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

FIFTH SEMESTER B.TECH. (ELECTRONICS & INSTRUMENTATION ENGG.)

END SEMESTER DEGREE EXAMINATIONS, MARCH - 2021

SUBJECT: Modern Control Theory [ICE 3153]

TIME: 3 HOURS — 31-03-2021 — MAX. MARKS: 50

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

1A. For the system shown in Figure Q1A obtain state space representation where the output is $x_3(t)$.

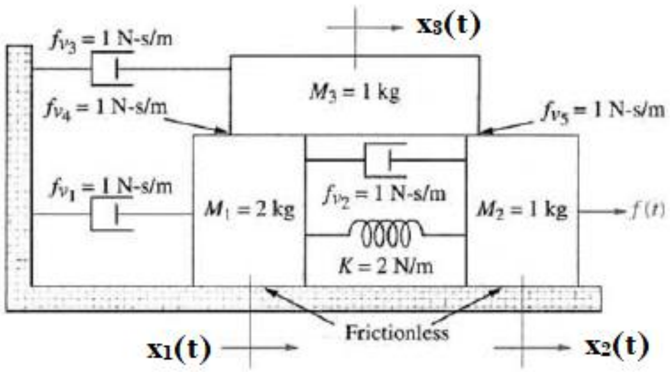

FIG Q1A

1B. For the system represented by following state model, obtain the state transition matrix. Also, obtain $\Phi^{-1}(t)$ by applying the property of state transition matrix.

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

1C. What are the advantages and drawbacks of choosing physical variables of the system as state variables?

(5+3+2)

2A. For the system given below,

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 \\ -2 & -3 & 0 \\ 0 & 2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix} u;\ y = [\,1\ \ 0\ \ 0]\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

Determine whether the system is completely controllable and observable using Gilbert's test.

2B. For the system described by transfer function Y(s)/ U(s), derive the state-space representation in controllable canonical form.

$$\frac{Y(s)}{U(s)} = \frac{s+6}{s^2+5s+6}$$

2C. Write necessary and sufficient conditions for arbitrary pole placement.

(5+3+2)

3A. A system is described by differential equation $\frac{d^2y}{dt^2} + 3\frac{dy}{dt} + 2y = U$. Obtain the state feedback gain K, so that the closed loop response will have settling time of 1 sec (2% settling). The desired characteristic polynomial is chosen as: $(\lambda^2 + 2\zeta\omega_n\lambda + \omega_n^2)$. Take $\zeta = 0.8$.

3B. Explain Delta method of drawing Phase trajectories.

3C. Derive the describing function for the nonlinearity ‘linear transfer through dead zone’.

(5+2+3)

4A. Explain i) jump phenomena ii) limit cycle oscillations exhibited by certain nonlinear systems

4B. Consider a nonlinear system described by $\dot{x}_1 = x_2 - x_1(x_1^2 + x_2^2)$ and $\dot{x}_2 = x_1 - x_2(x_1^2 + x_2^2)$. Determine the stability of equilibrium point at origin of phase plane.

4C. Consider a second order system described by $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}0 & 1\\ -1 & -1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$. Determine the stability of this system using Lyapunov’s method.

(2+3+5)

5A. Check the sign definiteness of the following (i) Q(x)= $x_1^2 + 4x_2^2 + x_3^2 + 4x_1x_2 - 4x_2x_3 + 2x_1x_3$
(ii) Q(x)= $x_1^2 + 3x_2^2 + x_3^2 + 4x_1x_2 + 2x_1x_3$

5B. Considering a second order system, classify all the six different type of singularities.

5C. For the nonlinear system shown in figure Q. 5C predict the possibility of existence of limit cycle oscillation. If exists verify whether it is stable or not.

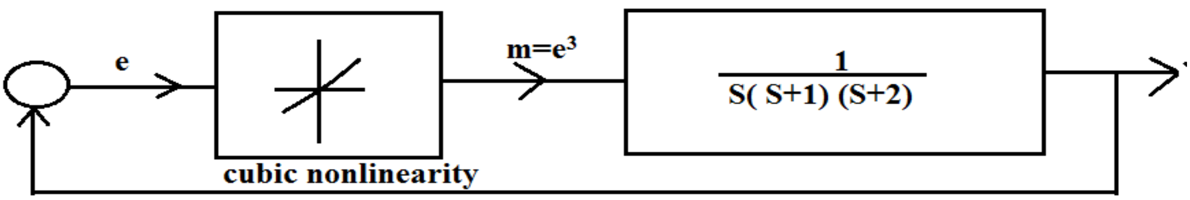

Fig Q.5C

(2+3+5)

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