M.C.S.E. FIRST YEAR FIRST SEMESTER EXAMINATION-2025
MACHINE LEARNING AND APPLICATIONS

Time: 3 hours **Full Marks: 100**

Question number 1 is compulsory. The remaining questions are in two parts: answer either part A or part B.

1.a) Compare classification and clustering.
b) What is finally produced by a Hierarchical Clustering?
c) You are training a logistic regression model and notice that it performs poorly on test data. Could the poor performance be due to underfitting? Justify.
d) What will happen when you increase the size of training data?
e) What would the regression look like when no linear relationship exists between two variables?
f) What do you mean by VC dimension?
g) Why is the "kernel trick" used?
h) What happens to the performance of the k-NN classifier for various k values?
i) Decision tree learners may create biased trees if some classes dominate. What's the solution to it
j) What is the link between entropy and information content

2 × 10

2.A.i). Consider this distance table given in Table 1 and perform hierarchical clustering using the following strategies

	A	B	C	D	E	F
A	0	1	7	8	1	2
B	1	0	2	7	8	2
C	7	2	0	4	5	4
D	8	7	4	0	2	9
E	1	8	5	2	0	12
F	2	2	4	9	12	0

Table-1

a) Single linkage
b) Average linkage

5 + 5

2.A.ii) Consider the following dataset
(0,1),(1,1),(1,2),(1,3), (2,1),(2,2),(2,3),(3,4),(5,5),(6,5),(6,6),(7,6),(7,7)
Perform clustering using the k-means clustering algorithm with two centers (k=2) as (0,1) and (6,1). (Two iterations only). **10**

OR

2.B.i) Explain how we can measure the distance between two arbitrary objects. Using that technique, compute the distance between a Laptop Computer and a Smartphone. **10**
2.B.ii)Compare DB-index for clusterings {(1,2), (3,5,6,8)} and {(1,2), (3,5), (6,8)} **10**

3.A.i) Realize XOR logic using a RBF network. **10**
3.A.ii) Explain the backpropagation learning algorithm with a diagram **10**

OR

3.B.i) Consider the Hebbian learning rule for an ANN with a single PE, a LTU. This PE has four inputs: x1, x2, x3, and x4. The corresponding weight vector is $w = [w_1, w_2, w_3, w_4]^T$. Assume that this ANN is to be trained using the following three input vectors: $[1, -1.5, 0.5, 0]^T$, $[-0.5, 1, 0, 1.5]^T$, $[-1, 0, -1, -0.5]^T$. Assume $\eta=1$ and $w^{(1)}=[1, 0, -1, 0]^T$. Find updated weight vectors after the first epoch. **10**
3.B.ii) Explain with an example when and why a multi-layer perceptron performs better than a single-layer perceptron. **10**

4.A.i) It is known that 1.5% of the population suffers from a particular disease. A blood test has a 95% chance of identifying the disease for a diseased individual and an 8% chance of falsely indicating that a healthy person has a disease.
(a) What is the probability that a random person has a positive blood test?
(b) If a blood test is positive, what's the probability that the person has the disease?
(c) If a blood test is negative, what's the probability that the person does not have the disease?

3 + 3 + 4

4.A.ii) Consider a 2-class problem with $P(C_1) = 3/4$, $P(C_2)=1/4$; a scalar feature x and three possible actions a_1, a_2, a_3 defined as:
a_1: choose C_1
a_2: choose C_2
a_3: do not classify
Let the loss matrix $\lambda(a_i | C_j)$ be:

	a_1	a_2	a_3
C_1	0	1	1/4
C_2	1	0	1/4

and let $P(x | C_1) = (2-x)/3$, $P(x | C_2) = 1/3$, $0 \le x \le 2$
(a)Which action to decide for a pattern x; $0 \le x \le 2$?
(b) What is the proportion of patterns for which action a_3 is performed (i.e., "do not classify")?
(c) Compute the total minimum risk
(d) If you decide to take action a_1 for all x, how much will the total risk be reduced or increased?

3 + 2 + 3 + 2

OR

4.B.i) Consider Table 2 and compute the parameters for a Naïve Bayes classifier for predicting parameters for predicting "Play Golf." **10**

Outlook	Temp	Humidity	Windy	Play Golf
Rainy	Hot	High	False	No
Rainy	Hot	High	True	No
Overcast	Hot	High	False	Yes
Sunny	Mild	High	False	Yes
Sunny	Cool	Normal	False	Yes
Sunny	Cool	Normal	True	No
Overcast	Cool	Normal	True	Yes
Rainy	Mild	High	False	No
Rainy	Cool	Normal	False	Yes
Sunny	Mild	Normal	False	Yes
Rainy	Mild	Normal	True	Yes
Overcast	Mild	High	True	Yes
Overcast	Hot	Normal	False	Yes
Sunny	Mild	High	True	No

Table 2

4.B.ii)(a) Explain SVM for two-class classification
(b) What is ensemble learning? Explain one technique for classifier combination.

5 + 5

5. A.i) Create a decision tree following the ID3 algorithm for data given in Table 2. **10**

5.A.ii) Consider the data given in Table 3. Determine a decision tree through the Gini index to find E based on four attributes: A, B, C, and D. **10**

Index	A	B	C	D	E
1	4.8	3.4	1.9	0.2	positive
2	5	3	1.6	1.2	positive
3	5	3.4	1.6	0.2	positive
4	5.2	3.5	1.5	0.2	positive
5	5.2	3.4	1.4	0.2	positive
6	4.7	3.2	1.6	0.2	positive
7	4.8	3.1	1.6	0.2	positive
8	5.4	3.4	1.5	0.4	positive
9	7	3.2	4.7	1.4	negative
10	6.4	3.2	4.7	1.5	negative
11	6.9	3.1	4.9	1.5	negative
12	5.5	2.3	4	1.3	negative
13	6.5	2.8	4.6	1.5	negative
14	5.7	2.8	4.5	1.3	negative
15	6.3	3.3	4.7	1.6	negative
16	4.9	2.4	3.3	1	negative

Table-3

OR

5.B.i) Find the least squares regression line for the data given in Table 4 **10**

Fire	1	2	3	4	5	6	7	8	9	10
Distance	3.4	2.8	4.5	2.1	3.4	5.8	1.0	3.2	2.3	4.6
Damage	27.1	20.2	31.7	22.5	28.4	36.2	15.2	22.9	18.7	32.1

Table-4

5.B.ii) For a given classifier, suppose the first ten predictions of our classifier and ten true observations are as follows:

Prediction	1	1	1	1	1	0	1	1	1	1
True label	0	1	1	1	0	0	0	1	1	1

Compute accuracy, precision, recall, specificity, and false positive rate. **10**