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Name :

**MAR ATHANASIUS COLLEGE OF ENGINEERING, KOTHAMANGALAM**

(Govt. Aided Autonomous Institution)

Fourth Semester B.Tech. Degree Examination, May, 2026

Course Code: B24CD2T01

Course Name: MACHINE LEARNING CONCEPTS

Max. Marks: 100

Duration:3 Hours

PART - A: 30 Marks (10 Qns x 3 Marks)**Answer all questions**

1. Explain the key difference between supervised and unsupervised learning with one real-world example for each.
2. Define proximity measures. What are the two main types of proximity measures used in machine learning?
3. Illustrate Multilayer Feed Forward Neural Network
4. List the main components of a biological neuron. What are their functions?
5. Why is the matrix (Normal Equation) method computationally expensive for large datasets? Also state one practical situation where Gradient Descent is preferred over the matrix method.
6. How can we interpret the output of a two-class logistic regression classifier as a probability?
7. List the steps involved in Agglomerative hierarchical clustering.
8. Define a dendrogram. What information does its height represent?
9. Define the Receiver Operating Characteristic (ROC) curve. What does it represent in classification evaluation?
10. Define F1 Score with example.

PART - B: 70 Marks (5 Qns x 14 Marks)**Answer any One full question from each module.****Module 1**

11. a. Let

$$V = \{(x, y) \in \mathbb{R}^2 \mid x + y = 1\}$$

Is V a vector space?

(7 Marks)

b. Let

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

Compute $X^T X$. Is the result symmetric?

(7 Marks)

OR

12. a. Discuss the significance of the zero vector in the theory of vector spaces. Why is it necessary for every subspace to contain the zero vector? (7 Marks)

b. Check whether the set $W = \{(x, y) \in \mathbb{R}^2 \mid y = 2x\}$ forms a subspace of $\mathbb{R}^2$. Justify your answer by verifying all the necessary conditions. (7 Marks)

Module 2

13. a) Compare and contrast L1 norm, L2 norm, and L_∞ norm. Discuss their properties, geometric interpretations, and applications in machine learning. Explain why L2 norm is most commonly used, but L1 norm is preferred for sparse solutions (7 Marks)

b) Show that the norm induced by an inner product satisfies the triangle inequality. (7 Marks)

OR

14. a) Design a McCulloch-Pitts neuron to implement the logical AND function for three inputs. Show the weights and threshold value. (7 Marks)

b) Determine whether a single perceptron can learn the XOR function. Justify your answer. (7 Marks)

Module 3

15. a) The following table contains measurements of yield from an experiment done at five different temperature levels. The variables are y = yield and x = temperature in degrees Fahrenheit. Compute a second degree polynomial regression model to predict the yield given the temperature 65. (7 Marks)

Temperature (x)	Yield (y)
50	3.0
70	2.7
80	2.6
90	2.9
100	3.3

b) Define non-linear regression. How is it different from linear regression?

(7 Marks)

OR

16. a) An experiment was done to assess how moisture content and sweetness of a pastry product affect the rating of the product. The following table summarises the findings.

Rating	Moisture	Sweetness
64	4	2
73	4	4
61	4	2
76	4	4
72	6	2
80	6	4
71	6	2
83	6	4
83	8	2
89	8	4
86	8	2
93	8	4
88	10	2
95	10	4
94	10	2
100	10	4

Compute a linear regression model to predict the rating of the pastry product based on the sweetness.
(7 Marks)

b) Discuss linear regression with single and multiple variables, along with suitable examples.
(7 Marks)

Module 4

17. (a) Explain PAM algorithm. (7 marks)
(b) Apply K-medoids on dataset {2, 4, 10, 12}. Use initial medoids 2 and 10. Perform one full iteration. (7 marks)

OR

18. Consider three document vectors: $D_1 = (1, 2, 0, 1)$, $D_2 = (1, 1, 0, 1)$ and $D_3 = (0, 1, 1, 0)$
(a) Compute the Cosine similarity between all pairs of documents. (8 marks)
(b) Using complete linkage hierarchical clustering, determine the first two merges and draw the partial dendrogram. (6 marks)

Module 5

19. (a) Explain the relationship between RMSE and R^2 . Can a model have high R^2 but high RMSE? Justify theoretically. (7 marks)
(b) Two regression models are evaluated on the same dataset:

Model	RMSE	R^2
A	2.8	0.88
B	2.1	0.74

Analyse both models in terms of prediction accuracy, explanatory power, and practical deployment.

Which model would you recommend for a forecasting task? Justify your answer with reasoning.

(7 marks)

OR

20.

Two clusters are formed with:

- Maximum intra-cluster distance in Cluster 1 = 5
- Maximum intra-cluster distance in Cluster 2 = 6
- Minimum inter-cluster distance = 12

For four sample points:

Point	a (intra)	b (nearest cluster)
P1	3	10
P2	4	8
P3	5	7
P4	6	9

(a) Compute Dunn's Index, Silhouette coefficient for each point, Average Silhouette Score. (9 Marks)

(b) Evaluate cluster compactness and separation using both metrics. (5 Marks)
