National University of Computer and Emerging Sciences, Lahore Campus

Course Name:	Artificial Intelligence	Course Code:	AI2002
Program:	BS (CS) BS(DS)	Semester:	Spring 2023
Duration:	180 Minutes	Total Marks:	66
Paper Date:	22-May-2023	Weightage	45
Section:	ALL	Page(s):	10
Exam Type:	Final		

Question	Q1 (CLO:2,3)	Q2 (CLO:3)	Q3 (CLO:2)	Q4 (CLO:2)	Q5 (CLO:2)	Q6 (CLO:3)	Total Marks
Marks	10	15	10	10	15	6	66
Obtained Marks							

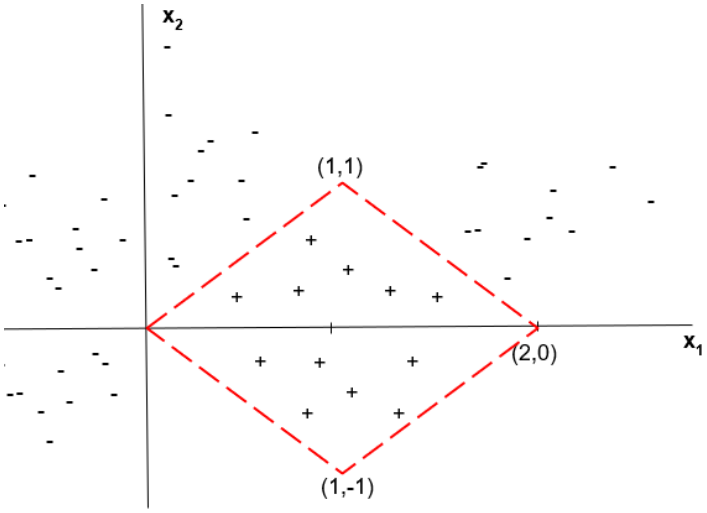
Student Name: _____ **Section:** _____ **Roll No.**_____

Do not use pencil or red ink to answer the questions**.** In case of confusion or ambiguity make a reasonable assumption. *Attempt **all questions** on the question paper in space provided.*

QUESTION 1:

Part a. (5)

Draw a complete neural network that learns the following classification problem. Clearly state the activation function being used at each node. The input to the neural network should be the coordinates X_1 and X_2.



Note:

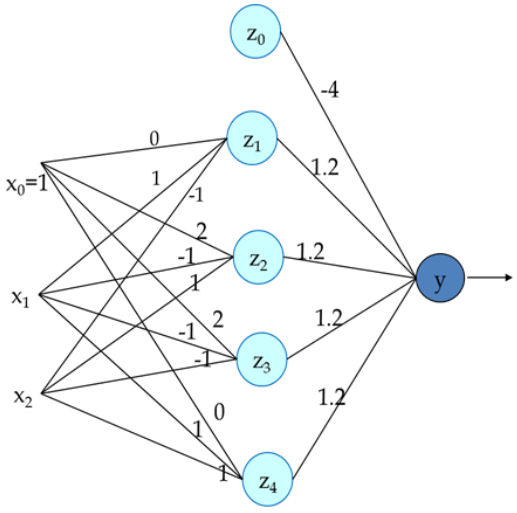
The following have to be satisfied for a point to be classified as a positive example.

X_1-X_2 >0 AND

-X_1+X_2+2 > 0 AND

-X_1-X_2+2 > 0 AND

X_1+X_2 > 0 AND



At each unit the activation function used is the Bipolar function defined as:

f(x) = +1 if x>0

f(x) = -1 if x <= 0

Part b. (2+3)

A company wants to predict if their marketing campaigns will be successful based on various factors [**Successful** (1), **Not successful** (0)]. They have collected data for multiple campaigns, including the campaign duration (in days), the number of social media ads, the number of email newsletters sent, the budget allocated for each campaign and number of employees assigned to each campaign.

