

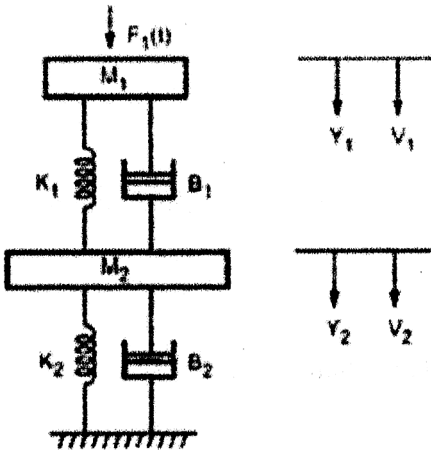
B.E. MECHANICAL ENGINEERING FOURTH YEAR FIRST SEMESTER EXAM 2025**SUBJECT: MATHEMATICAL METHODS IN MECHANICAL ENGINEERING (HONS.)**

Time: 3 hours

Full Marks: 100

[Use separate answer scripts for PART - I and PART - III]**PART-I (50 Marks)****[answer any 3 (three)]****[2 (two) marks for neatness]**1. Find the state transition matrix for the equation $X' = AX + BU$, where $A = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$, $B = \begin{bmatrix} 1 & 1 \end{bmatrix}^T$ Also find the time response for the system if $U(t)$ is the unit step occurring at $t = 0$ and

$$X(0) = \begin{bmatrix} 2 & 0 \end{bmatrix}^T \quad [16]$$

2. Consider the mechanical system shown in the figure. For shown displacements and velocities obtain the state model in standard form. Consider Y_2 to be output.

[16]

3. Find the P.I.s of

a. $(D^2 + D - 2)y = e^{-2x} + e^x$

b. $(D^2 - D)y = x^2 + 4$

[8+8]

4. Using Runge's method solve:

$$dy/dx = (y^2 - 2x) / (y^2 + x) \text{ with } y(0) = 1$$

for $x = 0.2, 0.3$

[16]

[Turn over

PART- II (50 Marks)**(Question No. 6 compulsory and answer any five from the rest)**

5. The data in the table below represent the water level of a Lake Huron for years 1 to 3.

Month	Year		
	1	2	3
Jan	10	11	9
Feb	11	11	9
Mar	12	10	9
Apr	11	10	9
May	11	9	9
Jun	11	9	10
Jul	10	10	10
Aug	11	10	9
Sep	10	8	10
Oct	10	9	10
Nov	11	9	9
Dec	12	9	9

Plot the time series of data as shown. Comment on the system. Can you identify seasonal fluctuations and/or trend? Assume trend as linear. [25]

6. State classification of states of Markov Chain. [5]
7. What do you mean by Markov Chain? State two characteristics of a Markov Chain. [5]
8. Explain the Stochastic Process with example. [5]
9. Suppose that whether or not it rains today depends on previous weather conditions through the last two days. Specifically, suppose that if it has rained for the past two days, then it will rain tomorrow with probability 0.75; if it rained today but not yesterday, then it will rain tomorrow with probability 0.5; if it rained yesterday but not today, then it will rain tomorrow with probability 0.4; if it has not rained in the past two days, then it will rain tomorrow with probability 0.2.

Explain states and develop transition matrix. [5]

10. What do you mean by time-series data? What are the objectives of time-series data analysis? [5]
11. Explain IID Noise. [5]
12. The one-step transition probability matrix is given by

$$\begin{bmatrix} 0.7 & 0.3 \\ 0.4 & 0.6 \end{bmatrix}$$

Calculate the desired probability P_{00}^4 .

[5]