Reg. No. :

Question Paper Code : X 10355

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2020 AND APRIL/MAY 2021

Third/Fourth/Fifth Semester

Electronics and Communication Engineering

EC 8391 – CONTROL SYSTEMS ENGINEERING

(Common to Electronics and Telecommunication Engineering/Mechatronics Engineering/Medical Electronics)

(Regulations 2017)

Time : Three Hours Maximum : 100 Marks

(Provide Semilog Sheet and Ordinary Graph Sheet)

Answer ALL questions

PART – A **(10×2=20 Marks)**

1. Why negative feedback is preferred in control systems ?

2. Determine the gain of the system shown in Figure 1.

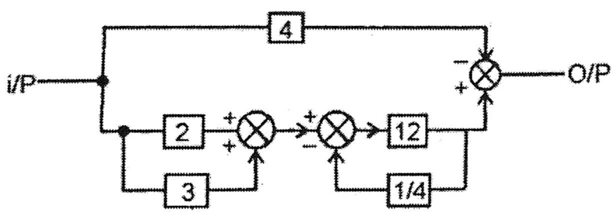

Figure 1

3. A system is described by the following differential equation $\frac{d^2y}{dt^2} + 3\frac{dy}{dt} + 2y = x(t)$ is initially at rest. For input x(t) = 2u(t), determine the output y(t).

4. The unit impulse response of a system given as $c(t) = -4e^{-t} + 6e^{-2t}$. Find the step response of the same system for $t \geq 0$.

5. The Nyquist plot of G(jω) H(jω) for a closed loop control system, passes through (–1, j0) point in the GH plane. Find the gain margin in dB.

6. The transfer function of a phase lead compensator is given by $G_c(S) = \frac{1+3TS}{1+TS}$ where T > 0. What is the maximum phase shift provided by such a compensator ?

7. Find the number and direction of encirclements around the point – 1 + j0 in the complex plane by the Nyquist plot of $G(s) = \frac{1-s}{4+2s}$.

8. What is dominant pole ?

9. How many state variables are associated with the circuit shown in Figure 2 ?

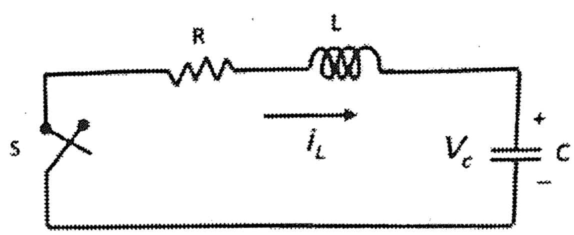

Figure 2

10. A system is represented in state-space as $\dot{x} = Ax + Bu$, where $A = \begin{bmatrix} 1 & 2 \\ \alpha & 6 \end{bmatrix}$ and $B = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$. Find the value of α for which system is not controllable.

PART – B **(5×13=65 Marks)**

11. a) i) Find the transfer function $G(s) = \frac{X_3(s)}{F(s)}$, for the translational mechanical system shown in Figure 3. **(7)**

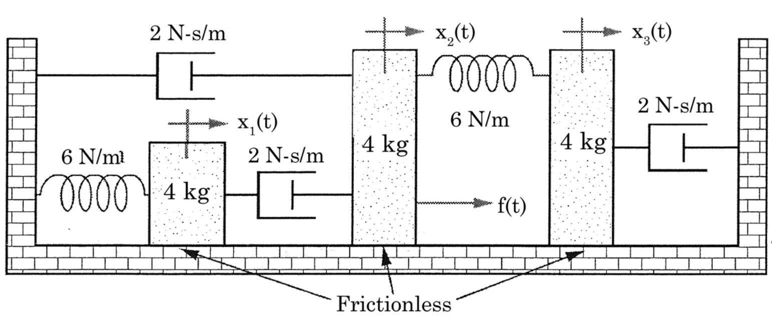

Figure 3

ii) Derive an expression for the transfer function of an armature controlled DC motor. **(6)**

(OR)

b) Determine the transfer function of the system shown in Figure 4 using block diagram reduction technique and verify it using Mason's gain formula. **(13)**