They want to build a predictive model using a neural network to classify the output based on these features and automate the process by using a fully connected **feed-forward network**. The network has one hidden layer of 2 neurons and a single output neuron with linear activation function used in the hidden neurons and sigmoid activation used at the output neuron. The trained network weights for both campaigns are provided below:

Hidden Neuron Weights						**Output Neuron Weights**		
H1	**0.5**	**-0.2**	**0.5**	**0.5**	**-0.4**	**O1**	**1**	**1**
H2	**0**	**1**	**-1**	**0.3**	**-0.6**			

i. Assuming that the neurons DO NOT have bias terms, find if the following campaign will be successful given the campaign data: [5, -0.4, 0.8, -0.1, 0.3]

$net\_H_1 = (0.5 \times 5) + (-0.2 \times -0.4) + (0.5 \times 0.8) + (0.5 \times -0.1) + (-0.4 \times 0.3) = 2.81$

$\boldsymbol{O(net\_H_1) = 2.81}$

$net_{H_2} = (0 \times 5) + (1 \times -0.4) + (-1 \times 0.8) + (0.3 \times -0.1) + (-0.6 \times 0.3) = -1.41$

$\boldsymbol{O(net\_H_2) = -1.41}$

$net_{O_1} = (1 \times 2.81) + (1 \times -1.41) = 1.4$

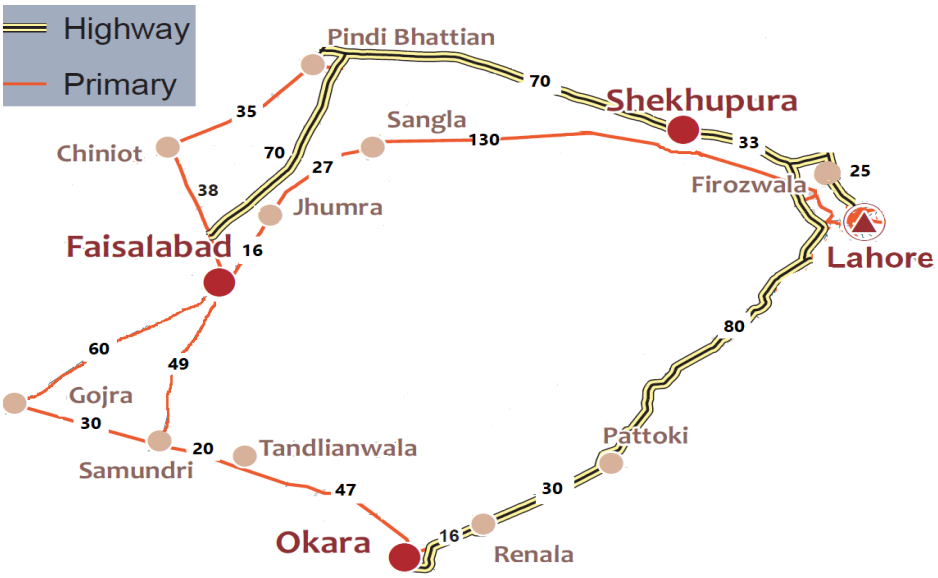
$$\boldsymbol{O(net\_O_1) = \frac{1}{1 + e^{-1.4}} = 0.802}$$

$\boldsymbol{0.802 > 0.5 = 1}$

ii. If the company wants to predict the rate of success, how can this problem be tailored to give you the rate of success?

We aim to convert the classification problem into a regression one. If we eliminate the activation function in the output neuron, the problem will be transformed into a regression one and we will get the success rate for each campaign. By removing the activation function, the output neuron will directly provide the raw predicted value, which can be any real number.

