loop control systems

1) **04**



2) **03**



OR

Q.4 **(a)** Two non-interacting tanks operating in series at a steady flow rate of $20m^3$/minute. At time t=0, $10m^3$ of water is quickly added to the 1st tank. **07**

Data:

$A_1 = A_2 = 10m^2$

$R_1 = 0.1 min/m^2$

$R_2 = 0.35 min/m^2$

$q_s = q_{1s} = q_{2s} = 20m^3/min$

Determine,

1) The level in both tanks
2) The maximum deviation in level in both tanks from the ultimate steady state values and the time at which each maximum occurs.

(b) Two interacting tanks are operating at a steady state flow rate of $4 \times 10^{-3} m^3/\min$. At time t= 0, the inlet flow rate to the 1st tank is suddenly increased to 14 $\times 10^{-3} m^3/\min$. **07**

Data:

$A_1 = A_2 = 0.04m^2$

$R_1 = 100 min/m^2$

$R_2 = 150 min/m^2$

Find the height in the level of each tank as a result of this disturbance.

Q.5 **(a)** Describe the bubbler system for liquid level measurement with neat sketch. **07**

(b) Explain principle, construction and working of venturimeter **07**

OR

Q.5 **(a)** Explain gain margin and phase margin. Give significance of each. **07**

(b) Explain working and construction of bimetallic thermometers. **07**

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