Group – E

8. (a) Obtain the characteristic equation and the poles for the control system having state space model as

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix}=\begin{bmatrix}-1 & 0\\ 0 & -2\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}+\begin{bmatrix}0\\ 1\end{bmatrix}[u(t)];\ Y=[1\ \ 2]\begin{bmatrix}x_1\\ x_2\end{bmatrix}$$

Also check for controllability.

(b) Obtain the transfer function for the state space representation of a system given by

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix}=\begin{bmatrix}-3 & 1\\ 0 & -1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}+\begin{bmatrix}1\\ 1\end{bmatrix}[u(t)];\ Y=[1\ \ 1]\begin{bmatrix}x_1\\ x_2\end{bmatrix}$$

8 + 4 = 12

9. Write short notes on **any three:** **(3 × 4) = 12**

(i) PI and PD controller

(ii) Gain margin and Phase margin

(iii) Nyquist stability criterion

(iv) Time domain specifications of a second order system

(v) Effect of addition of poles to a closed loop system.

CONTROL SYSTEMS
(ECEN 3102)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Given $G(s)=\frac{k}{s^2(s+2)(s+3)}$, the type and order of the system is
(a) 3 and 3 (b) 3 and 0 (c) 2 and 4 (d) 3 and 1.

(ii) Whether a linear system is stable or unstable, depends on
(a) the property of the system only (b) the input function only
(c) both (a) and (b) (d) either (a) or (b).

(iii) The initial slope of the Bode plot gives an indication of
(a) Type of system (b) Order of system
(c) Stability (d) Gain margin.

(iv) The viscous friction co-efficient, in force-voltage analogy, is analogous to
(a) charge (b) resistance
(c) reciprocal of inductance (d) reciprocal of conductance.

(v) In case of type-1 system steady state acceleration error is
(a) unity (b) infinity (c) zero (d) 10.

(vi) The type of a transfer function denotes the number of
(a) Zeros at the origin (b) Poles at infinity
(c) Poles at the origin (d) None of these.

(vii) If the unity feedback system is given by the open loop transfer function $G(s) = Ks^2 / [(1 + 0.3s)(1+ 0.05s)]$, what would be the initial slope of magnitude plot?
(a) 20 dB/decade (b) 40 dB/decade
(c) 60 dB/decade (d) Unpredictable.

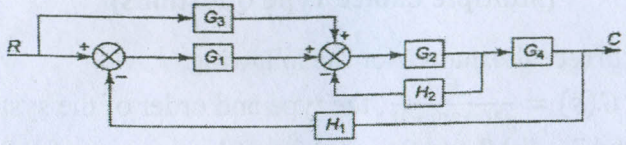
(viii) State model representation is possible using _____
(a) Physical variables (b) Phase variables
(c) Canonical state variables (d) All of the above.

(ix) The phase margin of a system is used to specify
(a) Time response (b) Frequency response
(c) Absolute stability (d) Relative stability.

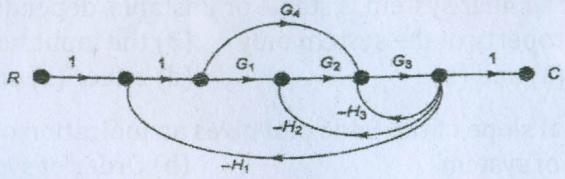
(x) The steady state error of unit ramp input in type two system is
(a) Infinite (b) Zero (c) One (d) Five.

Group - B

2. (a) Find out the overall transfer function of the system using block diagram reduction technique.



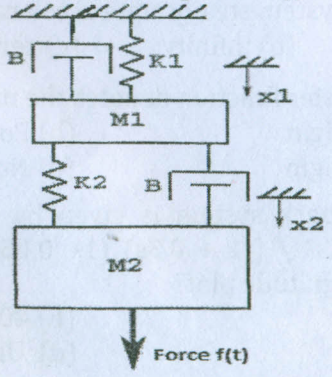
(b) Find out the overall transfer function using Mason's Gain formula.



6 + 6 = 12

3. (a) Explain the effect of negative feedback on the sensitivity of a system. What do you mean by time variant and time invariant control system?

(b) Obtain the electrical circuit analogous to the mechanical system shown in the figure based on force-voltage analogy.



(c) Write down the Mason's Gain formula and explain in the connection of signal flow graph.

(3+2) + 5 +2 = 12

Group – C

4. (a) Explain the effect of adding a pole on the unit step response of a second order system having transfer function,
$\frac{w_n^2}{s^2+2\xi w_n s+w_n^2}$. ($w_n$ and ξ have their usual meanings.)

(b) Discuss the necessary conditions for formulating the root loci for a system. A unity feedback control system has an open-loop transfer function $G(s) = \frac{k\,(s+2)}{s^2(s+10)}$. Sketch the root locus of the system.

3 + (2 + 7) =12

5. (a) Obtain the step response of a unity feedback system having open loop transfer function $G(s) = \frac{4}{s(s+5)}$.

(b) Draw the root locus for the unity feedback system whose open loop transfer function is $G(s) = \frac{k}{s(s+1)(s+3)}$. Determine the value of k for marginal stability and the frequency of sustained oscillation.

4 + 8 = 12

Group – D

6. (a) The forward path transfer function of a unity feedback control system is given by $G(s)H(s) = \frac{K}{s(1+0.1s)(1+s)}$. Draw the Bode plot.

Also determine the value of system gain, K, for the gain cross-over frequency ω_c to be 5 rad/sec. For this value of K, what is the phase margin?

(b) What do you mean by minimum and non-minimum phase transfer function?

(3 + 4 + 3) + 2 = 12

7. (a) The open loop transfer function of a unity feedback system is given by. $G(s) = \frac{5}{s(s+1)(s+3)}$. Draw the Nyquist plot and hence comment on its stability.

(b) Define relative stability.

10 + 2 = 12