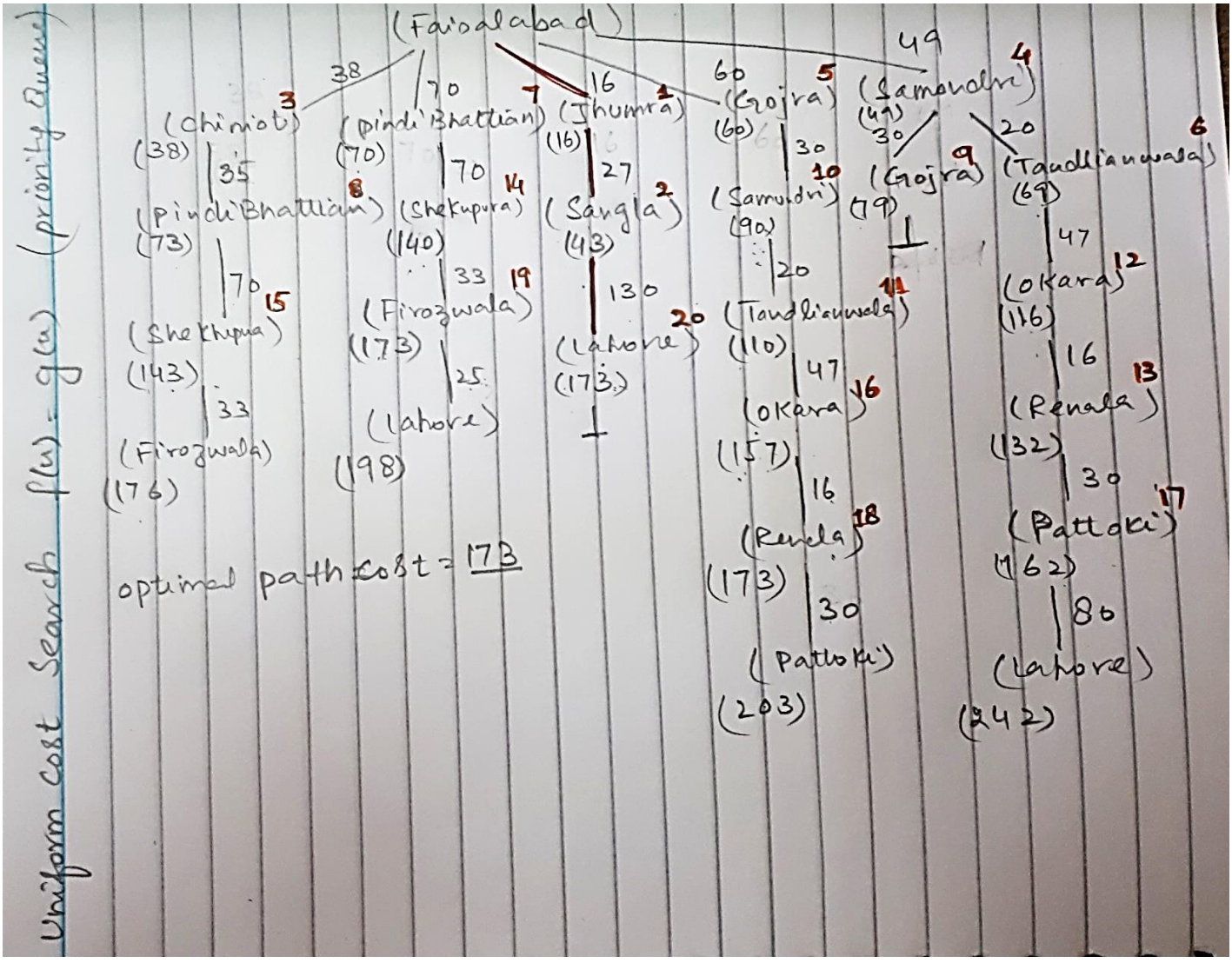
QUESTION 2: Consider the following map of Punjab cities with labeled distances in **km**. The problem is to find the path with the shortest distance from Faisalabad to Lahore city. The heuristic function h_{SLD} straight-line distance from all cities to Lahore is provided in table below.



Source Cities	h_{SLD} to Lahore
Faisalabad	160
Chiniot	160
Gojra	160
Jhumra	150
Samundari	145
Tandlianwala	130
Sangla	120
Pindi Bhattian	110
Okara	100
Renala	90
Pattoki	70
Shekhupura	50
Firozwala	10
Lahore	0

