Code No: R09221004 | R09 | SET-1

B.Tech II Year - II Semester Examinations, April-May, 2012
CONTROL SYSTEMS
(COMMON TO ELECTRONICS AND INSTRUMENTATION ENGINEERING, INSTRUMENTATION AND CONTROL ENGINEERING)

Time: 3 hours **Max. Marks: 75**

Answer any five questions
All questions carry equal marks
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1.a) Distinguish between open loop and closed loop systems. Explain merits and demerits of open loop and closed loop systems.
b) Obtain the mathematical model for the system shown in Figure.1. [7+8]

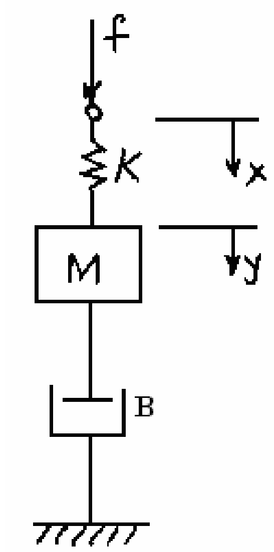

Figure.1

2.a) Derive from fundamentals, the transfer function of AC Servo Motor.
b) Using block diagram reduction techniques, find the closed loop transfer function of the system whose block diagram is given in Figure.2. [7+8]

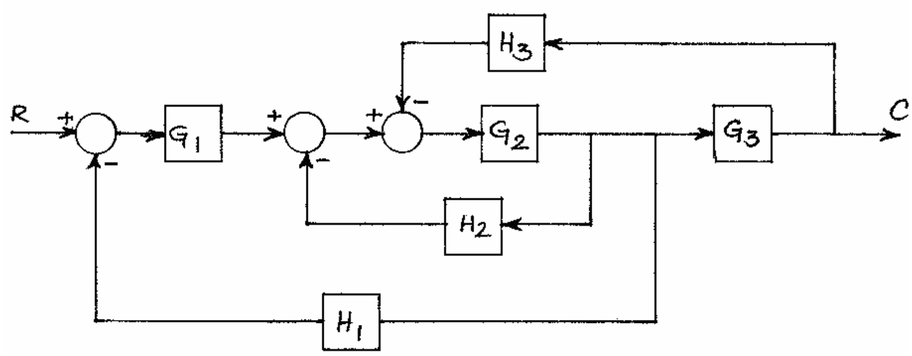

Figure.2

3. A unity feedback system has a forward transfer function of $\frac{K}{s^2}$ and a feedback elements transfer function of (as+ b). Determine steady-state error, when the input is $r(t) = 1 + t + t^2/2$. Specify the values of K, **a** and **b** to limit the steady state error for this input to 0.02. [15]

4.a) Construct the root-locus plot for the control system shown in Figure.3.

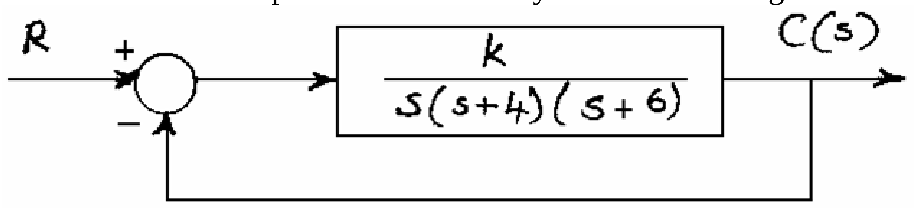

Figure.3

b) The characteristic equation of a servo system is given by $a_0 s^4 + a_1 s^3 + a_2 s^2 + a_3 s + a_4 = 0$. Determine the conditions which must be satisfied by the coefficients of the characteristic equation for the system to be stable. [15]

5.a) Consider the open loop transfer function of the system $G(s) = \frac{3}{s(0.05s+1)(0.2s+1)}$ with unity feed back. Obtain the maximum gain $M_{p\omega}$, resonant frequency ω_r and the band width ω_b of the system.

b) Explain the procedure to construct the Bode plot. [10+5]

6.a) Sketch the polar plot of the transfer function $G(s) = \frac{1}{(1+T_1 s)(1+T_2 s)(1+T_3 s)}$.
Determine the frequency at which the polar plot intersects the real and imaginary axis of $G(j\omega)$ plane.

b) Explain the term relative stability in detail. Also discuss determination of phase and gain margins from Nyquist plot.

