Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Fifth Semester B.Tech Degree Examination December 2021 (2019 scheme)

Course Code: ECT 307

Course Name: CONTROL SYSTEMS

Max. Marks: 100 Duration: 3 Hours

PART A

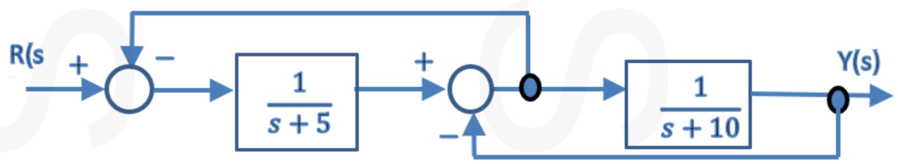
(Answer all questions; each question carries 3 marks) Marks

1	Compare open loop and closed loop control systems. Give one example to both.	3
2	What is the criterion on the roots of the characteristic equation for the stability? How is it connected to the BIBO stability?	3
3	Draw the signal flow graph for the following set of algebraic equations: $x_1 = ax_0 + bx_1 + cx_2$ $x_2 = dx_1 + ex_3$	3
4	State the angle and magnitude criteria that roots of the characteristic equation must be satisfied.	3
5	In a system represented by the state vector differential equation, let **A** is the coefficient matrix of the state variable vector. Then, if $\mathbf{A} = \begin{bmatrix} 0 & 1 \\ -1 & -1 \end{bmatrix}$, find the characteristic roots of the system.	3
6	Draw the response of an underdamped second order system with complex poles on the left half of s-plane showing the rise time, peak overshoot, and settling time.	3
7	Distinguish between Order of a system and Type of a system.	3
8	Draw the s-plane contour used for mapping, for stability analysis, to the plane of open-loop transfer function. $G(s)H(s) = \frac{1}{s(s+1)}$ Explain the choice of the contour	3
9	Write and explain the transfer function for a first order phase lag compensator. State the function of a phase lag compensator in a control system.	3
10	Give two advantages for using state variable representation of systems.	3

PART B

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

11 a) 7

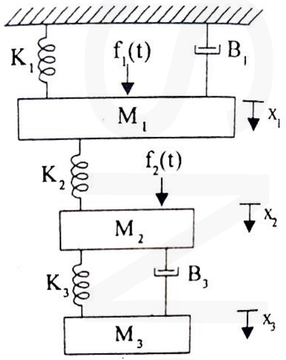


Find the transfer function of the system shown by the block diagram using direct block diagram reduction rules.

b) Draw the signal flow graph for the system in question 11 (a) and obtain the gain using the Mason's Formula. 7

12 a) Draw the schematic of a second order spring-mass-damper (SMD) system and obtain its transfer function. Draw the Force current and force voltage analogy circuits of the SMD system. 7

b) Find the differential equation governing the mechanical system shown in fig. 7
Draw the corresponding Force-Voltage analogous circuit



Module -2

13 a) Define position, velocity and acceleration error constants for a unity feedback control system. 7

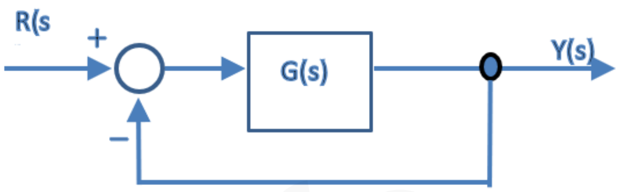
b) For the second order system with complex poles on the left half of s-plane, derive the expression for rise time, settling time, and steady state error parameters. 7

14 a) Find the response of a system with transfer function 7

$T(s) = \frac{1}{(s+1)(s(+3)}$ when subjected to unit step input.

b) For the system in the block diagram, 7

$$G(s) = \frac{10}{s^2 + 14s + 50}$$



Find the steady state error values for unit step and unit ramp inputs.

Module -3

15 a) A system has characteristic equation, $s^3 + 3s^2 + (K+1)s + 4 = 0$. Find the range of K for the stable system. 7

b) For a system having open loop transfer function, 7

$$G(s)H(s) = \frac{K}{(s+1)(s+3)(s+6)}$$

Plot the root locus stating the steps.

16 a) Explain the effect of adding a pole to a second order system. 7

b) Write the general transfer functions of P, PI and PID controllers. Explain their role in a control system design. 7

Module -4

17 Using the Nyquist contour, analyse the following system to obtain the limit of K for the stability. The system has the open-loop transfer function 14

$$G(s)H(s) = \frac{K}{s(\tau_1 s+1)(\tau_2 s+1)}$$

Find the expression for gain margin of the system. Determine phase margin of the system from the graph plotted.

18 a) State Cauchy's argument principle with the conditions to be applied on the contour of mapping. State the Nyquist criterion of stability on the open loop transfer function of a control system. 7

b) Draw the bode plots of the system with open loop transfer function. 7

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

Explain how the plot can be used for analysing the stability of the system.