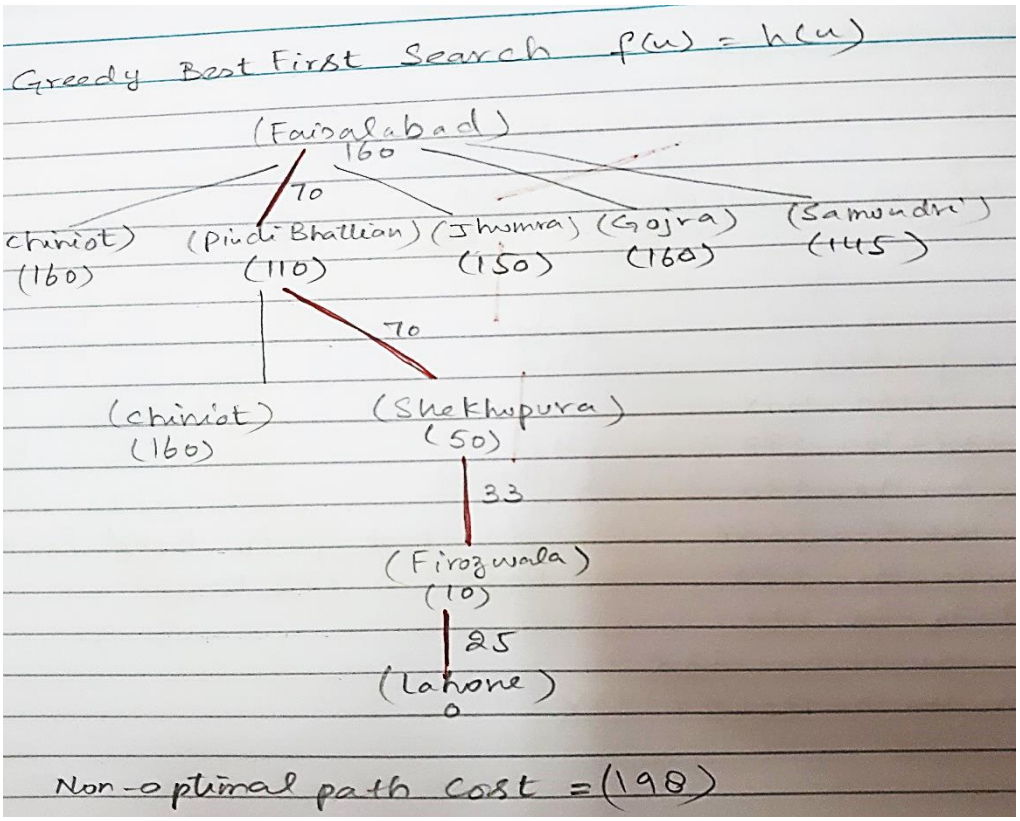
Part a. (5)

Apply the **Uniform Cost Search** to find the shortest path from Faisalabad to Lahore. Draw the state space search tree.



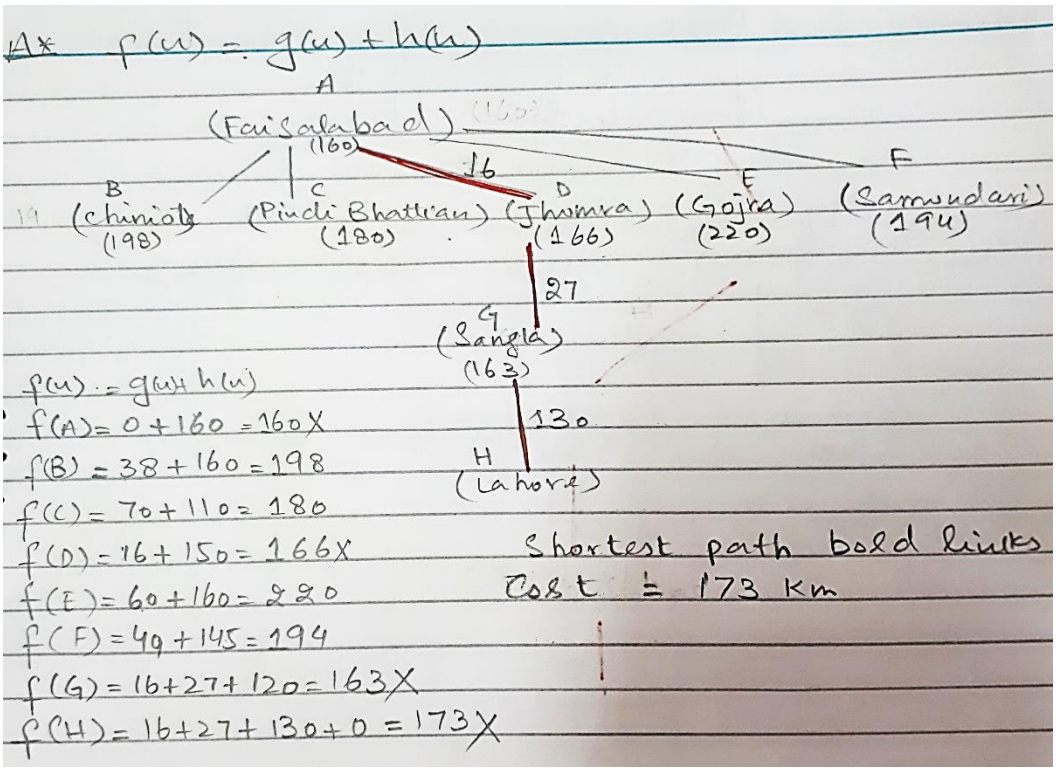
Part b. (5)

Perform the **Greedy Best first Search** to find the shortest path from Faisalabad to Lahore. Draw the state space search tree.

