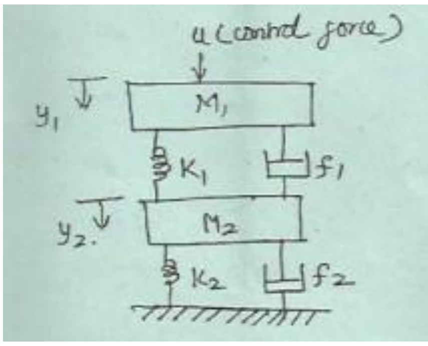
IN 5152 System Theory

Important 13 Marks Questions

Unit I

1. A feedback system has a closed loop transfer function $\frac{c(s)}{u(s)} = \frac{10(s+4)}{s(s+1)(s+3)}$ construct three different state models for this system and give block diagram representation for each state model.
2. Consider an armature controlled DC machine or a physical system of your choice. Obtain the state model of the chosen system. Show that the system can have infinite choices of state variable definition.
3. Calculate the state space model for (i) Series RLC Circuit.
4. Illustrate the expression for the state space model for the continuous system and also draw the state diagram for it.
5. Consider the mechanical system in figure, choose suitable state variables and construct the state model of the system.



Unit II

1. Obtain the unit step response of the following time varying state equation.

$$x_1 = -x_1 + tx_2$$

$$x_2 = -2x_2 + u$$

2. Consider a state model $x = AX + Bu$ where $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -40 & -34 & -10 \end{bmatrix}$;$B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$

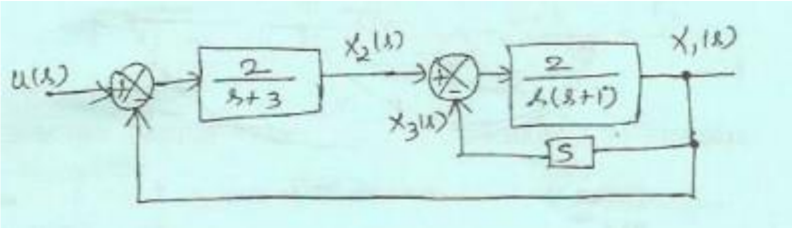
   (i) Find the eigen values of A.

   (ii) Suggest a suitable transformation matrix M so that $M^{-1}AM = \Lambda$

3. For a system represented by the state equation $x(t) = Ax(t)$ the response is $x(t) = \begin{bmatrix} e^{-2t} \\ -2e^{-2t} \end{bmatrix}$ when $x(0) = \begin{bmatrix} 1 \\ -2 \end{bmatrix}$ and $x(t) = \begin{bmatrix} e^{-t} \\ -e^{-t} \end{bmatrix}$ when $x(0) = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$. Determine the system matrix A and the state transition matrix.
4. Illustrate the expression by (i) matrix Exponential Method (ii) Laplace transform Method for state transition of matrix
5. Consider a system with the state model $X = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} X + \begin{bmatrix} 0 \\ 2 \end{bmatrix} u; X(0) = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$. Compute the state transition matrix.

Unit III

1. Examine the observability of the system
$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$
$$Y = \begin{bmatrix} 3 & 4 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}.$$
2. Consider a system with $G(s) = \frac{s+1}{s^2+5s+4}$. Obtain one minimal and non-minimal realization of the system.
3. Derive the conditions for controllability of linear time invariant systems in terms of the controllability grammian.
4. Explain in detail about stabilizability and detectability.
5. Write the state equation of the system in figure in which $x_{1,}x_{2,}x_3$ constitute the state vector. Determine whether the system is completely controllable and observable.



Unit IV

1. Consider a non-linear system described by the equations
$x_1 = -3x_1 + x_{2;}$ $\quad x_2 = x_1 - x_2 - x_2^3$
Use Krasovskii's method with P as identity matrix to check the stability of the equilibrium state.
2. Test the stability of the following system using Lyapunov's approach for Linear time invariant system.
$$x = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x.$$
3. Design a state observer for the given linear system described by the equation.
$$X = \begin{bmatrix} 1 & 2 & 0 \\ 3 & -1 & 1 \\ 0 & 2 & 0 \end{bmatrix} X + \begin{bmatrix} 2 \\ 1 \\ 1 \end{bmatrix} u \,;\, y[0 \quad 0 \quad 1]X.$$
4. Discuss in detail the Lyapunov function.
5. Determine stability of the system described by the following equation $X = AX$.
$A = \begin{bmatrix} -1 & -2 \\ 1 & -4 \end{bmatrix}$; check the stability of the system.

Unit V

1. Explain in detail the effect of state feedback on controllability and observability.
2. Design an observer for the given linear system.
$$x = \begin{bmatrix} 1 & 2 & 3 \\ 3 & -1 & 1 \\ 0 & 2 & 0 \end{bmatrix} X + \begin{bmatrix} 2 \\ 1 \\ 1 \end{bmatrix} u \text{ and } y = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix} X.$$

3. With state feedback loops open, the system is described by

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & -1 & 1 \\ 0 & -1 & -10 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 10 \end{bmatrix} u$$

Design a suitable state feedback with G=0.5 and W_n=2 rad/sec.

4. Show that more than one state feedback solution is possible for the following system to assign the closed loop poles at -1 and -2. $x = \begin{bmatrix} 0 & 1 \\ 2 & 3 \end{bmatrix} x + \begin{bmatrix} 0 & 0 \\ 1 & 1 \end{bmatrix} u$

5. Design full and reduced order observers for the following system, so that observation error dynamics dies out in 0.1 seconds.

$$x = \begin{bmatrix} 0 & -1 \\ -2 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u \; ; \; y = \begin{bmatrix} 1 & 0 \end{bmatrix} x.$$