Question Paper

Exam Date & Time: 30-Dec-2022 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

FIFTH SEMESTER B.TECH END SEMESTER MAKE UP EXAMINATIONS, ICE DEPARTMENT, DEC-JAN 2023

MODERN CONTROL THEORY [ICE 3153]

Marks: 50 **Duration: 180 mins.**

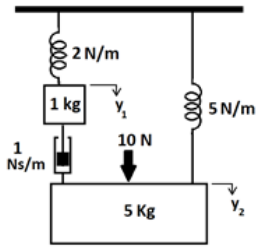
A

Answer all the questions.

Instructions to Candidates: Missing data may be suitably assumed

1) Obtain the state space model for the mechanical system shown below. [CO1, PO-1,2,3 BL3] (5)

A)



B) Diagonalize the following matrix, [CO2, PO-1,2,3,4 BL3] (3)

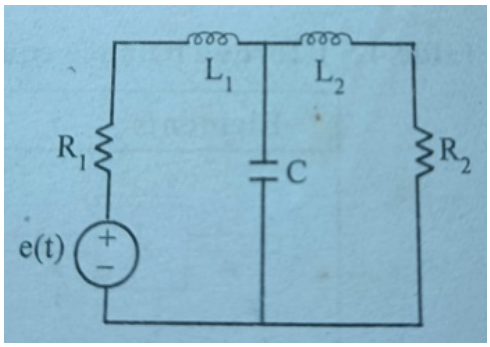
$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 12 & 13 & 0 \end{bmatrix}$$

C) Comment on the stability of the given system matrix, [CO2, PO-1,2,3,4 BL4] (2)

$$A = \begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & 0 \\ 0 & 0 & -1 \end{bmatrix}$$

2) Assign the state variables and obtain the state model from the following electrical circuit. [CO1, PO-1,2,3 BL3] (5)

A)



B) Design a full-order state feedback controller which will give closed loop poles at -10 and -2 ± 4j. (3)
[CO3, PO-1,2,3,4 BL5]

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix} X + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} U$$

C) Examine the controllability of the system given below: [CO3, PO-1,2,3,4 BL4] (2)

$$\dot{X} = \begin{bmatrix} -1 & 0 & 0 \\ 1 & -2 & 0 \\ 2 & 1 & 3 \end{bmatrix} X + \begin{bmatrix} 10 \\ 1 \\ 0 \end{bmatrix} U \qquad y = [-1 \quad 0 \quad 1] X$$

3) Consider the undamped simple pendulum equation given below. Find the equilibrium points and linearize the system for small perturbations. Also comment on the (4)

stability. [CO4, PO-1,2,3 BL4]

A)

$$\ddot{\theta} + \frac{g}{\ell}\sin\theta = 0$$

B) For the nonlinear systems given below find the equilibrium points and determine the type of each isolated equilibrium point. [CO4, PO-1,2,3 BL4] (4)

$$\dot{x_1} = x_1 + x_1x_2$$

$$\dot{x_2} = -x_2 + x_2^2 + x_1x_2 - x_1^3$$

C) List the procedure to construct phase trajectory using analytical method. [CO4, PO-1,2,3 BL3] (2)

4) Draw the sinusoidal response of a saturation nonlinearity and derive the describing function. [CO4, PO-1,2,3 BL3] (5)

A)

B) With an example explain Lyapunov direct method for stability analysis. [CO5, PO-1,2,3,4 BL4] (3)

C) Explain Sylvester's criteria for sign definiteness. [CO5, PO-1,2,3,4 BL3] (2)

5) A linear second order servo is described by the equation given below. Determine the singular point and construct the phase trajectory using the method of isocline. [CO4, PO-1,2,3 BL4] (5)

A) $\ddot{C} + 2\xi\omega_n \dot{C} + \omega_n^2 C = 0,$ where, $\xi = 0.15,\ \omega_n = 1$ rad/sec, $C(0) = 1.5$ and $\dot{C} = 0$

B) Assume a suitable Lyapunov function, *V(x)* and show that the origin is asymptotically stable for the system represented below. [CO5, PO-1,2,3,4 BL4] (3)

$$\dot{x}_1 = x_1(x_1^2 + x_2^2 - 2) - 4x_1x_2^2$$
$$\dot{x}_2 = 4x_1^2x_2 + x_2(x_1^2 + x_2^2 - 2)$$

C) Define stability and asymptotic stability in the sense of Lyapunov. [CO5, PO-1,2,3,4 BL2] (2)

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