National Forensic Sciences University
School of Cyber Security and Digital Forensics

Course Name: M.Tech Artificial Intelligence and Data Science (Batch: 2023-25)
Semester - II **Exam:** TA - I (FEB – 2025)

Subject Code: CTMTAIDS SII P1 **Time:12:00pm-1:15pm**
Subject Name: Advanced Machine Learning for Cybersecurity and Forensics **Date:10/2/2025**

Q1. Given the cost function for linear regression with a single feature and multiple training examples:

$$J(\theta) = \frac{1}{2m} \sum_{i=1}^{m} (h_\theta(x^{(i)}) - y^{(i)})^2$$

where the hypothesis function is defined as:

$$h_\theta(x) = \theta^T x$$

derive the normal equation:

$$\theta = (X^T X)^{-1} X^T y$$

Show all steps clearly. **6 marks**

Q2. Suppose you are using **gradient descent** for a univariate linear regression problem. The hypothesis function is:

$$h_\theta(x) = \theta_0 + \theta_1 x$$

The cost function is:

$$J(\theta) = \frac{1}{2m} \sum_{i=1}^{m} (h_\theta(x^{(i)}) - y^{(i)})^2$$

You have a dataset with **two training examples:**

x	y
1	2
3	6

Assume the learning rate $\alpha = 0.1$ and initial values $\theta_0 = 0$, $\theta_1 = 0$. Perform **one iteration** of gradient descent and compute the updated values of θ_0 and θ_1. **6 marks**

Q3. You are given the following dataset for training:

x_1	x_2	y
1	2	5
3	4	10
5	6	15

If the hypothesis function is

$$h_\theta(x) = \theta_0 + \theta_1 x_1 + \theta_2 x_2$$

Write the correct design matrix X used in the normal equation? **2 marks**

Q4. You are given a logistic regression model with parameters: $\theta_0 = -2$ and $\theta_1 = -0.5$. For an input value $x = 6$, calculate the probability that the output is class 1 using the logistic (sigmoid) function:

$$h_\theta(x) = \frac{1}{1 + e^{-(\theta_0 + \theta_1 x)}}$$

Based on the probability threshold of 0.5, determine the predicted class label. Assume $h_\theta(x) > 0.5$ is labelled as class 1. **6 marks**

Q5. What is the effect of increasing the regularization parameter λ in logistic regression with L2 regularization? **3 marks**

a) It increases the model's complexity by allowing the weights to grow larger.

b) It decreases the model's complexity by shrinking the weights towards zero, helping to avoid overfitting.

c) It has no effect on the model's complexity, only on the training time.

d) It decreases the model's accuracy by forcing the weights to be very large.

Q6. Which of the following statements best explains why logistic regression is preferred over linear regression for classification tasks? **2 marks**

a) Logistic regression minimizes the Mean Squared Error (MSE), which ensures a good classification model.

b) Logistic regression outputs continuous values, which are better suited for classifying continuous targets.

c) Linear regression may predict values outside the [0, 1] range, which is not interpretable as probabilities in classification tasks.

d) Logistic regression requires less computational power than linear regression for large datasets.