CBCS SCHEME

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17EC43

Fourth Semester B.E. Degree Examination, Dec.2019/Jan.2020
Control Systems

Time: 3 hrs. Max. Marks: 100

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 closed loop control systems and list its advantages and disadvantages with examples. **(04 Marks)**

b. For the mechanical system shown in Fig.Q.1(b), write i) The mechanical network ii) the equations of motion and iii) the force-current analogous electrical network. **(08 Marks)**

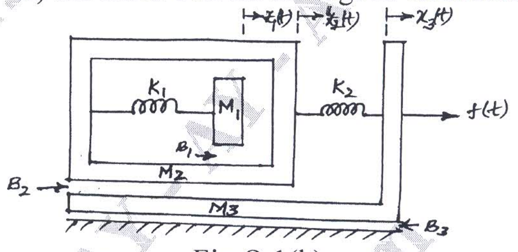

Fig.Q.1(b)

c. For the system represented by the following equations, find the transfer function X(S)/U(S) by signal flow graph technique.

$x(t) = x_1(t) + \beta_3 u(t)$

$x_1^1(t) = -a_1 x_1 + x_2 + \beta_2 u(t)$

$x_2^1(t) = -a_2 x_1 + \beta_1 u(t)$ **(08 Marks)**

OR

2 a. Define analogous systems. Show that two systems shown in Fig.Q.2(a) are analogous systems, by comparing their transfer functions. **(08 Marks)**

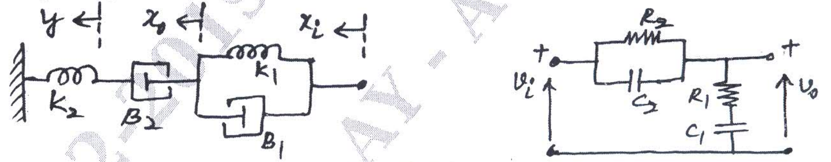

Fig.Q.2(a)

b. For the block diagram shown in Fig.Q.2(b), determine the transfer function C(S)/R(S) using block diagram reduction technique. **(08 Marks)**

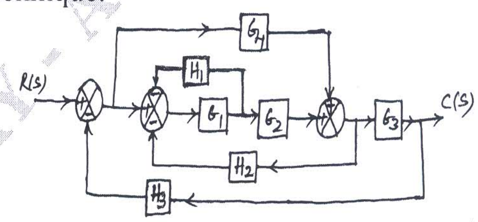

Fig.Q.2(b)

c. Define the following terms in connection with signal flow graph:
i) Node
ii) Forward path gain
iii) Feedback loop
iv) Non-touching loops. **(04 Marks)**

Module-2

3 a. Define the following time response specifications for an underdamped second order system:
i) Rise time, t_r
ii) Peak time, t_p
iii) Peak-overshoot, M_p
iv) Settling time, t_s **(04 Marks)**

b. A system is given by the differential equation $y''(t) + y'(t) + y(t) = x(t)$, where y(t) in the output. Determine all time domain specifications for unit step input. **(08 Marks)**

c. The open loop transfer function of a unity feedback system is given by $G(s) = \frac{K}{S(ST+1)}$
i) By what factor should the amplifier gain K be multiplied in order that the damping ratio is increased from 0.2 to 0.8?
ii) By what factor should K be multiplied so that the system overshoot for unit step excitation is reduced from 60% to 20%? **(08 Marks)**

OR

4 a. Derive the expressions for i) Rise time, t_r and ii) Peak overshoot, M_p for the underdamped response of a second order system for a unit step input. **(06 Marks)**

b. For the system shown in Fig.Q.4(b), compute the values of K and τ to give an overshoot of 20% and peak time of 2 sec for an unit step excitation. **(08 Marks)**

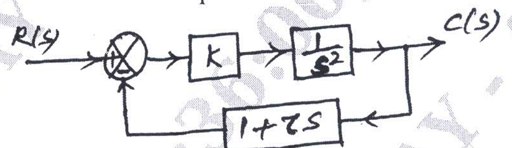

Fig.Q.4(b)

c. Find the position, velocity and acceleration error constant for a control system having open loop transfer function $G(S)H(S) = \frac{10}{S(S+1)}$. Also find the steady state error for the input $r(t) = 1 + t$. **(06 Marks)**