[8+7]

7. Consider a unity – feedback control system whose feed forward transfer function is given by $G(s) = \frac{10}{s(s+2)(s+8)}$. Design a compensator so that the static velocity error coefficient K_v is equal to 80 sec^{-1} and the dominant closed-loop poles are located at $s = -2 \pm j2\sqrt{3}$. [15]

8.a) A feed back system has a closed loop transfer function. $\frac{Y(s)}{R(s)} = \frac{10}{s(s+1)(s+4)}$.
Construct a state variable model for the system.

b) Consider the homogeneous equation
$\dot{X}(t) = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} X(t)$. Find the response X(t) when $X(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$. [7+8]

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1.a) For the given lever system shown in Figure.1, determine the equation relating f and x.

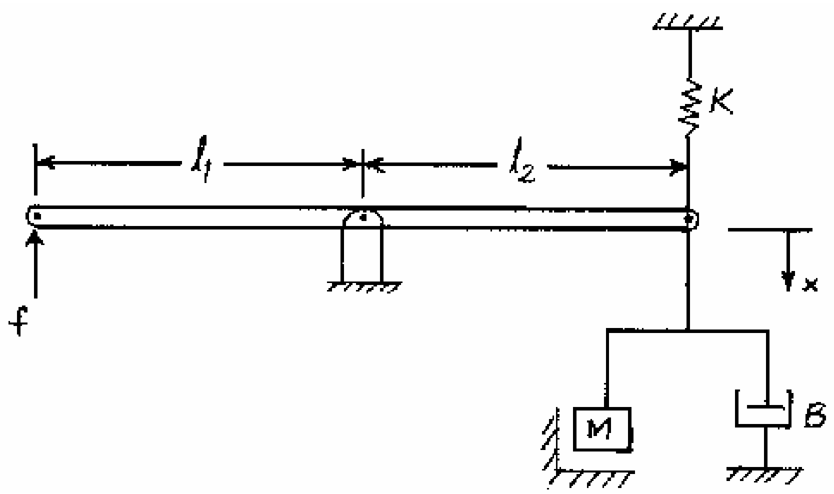

Figure.1

b) What are the various types of control systems? Give an example of each? What are advantages and disadvantages of open loop and closed loop systems? [8+7]

2. From the block diagram shown in Figure.2, determine $\frac{C_1}{R_1}$ and $\frac{C_2}{R_2}$ by making suitable assumptions. Also verify with signal flow graph technique. [15]

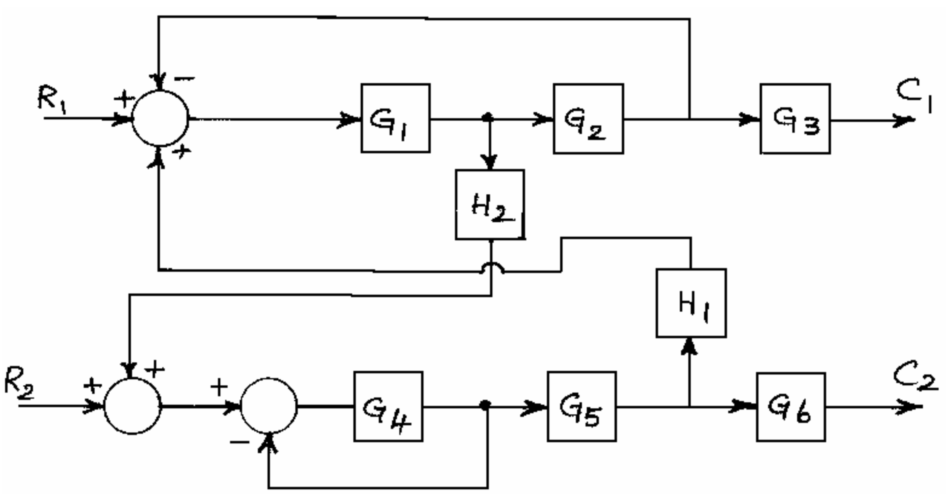

Figure.2

3. The block diagram of a feedback control system is shown in Figure.3 below. It is desired that
i) The steady state error due to a unit step function input is zero.
ii) The characteristic equation of the overall system is $s^3 + 4s^2 + 6s + 10 = 0$. Find the third order open loop transfer function G(s), so that the above two requirements are satisfied simultaneously. [15]

