SIDDHARTH GROUP OF INSTITUTIONS :: PUTTUR

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QUESTION BANK (DESCRIPTIVE)

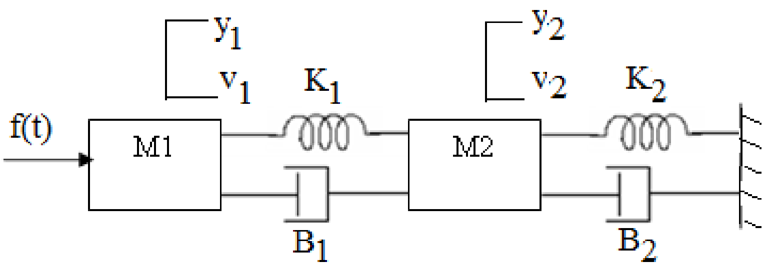
Subject with Code :SYSTEM THEORY(16EE7501) **Course & Branch**: M.Tech - EEE

Year &Sem: I-M.Tech& I-Sem **Regulation:** R16

UNIT-I

1. (a) Consider the mechanical system shown in figure. Obtain state model for shown displacement and velocities. [5M]

   (b) What are the advantages of state space approach compare with the all other control system representations. [5M]



2. (a) What are the different properties of state transition matrix? Explain [5M]

   (b) Compute state transition matrix e^{At} for the state model [5M]

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} X + \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix} U$$

3. Derive state transition matrix and its properties [10M]
4. (a) Derive a state space representation of the following system [5M]

$$\frac{Y(S)}{U(S)} = \frac{1}{S^3 + 6S^2 + 4S + 6}$$

   (b) What are the properties of state transition matrix? [5M]

5. Find the solution of the following state equation [10M]

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

   The initial conditions are given as $x_1(0)=1$ and $x_2(0)=-1$

6. Consider the system defined by $\dot{x} = Ax + Bu; \quad y = Cx$ where

$$A=\begin{bmatrix}-1 & 0 & 1\\ 1 & -2 & 0\\ 0 & 0 & -3\end{bmatrix};\quad B=\begin{bmatrix}0\\0\\1\end{bmatrix};\quad C=\begin{bmatrix}1 & 1 & 0\end{bmatrix}\quad \textit{obtain the transfer function } \frac{y(s)}{u(s)}$$

[10M]

7. (a) For the system described by the differential equation $\dddot{y}+6\ddot{y}+11\dot{y}+6y=6u$ where u is the input and y is the output. Obtain state model and also draw its state diagram. [5M]
   (b) State and prove non-uniqueness of state model. [5M]

8. Obtain the expression for the solution of linear time-invariant continuous time state equation [10M]
   $\dot{x}(t)=Ax(t)+Bu(t);\quad x(t_o)=x^o$

9. Obtain the state model of the system whose transfer function is given as [10M]
   $$\frac{y(s)}{u(s)}=\frac{10}{S^3+4S^2+2S+1}$$

10. (a) Explain in details about the conversion of state space model to transfer function model using Fadeeva algorithm. [5M]
    (b) State the similarity transform and invariance of the system. [5M]

UNIT-II

1. Determine the canonical state model of the system, whose transfer function is given by

   $T(s)=\dfrac{2(S+5)}{(S+2)(S+4)(S+3)}$ also give the diagrammatic representation. [10M]

2. Find the transformation matrix P that transforms the matrix A into diagonal or Jordon canonical form, where

   $$A=-\begin{bmatrix}4 & 1 & -2\\ 4 & 0 & 2\\ 4 & -1 & 3\end{bmatrix}$$

   [10M]

3. State and prove the necessary and sufficient condition for arbitrary pole placement. [10M]

4. Given the transfer function $\dfrac{y(s)}{u(s)}=\dfrac{10}{S(S+1)(S+2)}$ design a feedback controller with a state feedback so that the closed loop poles are placed at-2, -1±j1(Using Ackerman's formula). [10M]

5. What is similarity transformation? And also discuss in detail various properties that are invariant under similarity transformation. [10M]

6. What is the procedure for the designing of controller using output feedback? Explain. [10M]

7. Consider the following system $\dot{X} = AX + BU$ where $\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix}$ and $B = \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix}$ By using state feedback control u=-Kx, it is desired to have the closed loop poles at S=-2+j4; -2-j4 and -10. Determine the state feedback gain matrix K. [10M]

8. For the system $\dot{X} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 3 \end{bmatrix} X + \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 1 & 1 \end{bmatrix} U$, design a linear state variable feedback such that the closed loop poles are located at -1, -2 and -3. [10M]

9. A single input system is described by the following state equation

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} -1 & 0 & 0 \\ 1 & -2 & 0 \\ 2 & 1 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 10 \\ 1 \\ 0 \end{bmatrix} u$$

Design a state feedback controller which will give closed loop poles at -1±j2,-6.By using state feedback control u=-Kx, it is designed to have the closed loop poles at s=-2+j4; -2-j4. [10M]

10. Explain in details the concepts of controllability and observability. [10M]

UNIT-III

1. (a) Explain the linear quadratic regulator problem. [5M]

   (b) Describe the solution of algebraic Riccati equation using alternative method. [5M]

2. Derive the solution or Riccati equation using eigen values and eigen vector method.

3. (a) State and explain the continuous linear quadratic regulator problem: [5M]

   (b) For the system $\dot{X} = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} U;\quad Y = \begin{bmatrix} 1 & 0 \end{bmatrix} X$ consider $J = \int_0^\infty X^T + u^2 dt$ Find Riccatti matrix K(t) and state feedback matrix. [5M]

4. (a) Define eigen value and eigen vector. [5M]

   (b) Explain canonical form of representation of linear system. [5M]

