APJ ABDULKALAM TECHNOLOGICAL UNIVERSITY

08 PALAKKAD CLUSTER

Q. P. Code: PE0821121-I **(Pages: 4)** **Name: ....**

Reg. No: ....

FIRST SEMESTER M.TECH. DEGREE EXAMINATION DECEMBER 2021

Branch: Electrical and Electronics Engineering **Specialization: POWER ELECTRONICS**

08EE6221 SYSTEM DYNAMICS

Time: 3 hours **Max. Marks: 60**

Answer all six questions.

Modules 1 to 6: Part 'a' of each question is compulsory and answer either part 'b' or part 'c' of each question.
(Answer all questions with relevant diagrams &/expressions only)

Q. No.	Module 1	Marks
1. a	Mathematically analyse the sensitivity of eigen values to system parameters, when the system is modelled in state space form.	3
	Answer b or c	
b	Consider the system function given below $$G(s) = \frac{(s+5)}{(s+2)(s^2+3s+4)}$$ Obtain state models by direct and cascade decompositions. Draw the relevant diagrams also.	6
c	How will you obtain the solution of a state equation? Obtain the solution, of the state equation given by $$\dot{x} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x + \begin{bmatrix} 2 \\ 5 \end{bmatrix} u$$ $$y = [1 \ \ 2]\, x$$	6

Q. No.	Module 2	Marks
2. a	How will you find the solution of a discrete time system, modelled in state space. Explain any one method.	3
	Answer b or c	

b	Consider the system defined by its transfer function $$G(z) = \frac{0.2838z + 0.1485}{(z-1)(z-0.1353)}$$ Obtain state models in controllable canonical form and diagonal forms.	6
c	Consider the system defined by transfer function $$G(s) = \frac{1}{s(s+3)}$$ Obtain the discrete time system model valid at the sampling instants. Also obtain the specific expressions for the system model when T = 1 sec.	6

Q. No.	Module 3	Marks
3. a	What is the importance of sign definiteness of scalar functions in the stability analysis by Liapunov's method? What is the significance of quadratic forms?	3
	Answer b or c	
b	Analyse the stability of the equilibrium point of a nonlinear spring mass damper system, using Liapunov's method. The system equation is given as: $$m\ddot{x} + b\,\dot{x}\,|\dot{x}| + k_0x + k_1x^3 = 0$$	6
c	Explain Krasovskii's theorem for analysing the stability of nonlinear systems. By use of Krasovskii's theorem examine the stability of the equilibrium state of the following system: $$\dot{x}_1 = -x_1$$ $$\dot{x}_2 = x_1 - x_2 - x_2^3$$	6

Q. No.	Module 4	Marks
4. a	What do you mean by output controllability of a LTIV system? Discuss any one method to determine the output controllability	3
	Answer b or c	
b	What do you mean by observability matrix? Derive an expression for the observability matrix of a LTIV discrete time system.	6

c	Analyse the following systems for state controllability. Verify your answers with the help of diagrams also.	6

$$\dot{x} = \begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix} x + \begin{bmatrix} 2 \\ 5 \end{bmatrix} u$$

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

Q. No.	Module 5	Marks
5. a	What do you mean by duality principle related to controllability and observability? Analyse duality principle with an example.	4

Answer b or c

b Consider the system **8**

$$G(s) = \frac{1}{s^2}$$

Design a pole placement controller such that the closed loop poles are at

$s = -1 \pm j$. Draw the block diagram of the compensated system also. What is the control law you designed? Verify your answer using any other method of controller design also.

c Design a state observer to the given system such that the observer eigen values are at **8**

$$\mu = -2 \pm j2\sqrt{3},\ \mu = -5.$$

The system is given as

$$\dot{x} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ -6 & -11 & -6 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

$$y = [1 \quad 0 \quad 0]\, x$$

Q. No.	Module 6	Marks
6. a	Analyse parameter optimisation problem of discrete time systems. What is the cost function? How will you find a solution by Liapunov's method.	4

Answer b or c

b Determine the optimal control function u for the system described by 8

$$\dot{x} = Ax + Bu$$

Where,

$$x = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix},\ A = \begin{bmatrix} 0 & 1 \\ 0 & -1 \end{bmatrix},\ B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

Such that the following performance equation is minimised:

$$J = \int_0^{\infty} (x'x + u'u)\, dt$$

c Consider a unity feedback system with closed loop transfer function 8

$$\frac{Y(s)}{R(s)} = \frac{1}{s^2 + 2\xi s + 1}$$

Determine the value of ξ so that, when the system is subjected to a unit step input, the following performance index is minimised:

$$J = \int_{0+}^{\infty} (e^2 + \mu \dot{e}^2)\, dt$$

Where, e = r - c, error signal