Reg. No.

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

FIRST SEMESTER M.TECH. (AEROSPACE ENGG.)
END SEMESTER DEGREE EXAMINATIONS, FEBRUARY - 2021

SUBJECT: CONTROL SYSTEM DESIGN [ICE 5172]

TIME: 3 HOURS 24-02-2021 MAX. MARKS: 50

Instructions to candidates :*Answer ALL questions and missing data may be suitably assumed.*

1A. Explain the significance of Peak overshoot in controller design.

1B. Figure Q1B (a) shows a mechanical vibratory system. When 2 lb of force (step input) is applied to the system, the mass oscillates, as shown in Fig. Q1B (b). Determine *m*, b, and k of the system from this response curve. The displacement x is measured from the equilibrium position.

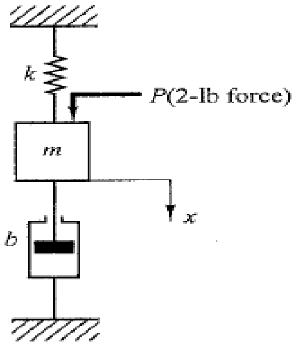

Fig. Q1B (a)

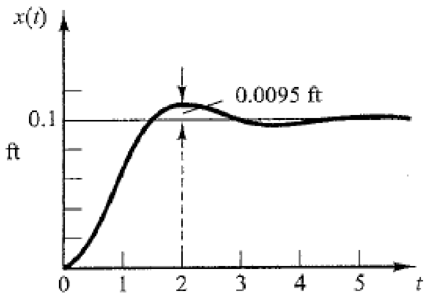

Fig. Q1B (b)

1C. Derive the response of an underdamped second order system when excited with a unit step input.

(2+3+5)

2A. Define Gain margin and Phase margin.

2B. Consider a unity-feedback control system with the closed-loop transfer function $\frac{C(s)}{R(s)} = \frac{Ks+b}{S^2+as+b}$. Determine the open-loop transfer function $G(s)$. Show that the steady-state error in the unit-ramp response is given by $e_{ss} = \frac{1}{K_v} = \frac{a-K}{b}$.

2C. Consider a unity feedback system with open loop transfer function $G(s) = \frac{K}{s(s+4)(s+7)}$. Design a lead compensator to meet the following specifications.

(i) Percentage peak overshoot = 12.63%
(ii) Natural frequency of oscillation =8 rad/sec
(iii) $K_v \geq 2.5$ sec^{-1}

(2+3+5)

3A. List the advantages and disadvantages of derivative control action.

3B. What are the advantages of diagonalization? Prove the invariance of Eigen values under a linear transformation.

3C. Obtain the state model representation for the electrical circuit shown in Fig. Q3C.

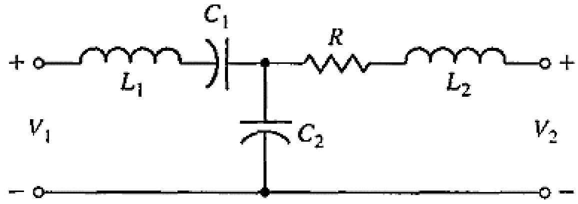

Fig. Q3C

(2+3+5)

4A. Define Eigen values and Eigen vectors.

4B. Obtain a state-space representation of the system shown in Fig. Q4B

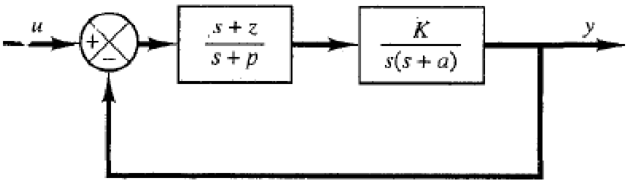

Fig. Q4B

4C. Obtain the step response *y(t)* of the following system $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -1 & -0.5 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0.5 \\ 0 \end{bmatrix} u$,

$y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$, Given $x(0) = \begin{bmatrix} 1 & -1 \end{bmatrix}$.

(2+3+5)

5A. Explain the properties of state transition matrix.

5B. For the system described by following transfer function, obtain the controllable canonical form of state space representation and draw the equivalent state diagram.

$$\frac{Y(s)}{R(s)} = \frac{s^2+2s+10}{s^3+4s^2+6s+10}$$

5C. Consider a system defined by $\dot{x} = Ax + Bu;\ y = Cx$ where, $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix};\ B = \begin{bmatrix} 0 \\ 2 \end{bmatrix};\ C = \begin{bmatrix} 1 & 0 \end{bmatrix}$. It is desired to have eigenvalues at -3 and -5 by using a state-feedback control $u = -Kx$. Determine the necessary feedback gain matrix K and the control signal *u*.

(2+3+5)

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