CBCS SCHEME

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15EC43

Fourth Semester B.E. Degree Examination, July/August 2022
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. Define control system. What are the requirements of a good control system? **(04 Marks)**

b. For the mechanical system shown in Fig.Q1(b).
(i) Draw the mechanical network
(ii) Write the differential equations
(iii) Draw an electrical network based on Force-Voltage Analogy

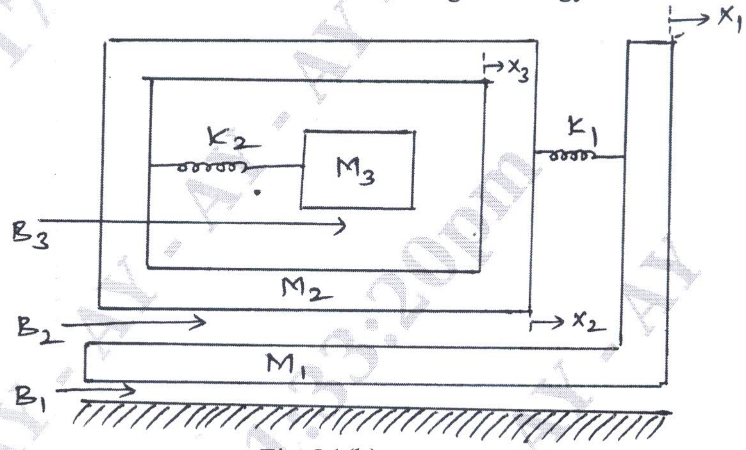

Fig.Q1(b) **(06 Marks)**

c. Draw the signal flow graph shown in Fig.Q1(c). Determine the transfer function using Mason's gain formulae.

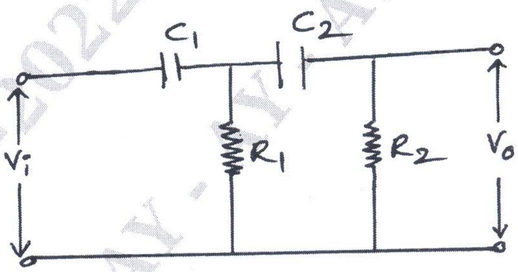

Fig.Q1(c) **(06 Marks)**

OR

2 a. Define the following terms related to signal-flow graph with a neat schematic:
(i) Forward path
(ii) Feedback loop
(iii) Self loop
(iv) Source node **(04 Marks)**

b. For the mechanical system shown in Fig.Q2(b).
   (i) Draw equivalent mechanical network.
   (ii) Write the performance equations.
   (iii) Draw torque-current analogy.

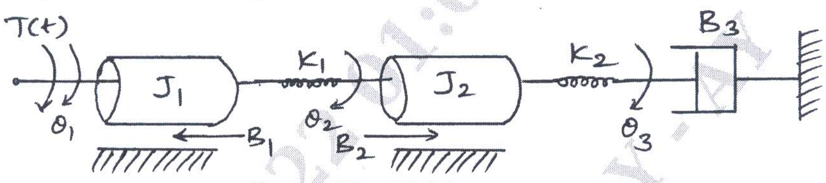

Fig.Q2(b) **(06 Marks)**

c. Obtain the transfer function of the control system whose block diagram is shown in Fig.Q2(c) using block diagram reduction techniques.

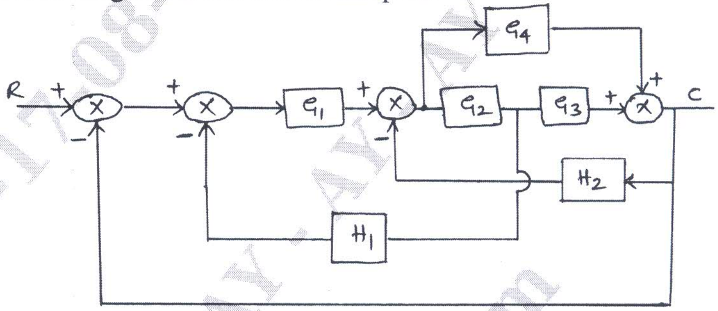

Fig.Q2(c) **(06 Marks)**

Module-2

3 a. Draw the transient characteristics of a control system to a unit step input and define the following:
   (i) Delay time (ii) Rise time (iii) Peak time
   (iv) Settling time (v) Maximum overshoot **(06 Marks)**

b. A unity feedback control system has an open-loop transfer function $G(s)=\dfrac{5}{s(s+1)}$, find the rise time, percentage overshoot, peak time and settling time for a step input of 10 units. **(06 Marks)**

c. Determine the static error coefficients for a unity feedback system given by

$$G(s)=\frac{K}{s^2(s+20)(s+30)}$$ **(04 Marks)**

OR

4 a. The response of a serve mechanism is $c(t)=1+0.2e^{-60t}-1.2e^{-10t}$ when subjected to a unit step input. Obtain an expression for closed loop transfer function. Determine the undamped natural frequency and damping ratio. **(04 Marks)**

b. A second order control system is represented by a transfer function given below:

$$\frac{\theta_0(s)}{T(s)}=\frac{1}{Js^2+Fs+K}$$

where $\theta_0(s)$ = proportional output; T = input torque. A step unit of 10 N-m is applied to the system and test results are given below:
   (i) Maximum overshoot is 6%.
   (ii) Peak time is 1 sec
   (iii) The steady state value of the output is 0.5 radian.
Determine the values of J, F and K. **(06 Marks)**

c. Find K_p, K_v and K_a for the unity feedback system represented by the following open loop transfer function $G(s) = \dfrac{100}{s^2(s+2)(s+5)}$. Determine the steady state error when input is $r(t) = 1 + t + 2t^2$. **(06 Marks)**

