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

II B.Tech II Semester, Regular Examinations, April/May – 2012
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) Write the differential equations governing the mechanical system shown below fig. 1.1 and determine the transfer function $Y_1(s)/F(s)$.

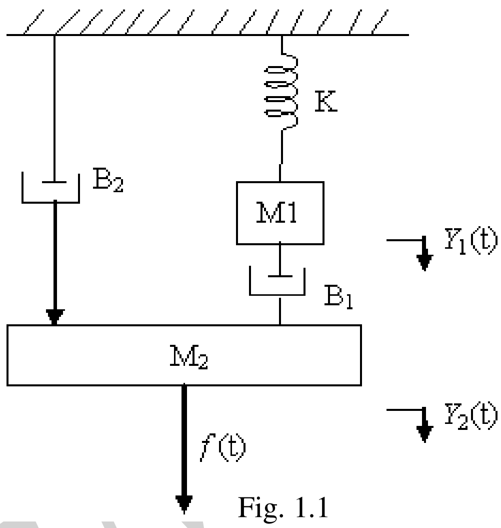

Fig. 1.1

b) Discuss the advantages and disadvantages of closed loop control systems

2. a) Explain the working principle of AC servomotor.
b) Find the overall gain C(S)/R(S) for the block diagram shown below fig.2.1.

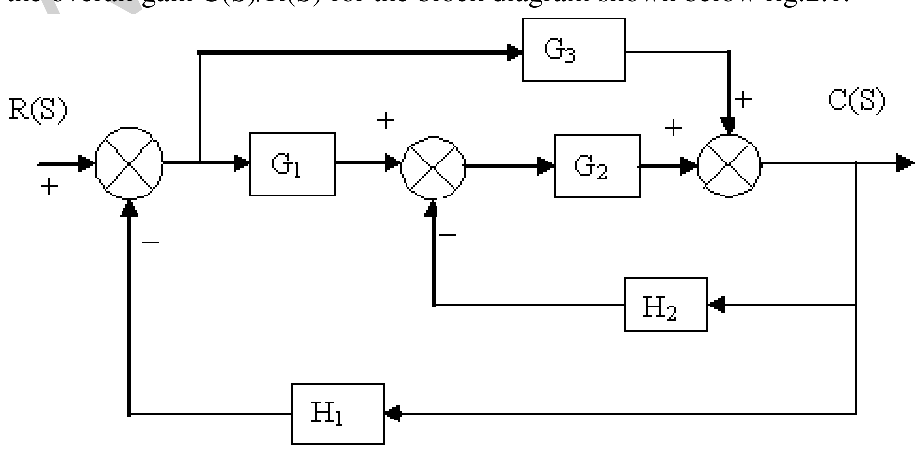

Fig. 2.1
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3. a) The open-loop transfer function of a negative unity feedback control system is $G(s) = \frac{K}{s(s+10)}$

   Find the range of K for which the peak overshoot is less than 12 %. For K = 64, obtain rise time, percentage overshoot, peak time and settling time when subjected to unit step input.

   b) Show that a derivative feedback has the effect of increasing the damping ratio without affecting the undamped natural frequency of oscillations.

4. a) By means of Routh criterion, determine the stability of the system represented by the characteristic equation $s^4 + s^3 + 2s^2 + 2s + 5 = 0$. Comment on the location of the roots of the characteristic equation.

   b) The characteristic equation of a second order feedback control system is $s^2 + 7s + (K + 12) = 0$. Show that there exists a break-away point on the real axis for the root locus of the system. Find the break-away point, the value of K at this point, the open-loop poles and the closed loop poles.

5. Draw the log-magnitude plot and phase plot for a system with open-loop transfer function

   $$G(s)H(s) = \frac{12650}{(S+10)(S+20)^2}$$

   And obtain the gain margin and phase margin of the closed-loop system.