5. What are linear quadratic regulator (LQR) problems? Explain in detail the method to solve the LQR problems through solutions of algebraic riccati equation. [10M]

6. Explain in detail the concept of linear quadratic regulator. [10M]

7. (a) State and Explain fundamental theorem of calculus of variation. [5M]

   (b) State and explain the solution of algebraic riccati equation. [5M]

8. Explain in details about the Iterative method. [10M]

9. Write in details the controller design using output feedback method. [10M]

10. Write the procedure of solution of algebraic riccati equation using eigenvalue and eigenvector methods. [10M]

UNIT-IV

1. (a) Explain the controller design using output feedback method. [5M]

   (b) Design the full order observer using Ackermann's formula. [5M]

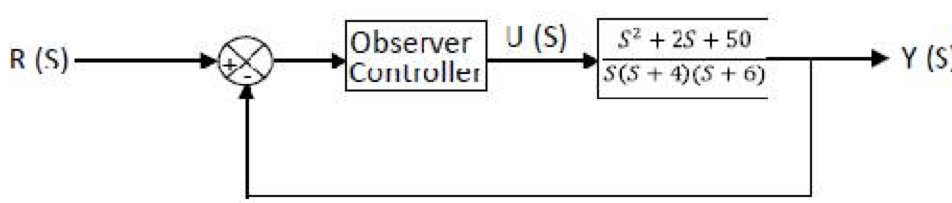
2. Consider the system $\dot{X} = Ax + Bu; \quad Y = Cx$ where $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix}; \quad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}; \quad C[1 \quad 0 \quad 0]$

   Design a reduced ordered observer. Assume the desired eigen values for minimum order observer are $\mu_1 = -2 + j2\sqrt{3} \quad \mu_2 = -2 - j2\sqrt{3}$. [10M]

3. Obtain observability and observable canonical form for the following state model: [10M]

$$\dot{X} = \begin{bmatrix} 2 & -2 & 3 \\ 1 & 1 & 1 \\ 1 & 3 & -1 \end{bmatrix} X + B = \begin{bmatrix} 11 \\ 1 \\ -14 \end{bmatrix} U; \quad Y = [-3 \quad 5 \quad -2]X$$

4. Using the pole placement with observer approach, design full order observer controller for the system shown in figure. The desired closed loop poles for the pole placement part are: S = -1+j2, S = -1-j2, S = -5. The desired observer poles are: S = -10, -10, -10. [10M]



5. Consider the system Ẋ=AX+BU Y=CXwhere $A = \begin{bmatrix} 0 & 20.6 \\ 1 & 0 \end{bmatrix} \quad B = \begin{bmatrix} 1 \\ 0 \end{bmatrix} \quad C = [0 \quad 1]$Design a full ordered observer. Assume the desired eigen values for observer matrix and μ1=−1.8+j2.4, μ2=−1.8+j2.4. [10M]

6. Consider the system $\dot{X} = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix} X + \begin{bmatrix} 1 \\ 1 \end{bmatrix} U; \quad Y = [2 \quad -1]X$. Design a reduced ordered observer that makes the estimation error to decay atleast as fast as e^{-10t}. [10M]

7. 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 $\mu 1=-5$, $\mu 2=-5$. [10M]

8. The state model of a system is given by

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

   Convert the state model into observable phase variable form. [10M]

9. The coefficient matrices of a state model are

   $\begin{bmatrix} -2 & 1 & 0 \\ 0 & -2 & 0 \\ -1 & -2 & -3 \end{bmatrix}; \quad B = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}; \quad C = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \quad and \quad D = \begin{bmatrix} 0 \end{bmatrix}$ Find the transformation X(t)=QX(t) so that the state canonical form. [10M]

10. Write short notes on full order and reduced order state observers with a suitable examples. [10M]

UNIT-V

1. (a) Explain the asymptotic stability of linear time invariant continuous. [5M]

   (b) Explain the asymptotic stability of time invariant discrete system. [5M]

2. (a) Explain about sensitivity and complementary sensitivity functions. [5M]

   (b) Describe the method of decoupling by state feedback giving an example. [5M]

3. State and prove Lyapunov stability theorem of linear time invariant continuous time systems[10M]

4. (a) Explain the stability in the sense of Lyapunov. [5M]

   (b) Describe with a neat sketch the internal stability of the system. [5M]

5. Explain in details about asymptotic stability of linear time invariant continuous and discrete time system. [10M]

6. A second order system is represented by X = AX, A = $\begin{bmatrix} -1 & 1 \\ -2 & -4 \end{bmatrix}$ use Lyapunov theorem and determine the stability of the origin of the system. Write the Lyapunov function V(x). [10M]

7. (a) State and Explain lyapunov stability theorem. [5M]

   (b) Determine the stability of the origin of the following $\dot{x}_1 = -x_1 + x_2 + x_1\left(x_1^{\,2} + x_2^{\,2}\right)$

consider the following quadratic function as a $\dot{x}_2 = -x_1 + x_2 + x_2\left(x_1^2 + x_2^2\right)$ possible lyapunov function $v(x)=x_1^2+x_2^2$. [5M]

8. Draw the phase trajectory of the system described by the equation $\ddot{x}+\dot{x}+x^2 = 0$ comment on the stability of the system. [10M]

9. (a) Determine asymptotic stability condition of a system using lyapunov approach. [5M]

   (b) Determine the stability of the system dynamics $\dot{x} = -x_1 - 2x_2 + 2; \quad \dot{x} = x_1 - 4x_2 - 1$ [5M]

10. (a) State and prove lyapunov stability theorem . [5M]

    (b) Find the stability of the system described by the equation $\dot{x}_1 = -x_1 + 2x_1^2 x_2; \quad \dot{x}_2 = -x_2$ [5M]

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