Air University
(Final-Term Examination: Fall 2025)
Department of Cyber Security

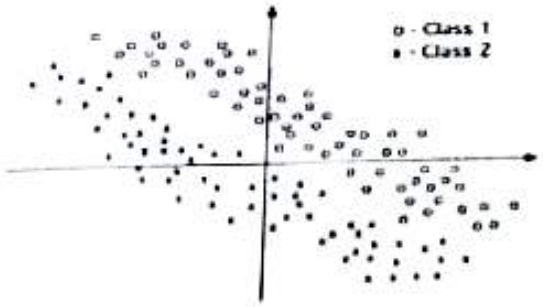
Student Name: _____ **Student ID:** 23309
Subject: Artificial Intelligence **Total Marks: 100**
Course Code: CS-344 **Date:** _____
Class: BSCYS F23 **Duration: 3 Hours**
Section: B **FM Name: Dr. Balawal Shabir**

Instructions

- **Understanding questions is part of the exam.**
- **Return the question paper back.**

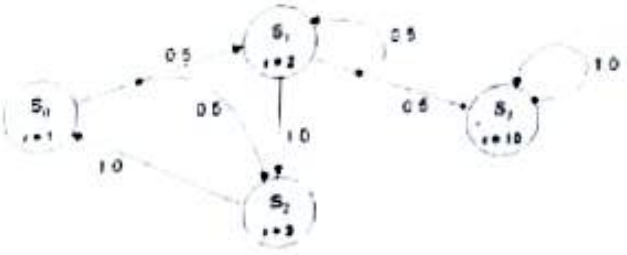
Question 1 CLO-1 [20 points]

Q1 [20 pts] Suppose, you are given 2D feature vectors for a classification task which are distributed according to the figure below. You apply PCA to the data from each class separately, keeping only a single eigenvector in each case. On the figure, for each class draw the location of the mean and the direction of the eigenvector which corresponds to the largest eigenvalue **[20]**

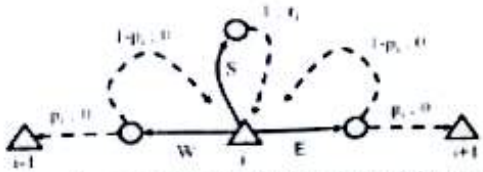


Question 2: RL [25 points] CLO-2

Q2A[15 points] Consider the MDP given in the figure below. Assume the discount factor γ = 0.9. The r-values (written within the node) are rewards that the agent gets when he reaches a node. the numbers next to arrows are probabilities of outcomes. Note that only state S1 has two actions. The other states have only one action for each state. Write down the optimal value of state S1. (Hint: first find the optimal policy for S3 using the closed form)



Q2B [10 points] There are N cities along a major highway numbered 1 through N. You are a merchant from city 1 (that's where you start). Each day, you can either travel to a neighboring city (actions East or West) or stay and do business in the current city (action Stay). If you choose to travel from city i, you successfully reach the next city with probability pi, but there is probability 1 − pi that you hit a storm, in which case you waste the day and do not go anywhere. If you stay to do business in city i, you get ri > 0 in reward; a travel day has reward 0 regardless of whether or not you succeed in changing cities. The diagram below shows the actions and transitions from city i. Solid arrows are actions; dashed arrows are resulting transitions labeled with their probability and reward, in that order. The triangle depicts the state/city and the circle depicts the intermediate chance state.



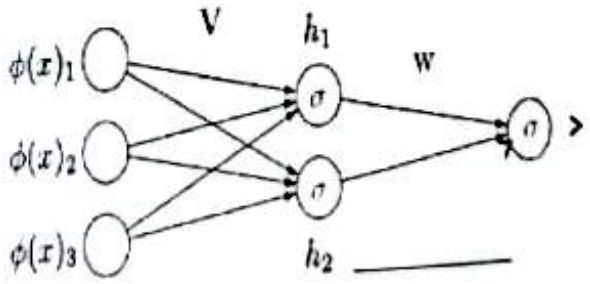
[5 points] If for all i, ri = 1, pi = 1, and there is a discount $\gamma = 0.5$, what is the optimal value $V^*(1)$ of being in city 1?

[5 points] If the ri 's and pi 's are known positive numbers (each city i can have a different ri and pi) and there is no discount, i.e. $\gamma = 1$, describe the optimal policy. You may define it formally or in words, e.g. "always go east," but your answer should precisely define how an agent should act in any given state. Hint: You should not need to do any computation to answer this question.

Question 3 – Artificial Neural Networks [15 points] CLO- 2

Xor function is not linearly separable. You will therefore use neural network with one hidden layer to implement the xor function. The training data is given in the table below. (Use sigmoidfunction to approximate the step function.

$\phi(x)$	1 0 0	1 0 1	1 1 0	1 1 1
y	0	1	1	0



Part A: Label the given figure, corresponding to the two-layer neural network drawn above, with partial derivates at each edge **[10 points]**.

Part B: Fill the following table with partial derivatives **[5 points]**.

$\frac{\partial L}{\partial c_1}$	
$\frac{\partial L}{\partial c_2}$	
$\frac{\partial L}{\partial c_3}$	

QUESTION 4: Answer the following [20 points] CLO-3

i. What is the role of λ in regularized linear regression? (2)

ii. Suppose you have implemented regularized linear regression to predict housing prices. However, when you test your hypothesis in a new set of houses, you find that it makes unacceptably large errors in its prediction. What will each of the following actions do? Your task is mention whether it would fix variance/bias (Low, High).

a. Geting more training examples will fix ____
b. Trying smaller sets of features will fix ____
c. Trying getting additional features will fix ____
d. Trying adding polynomial features will fix ____
e. Trying decreasing λ fix ____
f. Trying increasing λ fix ____

QUESTION 5: Answer the following [20 points] CLO-3

[10 pts A] Suppose your learning algorithm is performing less well than you were hoping. How do you determine if it's a bias or a variance problem.

[10 pts B] How do you choose the regularization parameter λ? Explain with the help of graph $Jtrain, Jcv$ vs regularization parameter