Code No: R22026 **R10** SET - 1

II B. Tech II Semester Regular Examinations August - 2014
CONTROL SYSTEMS
(Com. to EEE, ECE, EIE, ECC, AE)

Time: 3 hours Max. Marks: 75

Answer any **FIVE** Questions
All Questions carry **Equal** Marks
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1. a) State essential differences by giving suitable examples and also highlight their merits and demerits for open loop and closed loop systems.
   b) Write the differential equations for the Mechanical rotational system shown in Figure 1. Draw the Torque-voltage and Torque-current electrical analogous circuits. (8M+7M)

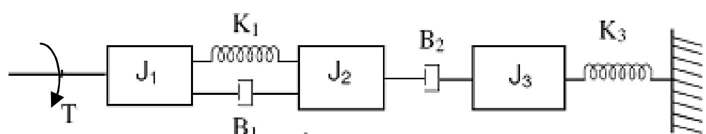

Figure 1

2. a) Derive the transfer function of armature controlled dc servomotor.
   b) For the system illustrated by the signal flow graph shown in Figure 2, obtain the overall transfer function by means of Mason's formula. (7M+8M)

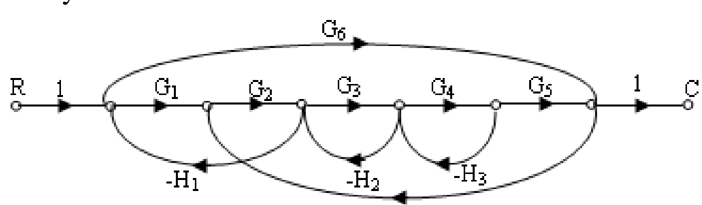

Figure 2

3. a) Illustrate the effects of proportional integral control on transient performance of feedback control systems.
   b) For a unity feedback system with open loop transfer function $G(s) = \dfrac{50}{(1+0.1s)(1+2s)}$ determine position, velocity and acceleration error constants. (8M+7M)

4. a) Construct Routh array and determine the stability of the system represented by the characteristic equation, $s^7 + 7s^6 + 20s^5 + 24s^4 + 24s^3 + 20s^2 + 20s + 15 = 0$. Comment on the location of the roots of characteristic equation.
   b) Sketch the root locus plot of unity feedback system having open loop transfer function given by: $G(s) = \dfrac{K(s+1.5)}{s(s+1)(s+5)}$. (7M+8M)
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5. The open loop transfer function of a unity feedback control system is given by:

$$G(s) = \frac{1000}{s(0.1s+1)(0.001s+1)}.$$

Draw Bode plots and from these plots determine gain margin and phase margin. (15M)

6. For a unity feedback system having open loop transfer function given by

$$G(s) = \frac{K}{s(s+1)(s+2)}.$$

Find the range of values of K for closed loop system stability using Nyquist criterion. (15M)

7. a) Draw electrical network configuration for phase-lead compensator and hence derive the transfer function for the same.
   b) Explain the procedural steps to design a phase lag compensator using Bode analysis.
   (7M+8M)

8. a) Explain about the concept of controllability and observability.
   b) Check the controllability and observability of the system described by (7M+8M)

$$\dot{x} = Ax + Bu$$
$$y = Cx$$

With

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -3 \end{bmatrix}, \ B = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} \ and\ C = \begin{bmatrix} 3 & 4 & 1 \end{bmatrix}$$

Code No: R22026 **R10** SET - 2

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1. a) Explain the necessity and effect of feedback in control systems?
   b) Determine the transfer function $E_o(s)$ to $E_i(s)$ for the network shown in figure (1).

(7M+8M)

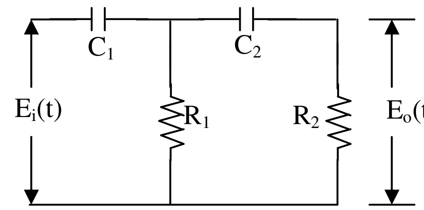

Figure (1)

2. a) Derive the transfer function for AC servomotor.
   b) Obtain the overall transfer function C(s)/R(s) of the system shown in figure 2 using block diagram reduction technique. Draw the signal flow graph for the same system and verify the result by using Mason's formula. (8M+7M)

