Time: 3 Hours **Total Marks: 80**

1. Question no. 1 is **compulsory**.
2. Answer any **three** from remaining.
3. Figures to the **right** indicate **full marks.**

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

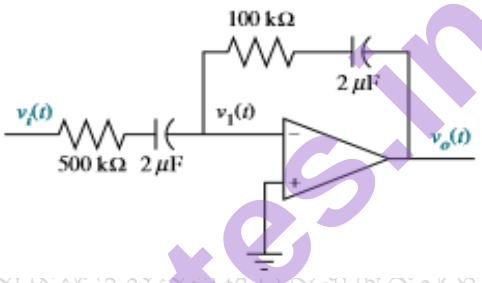
a. A system is defined by

$$\dot{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix} x + \begin{bmatrix} 10 \\ 0 \\ 0 \end{bmatrix} u$$

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

Find the transfer function, *T(s) = Y(s)/U(s)* where *U(s)* is the input and *Y(s)* is the output.

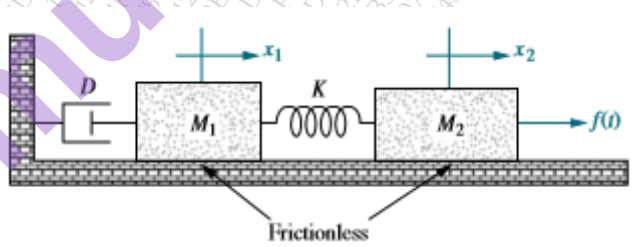
b. Find the transfer function relating the output voltage $V_o(s)$, to the input voltage, $V_i(s)$ in the following figure



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

d. Compare open loop and closed loop control systems.

e. Find the state equations for the translational mechanical system shown below



Q.2 a. Represent the given system in cascade, parallel and phase variable form of state space representation. Also draw SFG. 10

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

b. A unity feedback system has the following forward transfer function:

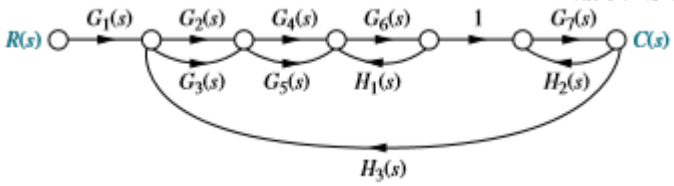
$$G(s) = \frac{1000(s+8)}{(s+7)(s+9)}$$

(i) Evaluate system type, K_p, K_v, and K_a.

(ii) Use your answers of (i) to find the steady-state errors for the standard step, ramp, and parabolic inputs.

10

Q.3 a. Obtain transfer function $G(s) = \frac{C(s)}{R(s)}$ using Mason's rule. 10

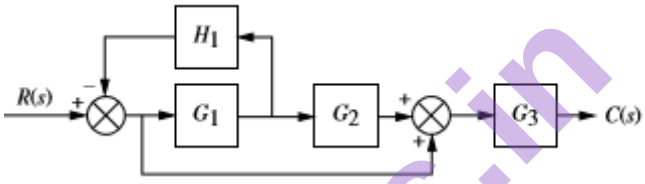


b. Derive the formula for Laplace transform solution using state space. 10

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

$$\boldsymbol{G(s) = \frac{(s+3)}{(s+2)\,(s^2+2s+25)}}$$

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. Derive and explain Nyquist stability criteria. 10

b. A unity feedback system has an open-loop transfer function

$$G(s) = \frac{K(s-2)(s-4)}{(s^2+6s+25)}$$

Sketch the root locus

Q.6 a. The characteristics equation of a feedback control system is 10
$s^4 + 2s^3 + 15s^2 + 2s + K = 0$

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.

b. For the system shown in below, find the peak time, percent overshoot, and settling time. 10