Reg No.:_______________ Name:____________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S7 (R,S) (FT/WP/PT) Examination November 2025 (2019 Scheme)

Course Code: EET401

Course Name: ADVANCED CONTROL SYSTEMS

Max. Marks: 100 **Duration: 3 Hours**

PART A

Answer all questions, each carries 3 marks. Marks

1	What is state space? What are the advantages of state space analysis?	(3)
2	A series RLC circuit is excited by a voltage source, *v(t)* volts and the output is measured across the resistor. Derive the state model of the electrical system.	(3)
3	A system is characterised by the differential equation $\frac{d^2 y}{dt^2} + 10\frac{dy}{dt} + 7y - u = 0$. Determine its transfer function.	(3)
4	Derive the relationship between transfer function and state space model of a system.	(3)
5	Define observability and explain Kalman's method for determining observability.	(3)
6	Explain the concept of duality referred to controllability.	(3)
7	Explain with suitable characteristics jump resonance phenomenon in non linear system.	(3)
8	Explain any three characteristics of nonlinear systems.	(3)
9	Explain with neat diagram, what is phase trajectory and phase portrait?	(3)
10	Determine whether the given function is positive definite or not	(3)

$$v(x) = 10x_1^2 + 4x_2^2 + x_3^2 + 2x_1x_2 - 2x_2x_3 - 4x_1x_3$$

PART B

Answer any one full question from each module, each carries 14 marks.

Module I

11 a) Derive the state model of armature controlled DC motor. (7)

b) Obtain a state space model in phase variable form of a system with transfer function,

$$\frac{Y(s)}{U(s)} = \frac{1}{s^3 + 7s^2 + 8s + 2} \quad (7)$$

OR

12 a) Obtain the state space model of the system with transfer function (10)

$$\frac{Y(s)}{U(s)} = \frac{1}{s^3 + 6s^2 + 11s + 6}$$

in canonical form.

b) What is similarity transformation? How similarity transformation is helpful for state space analysis? (4)

Module II

13 a) The input output relationship of a sampled data system is described by the equation c(k+2)+3c(k+1)+4c(k+1)=r(k+1)-r(k). Determine the pulse transfer function. Also obtain the weighting sequence of the system. (10)

b) List the properties of state transition matrix of discrete time systems. (4)

OR

14 a) Find the state transition matrix using Cayley-Hamilton theorem for the system matrix given below $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$ (8)

b) Determine the transfer function of system given below (6)

$$\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \end{bmatrix} = \begin{bmatrix} 1 & -2 \\ 4 & -5 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} 2 \\ 1 \end{bmatrix} u \qquad y = \begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix}$$

Module III

15 a) Distinguish between full order and reduced order state observers. (4)

b) Consider the system described by the state model $\dot{X} = AX$, y = CX where A $= \begin{bmatrix} -1 & 1 \\ 1 & -2 \end{bmatrix}$; C = [1 0]. Design a full-order state observer. The desired eigen values for the observer matrix are μ_1 = -5; μ_1 = -5; (10)

OR

16 a) Consider a linear system described by the transfer function (10)

$$\frac{Y(s)}{U(s)} = \frac{10}{s(s+1)(s+2)}$$

Design a feedback controller with state feedback so that the closed loop poles are placed at -2, (-1+j1) and (-1-j1).

b) Explain the significance of PBH test for controllability. (4)

Module IV

17 a) Derive the describing function of dead-zone non-linearity. (8)

b) Explain the linearization concept and assumptions made referred to describing function analysis. (6)

OR

18 a) Derive the describing function of saturation nonlinearity. (8)

b) Explain any three types of non-linearities that occur in electrical systems (6)

Module V

19 a) A linear second order system is described by the equation (10)

$\ddot{e} + 2\delta\omega_n\dot{e} + \omega_n^2 e = 0$, Where $\delta = 0.25$, $\omega_n = 1$rad/sec, e(0)=1, and $\dot{e}(0) = 0$. Determine the singular point and state the stability by constructing the phase trajectory using the method of isoclines.

b) Define (*i*) singular point (*ii*) vortex point (*iii*) saddle point and (iv) focus point. (4)

OR

20 a) Use Lyapunov theorem to determine the stability of the nonlinear system given below (4)

$$\dot{X} = \begin{bmatrix} -4 & 0 \\ 3x_2^2 & -2 \end{bmatrix} X$$

b) A second order system is represented by $\dot{X} = AX$ where A = $\begin{bmatrix} 0 & 1 \\ -1 & -1 \end{bmatrix}$. Assuming matrix Q to be identity matrix, solve for matrix P in the equation $A^TP+PA = -Q$. Use Lyapunov theorem and determine the stability of the system. Write the Lyapunov function V(x) (10)

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