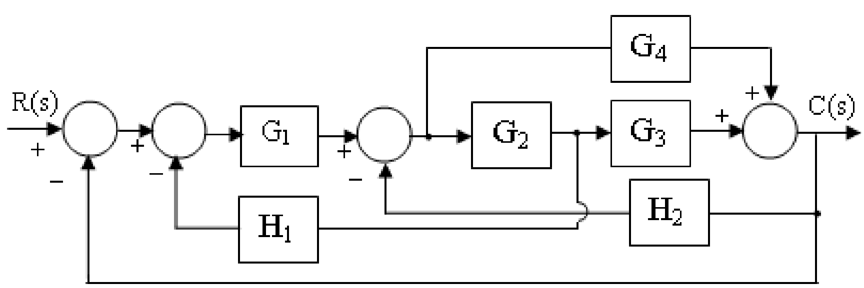

Figure 2

3. a) Sketch the unit step response of a prototype second order system and show that the percentage over shoot is a function of a damping factor alone.
   b) For a unity feedback system the open loop transfer function is given by

$$G(s) = \frac{200}{s(s+10)}$$

Determine: i) maximum overshoot ii) rise time iii) settling time and iv) steady state error if the input is a unit step. (7M+8M)

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4. a) Open loop transfer function of a unity feedback system is

$$G(s) = \frac{K}{(s+1)(s+3)(s^2+6s+25)}$$

By applying Routh Criterion, determine the values of K which will cause sustained oscillations in the closed-loop system. What are the corresponding oscillations of frequency?

b) Sketch the root locus diagram for the unity feedback system having open loop transfer function

$$G(s) = \frac{K}{s(s+4)(s^2+4s+20)}$$

(7M+8M)

5. Draw Bode plots for $G(s)H(s) = \frac{70}{s(0.25s+1)(0.1s+1)}$.

Determine gain margin and phase margin from these plots. (15M)

6. The open loop transfer function of a unity feedback control system is $G(s) = \frac{K}{(s+1)(2s+1)}$.

Use Nyquist stability criterion to determine the critical value of gain 'K' for stability. (15M)

7. a) Draw electrical network configuration for phase-lag compensator and hence derive the transfer function for the same.

b) Explain the procedural steps to design a phase lead compensator using Bode analysis.

(7M+8M)

8. a) What do you understand by state transition matrix? State and prove its properties.

b) Determine the time response of the following system

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$$

$$y(t) = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Where $u(t)$ is the unit step input and $x_1(0) = x_2(0) = 0$. (8M+7M)

Code No: R22026 **R10** SET - 3

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1. a) What is the classification of control systems and discuss the importance of mathematical modeling of a control system.
   b) For the geared system shown below in Figure 1, find the transfer function relating the angular displacement θ_L to the input torque T_1, where J_1, J_2, J_3 refer to the inertia of the gears and corresponding shafts. N_1, N_2, N_3, and N_4 refer to the number of teeth on each gear wheel. (7M+8M)

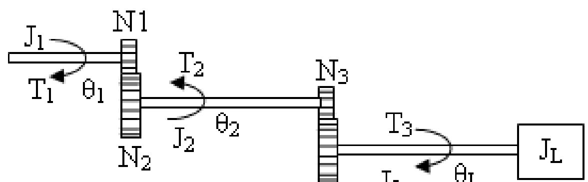

Figure 1

2. a) Explain the working of Synchro transmitter and receiver.
   b) For the system illustrated by the signal flow graph shown in Figure 2, obtain the overall transfer function by means of Mason's formula. (8M+7M)

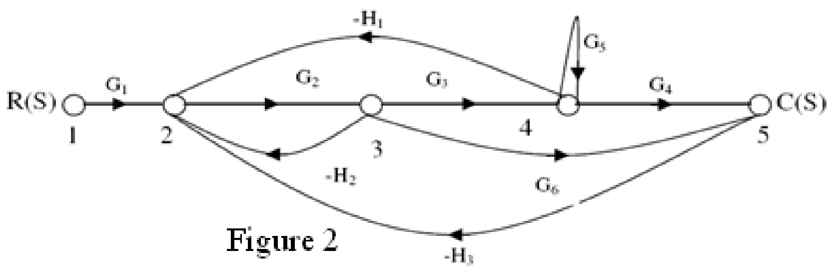

Figure 2

3. a) Illustrate the effects of proportional derivative control on transient performance of feedback control systems.
   b) For a unity feedback control system the open loop transfer function is given by

$$G(s) = \frac{10}{s(s+4)}.$$

   Determine damping ratio, natural un-damped resonance frequency, percentage peak overshoot and an expression for error response for a unit step input function. (8M+7M)
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4. a) For the system whose characteristic equation is given by
$F(s) = s(s+5)(s+6)(s^2+4s+25) + K(s+3) = 0,$
Determine the values of K which will cause sustained oscillations in the closed-loop system using Routh Criterion. What are the corresponding oscillations of frequency?
b) Sketch the root locus for the unity feedback system having open loop transfer function

$$G(s) = \frac{K}{s(s+4)(s^2+4s+40)}.$$ (7M+8M)