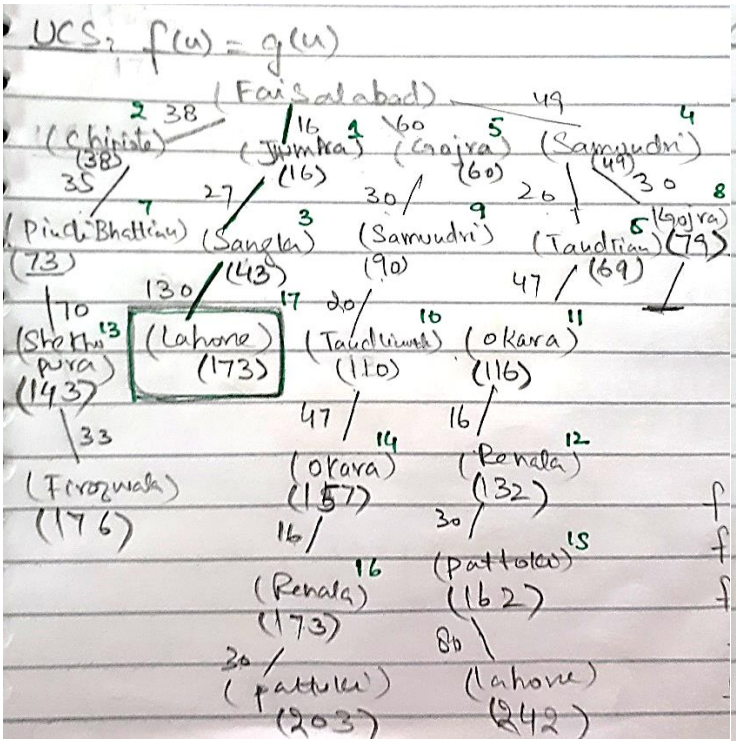


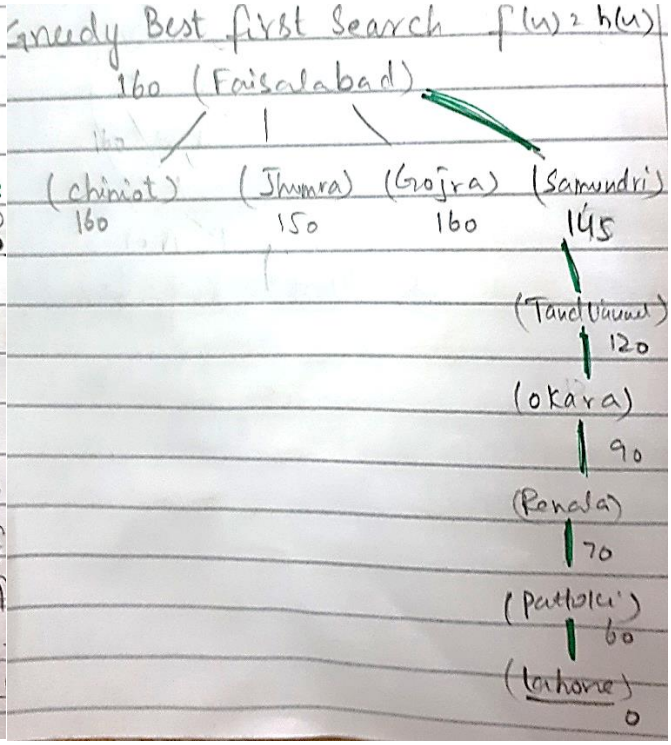
Part c. (5)

