Code: 15A02704 **R15**

B.Tech IV Year I Semester (R15) Regular Examinations November/December 2018

MODERN CONTROL THEORY

(Electrical & Electronics Engineering)

Time: 3 hours Max. Marks: 70

PART – A

(Compulsory Question)

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1 Answer the following: (10 X 02 = 20 Marks)

(a) Define state space.

(b) What is state diagram?

(c) State he principle of duality.

(d) Define controllability.

(e) What is the necessary and sufficient condition for arbitrary pole placement?

(f) What is the difference between full order and reduced order observers?

(g) Define singular points.

(h) Mention few common nonlinearities present in physical systems.

(i) State Lyapunov's in stability theorem.

(j) Define positive definiteness of a system.

PART – B

(Answer all five units, 5 X 10 = 50 Marks)

UNIT – I

2 Obtain state space representation for the following system(t)s:

(a) $\frac{d^3y(t)}{dt^3} + 6\frac{d^2y(t)}{dt^2} + 11\frac{dy(t)}{dt} + 6y(t) = \frac{d^3u(t)}{dt^3} + 8\frac{d^2u(t)}{dt^2} + 17\frac{du(t)}{dt} + 8u(t)$

(b) $\frac{Y(s)}{U(s)} = \frac{5}{(s+1)^2(s+2)}$.

OR

3 Given the system equation:

$$\begin{bmatrix} \dot{x} \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 2 & 1 & 0 \\ 0 & 2 & 1 \\ 0 & 0 & 2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

Find the solution in terms in initial conditions $x_1(0)$, $x_2(0)$ and $x_3(0)$

UNIT – II

4 A system is represented by the state model:

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 2 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 1 & 3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 & 1 \\ 1 & 0 \\ 0 & 1 \end{bmatrix} u(t)$$

$$y(t) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

Check whether the system is: (a) Completely controllable. (b) Completely observable.

OR

5 Consider a system defined by:

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -9 \end{bmatrix} 6 \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(t)$$

$$y(t) = \begin{bmatrix} c_1 & c_2 & c_3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

Except for an obvious choice of $c_1=c_2=c_3=0$, find an example of a set of c_1, c_2, c_3 that will make the system unobservable.

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UNIT – III

6 Explain various methods of design of pole placement controller using state feedback.

OR

7 Consider the system defined by:

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -5 & -6 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(t)$$

$$y(t) = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

Design a full order state observer assuming the desired poles for the observer are located at -10, -10,-15.

UNIT – IV

8 Derive the describing function of backlash and relay nonlinearities.

OR

9 Explain with example, the analysis of nonlinear systems using phase plane analysis.

UNIT – V

10 Consider the nonlinear system:

$$\dot{x}_1 = x_2$$
$$\dot{x}_2 = -x_1 - x_1^2 x_2$$

Investigate the stability of this nonlinear system around its equilibrium point at origin.

OR

11 Consider a nonlinear system described by the equation:

$$\dot{x}_1 = x_2$$
$$\dot{x}_2 = -(1 - |x_1|)x_2 - x_1$$

Find the region in the state plane for which the equilibrium state of the system is asymptotically stable.

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