National University of Computer and Emerging Sciences, Lahore Campus

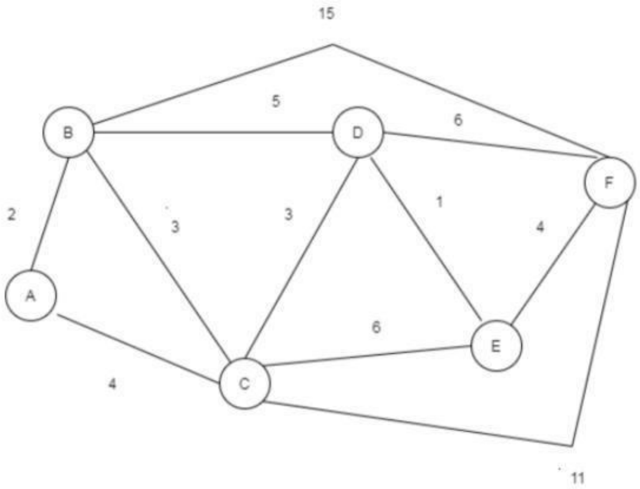
	Course:	**Artificial Intelligence**	**Course Code:**	**AI2002**
	Program:	**BS(CS)**	**Semester:**	**Spring-24**
	Exam Type:	**Assignment 2**	**Total Marks:**	**TBD**
	Due Date:		**Weight**	**TBD**
	Section:	**SecB**	**Page(s):**	**5**
	Name:	**1-03-2024**	**Roll No :**	

Instructions:

- **Do the work by yourself, this is an individual assignment.**
- **Plagiarism cases will be dealt with strictly.**
- **Q1-Q3 are handwritten questions, Q4 is implementation based.**
- **Submit Q1-Q3 as a single pdf file, for Q4 submit the python file.**

Question 1:

Suppose you have been given a map of 6 cities connected with each other via different paths. Your job is to visit every city just once covering the minimum distance possible. Solve this problem using Genetic Algorithm. You can start at any point and end at any point. Just make sure that all the cities have been covered.



1. Encode the problem and create an initial population of 3 different chromosomes and choose any one parent from your above solution and identity the following:
    - Gene
    - Chromosome

2. Think of an appropriate fitness function to this problem and give proper justification.

3. Use the fitness function to calculate the fitness level of all the chromosomes in your population. Select the fittest 2 chromosomes based on the fitness function.

4. Perform crossover that you have been taught in the class on the selected parents. Now based on the offspring, for this problem do you think that is the best way to perform crossover? If not, explain why.

5. Perform mutation that you have been taught in the class on the produced offspring. Now based on the mutated offspring, for this problem do you think that is the best way to perform mutation? If not, explain why.

Question 2:

Consider the following population of four chromosomes and the fitness function f(x).

$f(x) = x^3 - 60*x^2 + 900*x + 100$

a) Calculate the decimal values for x and the fitness of each chromosome in the table below.

Chromosome	Binary String	x	Fitness
P1	**001111**		
P2	**000100**		

b) Perform crossover at the midpoint and mutation on the third gene from the right to form a new population. (start crossover from the left of P1)

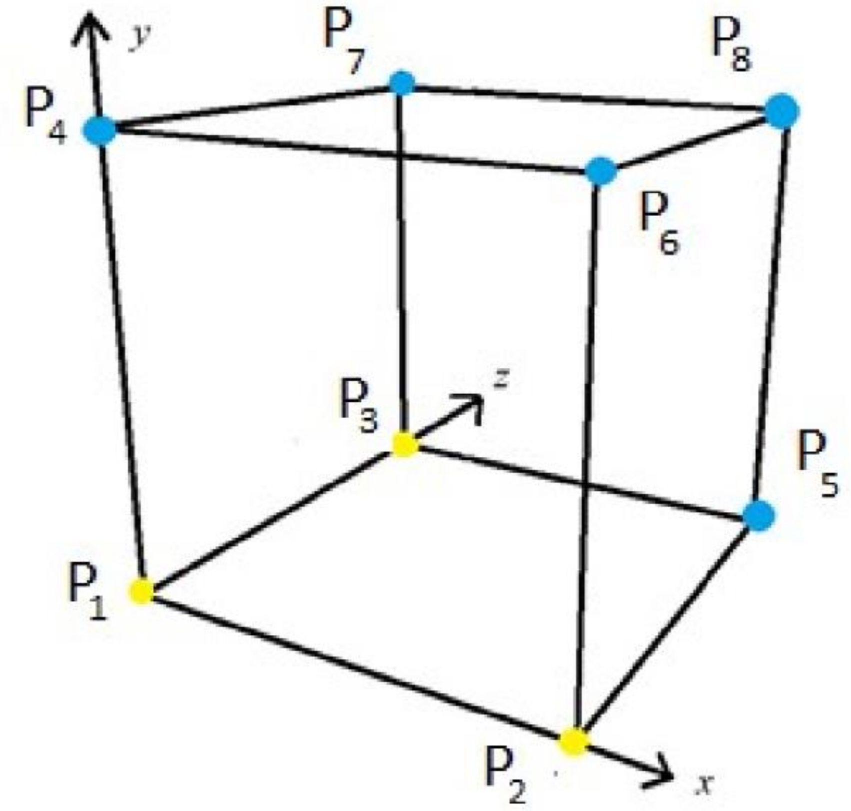
Chromosome	Binary String	x	Fitness
O1(Offspring)		**8**	
O2(Offspring)		**11**	

c) Has the overall fitness improved?

d) What is the fitness of the optimal solution?

