G 496 (Pages : 4) Reg. No.................................

Name....................................

B.TECH. DEGREE EXAMINATION, MAY 2014

Sixth Semester

Branch : Applied Electronics and Instrumentation

CONTROL SYSTEM THEORY (A)

(Prior to 2010 Admissions)

[Old Scheme—Supplementary/Mercy Chance]

Time : Three Hours Maximum : 100 Marks

Graph sheet and Semilog sheets to be supplied.

Part A

Answer **all** *questions briefly.*
Each question carries 4 *marks.*

1. Derive the electrical analogous quantities in F-V analogy for a simple mechanical translational system containing M, B, K and F.

2. Obtain the transfer function $\frac{X(s)}{F(s)}$ of the following system shown in Fig. 1.

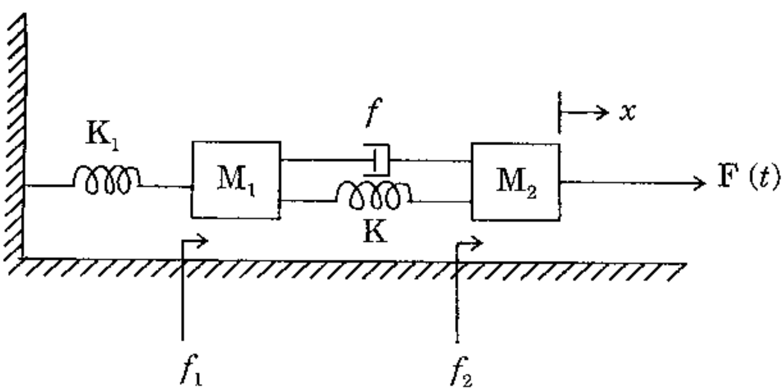

Fig. 1

3. Obtain step response of first order system.

4. Derive the expression for the static error coefficients in terms dynamic error coefficients.

5. "Addition of poles to the loop transfer function reduces the closed loop stability". Justify :

6. Define and explain the following frequency domain specifications :

   (i) Bandwidth.

   (ii) Peak resonance.

Turn over

7. Explain how the phase margin and gain margin can be read using Bode plots. Draw a typical Bode plot for a stable system and illustrate.

8. The closed loop transfer function of a system is :

$$\frac{C(s)}{R(s)} = \frac{k}{s^4 + 6s^3 + 30\,s^2 + 60s + k}.$$

Determine the range of k, for the closed loop poles to lie in the left of $\sigma = -1$ in the s-plane.

9. The characteristic equation of a discrete data system is :

$z^3 + 3.3z^2 + 4z + 0.8 = 0$. Perform Jury's test and comment on stability.

10. Differentiate the characteristics of lag and lead compensation using RC networks.

(10 × 4 = 40 marks)

Part B

Answer **all** *questions.*
Each full question carries 12 *marks.*

11. Obtain closed loop transfer function of the system given in Fig. 2 below, using signal flow chart.

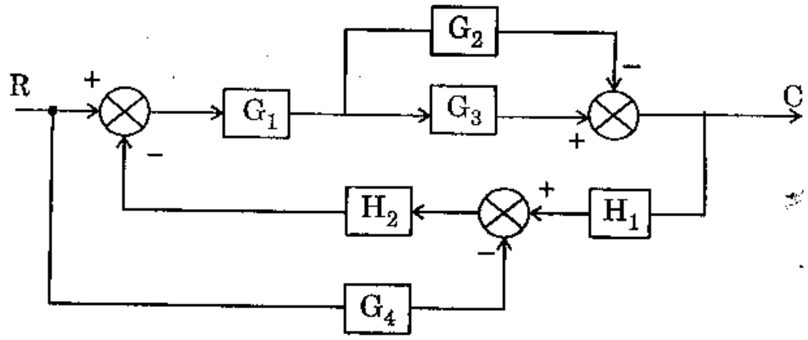

Fig. 2

Or

12. For the block diagram shown in Fig. 3, determine the overall transfer function $\frac{C(s)}{R(s)}$ by block diagram reduction and verify the results by using the Mason's gain formula.