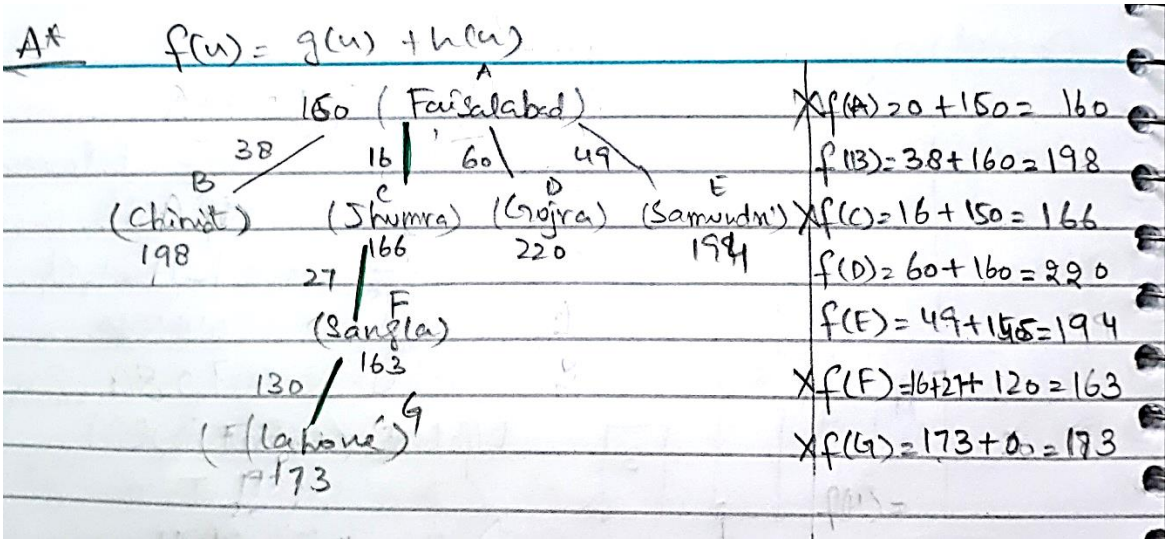
Apply **A* Search** to find the shortest path from Faisalabad to Lahore and build the search tree. Clearly indicate the order in which each state is expanded with open list (frontier) and closed list (visited nodes) updates.



