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17EC43

**Fourth Semester B.E. Degree Examination, July/August 2022**  
**Control Systems**

Time: 3 hrs.

Max. Marks: 100

*Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.  
2. No Handbook, No Charts, No Tables permitted.*

**Module-1**

- 1 a. Define control system. Compare open loop and closed loop system. (06 Marks)
- b. Find the transfer function  $\frac{X(s)}{E(s)}$  for an electrochemical system shown in Fig.Q1(b).

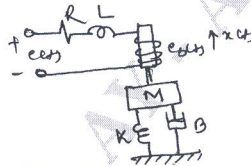


Fig.Q1(b)

- c. The system block diagram is shown in Fig.Q1(c). Find  $C(s)/R(s)$ .

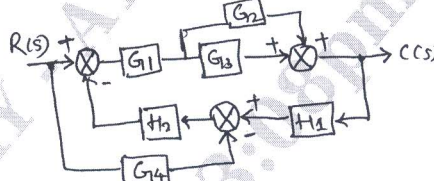


Fig.Q1(c)

**OR**

- 2 a. Define the signal flow graph and list the properties of signal flow graph. (06 Marks)
- b. Find  $C(s)/R(s)$  by Mason's gain formula shown in Fig.Q2(b).

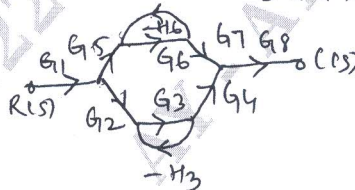


Fig.Q2(b)

- c. For the mechanical system shown in Fig.Q2(c)  
(i) Draw the mechanical network (ii) Draw force - voltage analogous electric network.

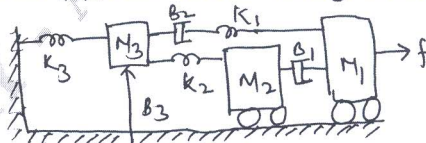


Fig.Q2(c)

**Module-2**

- 3 a. Define the following time response specifications for an underdamped 2<sup>nd</sup> order system:  
(i) Rise time  $t_r$  (ii) Peak time  $t_p$  (iii) Peak overshoot  $M_p$  (iv) Settling time  $t_s$  (04 Marks)

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.

- b. For the system shown in the Fig.Q3(b) obtain the closed loop transfer function damping ratio natural frequency and expression for the output response if subjected to unit step input.



Fig.Q3(b)

(08 Marks)

- c. The response of servo mechanism is  $c(t) = 1 + 0.2e^{-60t} - 1.2e^{-10t}$  when subjected to a unit step input, obtain an expression for the closed loop transfer function. Determine natural frequency and damping ratio. (08 Marks)

**OR**

- 4 a. Explain the PID controller and its effect. (04 Marks)

- b. For a unity feedback control system with  $G(s) = \frac{10(s+2)}{s^2(s+1)}$ , find

(i) The static error coefficients

(ii) Steady state error when the input transform is  $R(s) = 3/s + 2/s^2 + 1/3s^3$ . (08 Marks)

- c. A unity feedback system has  $G(s) = \frac{40(s+2)}{s(s+1)(s+4)}$

(i) Determine All error coefficient (ii) Error for ramp input and magnitude of 4. (08 Marks)

**Module-3**

- 5 a. State and explain Routh's stability criterion for determining stability of the system. (04 Marks)

- b. A unity feedback control system has  $G(s) = 20k / [s(s+1)(s+5)+20]$ , where  $r(t) = 2t$ . It is desired that for ramp input  $e_{ss} \leq 1.5$ . What minimum value must  $k$  have for this condition to be satisfied? With this  $k$ , is the system stable? (08 Marks)

- c. A unity feedback system has  $G(s) = \frac{k(s+13)}{s(s+3)(s+1)}$ , using Routh's criterion calculate the range of 'k' for which the system is (i) Stable (ii) has its closed loop, poles more negative than -1. (08 Marks)

**OR**

- 6 a. Derive the condition used to determine the trajectories of the root loci in the S-plane. (04 Marks)

- b. For a system having  $G(s)H(s) = \frac{k}{s(s+3)(s^2+3s+11.25)}$

Find the valid break away points and angle of departure. (08 Marks)

- c. Sketch the rough nature of the root locus of a certain control system whose characteristics equation is given by  $s^3 + 9s^2 + Ks + K = 0$ . Comment on stability. (08 Marks)

**Module-4**

- 7 a. Derive the expression for resonant peak  $M_r$  and resonant frequency  $W_r$  for a standard second order system in terms of  $\xi$  and  $\omega_n$ . (06 Marks)

- b. The closed loop transfer function of a feedback system is given by

$$T(s) = 1000 / (s+22.5)(s^2 + 2.45s + 44.4)$$

Determine

(i) resonance peak  $M_r$  and resonant frequency ( $W_r$ ) of the system by drawing the frequency response curve.

(ii) What should be values of damping ratio ( $\xi$ ) and undamped natural frequency ( $\omega_n$ ) of an equivalent 2<sup>nd</sup> system which will produce the same  $M_r$  and  $W_r$  as determined in part (i)

(iii) Determine the bandwidth of the equivalent 2<sup>nd</sup> order system. (14 Marks)



OR

- 8 a. Sketch the Bode plot for the transfer function  
 $G(s) = ks^2 / (1 + 0.2s)(1 + 0.2s)$   
 Determine the value of 'k' for the gain cross-over frequency to be 5 Rad/sec. (10 Marks)
- b. What is polar plot and list its applications. (04 Marks)
- c. State the effects of lag and lead compensating networks. (06 Marks)

**Module-5**

- 9 a. Explain the terms (i) State (ii) State variable (iii) State vector (iv) State space (04 Marks)
- b. Obtain the state equation and output equation of the electric network as shown in Fig.Q9(b).

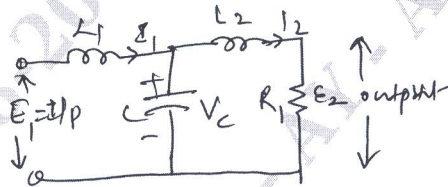


Fig.Q9(b)

- c. Explain spectrum analysis of sampling process. (06 Marks)

OR

- 10 a. State the properties of state transition matrix. (06 Marks)
- b. What is Signal Reconstruction? Explain it with SAMPLE and HOLD circuit. (06 Marks)
- c. Obtain the transition matrix  $Q(t)$  of the following system

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Also obtain the inverse of the transition matrix  $\phi^{-1}(t)$

(08 Marks)

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