Module-3

5 a. State and explain Routh's stability criterion for determining the stability of the system and mention its limitations. **(06 Marks)**

b. Determine the number of roots that are
i) in the right half of s-plane
ii) on the imaginary axis and
iii) in the left half of s-plane
for the system with the characteristic equation $s^6 + s^5 - 2s^4 - 3s^3 - 7s^2 - 4s - 4 = 0$. **(06 Marks)**

c. Sketch the root locus plot of a certain control system, whose characteristic equation is given by $s^3 + 10s^2 + ks + k = 0$, comment on the stability. **(08 Marks)**

OR

6 a. For a system with characteristic equation $s^4 + ks^3 + s^2 + s + 1 = 0$, determine the range of K for stability. **(04 Marks)**

b. Determine the values of 'k' and 'a' for the open loop transfer function of a unity feedback system is given by $G(s) = \dfrac{K(s+1)}{s^3 + as^2 + 3s + 1}$, so that the system oscillates at a frequency of 2rad/sec. **(06 Marks)**

c. Draw the root locus diagram for the system shown in Fig.Q.6(c), show all the steps involved in drawing the root locus. Determine:

i) The least damped complex conjugate closed loop poles and the value of 'K' corresponding to these roots

ii) Minimum damping ratio. **(10 Marks)**

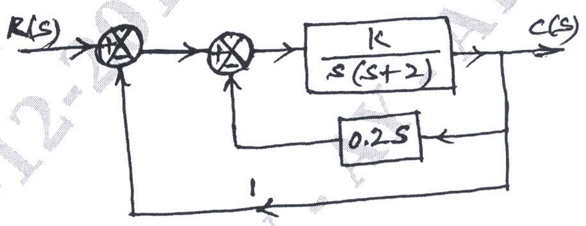

Fig.Q.6(c)

Module-4

7 a. Define the following terms in connection with bode plots:

i) Gain cross over frequency

ii) Phase crossover frequency

iii) Gain margin

iv) Phase margin. **(04 Marks)**

b. A negative feedback control system is characterized by an open loop transfer function $G(S)H(S) = \dfrac{20}{S(S+1)(S+2)}$. Sketch the polar plot and hence determine w_{gc}, w_{pc}, G_M and P_M. Comment on the stability. **(06 Marks)**

c. A unity feedback control system has $G(s) = \dfrac{100(1+0.1s)}{s(s+1)^2(0.01s+1)}$. Draw the Bode plots and hence determine W_{gc}, W_{pc}, GM and PM. Comment on the stability. **(10 Marks)**

OR

8 a. A unity feedback control system has $G(s) = \dfrac{200(s+2)}{s(s^2+10s+100)}$. Draw the bode plots and hence determine stability of the system. **(10 Marks)**

b. Using Nyquist stability criterion, find the range of K for closed loop stability for the negative feedback control system having the open loop transfer function $G(S)H(S) = \dfrac{K}{S(S^2+2S+2)}$. **(10 Marks)**

Module-5

9 a. State the advantages of state variable analysis. **(04 Marks)**

b. Obtain the state model for the electrical system shown in Fig.Q.9(b). Take $i_o(t)$ as output. **(06 Marks)**

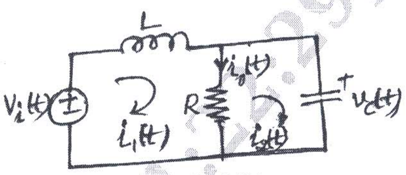

Fig.Q.9(b)

c. For a system represented by the state model

$$\begin{bmatrix} x_1'(t) \\ x_2'(t) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t) \text{ and } y(t) = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix}$$

Determine:

i) The state transition matrix, $\phi(t)$ and

ii) The transfer function of the system. **(10 Marks)**

OR

10 a. Define state transition matrix and list its properties. **(04 Marks)**

b. Consider a state model with matrix $A = \begin{bmatrix} 0 & 1 & 0 \\ 3 & 0 & 2 \\ -12 & -7 & -6 \end{bmatrix}$. Determine the model matrix M. **(06 Marks)**

c. Obtain the time response of the following non homogeneous state equation:

$$\begin{bmatrix} x_1'(t) \\ x_2'(t) \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u(t)$$

where u(t) is a unit step function, when $x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$ **(10 Marks)**

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