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

FIFTH SEMESTER B. TECH. (INSTRUMENTATION AND CONTROL ENGG.)

END SEMESTER DEGREE EXAMINATIONS, NOVEMBER - 2018

SUBJECT: MODERN CONTROL THEORY [ICE 3101]

TIME: 3 HOURS **MAX. MARKS: 50**

Instructions to candidates: (i) Answer **ALL** questions.
(ii) Missing data may be suitably assumed.

1A Enumerate the properties of state transition matrix. 02

1B For the electrical system shown in Fig (Q1.B) select minimal state variables and obtain the state model in any form. Take voltage drop across R_2 as the output. 03

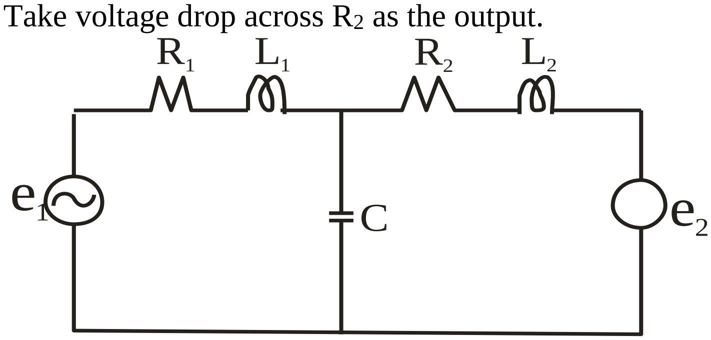

Fig (Q1.B)

1C Diagonalize the system, if 05

$$A = \begin{bmatrix} 0 & 1 & -1 \\ -6 & -11 & 6 \\ -6 & -11 & 5 \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \quad C = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \text{ and } D = 0$$

2A Derive transfer function from state model given by, 02

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

2B Derive the state model in controllable canonical form for the differential equation model $\dddot{y} + 8\ddot{y} + 3\dot{y} + 2y = \ddot{u} + 2\dot{u} + 7u$. 03

2C A system is described by the state model 05

$A = \begin{bmatrix} 0 & 1 \\ -10 & -7 \end{bmatrix}$; $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$; $C = \begin{bmatrix} 1 & 0 \end{bmatrix}$; $D = 0$ and initial condition $x(0) = \begin{bmatrix} 0 & 1 \end{bmatrix}^T$. Obtain the unit step response of the system.

3A Find the Z transform of (i) Unit step function (ii) Impulse function. 02

3B Find the inverse Z transform of 03

$$G(z) = \frac{z}{(z+1)^2(z+3)}.$$

3C For the given transfer function, 05

$\frac{y(s)}{u(s)} = \frac{s^2+4s+4}{s^3+4s^2+3s}$. Obtain the state model in (i) Observable canonical form (ii) Controllable canonical form.

4A Check the sign definiteness of the scalar function (i) $V(x) = x_1^2+2x_2^2+2x_3^2+6x_1x_2+4x_2x_3-4x_3x_1$ 02

(ii) $V(x) = 3x_1^2+2x_2^2+2x_3^2+4x_1x_2-2x_2x_3+6x_3x_1$.

4B A discrete-time system is described by the difference equation, 03

$y(k+3) + 5y(k+2) + 7y(k+1) + 3y(k) = r(k+1) + 2r(k)$. Obtain the state model of the system in Jordan canonical form. Also draw the state diagram.

4C Discretize the continuous time system 05

$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix}u$; and T= 0.1sec.

5A State stability and instability in the sense of Lyapunov. 02

5B A linear autonomous system is described by the discrete state model 03

$x(k+1) = \begin{bmatrix} 0 & 1 \\ -0.5 & -1 \end{bmatrix}x(k)$ Using Lyapunov direct method, determine the stability of the equilibrium state.

5C A discrete regulator system has the plant 05

$x(k+1) = \begin{bmatrix} 1 & 0.1 \\ 0 & 1 \end{bmatrix}x(k) + \begin{bmatrix} 0.005 \\ 0.1 \end{bmatrix}u(k),\ y(k) = \begin{bmatrix} 1 & 0 \end{bmatrix}x(k)$. Design a state feedback control law such that the response of the closed loop system has the damping ratio= 0.6 and undamped natural frequency ω_n = 8 rad/sec. Take T = 1sec.

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