6. The open loop transfer function of a negative feedback control system is given by

   $$G(s)H(s) = \frac{K}{(S+1)(S+2)(S+3)}$$

   Using Nyquist stability criterion, find the range of values of K for which the system remains stable.

7. The open loop transfer function of a unity feedback system is

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

   Design a lead compensator to have a velocity-error constant of 20 s^{-1} and a phase margin of atleast 50^0.

8. a) Obtain the state space representation of an armature controlled dc motor.

   b) The state equation of a linear system is given by $[\dot{x}] = \begin{bmatrix} -1 & -2 \\ 0 & -4 \end{bmatrix}[x] + \begin{bmatrix} 1 \\ 0 \end{bmatrix}[u]$

   Obtain the state transition matrix.

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

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1. a) Discuss about the reduction in effect of parameter variations by use of feedback.
   b) For the mechanical system shown below fig.1.2 find the transfer function X(S)/F(S).

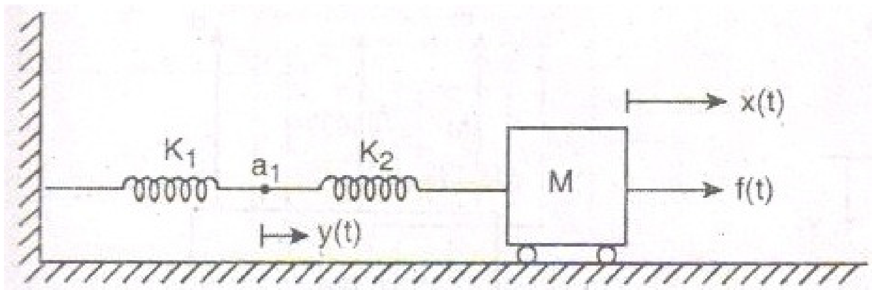

Fig. 1.2

2. a) For the signal flow graph shown below fig.2.2 using Mason's gain formula obtain C(s)/R(s).

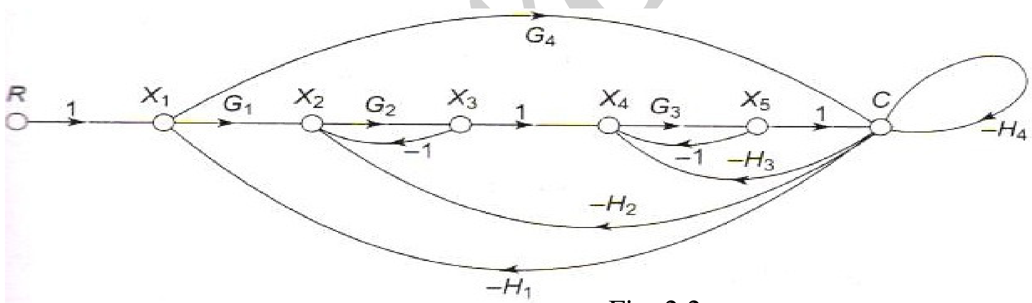

Fig. 2.2

   b) With the help of a schematic explain the operation of synchro transmitter.

3. a) A unity feedback system has an open loop transfer function $G(s)=\frac{10}{s(s+2)}$. Determine the rise time, percentage overshoot, peak time and settling time for a unit step input.
   b) Determine the position, velocity and acceleration error constants for a unity feedback control system whose open loop transfer function is given by
   $G(s)=\frac{k}{s(s+4)(s+10)}$ For k = 200, determine the steady state error for a unit ramp input.
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4. a) Determine the range of 'K' for which the unity negative feedback system whose open loop transfer function $G(s)=\frac{K}{s(s^2+s+1)(s+4)}$ is stable.

   Also determine the critical value of gain for which the system has sustained oscillations.

   b) Consider a negative feedback system with $G(s)H(s)=\frac{K}{s(s+1)(s+2)}$

   Sketch the root locus.

5. Sketch the bode plot for a system with unity feedback having the transfer function,

   $G(s)=\frac{1000(s+1)}{s(s+2)(s+5)(s+10)}$ and assess its closed-loop stability.

