A
00H-JB9NG

1000EET401112503

Pages: 4

Reg No.:_______________ Name:_______________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S7 (S,FE) (FT/WP/PT) Examinations May 2026 (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	Illustrate, using a block diagram, the state and output equations of a linear time-invariant continuous-time system.	(3)
2	Develop the state-space model of a series RLC circuit excited by an input voltage $V(t)$, taking the inductor current and capacitor voltage as the state variables, and the capacitor voltage as the output.	(3)
3	Derive the solution for an autonomous system using the Laplace transform approach.	(3)
4	Using the Cayley-Hamilton method, determine the state transition matrix for the system matrix $\mathbf{A} = \begin{bmatrix} 2 & 0 \\ 1 & 2 \end{bmatrix}$	(3)
5	What are the limitations of state feedback controllers in real-world systems?	(3)
6	Explain Gilbert's method for testing the observability of a system with repeated eigenvalues.	(3)
7	Explain intentional and inherent nonlinearities with a suitable example.	(3)
8	How is the describing function method used to determine the existence of limit cycles?	(3)
9	Explain how stability is analysed by the second method (direct method) of Lyapunov.	(3)
10	Determine the definiteness of the function $V(x) = (x_1 + x_2)^2 + x_3^2$	(3)

PART B

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

Module I

11 a) Model the system described by the following differential equations in phase variable form. (5)

$$\frac{d^2y_1}{dt^2} + \frac{dy_1}{dt} + 3\frac{dy_2}{dt} + 2y_1 = 2u_1 + u_2$$

$$\frac{d^2y_2}{dt^2} + 4\frac{dy_2}{dt} + \frac{dy_1}{dt} + 2y_2 = u_1 + 4u_2$$

b) Derive the state-space model of an armature-controlled DC motor. Identify the state variables, input, and output, and briefly comment on the physical significance of each. (9)

OR

12 a) Justify the statement "The state-space representation of a system is not unique" with an appropriate example. (6)

b) Consider the system given by (8)

$$\frac{Y(s)}{U(s)} = \frac{4}{(s+1)(s+2)(s+3)}$$

Obtain the block diagram and construct the diagonal canonical form of the system.

Module II

13 a) Derive the transfer function for the plant model of a position control system given by (5)

$$\dot{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & -1 & 1 \\ 0 & -1 & -10 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 10 \end{bmatrix} u$$

$$y = [1 \quad 0 \quad 0]\mathbf{x}$$

b) Obtain the response $y(t)$ of the following system to a unit step input under $\begin{bmatrix} 1 \\ 0 \end{bmatrix}$ initial conditions. (9)

$$\dot{x} = \begin{bmatrix} -1 & 0 \\ 1 & -10 \end{bmatrix} x + \begin{bmatrix} 0 \\ 10 \end{bmatrix} u$$

$$y = [1 \quad 0]\mathbf{x}$$

OR

14 a) Obtain the state transition matrix $\phi(t)$ of the system described by (7)

$$\dot{x} = \begin{bmatrix} 0 & 0 & -2 \\ 0 & 1 & 0 \\ 1 & 0 & 3 \end{bmatrix} \mathbf{x}; \quad y = [0 \quad 1 \quad 0]\mathbf{x}$$

b) Derive the phase variable form for the discrete-time system described by (7)

$$\frac{Y(z)}{U(z)} = \frac{5}{z^3 + 7z^2 + 5z + 3}$$

Module III

15 a) Obtain the condition for complete state controllability for the electrical system described by the following state equations (5)

$$\begin{bmatrix} \dot{V}_c \\ \dot{I}_L \end{bmatrix} = \begin{bmatrix} -\frac{2}{RC} & \frac{1}{C} \\ -\frac{1}{L} & 0 \end{bmatrix} \begin{bmatrix} V_c \\ I_L \end{bmatrix} + \begin{bmatrix} \frac{1}{RC} \\ \frac{1}{L} \end{bmatrix} V_s$$

b) Consider a system described by the transfer function (9)

$$\frac{\mathrm{Y(s)}}{\mathrm{G(s)}} = \frac{20(s+5)}{s(s+1)(s+4)}$$

Design a state feedback controller to yield a percentage overshoot of 9.5% and a settling time of 0.74 seconds.

OR

16 a) What is an state observer? Under what conditions is an observer employed in the state feedback design of a control system? Briefly explain the configuration of an observer. (8)

b) Consider the following state model of the system given by $\dot{\mathbf{x}} = \mathbf{Ax} + \mathbf{Bu}$ and $\mathrm{y} = \mathbf{Cx}$ Where (6)

$$\mathbf{A} = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix} \ \mathbf{B} = \begin{bmatrix} 0 \\ 10 \end{bmatrix} \ \mathbf{C} = [1 \quad 0]$$

Design a full-order observer such that observer poles are placed at -1±j.

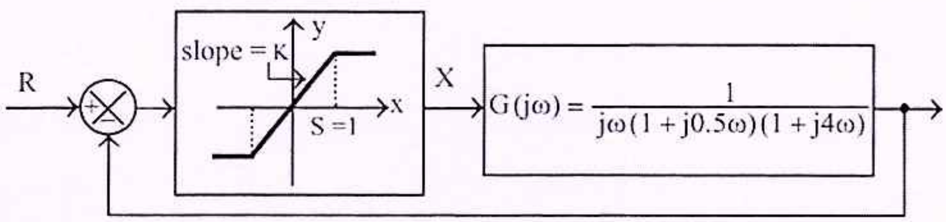
Module IV

17 a) Explain any six nonlinear system behaviours. (6)

b) Derive the describing function of saturation nonlinearity. (8)

OR

18 Consider a unity feedback system having a saturating amplifier with gain K. Determine the maximum value of K for the system to stay stable. What would be the frequency and nature of the limit cycle for a gain of K = 2.5? (14)



Module V

19 a) Consider the nonlinear system described by the differential equation (10)

$$\ddot{y} - 0.1\dot{y} + y + y^2 = 0$$

i) Find all singular points of the system

ii) Classify them

iii) Sketch the phase portrait in the neighbourhood of the singularities.

b) Consider the nonlinear system described by the state equations (4)

$$\dot{x}_1 = x_2$$

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

Check the stability of the equilibrium state of the system with $V(x) = x_1^2 + x_2^2$.

OR

20 a) With a neat sketch, explain the isocline method for the construction of a phase trajectory. (7)

b) Compute the Lyapunov function, $V(x)$, for which the system given below is asymptotically stable. (7)

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x$$

****