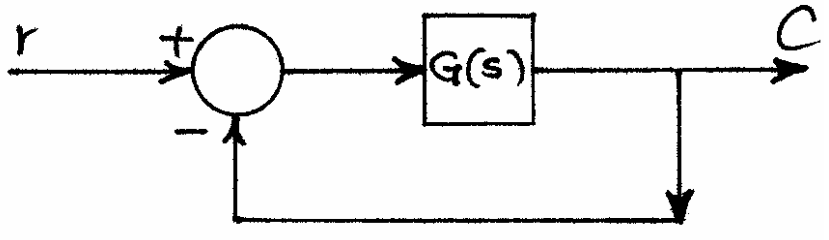

Figure.3

4. A feedback control system has an open-loop transfer function
$G(s)\,H(s) = \dfrac{K}{s(s+3)(s^2+2s+2)}$. Find the root locus as K is varied from 0 to ∞.
Also find the value of K on imaginary axis if locus crosses imaginary axis. [15]

5. Plot the approximate Bode plot for the transfer function $G(s) = \dfrac{100(s+3)}{s(s+1)^2\left(1+\dfrac{s}{30}\right)}$.
Also find the gain margin and phase margin. [15]

6.a) Explain the Nyquist criterion for assessing the stability of a closed loop system.
b) Sketch the Nyquist plot for the transfer function: $G(s)\,H(s) = \dfrac{52}{(s+2)(s^2+2s+5)}$.
Discuss its stability. [15]

7. Explain the design considerations of lead and lead-lag compensation based on frequency-response approach. [15]

8.a) Obtain the transfer function of the system described by
$\dot{X} = \begin{bmatrix} -5.0 & -1.0 \\ 3 & -1.0 \end{bmatrix} X + \begin{bmatrix} 2 \\ 3 \end{bmatrix} u$ and $Y = [1 \quad 2]\, X$.
b) The state space representation of a system is given by
$\dot{X} = \begin{bmatrix} -5.0 & 1 \\ -6 & 0.0 \end{bmatrix} X$. Find the value of $x_1(t)$ at t=1, if $x_1(0)$ and $x_2(0) = 0$. [15]

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1.a) Write the system dynamic equations for the given in figure.1 mechanical system

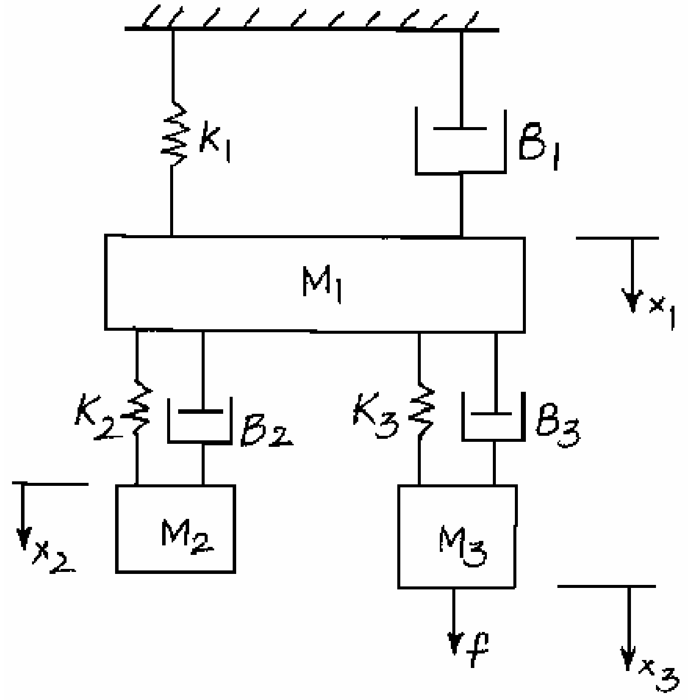

Figure.1

b) Distinguish between open loop and closed loop systems. [10+5]

2. Using block diagram reduction techniques find the closed loop transfer function of the system whose block diagram is given in Figure.2 and verify the result using signal flow graph technique. [15]

