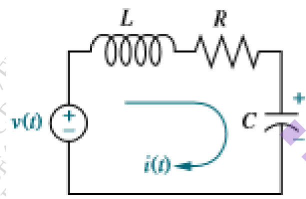
Time: (3 Hours) **Total Marks – 80**

N.B.:- (1) Question No.**1** is compulsory.
(2) **Attempt** any **three** questions out of remaining **five** questions.
(3) Draw neat diagrams wherever it is necessary.

Q. 1 **Answer any FOUR of the following** 20

a. Sketch the polar plot of the transfer function $G(s) = \frac{1}{s^2}$

b. Find the transfer function relating the capacitor voltage, $V_c(s)$, to the input voltage, V(s) in the following figure

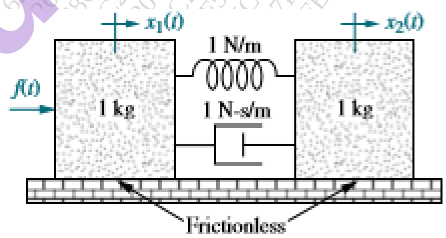


c. Represent the given system in cascade form of state space representation. Also draw SFG.

$$G(s) = \frac{5}{(s+3)(s+9)(s+7)}$$

d. Compare open loop and closed loop control systems with the help of suitable example.

e. Find the transfer function, $G(s) = \frac{X_2(s)}{F(s)}$, for the translational mechanical network shown



Q.2 a. Given the system represented in state space as follows: 10

$$\dot{x} = \begin{bmatrix} 0 & 1 & -2 \\ 0 & 3 & 1 \\ -5 & -2 & -3 \end{bmatrix} x + \begin{bmatrix} 1 \\ 0 \\ 2 \end{bmatrix} u$$

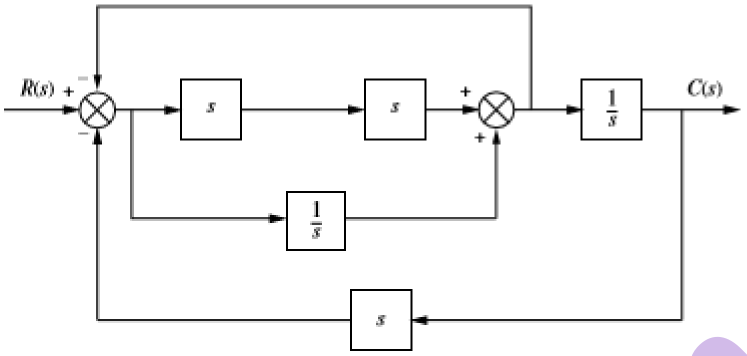
$$y = \begin{bmatrix} 1 & 3 & 2 \end{bmatrix} x$$

Convert the system to one where the new state vector, z is

$$z = \begin{bmatrix} 1 & 3 & -2 \\ 4 & -1 & 0 \\ 2 & 5 & 1 \end{bmatrix} x$$

b. Derive the formula for rise time, peak time, settling time and percentage overshoot for a second order system. 10

Q.3 a. Covert given block diagram into signal flow graph and obtain transfer function $G(s) = \frac{C(s)}{R(s)}$ using Mason's rule. 10



b. Obtain Laplace transform solution of the following system. 10

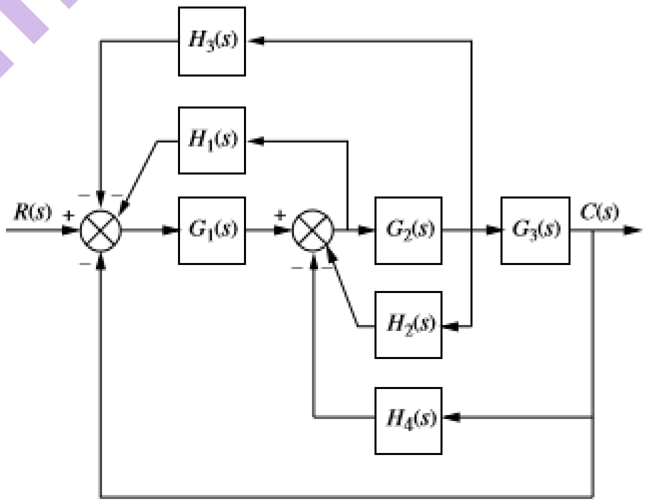
$$\dot{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -24 & -26 & -9 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} e^{-t}$$

$$y = [1 \quad 1 \quad 0]x$$

Q.4 a. Draw Bode plot for the following unity feedback system, determine ω_{gc}, ω_{pc},PM, GM and comment on the stability of the system. 10

$$\boldsymbol{G(s) = \frac{100(s+2)}{s(s+1)\,(s+4)}}$$

b. Reduce the block diagram shown below to a single block representing the transfer function, G(s) = C(s)/R(s) 10



Q.5 a. A unity feedback system has an open-loop transfer function 10

$$G(s) = \frac{K}{(s+2)(s+4)(s+6)}$$

Plot Nyquist diagram and using your diagram find the range of gain K for stability

b. The characteristics equation of a feedback control system is 10

$s^4 + 20s^3 + 15s^2 + 2s + K = 0$

a) Determine range of K for the system to be stable.

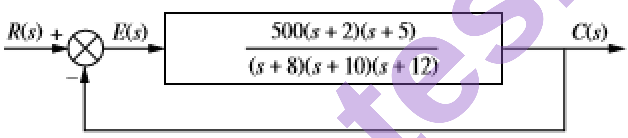
b) Can the system be marginally stable? If so, find the required value of K and the frequency of sustained oscillation.

Q.6 a. A unity feedback system has an open-loop transfer function 10

$$G(s) = \frac{K(s+3)}{s(s+1)(s+2)(s+4)}$$

Sketch the root locus

b. Evaluate the static error constants for the following system and find the expected error for the standard step, ramp, and parabolic inputs. 10



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