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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S5 (S, FE) / S3 (PT) (S) Examination June 2024 (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	Distinguish between open loop and closed loop system	3
2	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
3	Calculate the rise time of a second order system having damping ratio 0.5 and natural frequency of oscillation 10 rad/sec.	3
4	Derive the expression for unit step response of a first order unity negative feedback system.	3
5	Distinguish between absolute stability and marginal stability? Indicate the pole locations in S-plane for absolute stability and marginal stability.	3
6	Define the angle and magnitude criteria on the open-loop transfer function of a system used for constructing root locus plot	3
7	Explain the need of compensators and list the different types of compensators.	3
8	Draw the s-plane contour used for mapping, for stability analysis, to the plane of open-loop transfer function. $G(s)H(s) = \frac{2(s+1)}{s(s-1)}$ Explain the choice of the contour.	3
9	Obtain the state model of the system whose transfer function is given by $\frac{Y(s)}{U(s)} = \frac{10}{s^3 + 4s^2 + 2s + 1}$	3
10	List the properties of state transition matrix	3

PART B

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

Module -1

11 a) Find the transfer function of the following block diagram using block diagram reduction technique. Verify the same using SFG and mason's gain formula 10

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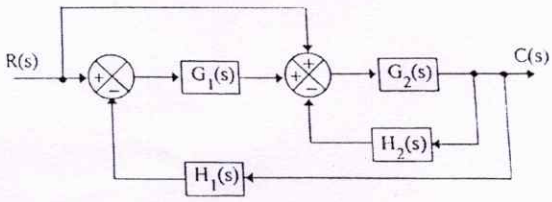
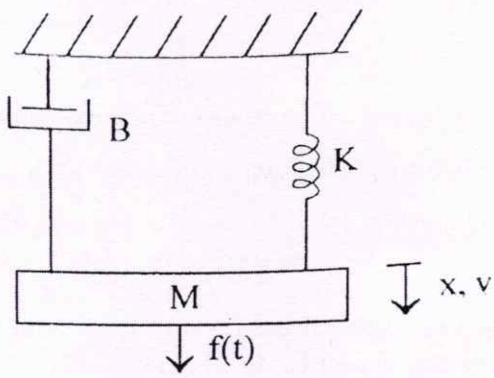
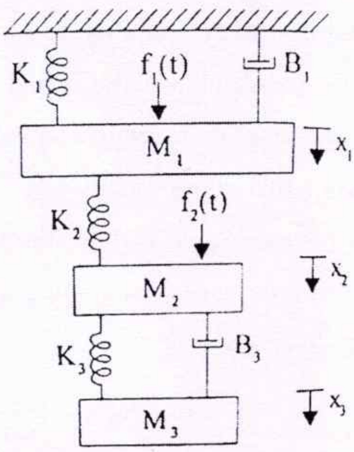


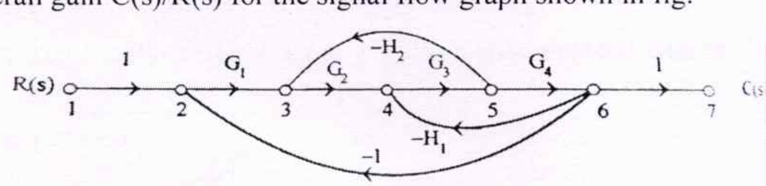
b) For the mechanical system shown in fig, derive the transfer function $\frac{X(s)}{F(s)}$ 4



12 a) Find the differential equation governing the mechanical system shown in fig. Obtain the corresponding Force-Voltage analogous circuit. 10



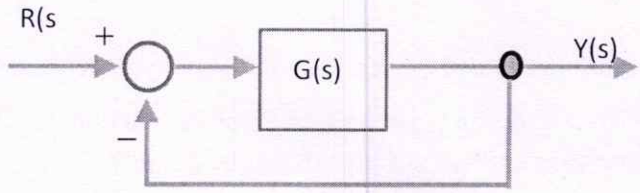
b) Find the overall gain C(s)/R(s) for the signal flow graph shown in fig. 4



Module -2

13 a) For the system in the block diagram, 7

$$G(s) = \frac{81}{s(s + 7.2)}$$



Find the output of the system for unit step input.

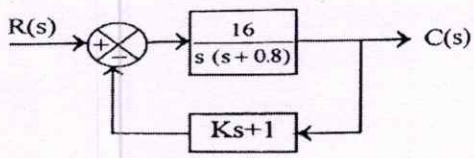
b) Evaluate the static error constants of a negative unity feedback system whose open loop transfer function is 7

$$G(s) = \frac{10}{s(0.1s+1)}.$$

Also find the steady state error when subjected to an input given by polynomial $r(t) = a_0 + a_1 t + a_2 t^2$

14 a) Derive the expression for peak time of a second order underdamped system with negative feedback when subjected to unit step input. 5

b) Determine the unit step response c(t) for a positional control system with velocity feedback as shown in the Fig. Given that $\zeta = 0.5$. Also calculate the rise time, peak time, maximum overshoot and settling time. 9



Module -3

15 a) Sketch the root locus of the system whose open loop transfer function is 10

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

Find the value of K so that the damping ratio of the closed loop system is 0.5

b) Compare P, PI and PID controllers 4

16 a) Sketch the root locus for a unity feedback control system that has an open loop transfer function 10

$$G(s) = \frac{K}{s(s^2+4s+13)}$$

b) Apply routh-hurwitz criterion to the characteristic equation 4

$s^5 + 2s^4 + 2s^3 + 4s^2 + 11s + 10 = 0$

and investigate the stability of the system.

Module -4

17 a) Design a phase lag compensator for the unity feedback control system given by 10

$$G(s) = \frac{K}{s(s+4)(s+80)}$$

It is desired to have a phase margin to be at least 33° and the velocity error constant $K_v = 30$ per sec.

b) Explain the effect of introduction of a phase lead network to an existing system 4

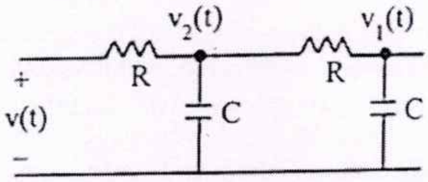
18 a) Sketch the bode plot for the following open loop transfer function and determine the system gain K for a gain cross over frequency to be 5 rad/sec. 10

$$G(s) = \frac{Ks^2}{(1 + 0.2s)(1 + 0.02s)}$$

b) Explain Nyquist stability criterion. 4

Module -5

19 a) Obtain the state model of the electrical network shown in the fig. by choosing $V_1(t)$ and $V_2(t)$ as state variables. 7



b) A system is characterised by the transfer function 7

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

Find the state and output equations in matrix form and also test the controllability and observability of the given system.

20 a) A linear time invariant system is described by the state equation 7

$$\dot{X}(t) = \begin{bmatrix} -1 & 2 \\ -1 & -3 \end{bmatrix} X(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} r(t).$$

Find the state transition matrix. If the initial state vector is $X(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$, Obtain the zero input response.

b) A system is described by the following transfer function 7

$$G(s) = \frac{20(10s + 1)}{s^3 + 3s^2 + 2s + 1}$$

Find the state and output equation of the system

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