6. The open loop transfer function of a negative feedback system is

   $G(s)H(s)=\frac{K(s+1)}{s^2(s+2)(s+11)}$ Using Nyquist stability criteria, determine the range of K for which closed loop system is stable.

7. Design a compensating network for $G(s)=\frac{K}{s(1+0.2s)(1+0.01s)}$ So that its phase margin at least will be 40^0 and the steady state error will be in the final position will not exceed 2 % of the final velocity.

8. a) Given the state equation $\dot{X} = AX$, where $A=\begin{bmatrix}-3 & 1 & 0\\ 0 & -3 & 1\\ 0 & 0 & -2\end{bmatrix}$. Determine the state transition matrix.

   b) Discuss about the properties of state transition matrix.

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

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1. a) For the mechanical system shown below fig.1.3 find the transfer function X(S)/F(S).

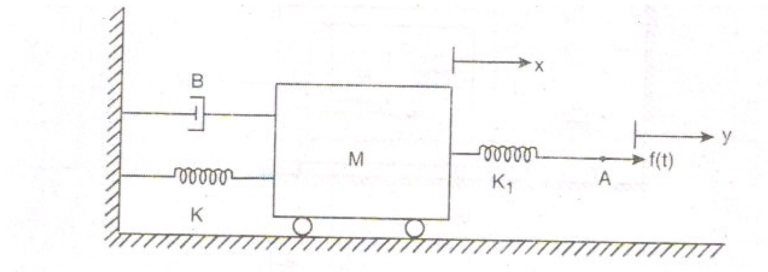

Fig. 1.3

b) Discuss the merits and demerits of closed loop control systems.

2. a) Determine the transfer function C(S)/R(S) of the system shown below fig. 2.3 by block diagram reduction method.

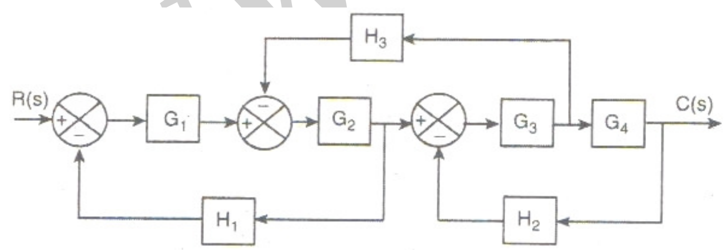

Fig. 2.3

b) Obtain the transfer function of armature voltage controlled DC Servo motor.

3. a) Derive the expressions for peak time and settling time of standard 2nd order system when subjected to a unit step input.

b) The open-loop transfer function of a unity feedback system is $G(s) = \frac{50}{s^2(s+2)}$. If the input is $r(t) = t^2+5t+3$, find the steady-state error.
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4. a) For a unity feedback system with $G(S)=\dfrac{K}{S(S^2+10S+36)}$. Find the range of K for which the system is stable. Also, determine the value of K for which the system response is oscillatory and the value of frequency of oscillations at this value of K.

   b) Discuss the effect of adding poles and zeros to G(s)H(s) on the root locus of the closed loop system.

5. The open loop transfer function, $G(S)H(S)=\dfrac{200(S+1)}{S(S+10)^2}$. Find the zero-dB frequency and phase angle at this frequency. What is the phase margin? Comment on the stability of the system.

6. The open loop transfer function of a unity feedback system is $G(S)=\dfrac{(1+4S)}{S^2(1+S)(1+2S)}$.

   i) Using Nyquist criterion, determine whether the closed loop system is stable, or not.

   ii) Does the polar plot of the open loop transfer function cross the real axis? If so find the frequency at which it crosses?

7. The open loop transfer function of a unity feedback system is $G(S)=\dfrac{4}{S(S+2)}$. Design a lead compensator for the system so that the static velocity error constant k_v = 20 sec^{-1}, the phase margin is at least 50^0, and the gain margin is at least 10 dB.

