

**SECTION—IV**

7. (a) Explain the concept of 'state' and 'state variables'. 4  
 (b) Given the state equation :

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & 3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

Determine the state transition matrix.

- (c) The transfer function of a control system is given by :

$$\frac{Y(s)}{U(s)} = \frac{4s+3}{s^2 + 5s + 10}$$

Find a state model for the system using decomposition technique.

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Total No. of Pages : 4

**BT6/M11****8614****Control System Engineering**

Paper : ECE-302E, Option : I

Time : Three Hours]

[Maximum Marks : 100]

Note : — Answer any FIVE questions, selecting at least ONE question from each section.

**SECTION—I**

1. (a) Explain in brief working of a stepper motor and derive a suitable mathematical model for it. 6  
 (b) Define parameter sensitivity and explain effect of feedback on it. 4  
 (c) For the mechanical system shown in Fig. 1, write equations of motion. Determine  $X_1(s)/F(s)$  and  $X_2(s)/F(s)$  and draw electrical analog circuit. 10

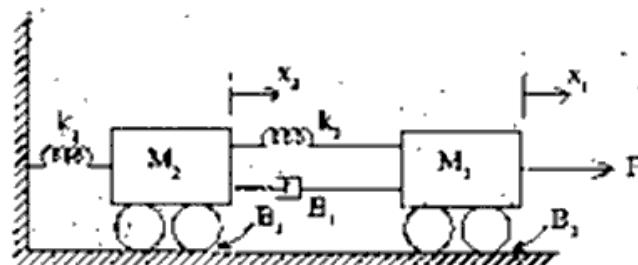


Fig. 1

2. (a) Explain the following terms with reference to signal flow graph :  
 (i) Node, (ii) Path, (iii) Loop, (iv) Transmitter. 8

- (b) Fig. 2 is a signal flow graph of a closed loop control system :  
 (i) Determine  $C(s)/R(s)$ .  
 (ii) If the branch  $K$  were made zero, the same transfer function could be still obtained by appropriately modifying  $G(s)$  branch. Determine the required modified  $G(s)$ . 12

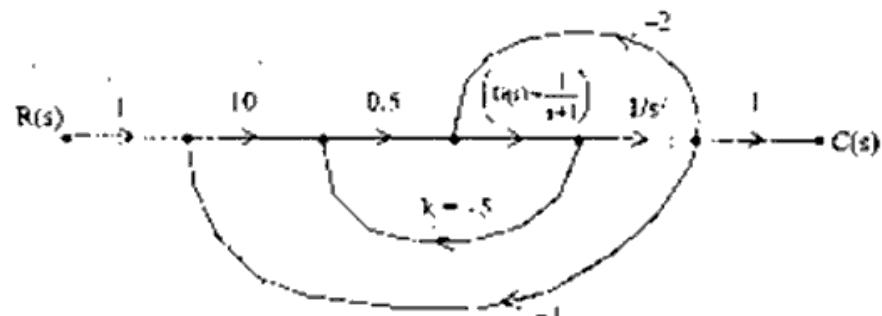


Fig. 2

### SECTION-II

3. (a) Distinguish between 'order' and 'type' of the system. 4  
 (b) The loop transfer function of a closed loop system is given by :

$$G(s) H(s) = \frac{20}{s(1+2s)}$$

Determine static error coefficients and steady state error when input is  $r(t) = 3 + 3t$ . 8

- (c) The forward path transfer function of a unity feedback control system is :

$$G(s) = \left(100 + \frac{k}{s}\right) \left(\frac{1}{2s(2s+1)}\right)$$

Determine the range of values  $k$  over which the system will remain stable. 8

4. (a) Explain time domain specifications of a second order system. Determine these quantities for a second order system characterized by transfer function :

$$\frac{C(s)}{R(s)} = \frac{40,000}{s^2 + 48.5s + 40,000} \quad 10$$

- (b) Sketch root locus of the system having  $G(s) = \frac{k}{s(s+1)}$  and  $H(s) = \frac{s+3}{s+2}$  for  $k \geq 0$ . 10

### SECTION-III

5. The open loop transfer function of a unity feedback control system is : <http://www.kuonline.in>

$$G(s) = \frac{k}{s(1+0.2s)(1+0.02s)}$$

Sketch Bode plot for  $k = 1$  and determine the gain margin, gain cross over frequency, phase margin and phase cross over frequency. Comment on effect of increasing  $k$  on the stability of the system.

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6. (a) Explain correlation between time domain and frequency domain responses. 8  
 (b) The open loop transfer function of a unity feedback system is given by  $G(s) = \frac{k}{s(s+a)}$ . Discuss stability of the system for  $k = 10$  and  $a = 2$  using Nyquist plot. Comment on stability as  $k$  and  $a$  are varied. 12