Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–IV(New) EXAMINATION – SUMMER 2016

Subject Code:2141004 Date:03/06/2016

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 Do as directed. (short questions) **14**

(1) List out the features of negative feedback in a closed loop system.

(2) What is steady-state error?

(3) Define pole, zero and order of a control system.

(4) What are the advantages of state space analysis?

(5) Draw the block diagram/signal flow graph representation of the system described by the state model $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}a_1 & a_2 & 0\\ 1 & 0 & 1\\ 0 & 1 & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}1\\ 0\\ 0\end{bmatrix}u$ and $y=x_3$.

(6) The closed loop transfer function of a second order system is given by $\frac{200}{s^2+20s+200}$. Determine the damping ratio and natural frequency of oscillation.

(7) What is polar plot? Draw the polar plot of $G(s)=1/(1+sT)$.

(8) With graphical representation, explain How the roots of characteristic equation are related to stability?

(9) What is Nyquist stability criterion?

(10) How will you find the gain K at a point on root locus?

(11) Sketch the frequency response (bode) plot of $G(s)=1/(1+sT)$.

(12) What is the effect on system performance, when a proportional controller is introduced in a system?

(13) State the transfer function of lead compensator and draw its pole-zero plot.

(14) What is PD-Controller and what are its effect on system performance?

Q.2 **(a)** For the given mechanical translation system as shown in Fig. 1. Write down differential equations, represents in Force-Voltage analogy. **03**

(b) Obtain the state space representation of armature controlled DC motor with load. Consider armature current i_a, the angular displacement of shaft θ, and the speed $d\theta/dt$ as state variables, and θ as output variable. **04**

(c) A linear feedback control system has the block diagram shown in Fig. 2. Using block diagram reduction rules, obtain overall transfer function $C(s)/R(s)$. **07**

OR

(c) For the signal flow graph shown in Fig. 3, using Masson's gain formula determine the overall transmission C/R. **07**

Q.3 **(a)** Define thermal resistance and thermal capacitance. Also derive the transfer function of Thermometer placed in water bath as a Thermal system. **03**

(b) Find the position, velocity and acceleration error constants, for a unity feedback control system has the open loop transfer function $G(s) = 10(s+2)/s^2(s+1)$. **04**

(c) Obtain the state model and give block diagram representation for a system whose closed-loop transfer function is given as, **07**

$$\frac{Y(s)}{U(s)} = \frac{10(s+4)}{s(s+1)(s+3)}$$

OR

Q.3 **(a)** Using suitable diagram derive the transfer function of liquid level system with interaction. **03**

(b) A unity feedback system has a open loop transfer function of $G(s) = \frac{20(s+5)}{s(s+0.1)(s+3)}$. Determine the steady-state error for parabolic input. **04**

(c) The open-loop transfer function of a unity feedback system is given by $G(s) = \mathrm{K}/s(s\mathrm{T}+1)$. where K and T are positive constant. By what factor should the amplifier gain K be reduced, so that the peak overshoot of unit step response of the system is reduced from 75% to 25%. **07**

Q.4 **(a)** State advantages and limitations of Routh's stability criterion. **03**

(b) Using R-H criterion determine the relation between K and T so that unity feedback control system whose open-loop transfer function given is stable $G(s) = \frac{K}{s[s(s+10)+T]}$. **04**

(c) Investigate the stability of a closed-loop system whose open-loop transfer function is $G(s)H(s) = \frac{5}{s(1+5s)}$ using Nyquist stability criterion. **07**

OR

Q.4 **(a)** What do you understand by absolute stability and relative stability? Which method indicates what type of stability? **03**

(b) Explain, How the gain and phase margin are obtained from Nyquist plots? **04**

(c) Draw the Bode plot for a system having $G(s)H(s) = \frac{100}{s(s+1)(s+2)}$. **07**

Find out Gain margin, Phase margin, Gain crossover frequency and phase cross over frequency.

Q.5 **(a)** What is breakaway and breakin point? How to determine them? **03**

(b) Determine the relation between the phase margin and damping ratio for an underdamped second-order system. **04**

(c) Sketch the root locus of the system whose open-loop transfer function **07**

is $G(s) = \dfrac{K}{s(s+2)(s+4)}$. Find the values of K so that the damping ratio of the closed-loop system is 0.5.

OR

Q.5 **(a)** How will you obtain the transfer function from Bode magnitude plot? **03**

(b) What is lag compensator? With respect to the electrical equivalent phase-lag compensator state the transfer function, draw its pole-zero plot, and the bode plot of lag compensator. **04**

(c) Design suitable lead compensator for a system with unity feedback and having open-loop transfer function **07**

$$G(s) = \frac{K}{s(s+8)}$$

to meet the following specifications:

(i) Percentage peak overshoot = 9.5%

(ii) Natural frequency of oscillation, $\omega_n = 12$ rad / sec

(iii) Velocity error constant, $K_v \geq 10$.

Fig. 1 (For Q.2 (a))

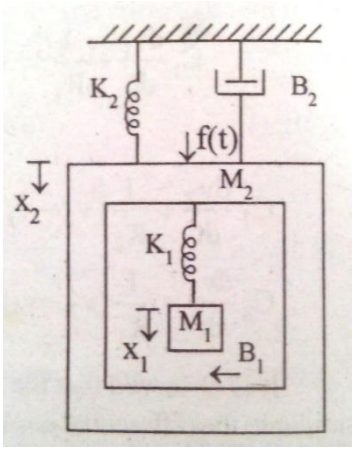

Fig. 2 (For Q.2 (c))

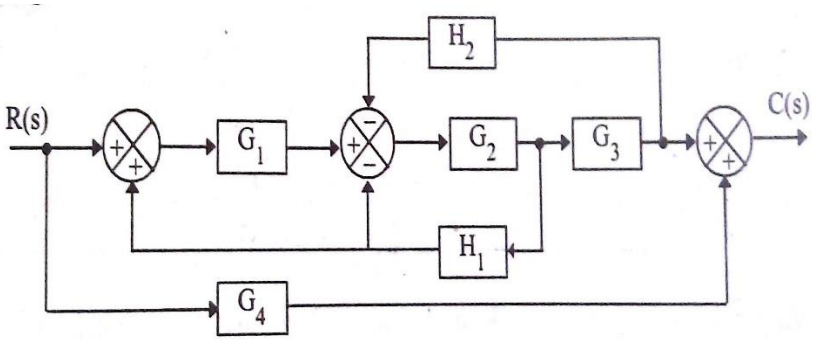

Fig. 3 (For Q.2 OR (c))