Also consider these solutions correct some students ignore Pindi Bhattian

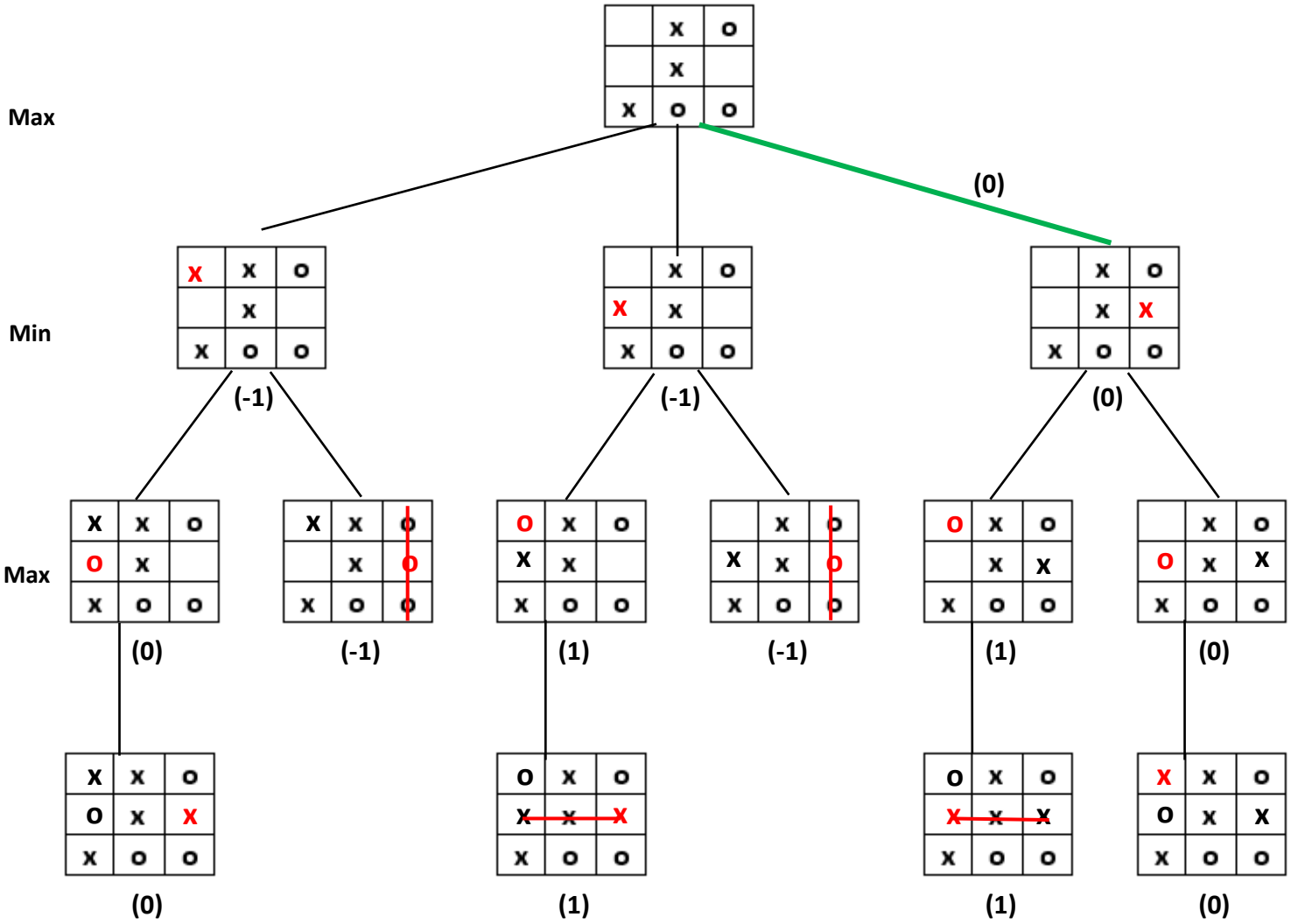






QUESTION 3: (10)

Consider a game of Tic Tac Toe. **x** = Max, **o**=Min. Its max's turn to play. Use minmax algorithm to find the optimum score and max's next move? The current board position of the game is given below make the complete game tree from this configuration onwards.



QUESTION 4: Consider the house data provided in the table below, the price of a house with No. of Bedrooms and Area in square feet.

Bedroom X_1	1	3	4	5	6	3	5	6	2	
Area X_2	60	120	200	200	250	80	250	200	80	
Price X_3	4000	6000	8000	9000	12000	6500	11000	10000	5000	
x_1	-3	-1	0	1	2	-1	1	2	-2	**-1**
x_2	-100	-40	40	40	90	-80	90	40	-80	**0**
x_3	-3944	-1944	56	1056	4056	-1444	3056	2056	-2944	**4**
x_1^2	9	1	0	1	4	1	1	4	4	**25**
x_2^2	10000	1600	1600	1600	8100	6400	8100	1600	6400	**45400**
x_3^2	15555136	3779136	3136	1115136	16451136	2085136	9339136	4227136	8667136	**61222224**
x_1x_2	300	40	0	40	180	80	90	80	160	**970**
x_1x_3	11832	1944	0	1056	8112	1444	3056	4112	5888	**37444**
x_2x_3	394400	77760	2240	42240	365040	115520	275040	82240	235520	**1590000**

Part a. (7)

Compute slopes and intercept to form the regression line equation.

Mean Method:

$$(X_3 - \overline{X}_3) = b_1 (X_1 - \overline{X}_1) + b_2 (X_2 - \overline{X}_2)$$

$$x_3 = b_1 x_1 + b_2 x_2$$

$$\overline{X}_1 = 3.9 = 4,\ \overline{X}_2 = 160,\ \overline{X}_3 = 7944$$

$$x_1 = (X_1 - 4)\ ,\ x_2 = (X_2 - 160),\ x_3 = (X_3 - 7944)$$

$$b_1 = \frac{\sum x_1 x_3 \sum x_2^2 - \sum x_2 x_3 \sum x_1 x_2}{\sum x_1^2 \sum x_2^2 - (\sum x_1 x_2)^2} \qquad b_1 = \frac{37444 * 45400 - 1590000 * 970}{25 * 45400 - (970)^2}$$

$$b_2 = \frac{\sum x_2 x_3 \sum x_1^2 - \sum x_1 x_3 \sum x_1 x_2}{\sum x_1^2 \sum x_2^2 - (\sum x_1 x_2)^2} \qquad b_2 = \frac{1590000 * 25 - 37444 * 970}{25 * 45400 - (970)^2}$$

$$b_1 = 812.25 \quad b_2 = 17.67$$

$$(X_3 - 7944) = 812.25(X_1 - 4) + 17.67\ (X_2 - 160)$$

$$b_1 = 812.25 \quad b_2 = 17.67$$

$$(X_1 - 4) = 17.67\ (X_2 - 160)\ + 812.25(X_3 - 7944)$$

$$(X_2 - 160)\ = 812.25(X_1 - 4) + 17.67(X_3 - 7944)$$

Part b. (3)