Question 3:

You are given a 2-class, 3-dimensional data set. The data is plotted in the graph below. Yellow and blue dots represent negative class (-1) and positive class (1) respectively. Basically, the samples/points represent the corners of a unit cube. The point P1 is at the center of the coordinate plane i.e. (0, 0, 0).



Using a single Perceptron, learn a linear model for this data that correctly classifies all the samples/points. You must start with the initial weights [-2 2 3 2] and use the points in order i.e. P1 then P2 ... P8 during the learning process. Further, the first weight i.e. -2 is that of the bias term the bias term is always 1 and learning rate is also 1.

Show all the working that you did to calculate the values of the weights. The activation function g(x) is given below:

$$g(x) = \{ 1, x \geq 0 \\ -1, x < 0\}$$

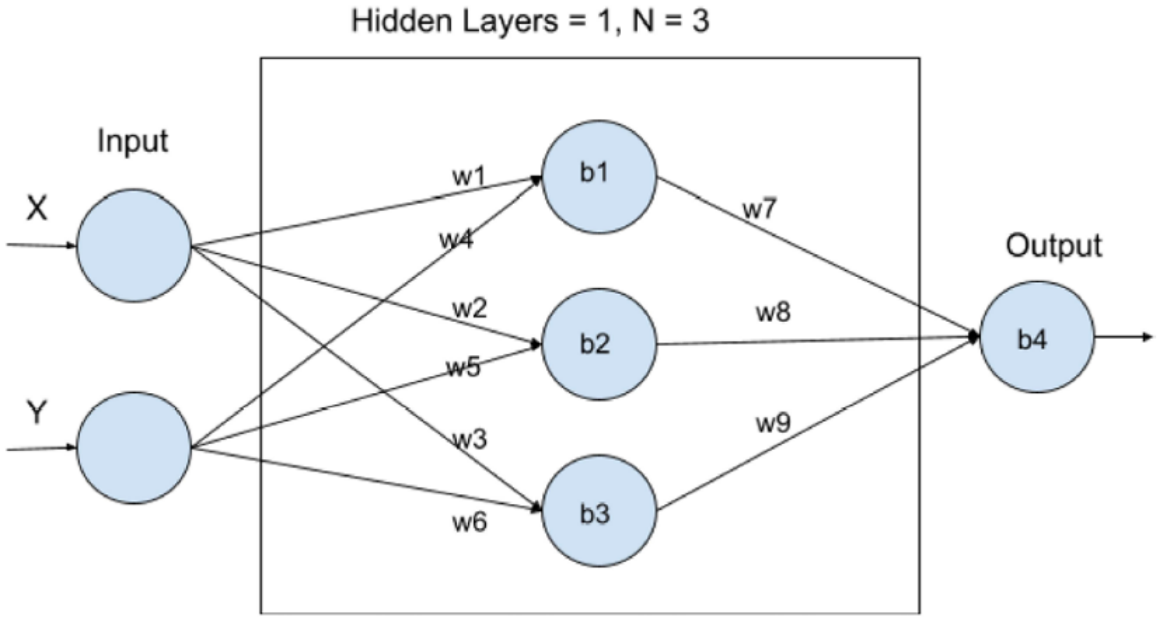
Question 4:
Implement a neural network. You are required to implement feed forward for XOR gate. Requirements are as follows:

1. Input size will be 2
2. Output size will be 1
3. Initialize the weights randomly
4. Number of hidden layers and N(number nodes in a hidden layer) will be parameters and set during initialization.
5. Activation Function will be Sigmoid

Use this neural network to predict the output of XOR. The following table shows the correct output of XOR:

X	Y	Output
0	0	0
0	1	1
1	0	1
1	1	0

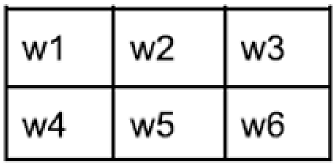
Example:



Hint:

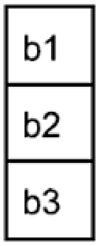
Weights and biases for the above example can be stored in matrices as:

W1 =



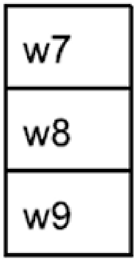
w1	w2	w3
w4	w5	w6

B1=



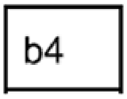
b1
b2
b3

W2 =



w7
w8
w9

B2 =



b4