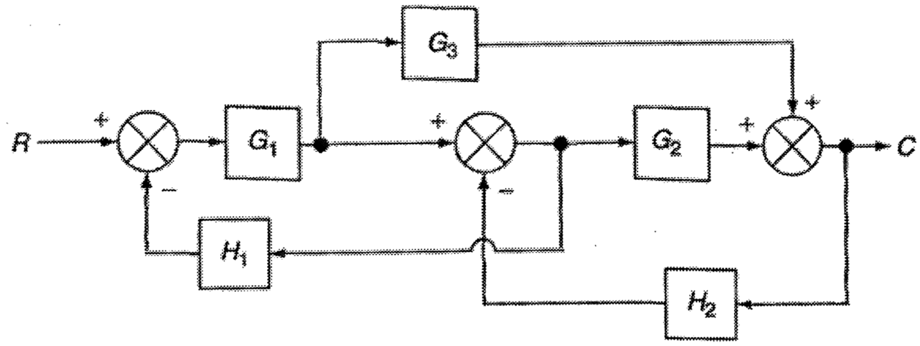

Figure 4

12. a) Derive the expression for the time response of a second order system subjected to unit step input for under damped system and also derive the expression for peak time and rise time. **(13)**

(OR)

b) With suitable block diagrams and equations, explain the following types of controllers employed in control system.

i) Proportional plus derivative controller **(4)**

ii) Proportional-plus-integral controller **(4)**

iii) PID controller **(5)**

13. a) A unity feedback system has a plant transfer function of $G(s) = \dfrac{K(s+4)}{(s-1)(s-2)}$.

i) For K=8, draw the Bode plots and find phase margin and gain margin.

ii) What would be the value of K for a phase margin of 30° and what is the corresponding gain margin ? **(8+5)**

(OR)

b) Design a lead compensator to meet the following specifications for a unity feedback system with open loop transfer function **(13)**

$$G(s) = \frac{K}{s(s+1)(s+5)}.$$

It is desired to have the velocity error constant $K_v \geq 50$ and phase margin is ≥ 20.

14. a) A feedback control system has an open loop transfer function **(13)**

$$G(s)\,H(s) = \frac{K}{s(s+3)(s^2+2s+2)}.$$

i) Sketch the root locus plot and find the range of values of K for which the system has damped oscillatory response.

ii) Find the gain K at the point where the locus crosses the 0.5 damping ratio line. **(8+5)**

(OR)

b) A unity feedback system has open loop transfer function is given by **(13)**

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

Sketch the Nyquist plot for the system and from their obtain gain margin.

15. a) Test the controllability and observability of the system by any one method whose state space representation is given as, **(13)**

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

$$\dot{y} = \begin{bmatrix} 0 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix} x$$

(OR)

b) i) Obtain state variable model in Jorden canonical form for the system with transfer function **(7)**

$$\frac{Y(s)}{U(s)} = \frac{s+3}{s^3+9s^2+24s+20}.$$

ii) A state space representation for the transfer function $\frac{Y(s)}{U(s)} = \frac{s+6}{s^2+5s+6}$ is $\dot{x} = Ax + Bu$, $y = Cx$, where $A = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$.

Determine the value C. **(6)**

PART – C **(1×15=15 Marks)**

16. a) i) Determine the values of Mass (M), Damper (D), Spring (K) for the mechanical system and its output response is shown in Figure 5. Assume that the system was initially relaxed. **(9)**

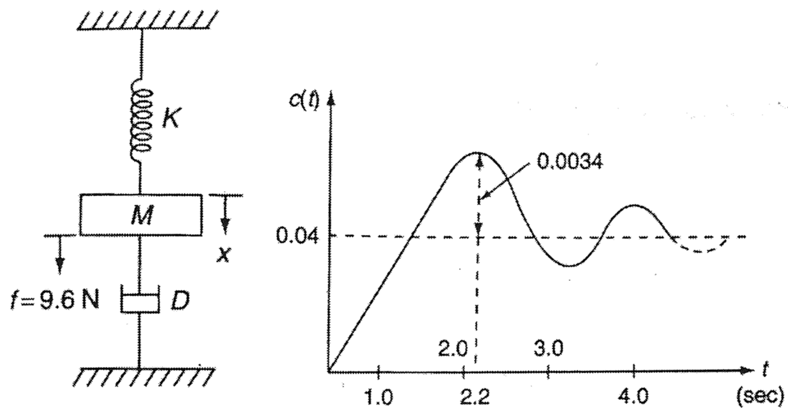

Figure 5

ii) If a unity negative feedback system having $G(s) = \frac{k(s+2)}{s^3 + ps^2 + 3s + 2}$ is marginally stable and oscillates with a frequency of 2.5 rad/sec. Determine the values of k_{mar} and p. **(6)**

(OR)

b) Sketch the root locus for the given unity feedback system that has the forward-path transfer function $G(s) = \frac{K}{(s+2)(s+4)(s+6)}$.

i) Using a second-order approximation, design the value of K to yield 10% overshoot for a unit-step input. **(10)**

ii) Determine the settling time (2% error), peak time, undamped natural frequency and steady-state error for the value of K designed in (i). **(5)**