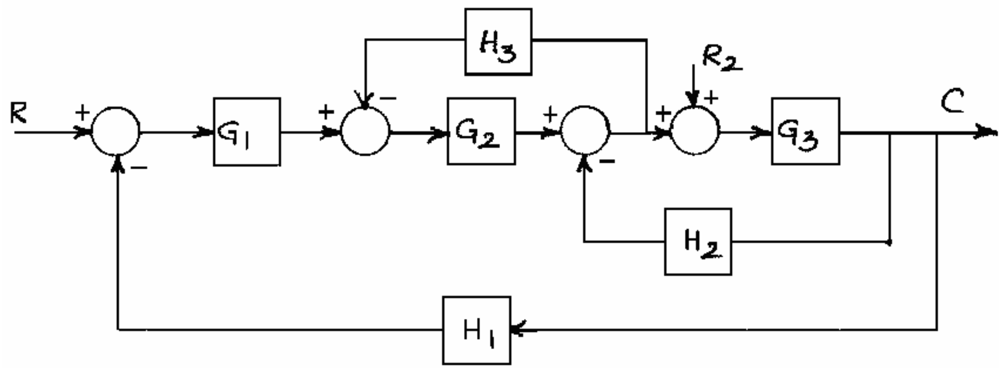

Figure.2

3. A feedback system employing output-rate damping is shown in Figure.3 below:

a) In the absence of derivative feedback ($K_o = 0$), determine the damping factor and natural frequency of the system. What is the steady-state error resulting from unit-ramp input?

b) Determine the derivative feedback K_o, which will increase the damping factor of the system to 0.6. What is the steady-state error to unit-ramp input with this setting of the derivative feedback constant?

c) Illustrate how the steady-state error of the system with derivative feedback to unit-ramp input can be reduced to same value as in part (a), While the damping factor is maintained at 0.6. [15]

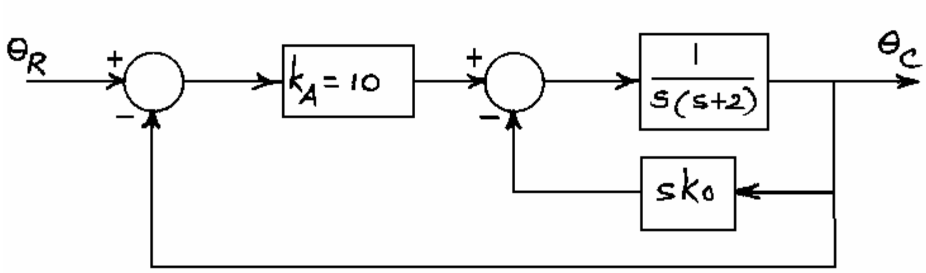

Figure.3

4. The unity feedback control system has an open-loop transfer function

G(s) = $\frac{K(1+2s)(1+0.25s)}{s^3(1+0.01s)(1+0.05s)}$. Sketch the root locus diagram. Determine the points of the loci on the jω axis and the corresponding values of gain K and frequency ω. [15]

5. Plot the approximate Bode plot for the following transfer function:

$G(s) = \frac{11.1(s^2+0.1s+9)}{s\left(1+\frac{s}{0.1}\right)\left(1+\frac{s}{10}\right)}$. Also find the gain margin and phase margin. [15]

6.a) For the given unity feedback system with: $G(s) = \frac{K(1+0.5s)(s+1)}{(1+10s)(s-1)}$, sketch the Nyquist plot and determine the range of K for which the system is stable.

b) Explain the phase margin and gain margin with respect to Nyquist criteria. [15]

7. The open loop transfer function of unity feedback system is G(s)=$\frac{k}{s(s+1)}$. It is desired to have the velocity error constant K_v=12 Sec^{-1} and phase margin as 40^0. Design lead compensator to meet the above specifications. [15]

8.a) What are the advantages of state space representation? Explain.

b) Obtain the transfer function of the system described by

$\dot{X} = \begin{bmatrix} -5.0 & -1.0 \\ 3 & -1.0 \end{bmatrix} X + \begin{bmatrix} 2 \\ 3 \end{bmatrix} u$ and Y = [1 2] X.

c) What are the properties of state transition matrix? Explain. [4+7+4]

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Time: 3 hours **Max. Marks: 75**

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1.a) Explain various types of control systems with suitable examples.
b) Explain the effects of feedback in closed loop control systems. [7+8]

2.a) Construct the Signal Flow Graph for the given set of equations
$x_2 = a_{12}\, x_1 + a_{32}\, x_3 + a_{42}\, x_4 + a_{52}\, x_5$
$x_3 = a_{23}\, x_2$
$x_4 = a_{34}\, x_3 + a_{44}\, x_4$
$x_5 = a_{35}\, x_3 + a_{45}\, x_4$.
and obtain the overall transfer function.
b) Find the closed loop transfer function of the system whose block diagram is given in Figure.1. [7+8]