8. a) The state equation of a linear-time invariant system is given as

   $$\dot{X}=\begin{bmatrix}0 & 5\\ -1 & -2\end{bmatrix}X+\begin{bmatrix}1\\1\end{bmatrix}u \quad \text{and} \quad y=[1\ \ 1]\,x.$$

   Determine state transition matrix.

   b) Write short notes on controllability and observability.

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1. a) Discuss the effect of feedback on bandwidth and disturbance signals in closed loop systems.
   b) Distinguish between open loop and closed loop systems. Give practical examples for both.

2. a) For the signal flow graph shown below fig.1.4, find the overall gain

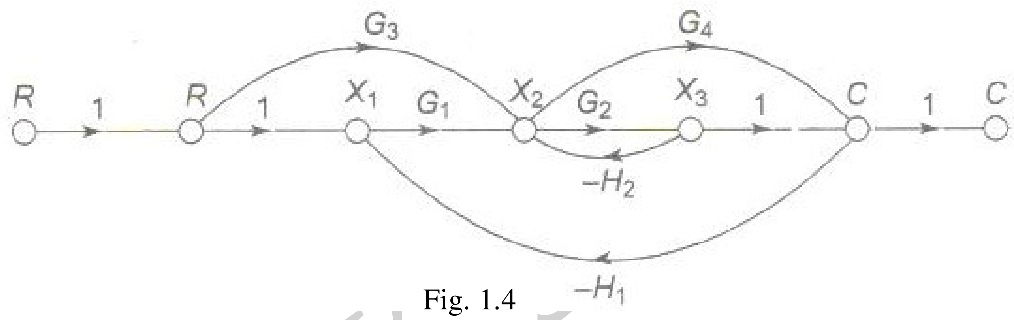

Fig. 1.4

   b) Obtain the transfer function of a field controlled DC Servo motor.

3. a) The open loop transfer function of a unity feedback system is $G(S)=\dfrac{K}{S(S+15)}$. If K = 225, what change must be made in the system to reduce the peak overshoot by 50 %, keeping the settling time the same. Also, find the new transfer function.
   b) Measurements conducted on a servomechanism show the system response to be $c(t)=2+0.4\,e^{-60t}-2.4\,e^{-10t}$ when subjected to step input of size 2. Determine the undamped natural frequency and damping ratio.

4. a) The open loop transfer function of a unity feedback control system is given by $G(S)=\dfrac{K}{(S+2)(S+4)(S^2+6S+25)}$. by applying Routh criterion, discuss the stability of the closed loop system as a function of K.
   b) Sketch the root locus of the control system whose forward path transfer function is $G(S)=\dfrac{K}{S(S^2+6S+25)}$.
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5. a) Obtain the expression for resonant frequency and resonant peak for a standard second order system.
   b) What is gain margin and phase margin? How stability analysis can be done using Bode plots?

6. a) Investigate the stability of a closed loop system with the following open-loop transfer function:
   $G(S)H(S) = \frac{K(S+3)}{S(S-1)}$. for k>1.
   b) Draw the polar plot for the following transfer function $G(S) = \frac{10(S+2)}{S(S+1)(S+3)}$.

7. The open loop transfer function of a unity feedback system is $G(S) = \frac{1}{S(S+1)(0.5\,S+1)}$.
   Design a lag compensator for the system so that the static velocity error constant $k_v = 5\ \text{sec}^{-1}$, the phase margin is at least 40^0, and the gain margin is at least 10 dB.

8. A state model of a system is given as,
   $$\dot{X} = \begin{bmatrix} 0 & 2 & 1 \\ 0 & -2 & 2 \\ -1 & -1 & -4 \end{bmatrix} X + \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix} u \text{ and } Y = [1\ 0\ 0]\ X.$$
   Determine
   i) The Eigen values
   ii) The state transition matrix
   iii) The transfer function Y(S)/R(S).