USN

15EC43

Fourth Semester B.E. Degree Examination, Jan./Feb. 2023

Control Systems

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. Explain any two effects of feedback on control systems. **(04 Marks)**

b. Inspect the mechanical system shown in Fig. Q1 (b) to,
   (i) Draw the mechanical network.
   (ii) Write differential equations govering the dynamic behavior of the system.
   (iii) Draw force-voltage analogous electric network of the system.

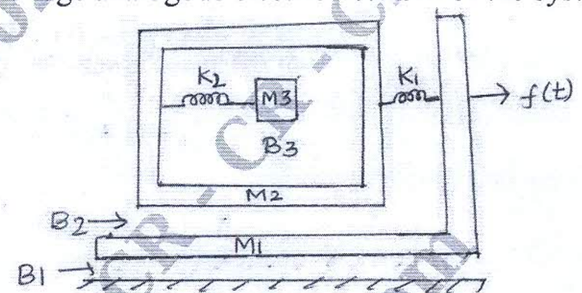

Fig. Q1 (b) **(08 Marks)**

c. Evaluate the transfer function of the system shown in Fig. Q1 (c) using Block diagram Reduction Algebra.

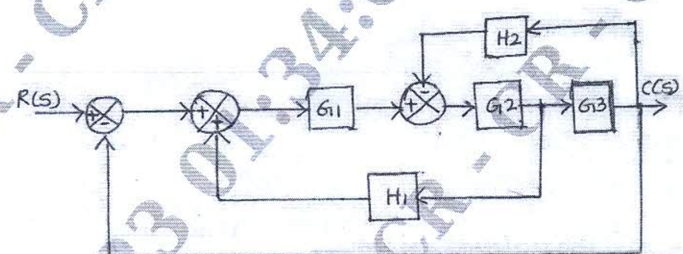

Fig. Q1 (c) **(04 Marks)**

OR

2 a. Define :
   (i) Open loop control system and closed loop control systems.
   (ii) Linear and Non-Linear control systems. **(04 Marks)**

b. Derive the transfer function of the system shown in Fig. Q2 (b)-(i) and Fig. Q2 (b)-(ii) and hence show that they are analogous to each other.

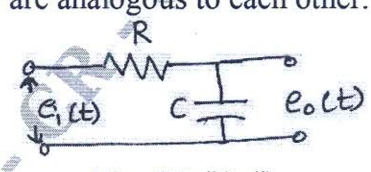

Fig. Q2 (b)-(i)

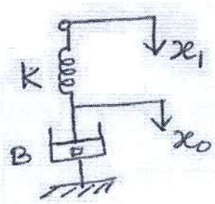

Fig. Q2 (b)-(ii)

(06 Marks)

c. Draw the signal flow graph of the block diagram shown in Fig. Q2 (c). Evaluate the transfer function using Mason's Gain formula.

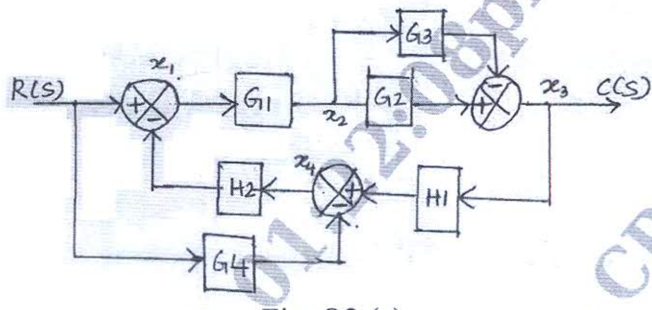

Fig. Q2 (c) **(06 Marks)**

Module-2

3 a. Define the time domain specifications : Rise Time - t_r, Peak overshoot – t_p, Settling time - t_s, Steady state error – $e_{ss}(t)$ **(04 Marks)**

b. For the unity feedback control system with $G(s) = \frac{125}{s(s+10)}$. Find (i) Peak over shoot (ii) Settling time for unit step input (iii) Steady state error an input of 5u(t). **(06 Marks)**

c. For the closed loop system with $G(s) = \frac{1}{(s+5)}$ and H(s) = 5. Evaluate the generalized error coefficients and find error series. **(06 Marks)**

