PART C — (1 × 15 = 15 marks)

16. (a) Develop the differential equations governing the mechanical translational system shown in figure 16a and determine the transfer function $\frac{V_1(S)}{F(S)}$

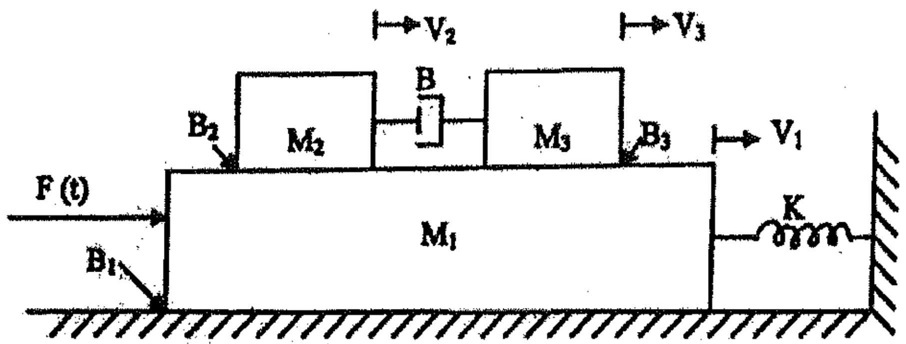

Figure 16a

Or

(b) Write the differential equations governing the mechanical system as shown it figure 16b. Draw force-voltage and force-current electrical analogous circuits.

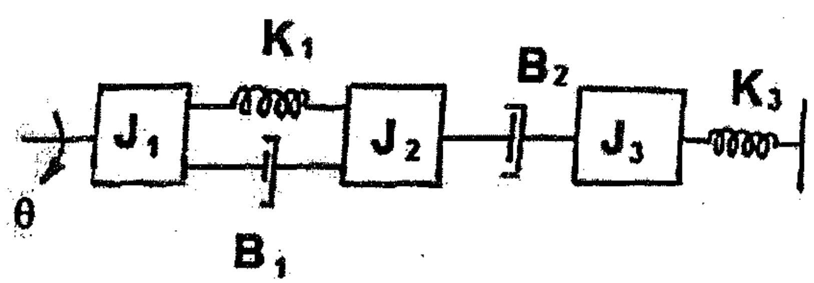

Figure 16b

Reg. No. :

Question Paper Code : 50768

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2023.

Fourth Semester

Instrumentation and Control Engineering

IC 8451 — CONTROL SYSTEMS

(Common to Electrical and Electronics Engineering/ Electronics and Instrumentation Engineering)

(Regulations 2017)

Time : Three hours Maximum : 100 marks

(Provide Semilog sheet, Polar graph and ordinary graph sheet)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Write Mason's gain formula and mention the advantages.

2. What are the advantages of a closed loop control system over open loop system?

3. The damping ratio and the undamped natural frequency of a second order system are 0.5 and 5 respectively. Calculate the resonant frequency.

4. Differentiate transient and steady state response.

5. Mention the frequency domain specifications and define resonant peak and bandwidth.

6. Draw the electrical equivalent of lag- lead compensator and write the transfer function

7. Define stability.

8. State Nyquist stability Criterion.

9. What are the advantages of state space modeling using physical variable?

10. List the important properties of a state transition matrix.

PART B — (5 × 13 = 65 marks)

11. (a) Obtain the transfer function $\frac{C(S)}{R(S)}$ for the block diagram shown in figure 11 a. using block diagram reduction technique.

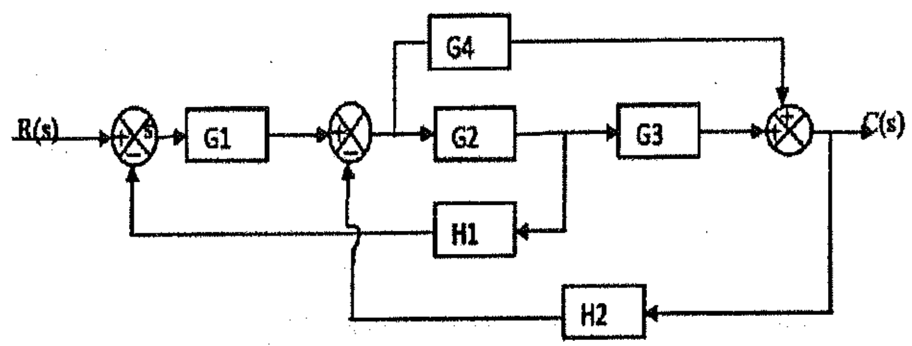

Figure 11a

Or

(b) Illustrate Mason's formula to derive the transfer function of a given signal flow graph in figure 11b.

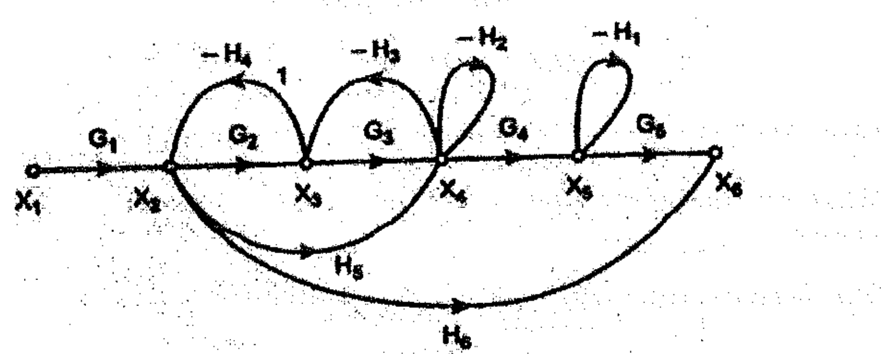

Figure 11b

12. (a) Estimate the step response of a second order under damped system. Use standard notations.

Or

(b) The unity feedback system characterized by open loop transfer function $G(S) = \frac{K}{S(S+10)}$ Evaluate the gain K such that damping ratio will be 0.5 and find time domain specifications for a unit step input.

13. (a) A unity feedback control system has $G(S) = \frac{15}{(S+1)(S+3)(S+6)}$. Draw the Bode plot.

Or

(b) Design a lead compensator to meet the following specifications for a unity feedback system with open loop transfer function $G(S) = \frac{K}{S(S+1)}$. It is desired to have the velocity error constant $K_v = 12\,\text{sec}^{-1}$ and phase margin is 40°.

14. (a) Consider the sixth order system with the characteristic equation $S^6 + 2S^5 + 8S^4 + 12S^3 + 20S^2 + 16S + 16 = 0$. Use Routh-Hurwitz criterion to examine the stability of the system and comment on location of the roots of the characteristics equation.

Or

(b) The open loop transfer function of a unity feedback system is given by, $G(S) = \frac{K}{S(S+1)+(S+5)}$ where $K > 0$. Apply Nyquist stability criterion to determine range of K over which the closed loop system will be stable.

15. (a) Solve the state equation for the system as given in below to obtain the time response $x(t)$ for a unit step input

$$X = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u; Y = \begin{bmatrix} 1 & 0 \end{bmatrix} X$$. Assume zero initial conditions.

Or

(b) Test the controllability and observability of the system by any one method whose state space representation is given as,

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(t);\ y(t) = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + o[u]$$