BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

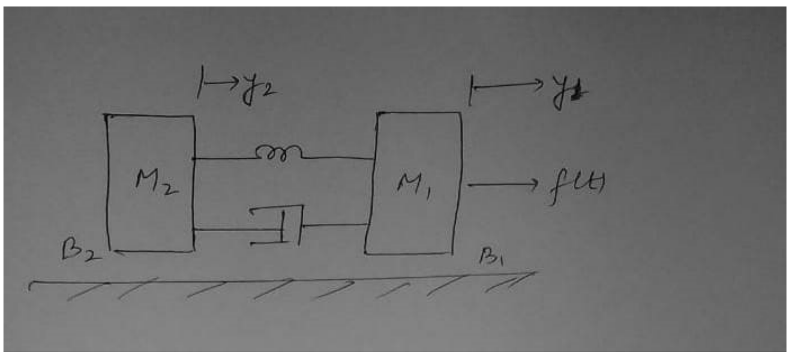
CLASS: M.Tech. **SEMESTER : I**
BRANCH: EEE **SESSION : MO/2022**

SUBJECT: EE503 MODERN CONTROL THEORY

TIME: 3:00 Hours **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
4. Before attempting the question paper, be sure that you have got the correct question paper.
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

Q.1(a) Distinguish between classical control theory and modern control theory. [2]
Q.1(b) Draw and explain the block diagram representation of a system in the form of state model. [3]
Q.1(c) Obtain the state model for the following system in Fig. [5]



Q.2(a) Differentiate between eigenvalues and eigenvectors. Explain how the eigenvalues are related to stability of a system. [2]
Q.2(b) Explain the Caley-Hamilton theorem. Explain any two applications also. [3]
Q.2(c) Draw the state diagram for the system given below by using direct decomposition. Assign the state variables in ascending order from right to left. Write the state equations from state diagram. [5]

$$G(s) = \frac{2(s+2)}{s^2(s+1)(s+5)}$$

Q.3(a) List the significance of state transition matrix. [2]
Q.3(b) Explain any two methods for evaluation of STM. [3]
Q.3(c) Consider the system described by [5]

$$\begin{bmatrix} \dot{x_1} \\ \dot{x_2} \end{bmatrix} = \begin{bmatrix} -2 & -1-j \\ -1+j & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Determine the stability of the equilibrium state described by the following equation using Liapunov stability criteria.

Q.4(a) Present the motivation behind the concept of controllability and observability. [2]
Q.4(b) Compare the Kalman's and Gilbert's tests for controllability and observability. [3]

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Q.4(c) Determine the controllability of the following systems: [5]

(i) $A = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix}, B = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}$

(ii) $A = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -2 & 0 \\ 0 & 0 & -3 \end{bmatrix}, B = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}$

Q.5(a) Draw and explain the block diagram of state observer. [2]

Q.5(b) Derive the Ackermann's formula for determining the state feedback gain matrix K using pole placement technique. [3]

Q.5(c) Consider a system described by $\dot{x} = Ax + Bu$, where $A = \begin{bmatrix} 0 & 1 \\ 0 & -1 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$. The performance index J is given by $J = \int_0^\infty (x'Qx + u'Ru)dt$, where $Q = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}, R = [1]$. Assume that the following control u is used, u=-Kx. Determine the optimal feedback gain matrix K. [5]

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