OR

4 a. Explain PID controller with neat block diagram. **(04 Marks)**

b. The overall transfer function of a unity feedback system is given by $\frac{C(s)}{R(s)} = \frac{10}{s^2+6s+10}$. Evaluate the values of error constants. Also find the steady state error for the input $r(t) = 1 + t + t^2$. **(06 Marks)**

c. Obtain the rise time, peak time, maximum peak overshoot and settling time of the unit step response of a closed loop system given by,
$\frac{C(s)}{R(s)} = \frac{16}{s^2+2s+16}$ **(06 Marks)**

Module-3

5 a. Apply Routh Hurwitz criterion to determine the stability of the system whose characteristic equation is given by,
$s^5 + 2s^4 + 3s^3 + 6s^2 + 5s + 3 = 0$ **(08 Marks)**

b. The loop transfer function of a feed back control system is given by $G(s)H(s) = \frac{K(s+6)}{s(s+4)}$.
(i) Sketch root locus plot with 'K' as variable parameter and show that loci of complex roots are part of a circle.
(ii) Determine the break away and break in point, if any. **(08 Marks)**

OR

6 a. A unity feedback control system has open loop transfer function, $G(s) = \frac{K(s+13)}{s(s+3)(s+7)}$. Evaluate the range of K for which, the closed system is stable. **(06 Marks)**

b. Sketch the root locus for a unity feedback system with open loop transfer function, $G(s) = \frac{K}{s(s^2+8s+32)}$. From the plot find the range of K for which the system is stable. **(10 Marks)**

Module-4

7 a. Sketch the Bode plot showing the magnitude in decibles and phase angle in degrees as a function of log frequency for the transfer function given by,

$$G(s) = \frac{10}{s(1+0.5s)(1+0.1s)}$$

and hence determine the gain margin and phase margin of the system. **(10 Marks)**

b. The closed loop transfer function of a second order system is, $\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\tau\omega_n s + \omega_n^2}$; where τ = damping ratio and ω_n = undamped natural frequency. Obtain an expression for Resonant Peak - M_r. **(06 Marks)**

OR

8 a. The open loop transfer function of an unity feedback system is given by,

$$G(s)H(s) = \frac{5}{s(s+1)(s+2)}$$

Apply Nyquist stability criteria to assess the stability of the system. **(10 Marks)**

b. For the Bode plot shown in Fig. Q8 (b), evaluate the transfer function of the system.

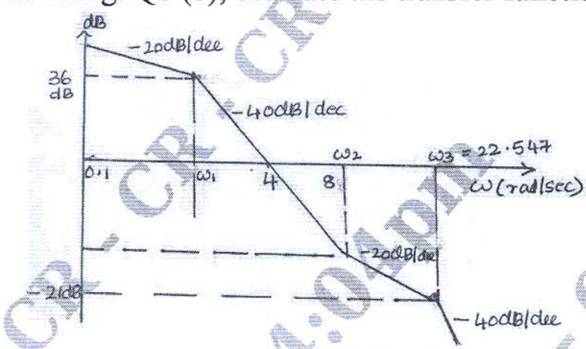

Fig. Q8 (b) **(06 Marks)**

Module-5

9 a. A sampled data system is described by the transfer function, $M(z) = \frac{y(s)}{R(z)} = \frac{1}{z^2 + a_1 z + a_2}$;

$a_1 = -\frac{3}{4}$ and $a_2 = \frac{1}{8}$; Find the response y(k) to the input, (i) $r(k) = \delta(k)$ (ii) $r(k) = u(k)$ **(06 Marks)**

b. For the system shown in Fig. Q9 (b). Evaluate the state equations.

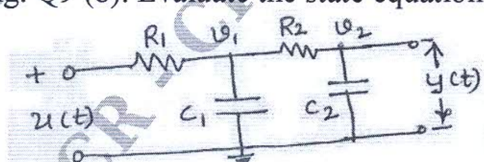

Fig. Q9 (b) **(10 Marks)**

OR

10 a. For the matrix given find the diagonalisation matrix.

$$A = \begin{bmatrix} 3 & -2 \\ -1 & 2 \end{bmatrix}$$ **(10 Marks)**

b. State the properties of state transition matrix. **(06 Marks)**

* * * * *