Reg. No. :

Question Paper Code : 70790

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 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

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. For the block diagram shown in the figure. 1, find the transfer function $\frac{Y(s)}{R(s)}$.

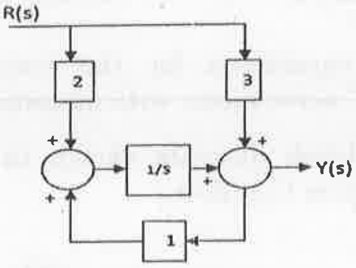

Figure. 1

2. For the mechanical system shown in Figure.2, draw the corresponding force-voltage analogy circuit.

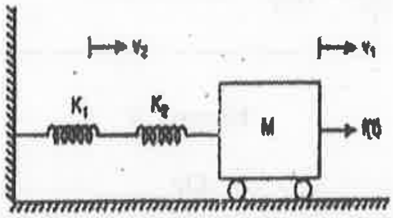

Figure. 2

3. The velocity error constant of a unity feedback control system is $K_v = 50$. Identify the information available from the given specification.

4. Mention the effects of Proportional-Integral controller on the system performance.

5. Enumerate the advantages of frequency response analysis.

6. Define gain margin and phase margin.

7. A feedback control system has characteristic equation, $s^4 + 2s^3 + 3s^2 + s + 5 = 0$. Check whether the system is stable or not.

8. The transfer function of a compensator is given as $G_c(s) = \frac{s+a}{s+b}$. If $G_c(s)$ is a lead compensator, find the value of a and b.

9. The state space representation of a separately excited DC servo motor dynamics is given as

$$\begin{bmatrix} \frac{d\omega}{dt} \\ \frac{di_a}{dt} \end{bmatrix} = \begin{bmatrix} -1 & 1 \\ -1 & -10 \end{bmatrix} \begin{bmatrix} \omega \\ i_a \end{bmatrix} + \begin{bmatrix} 0 \\ 10 \end{bmatrix} u$$

where ω is the speed of the motor, i_a is the armature current and u is the armature voltage. Find the transfer function of the motor $\frac{\omega(s)}{u(s)}$.

10. Define controllability and observability.

PART B — (5 × 13 = 65 marks)

11. (a) (i) Derive the expression for the transfer function of armature controlled DC servo motor with suitable assumptions. (6)

(ii) Reduce the block diagram shown in Figure.3 to determine the transfer function C(s)/R(s). (7)

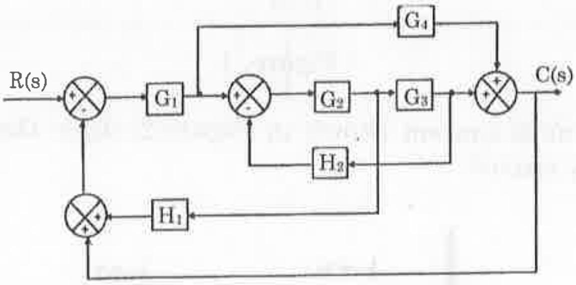

Figure. 3

Or

(b) (i) A mass-spring-dashpot system as shown in Figure.4 is mounted on a cart. The mass of the cart is M_1. The cart is moved at a constant speed. Obtain the transfer function $Y_2(s)/Y_1(s)$. (6)

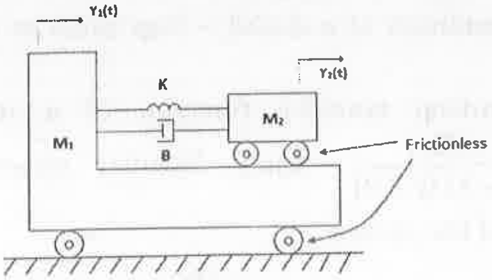

Figure. 4

(ii) From the signal flow graph shown in Figure. 5, determine the transfer function C(s)/R(s). (7)

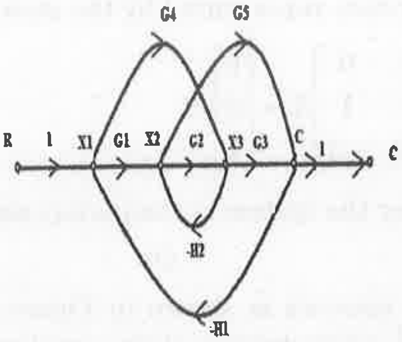

Figure. 5

12. (a) (i) Sketch the time-domain response a typical under damped second order system to a step input and indicate the relevant time domain specifications. (6)

(ii) A unity feedback system is characterized by the open loop transfer function $G(s) = \dfrac{1}{s(0.5s+1)(0.2s+1)}$. Determine the steady state errors to unit step, unit ramp and unit parabolic inputs. (7)

Or

(b) Sketch the root locus for a system with open-loop transfer function, $G(s)H(s) = \dfrac{K}{s(s+1)(s+3)}$.

13. (a) Sketch the asymptotic bode plot for the given open loop transfer function of a unity feedback system is $G(s) = \dfrac{200}{s(s+2)(s+20)}$. Calculate the gain margin and phase margin from the bode plot and assess the closed loop stability of the system.

Or

(b) Show that the magnitude response of a system with closed-loop transfer function $\frac{C(s)}{R(s)} = \frac{10}{(s+2)(s+5)}$ does not have peak resonance. Also show that the addition of a closed – loop zeros at $s = -1$ introduces resonant peak.

14. (a) The open-loop transfer function of a unity feedback system is $G(s) = \frac{Ks}{(s+1)(s+2)}$. Apply Nyquist criterion and investigate the stability of the system.

Or

(b) What are the factors to be considered for choosing suitable compensators? Realize the lag and lead compensators using electrical network and obtain the transfer functions.

15. (a) A dynamic system represented by the state equation

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

Check whether the system is completely controllable.

Or

(b) An electrical network is shown in Figure.6, select a set of proper state variables and write down a state equation in physical variable form to represent the system.

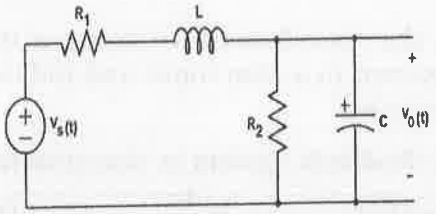

Figure. 6

PART C — (1 × 15 = 15 marks)

16. (a) A positional control system can be characterized by a unity feedback system with plant transfer function, $G_p(s) = \frac{6}{s(s+1)(s+2)}$. Design a lag compensator so that the compensated system has a phase margin of 45°.

Or

(b) For a linear time-invariant system, the transfer function is given as, $\frac{Y(s)}{R(s)} = \frac{2s+5}{s^2+4s+6}$. Draw two signal flow graphs and hence obtain two state models for the system.