Module-3

5 a. For system $s^4 + 22s^3 + 10s^2 + s + K = 0$, find K_{mar} and 'ω' at K_{mar}. **(04 Marks)**

b. A given system shown in Fig.Q5(b) oscillates with frequency 2 rad/sec. Find the value of K_{mar} and P. No poles are in RHS.

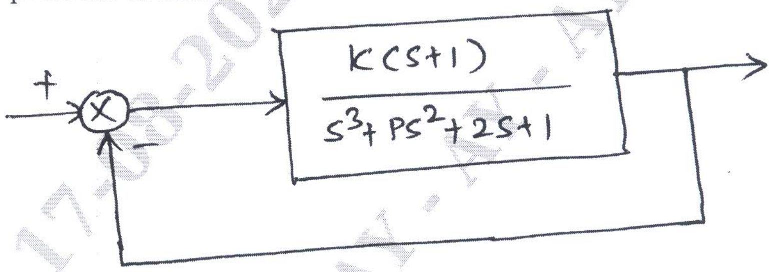

Fig.Q5(b) **(06 Marks)**

c. The open loop transfer function of control system is given by

$$G(s)H(s) = \frac{K(s+1)}{s(s-1)(s^2+5s+20)}.$$

Determine the valid break away points. **(06 Marks)**

OR

6 a. What are the necessary and sufficient conditions for a system to be stable according to Routh-Hurwitz criterion. **(04 Marks)**

b. A feedback control system has open loop transfer function

$$G(s)H(s) = \frac{K}{s(s+4)(s^2+4s+20)}.$$

Plot complete root locus for K = 0 to ∞. Indicate all the points on it. **(10 Marks)**

c. Examine the stability of given equation using Routh's method $s^3 + 6s^2 + 11s + 6 = 0$. **(02 Marks)**

Module-4

7 a. Plot the polar plot for the transfer function given $G(s)H(s) = \dfrac{1}{s(Ts+1)}$. **(06 Marks)**

b. For a certain control system $G(s)H(s) = \dfrac{K}{s(s+2)(s+10)}$. Sketch the Nyquist plot and hence calculate the range of value of 'K' for stability. **(10 Marks)**

OR

8 a. List the limitations of lead and lag compensations. **(06 Marks)**

b. A unity feedback control system has $G(s) = \dfrac{80}{s(s+2)(s+20)}$. Draw the Bode plot. Determine GM, PM, ω_{gc} and ω_{pc}. **(10 Marks)**

Module-5

9 a. Define the following terms:
(i) State (ii) State variable (iii) State space (iv) State trajectory **(04 Marks)**

b. Construct the state model using phase variables if the system is described by the differential equation

$$\frac{d^3y(t)}{dt^3} + 4\frac{d^2y(t)}{dt^2} + 7\frac{dy(t)}{dt} + 2y(t) = 5U(t)$$

where y(t) = output; U(t) = input to the system. Draw the state diagram. **(06 Marks)**

c. Consider a system having state model

$$\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \end{bmatrix} = \begin{bmatrix} -2 & -3 \\ 4 & 2 \end{bmatrix}\begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} 3 \\ 5 \end{bmatrix}U \quad \text{and} \quad Y[1 \ \ 1]\begin{bmatrix} X_1 \\ X_2 \end{bmatrix}$$

with D = 0 obtain its transfer function. **(06 Marks)**

OR

10 a. With a block diagram, explain sampled-data control system. **(04 Marks)**

b. Consider a matrix 'A' given below:

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 3 & 0 & 2 \\ -12 & -7 & -6 \end{bmatrix}$$

Determine: (i) Eigen values (ii) Eigen vectors (iii) Modal matrix **(06 Marks)**

c. Obtain the appropriate state model for a system represented by an electric circuit shown in Fig.Q10(c).

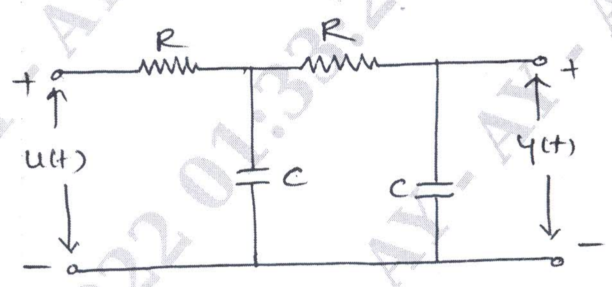

Fig.Q10(c) **(06 Marks)**

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