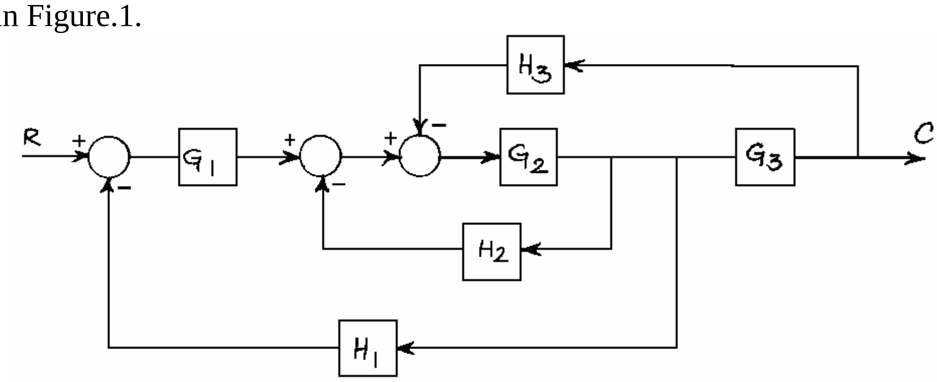

Figure.1

3\. To improve the transfer behaviour of the system, having a forward transfer function $G(s)=\dfrac{25}{s(s+2)}$ a controller with proportional and derivative action is added, as shown in Figure.2 below. Determine the value of K such that the resulting system will have a damping ratio of 0.5. What is the response C(t) of this resulting system to a unit step function excitation r(t) = u(t) when all initial conditions are zero. [15]

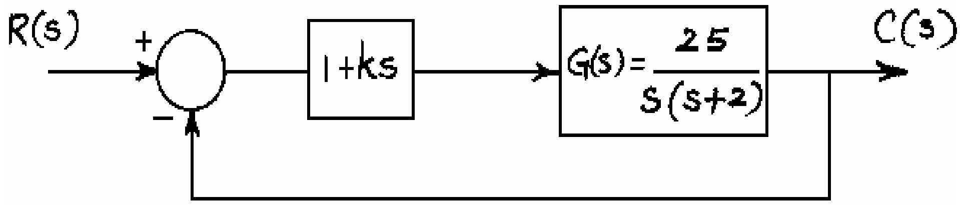

Figure.2

4. Construct the root locus diagram for the system given in Figure.3 below. Hence or otherwise find

a) The maximum and minimum values of K for system stability and

b) The value of K in the system characteristic equation that gives a damping ratio of 0.5. [15]

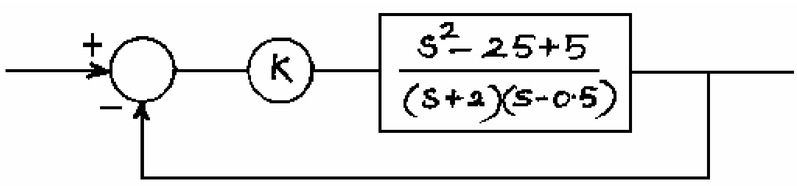

Figure.3

5. Sketch the Bode plot for the following transfer function and determine the system gain K for the gain cross over frequency ω_c to be 5 rad/sec. [15]

$$G(s) = \frac{Ks^2}{(1+0.2s)(1+0.02s)}.$$

6.a) State and explain the Nyquist stability criterion.

b) Sketch the Nyquist plot for the transfer function:

G(s) H(s) = $\frac{52}{(s+2)(s^2+2s+5)}$. Discuss its stability. [5+10]

7.a) What are different types of compensators available? Explain briefly.

b) Show that the lead network and lag network inserted in cascade in an open loop acts as proportional-plus-derivative control (in the region of small ω) and proportional-plus-integral control (in the region of large ω) respectively. [8+7]

8.a) What are the properties of state transition matrix? Explain.

b) The state space representation of a system is given by

$\dot{X} = \begin{bmatrix} -5.0 & 1 \\ -6 & 0.0 \end{bmatrix}$X. Find the value of $x_1(t)$ at t=1, if $x_1(0)$=1.0 and $x_2(0)$=0

[5+10]

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