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Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Fifth Semester B.Tech Degree Regular and Supplementary Examination December 2022 (2019 Scheme)

Course Code: ECT 307
Course Name: CONTROL SYSTEMS

Max. Marks: 100 Duration: 3 Hours

PART A

(Answer all questions; each question carries 3 marks) Marks

1 Compare open loop and closed loop control systems. Give example. (3)

2 Obtain the impulse response of a series RL high pass filter. (3)

3 A unity feedback system has the following forward path transfer function. $G(s) = \frac{180}{s(s+6)}$ and $r(t) = 4t$. Determine the corresponding static error coefficient and the steady state error. (3)

4 Compare the features of transient and steady state part of a system response. Give an example for a second order control system with natural frequency of 2 rad/s and damping ratio of 0.5. (3)

5 Explain absolute stability and relative stability of control systems. (3)

6 Compare PD, PI and PID controllers. (3)

7 Obtain the DC gain of a unity feedback control system whose overall transfer function is given by (3)

$$T(s) = \frac{10}{(s+3)(s+5)}$$

8 Starting with the principle of argument, state Nyquist stability criterion. (3)

9 Define state transition matrix. Mention any four properties of it. (3)

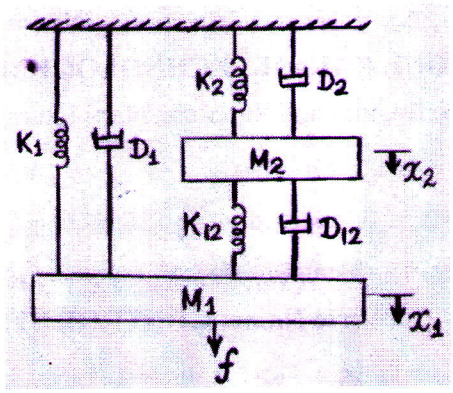
10 Define the terms state variable and state space. Mention any four distinct advantages of state space representation. (3)

PART B

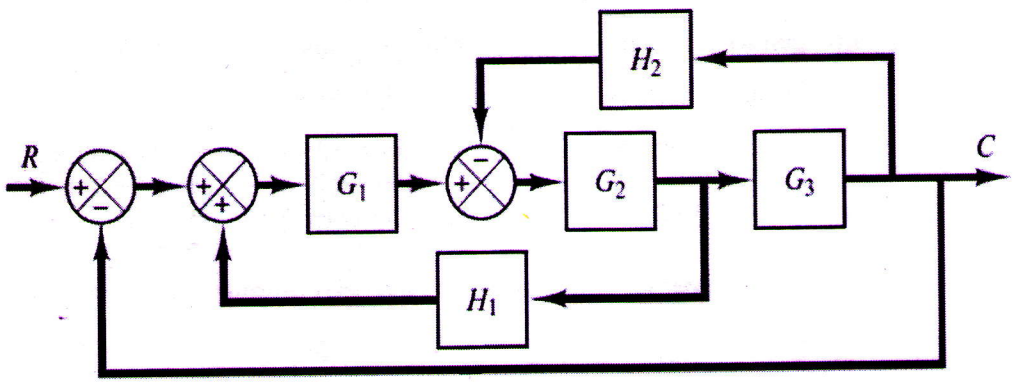
(Answer one full question from each module, each question carries 14 marks)

Module -1

11 a) Obtain the differential equations governing the mechanical system shown below and draw the *force-current* electrical analogous circuit. (7)

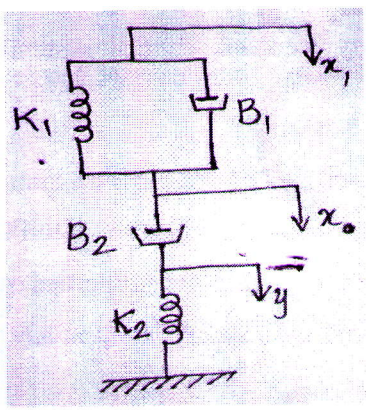


b) Find the transfer function of the given system using block diagram reduction method