5. The open loop transfer function of a unity feedback control system is given by
$$G(s) = \frac{K}{s(1+0.2s)(1+0.02s)}.$$
Draw Bode plots in magnitude and phase and hence determine the following:
i) Gain margin when K = 1.
ii) The value of K for gain margin to be 20 dB.
iii) The phase margin corresponding to the above value of K.
iv) Gain margin, phase margin and corresponding frequencies for K = 10. (15M)

6. Using Nyquist criterion determine condition for stability for the unity feedback system having open loop transfer function

$$G(s) = \frac{K}{s(1+\tau_1 s)(1+\tau_2 s)}.$$ (15M)

7. a) Draw electrical network configuration for phase lag-lead compensator and hence derive the transfer function for the same.
b) Explain the design procedure for lag- lead compensation in frequency domain. (7M+8M)

8. a) Define the term state variable. What are the advantages of state space representation?
b) Find the transfer function of the system whose state space representation is given by
$\dot{x} = Ax + Bu,\ y = Cx$ with
$$A = \begin{bmatrix} -1 & -4 & -1 \\ -1 & -6 & -2 \\ -1 & -2 & -3 \end{bmatrix}, \quad B = \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix} \quad and \quad C = \begin{bmatrix} 1 & 1 & 1 \end{bmatrix}.$$ (6M+9M)

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1. a) Define the transfer function and discuss the limitations in transfer function representation.
   b) Write the differential equations for the Mechanical system shown in Figure 1. Determine the transfer function . (7M+8M)

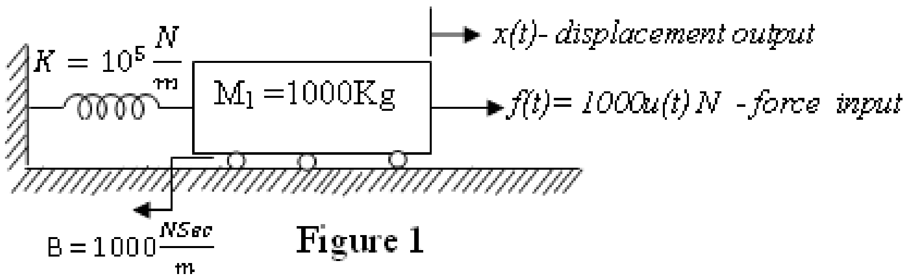

Figure 1

2. a) Derive the transfer function of field controlled dc servomotor.
   b) Obtain overall transfer function C(s)/R(s) of the system shown in figure 2 using block diagram reduction technique. Draw the signal flow graph for the same system and verify the result using Mason's gain formula. (7M+8M)

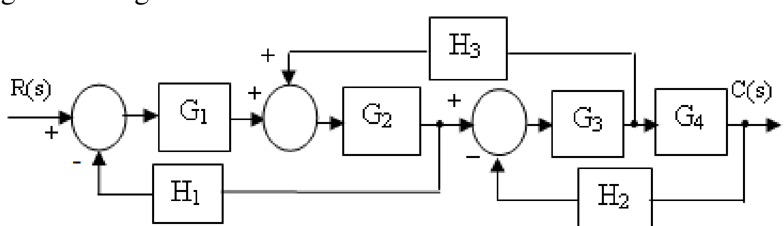

Figure 2

3. a) Illustrate the effect of the value of damping ratio on the location of closed-loop poles of a standard second order system.
   b) The open loop transfer function of a control system with unity feedback is

   $$G(s) = \frac{500}{s(1+0.1s)}.$$

   Evaluate the error series for the system and determine the steady state error of the system when an input of $r(t) = 1 + 2t + t^2; t > 0$ is applied. (6M+9M)
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4. a) Briefly explain about Routh-Hurwitz criterion.

   b) A feedback control system has loop transfer function $G(s)H(s) = \dfrac{K}{s(s+2)(s+10)}$.

   Sketch the root locus and determine the range of 'K' for which the system is stable.

   (6M+9M)

5. A unity feedback control system has forward path transfer function as $G(s) = \dfrac{36}{(s+1)(s+3)^2}$.

   Construct Bode plots and find the following:
   i) Gain crossover and phase crossover frequencies.
   ii) Gain margin and phase margin. (15M)

6. Plot the Nyquist plot for $G(s)H(s) = \dfrac{K(s-1)}{s(s+1)}$.

   For K > 0 find the number of closed loop poles in the right half s-plane and comment on stability. (15M)

7. a) Design a lag compensator that will provide a phase lag of 50^0 and alternation of 15 dB at 2 rad/sec. Also determine the transfer function

   b) Write the transfer function of a lag compensator and draw its pole zero and frequency response plots. (7M+8M)

8. a) Explain the concept of state, state various and stoke model.

   b) Find $x_1(t)$ and $x_2(t)$ of the system described by $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$ where the initial conditions are $x_1(0) = 1$ and $x_2(0) = -1$. (7M+8M)