Module -5

19 a) Let 7

$$T(s) = \frac{1}{s^2 + 20s + 100}$$

is the transfer function of a system. Draw its signal flow graph in phase variable form. Also represent the system in the state variable form.

b) Find the state transition matrix of a system represented by two state variables and having state coefficient matrix, $\mathbf{A} = \begin{bmatrix} 0 & 6 \\ -1 & -5 \end{bmatrix}$. 7

20 a) A single-input single-output system has the matrix equations 7

$$\dot{\mathbf{x}} = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix}\mathbf{x} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

$$y = \begin{bmatrix} 10 & 0 \end{bmatrix}\mathbf{x}$$

Determine the transfer function using the signal flow model.

b) A system characterised by the transfer function 7

$$\frac{Y(s)}{U(s)} = \frac{2}{s^3 + 6s^2 + 11s + 6}$$

Find the state and output equation in matrix form and also test the controllability and observability of the system

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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)

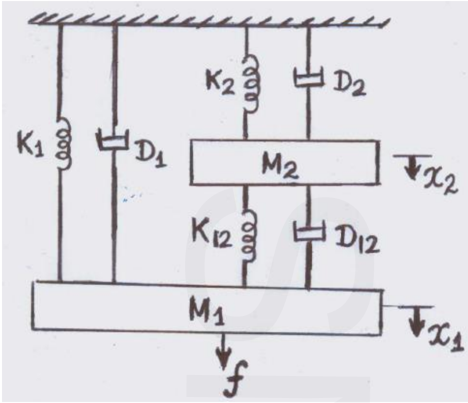
10 Define the terms state variable and state space. Mention any four distinct advantages of state space representation. (3)

PART B

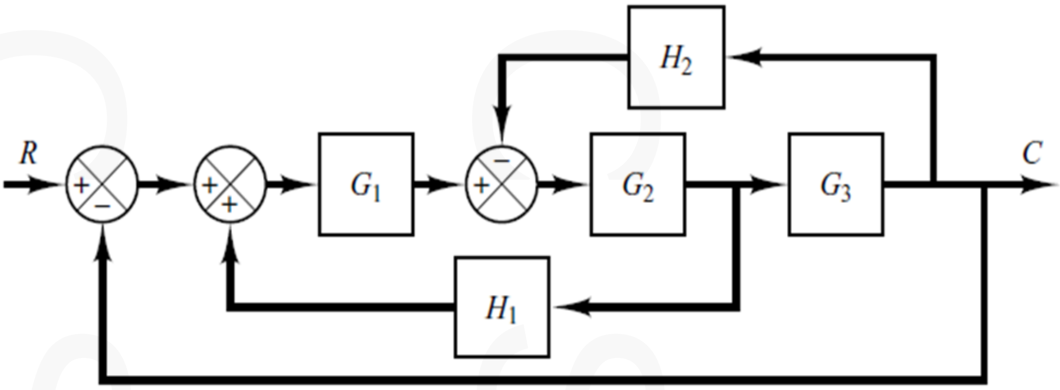
(Answer one full question from each module, each question carries 14 marks)

Module -1

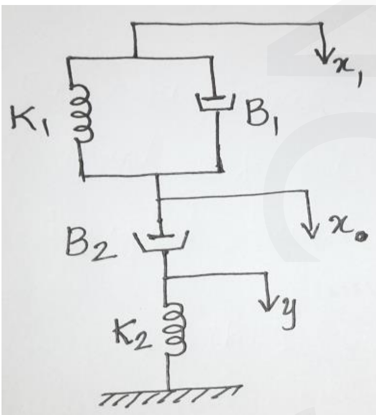
11 a) Obtain the differential equations governing the mechanical system shown below and draw the *force-current* electrical analogous circuit. (7)



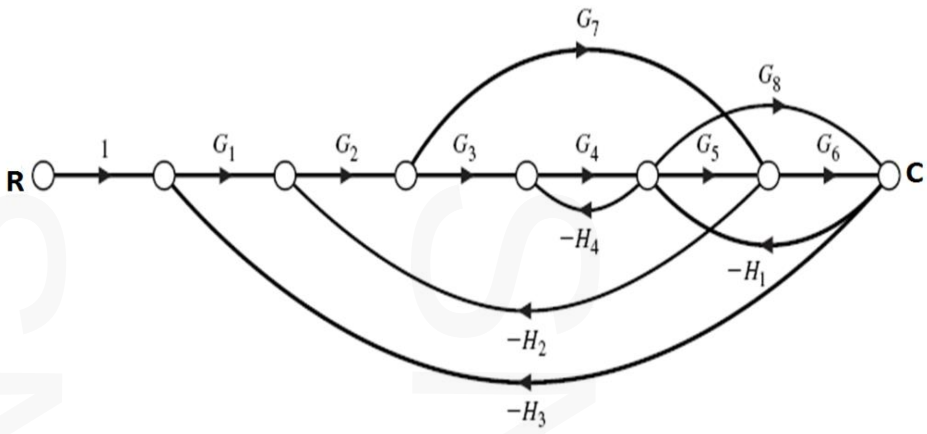
b) Find the transfer function of the given system using block diagram reduction method (7)



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)

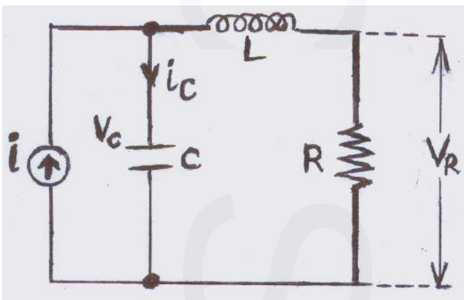
b) Draw the Nyquist plot for the system whose open loop transfer function is (9)

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

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)

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

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

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

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

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

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