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# Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)

**FIRST SEMESTER M.TECH (CONTROL SYSTEMS) END SEMESTER**

**END SEMESTER EXAMINATIONS, NOV/DEC 2015**

## SUBJECT: DYNAMICS OF LINEAR SYSTEMS (ICE503)

Time: 3 Hours MAX. MARKS: 50

**Instructions to Candidates:**

- Answer **ANY FIVE FULL** questions.
- Missing data may be suitably assumed.

**1A.** Obtain a state model for the following transfer function in diagonal canonical form **4**

$$\frac{y(s)}{u(s)} = \frac{s^3 + 10s^2 + 17s + 8}{(s+6)(s+2)(s+3)}.$$

**1B.** Derive the transfer function for the following state model. **3**

$$\dot{X}(t) = \begin{bmatrix} -3 & -2 \\ -2 & -3 \end{bmatrix} X(t) + \begin{bmatrix} 1 \\ 1 \end{bmatrix} U(t); \quad Y(t) = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} X(t)$$

**1C.** Define eigen values, eigen vectors, generalized eigen vectors. **3**

**2A.** Transform the following continuous time state model into diagonal form. **4**

$$\dot{X}(t) = \begin{bmatrix} -4 & 1 & 0 \\ 0 & -2 & 0 \\ 1 & 0 & -1 \end{bmatrix} X(t) + \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix} U(t); \quad y(t) = \begin{bmatrix} 1 & 2 & 0 \end{bmatrix} \underline{X}(t).$$

**2B.** Derive the state variable representation of armature controlled servo motor using physical variables. **3**

**2C.** Using Cayley Hamilton method determine the state transition matrix for A= $\begin{bmatrix} 0 & 3 \\ 4 & 4 \end{bmatrix}$. **3**

**3A.** Using Laplace transform, obtain the time response of the following system **5**

$\dot{X}(t) = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} X(t) + \begin{bmatrix} 1 \\ 1 \end{bmatrix} U(t);$ where U(t) is a unit step input occurring at t=0 and X(0)= $\begin{bmatrix} 1 \\ 0 \end{bmatrix}$.

**3B.** Derive the pulse transfer function **3**

$$X(k+1) = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -\frac{1}{4} & \frac{1}{2} & -\frac{1}{4} \end{bmatrix} X(k) + \begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix} U(K); \quad Y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \underline{X}$$

**3C.** State Lyapunov stability and instability theorems. **2**

**4A.** Consider the system $\dot{X}(t)=\begin{bmatrix}0 & 1 & 0\\ 1 & 0 & -11\\ 6 & 1 & -6\end{bmatrix}X(t)+\begin{bmatrix}1\\0\\0\end{bmatrix}U(t)$; Y(t)= $[0 \quad 0 \quad 1]$ X(t) **6**

Compute the state feedback gain matrix so that the control law u=-kX(t) places the closed loop poles at -1 $\pm\ j2$, -5.

**4B.** Given the state equations of a digital control system **4**

$$x_1(k+1)=x_2(k)$$
$$x_2(k+1)=x_3(k)$$
$$x_3(k+1)=0.4x_2(k)+0.3x_3(k)+u(k)$$
$$y(k)=x_1(k)$$

Transform the state equations into diagonal form and investigate the controllability and observability of the system.

**5A.** Discretize the continuous time system with sampling period 0.1 second. **5**

$$\dot{X}(t)=\begin{bmatrix}-3 & 2\\ 4 & -5\end{bmatrix}X(t)+\begin{bmatrix}1\\0\end{bmatrix}U(t).$$

**5B.** For a certain system, when x(0)= $\begin{bmatrix}1\\-3\end{bmatrix}$, then x(t)= = $\begin{bmatrix}e^{-3t}\\-3e^{-3t}\end{bmatrix}$ and when x(0)= $\begin{bmatrix}1\\1\end{bmatrix}$, then x(t)= $\begin{bmatrix}e^{t}\\e^{t}\end{bmatrix}$. Determine the system matrix A. **3**

**5C.** Define the concept of complete state controllability and observability for continuous time systems. How are they determined? **2**

**6A.** The system described by the pulse transfer function **6**

$$G(z)=\frac{z^3+8z^2+17z+8}{(z+1)(z+2)(z+3)}.$$

Obtain the state model (i) controllable canonical form (ii) Observable canonical form.

**6B.** A unity feedback system is characterized by the open-loop transfer function $G(z)=\dfrac{0.2385(z+0.876)}{(z-1)(z-0.2644)}$ ; for T = 0.2 sec; Determine the steady state errors for unit step, unit ramp and unit acceleration input. **4**

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