Seat No.: ________ Enrolment No. ________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– IV (New) EXAMINATION – WINTER 2019

Subject Code: 2141004 **Date: 13/12/2019**

Subject Name: Control System Engineering

Time: 10:30 AM TO 01:00 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)** Explain Masson's gain formula. **03**

(b) State and explain Open loop and Closed loop control systems. Also, compare their merits and demerits. **04**

(c) For the system shown in figure-1, determine the system transfer function $C(s)/R(s)$ using block diagram reduction technique. **07**

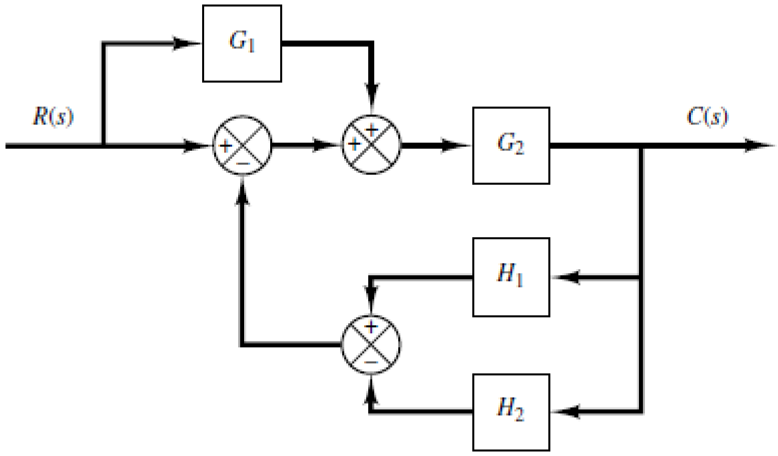

Figure – 1

Q.2 **(a)** Derive sensitivity s_G^T for closed loop control system. **03**

(b) Define: State variable, Sate trajectory, Delay time, Rise time **04**

(c) Define transfer function. Obtain the transfer of the system defined by **07**

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}-1 & 1 & 0\\ 0 & -1 & 1\\ 0 & 0 & -2\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 0\\ 1\end{bmatrix}u \qquad y=\begin{bmatrix}1 & 0 & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$$

OR

(c) Determine the value of *'K'* and *'a'* such that the system has a damping ratio of 0.8 and an undamped natural frequency of 3 rad/sec for the close loop system with $G(s) = K/s(s+2)$ and $H(s) = 1 + as$. **07**

Q.3 **(a)** Derive the expression for peak overshoot for a second order control system subjected to a unit step input. **03**

(b) What is analogous system? Explain Force-Voltage with suitable example. **04**

(c) Obtain the values of delay time t_d, rise time t_r, peak time t_p, settling time t_s and peak overshoot M_p for the given open loop transfer function of a unity feedback control system $G(s) = 25/s(s+5)$. **07**

OR

Q.3 **(a)** Derive the expression for peak time for a second order control system subjected to a unit step input. **03**

(b) Derive Correlation Between Transfer Functions and State-Space Equations. **04**

(c) Derive the expression for $e(t)$ for a unity feedback system having forward transfer function $G(s)=\dfrac{\omega_n^{\,2}}{s(s+2\xi\omega_n)}$. **07**

Q.4 **(a)** Define: Frequency response, Gain margin, Phase margin **03**

(b) Discuss: Relative stability **04**

(c) Sketch the Root locus plot for the unity feedback system having transfer function $G(s)=\frac{K}{s(s+1)(s+3)(s+5)}$ **07**

OR

Q.4 **(a)** Define: Root locus, Polar plot, Break-in point **03**

(b) Explain, how to obtain Gain margin and Phase margin using Polar plots? **04**

(c) Determine gain margin and phase margin using bode plot for the system having transfer function $G(s)H(s)=10/s(1+0.5s)(1+0.01s)$ and comment on stability. **07**

Q.5 **(a)** The characteristic equation of Feedback control system is **03**

$$s^4+2s^3+(4+K)s^2+9s+25=0$$

Determine range of K for system stability.

(b) Discuss in brief about PID controller. **04**

(c) What is compensator? Explain Phase-Lag compensator in detail. **07**

OR

Q.5 **(a)** By means of Routh criterion, determine the range of K for stability of the system described by characteristic equation, $s^3+8s^2+2s+4K=0$. **03**

(b) Draw the polar plot for the given transfer function $G(s)H(s)=\frac{10}{s(s+2)(s+5)}$ **04**

(c) A unity feedback system with open loop transfer function $G(s)=\frac{K}{s(s+2)}$ is to be compensated to meet the following specifications: **07**

- Damping ration $\xi=0.5$
- Damped natural frequency $\omega_n=4\ rad/sec$

Design the lead compensator to meet the given specifications.

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