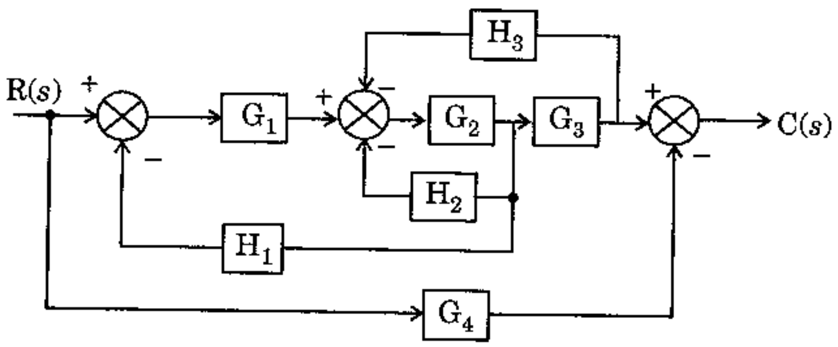

Fig. 3.

13. Find the values of k_p, k_v, k_a and the steady state error for an input of $5u(t), 5tu(t)$ and $5t^2\,u(t)$ for the system shown in Fig. 4.

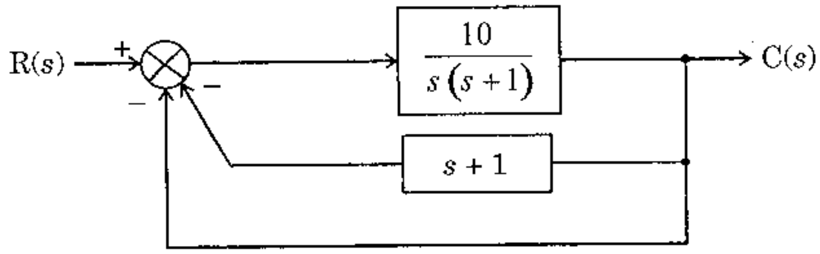

Fig. 4

Or

14. (a) The open loop transfer function of a unity feedback system is $G(s) = \frac{k}{s(\tau s + 1)}$ where k and τ are positive constants. By what factor should the amplifier gain be reduced so that the peak overshoot of unit step response of the closed loop system is reduced from 75 % to 25 % ?

(b) For a system with $GH(s) = \frac{5}{s+5}$, calculate the generalized error coefficients and steady state error. Assume $r(t) = 6 + 5\,t$.

15. Design a unity feedback system with plant transfer function $G(s) = \frac{k}{(s+1)(s+5)}$, given the following specifications :

(a) Overshoot $\leq$ 20 %

(b) Rise time $\leq$ 1 sec.

(c) Static positional error constant $\geq$ 4.

Use root locus technique.

Or

16. Draw the Bode plot for the system with open loop transfer function : $G(s)\,H(s) = \frac{10}{s(1+s)(1+0.5\,s)}$.

Hence comment on closed loop stability of the system.

Turn over

17. The open loop transfer function of a negative feedback system is $G(s)\,H(s) = \dfrac{s+1}{(s+0.1)\left(s^2+4\right)}$.

Determine the stability of the system, using Nyquist stability criteria.

Or

18. Plot the Nichol's chart of the open loop transfer function of a unity feedback system $G(s) = \dfrac{150}{s\,(s+5)}$.

19. (a) A dynamic system is represented by a state model

$$\dot{X} = \begin{bmatrix} 0 & 2 \\ -3 & -5 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u. \text{ Given } X(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}.$$

Determine state transition matrix, and obtain the unit step response of the system.

(b) Find the discrete time state transition matrix for the following system, whose discrete state equations are :

$$\dot{X}(k+1) = \begin{bmatrix} 0 & 1 \\ -10 & 6 \end{bmatrix} X(k) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(k)$$

$$y(k) = \begin{bmatrix} 1 & 1 \end{bmatrix} X(k).$$

Or

20. A unity feedback system with a forward transfer function $G(s) = \dfrac{k}{s\,(s+9)}$ is operating with a closed loop system response that has 15 % overshoot.

(a) Design a lag compensator using time domain method to improve the steady state error by a factor of 20.

(b) Evaluate the steady state error of compensated system for a unit ramp input.

(5 × 12 = 60 marks)