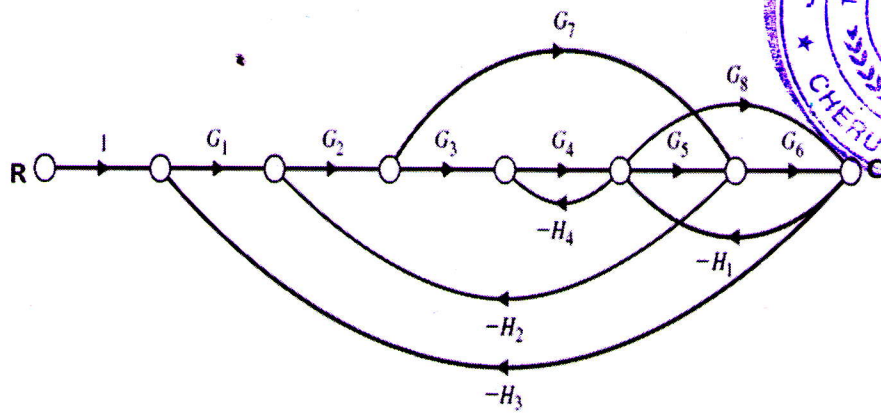


(7)

12 a) Obtain the differential equations governing the mechanical system shown below and draw the *force-voltage* electrical analogous circuit (7)



b) Obtain overall transfer function for the given system using Mason's gain formula (7)



Module -2

13 a) A unity feedback system has the following open loop transfer function, where **K** and **T** are constants. Determine the factor by which **K** should be multiplied to reduce the overshoot from 85% to 35%. (8)

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

b) Consider a unity feedback control system with the closed loop transfer function given by

$\frac{C(s)}{R(s)} = \frac{Ks+b}{s^2+as+b}$. Determine the open loop transfer function. Show that the steady state error in the unit ramp input response is $e_{ss} = \frac{a-k}{b}$ (6)

14 a) Starting from the generalized transfer function, derive expression for *peak time* of second order under-damped system subjected to unit step function. (9)

b) The open loop transfer function of a unity feedback control system is (5)

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

i) Determine the type and order of the system

ii) Find the minimum value of ***K*** for which the steady state error is less than 0.2 for a unit ramp input.

Module -3

15 a) Given the characteristic equation of a system. Using R.H criterion, Find the location of roots in s-plane and hence comment whether the system is fully stable, unstable or conditionally stable. (5)

$$F(s) = s^4 + 2s^3 + 11s^2 + 18s + 18 = 0$$

b) Sketch the root locus for the given open loop transfer function and find the value of K and ω for marginal stability. (9)

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

16 a) Given the characteristic equation of a system. Using R.H criterion, Find the range of K for the system to be stable. Also find the frequency of sustained oscillation at the marginal stability. (6)

$$F(s) = s^4 + 20s^3 + 15s^2 + 2s + K = 0$$

b) Sketch the root locus for the given open loop transfer function and comment on the system stability. (8)

$$G(s)H(s) = \frac{K(s+2)}{s(s+1)(s+4)}$$

Module -4

17 a) Compare lead, lag and lag-lead compensators. (4)

b) A unity feedback control system with given G(s), Draw the Bode plot. Find the gain margin and phase margin. Also check for the stability. (*Use semi-log sheet*) (10)

$$G(s) = \frac{5(1+2s)}{(1+4s)(1+0.25s)}$$

18 a) Explain the design procedure of phase lead compensator using Bode plot method. (5)

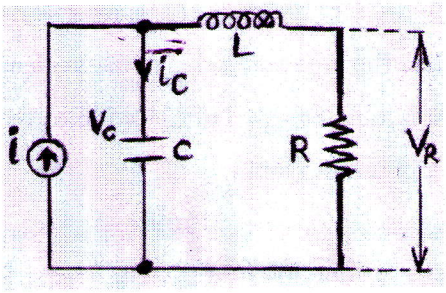
b) Draw the Nyquist plot for the system whose open loop transfer function is (9)

$$G(s)H(s) = \frac{K}{s(s+2)(s+10)}$$

Also comment on closed loop stability.

Module -5

19 a) Obtain the state model for the electrical network shown. (7)



b) Check the controllability and observability of the following system. (7)

$$\dot{X} = \begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} U; \quad Y = [1 \quad 2]\, X$$

20 a) Determine the transfer function of a system represented by (5)

$$\dot{X} = \begin{bmatrix} -2 & -2 \\ 4 & -8 \end{bmatrix} X + \begin{bmatrix} 1 \\ 1 \end{bmatrix} U; \quad Y = [1 \quad 0]\, U$$

b) An LTI system is represented by the state equation $\dot{X} = A\,X + BU$,where (9)

$$A = \begin{bmatrix} -3 & 0 & 0 \\ 0 & -1 & 1 \\ 0 & 0 & -1 \end{bmatrix} \text{ and } B = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix},$$ find the state transition matrix $\phi(t)$.

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