Predict the price of a house having 7 bedrooms and 400 square yards of area.

$$(X_3 - 7944) = 812.25(7 - 4) + 17.67\ (400 - 160)$$

$$X_3 = 14621.55$$

Least Square Method

Bedroom X_1	1	3	4	5	6	3	5	6	2	**35**
Area X_2	60	120	200	200	250	80	250	200	80	**1440**
Price X_3	4000	6000	8000	9000	12000	6500	11000	10000	5000	**71500**
X_1^2	1	9	16	25	36	9	25	36	4	**161**
X_2^2	3600	14400	40000	40000	62500	6400	62500	40000	6400	**275800**
$X_1 X_2$	60	360	800	1000	1500	240	1250	1200	160	**6570**
$X_1 X_3$	4000	18000	32000	45000	72000	19500	55000	60000	10000	**315500**
$X_2 X_3$	240000	720000	1600000	1800000	3000000	520000	2750000	2000000	400000	**13030000**

Multiple regression Equation:

$$X_3 = b_0 + b_1 X_1 + b_2 X_2$$

$$\sum X_3 = b_0 N + b_1 \sum X_1 + b_2 \sum X_2$$
$$\sum X_1 X_3 = b_0 \sum X_1 + b_1 \sum X_1^2 + b_2 \sum X_1 X_2$$
$$\sum X_2 X_3 = b_0 \sum X_2 + b_1 \sum X_1 X_2 + b_2 \sum X_2^2$$
$$N = 9$$
$$71500 = b_0 9 + b_1 35 + b_2 1440$$
$$315500 = b_0 35 + b_1 161 + b_2 6570$$
$$13030000 = b_0 1440 + b_1 6570 + b_2 275800$$
$$b_0 = 1948.60 , b_1 = 834.03, b_2 = 17.20$$

Predict the price of a house having 7 bedrooms and 400 square yards of area.

$$X_3 = b_0 + b_1 X_1 + b_2 X_2$$
$$X_3 = 1948.60 + 834.03 * 7 + 17.20 * 400$$
$$X_3 = 14666.81$$

QUESTION 5:

Consider the house data provided in the table below, the No. of Bedrooms and Area in square feet.

No. of Bedrooms	1	3	4	3	5	6	2
Area	60	120	200	80	250	200	80

Part a. (5)

Perform **k means** clustering on the above dataset with k = 2. Consider the data points (1, 60) and (4, 200) as initial centroids. Show your working for the initial two iterations of the algorithm.

Iteration 1: Calculate Euclidean Distances from all data points to centroids and assign them to closest centroids from points (1, 60) and (4, 200).

	1	2	3	4	5	6	7
No. of Bedrooms	1	3	4	3	5	6	2
Area	60	120	200	80	250	200	80
Distance from C1	0	60	140	20.1	190	140.1	20
Distance form C2	140	80	0	120	50.01	2	120
S1 =	{1, 2, 4, 7}						
S2 =	{3, 5, 6}						
Updated C1	(2.25, 85)						
Updated C2	(5, 217)						

Iteration 2: Calculate Euclidean Distances from all data points to centroids and assign them to closest centroids from points (2.25, 85) and (5, 217).

	1	2	3	4	5	6	7
No. of Bedrooms	1	3	4	3	5	6	2
Area	60	120	200	80	250	200	80
Distance from C1	25	35	115	5	165	115	5
Distance form C2	157	97	17	137	33	17	137
S1 =	{1, 2, 4, 7}						
S2 =	{3, 5, 6}						
Updated C1	(2.25, 85)						
Updated C2	(5, 217)						

Part b. (10)

Apply Agglomerative clustering on the above data set with **Single link**. Show your working and create the dendrogram.

	1	2	3	4	5	6	7
1	0	60	140	20	190	140	20
2	60	0	80	40	130	80.1	40
3	140	80	0	120	50	2	120
4	20	40	120	0	170	120	**1**
5	190	130	50	170	0	50	170
6	140	80.1	2	120	50	0	120.1
7	20	40	120	1	170	120.1	0

	1	2	3	(4,7)	5	6
1	0	60	140	20	190	140
2	60	0	80	40	130	80.1
3	140	80	0	120	50	**2**
(4,7)	20	40	120	0	170	120
5	190	130	50	170	0	50
6	140	80.1	2	120	50	0

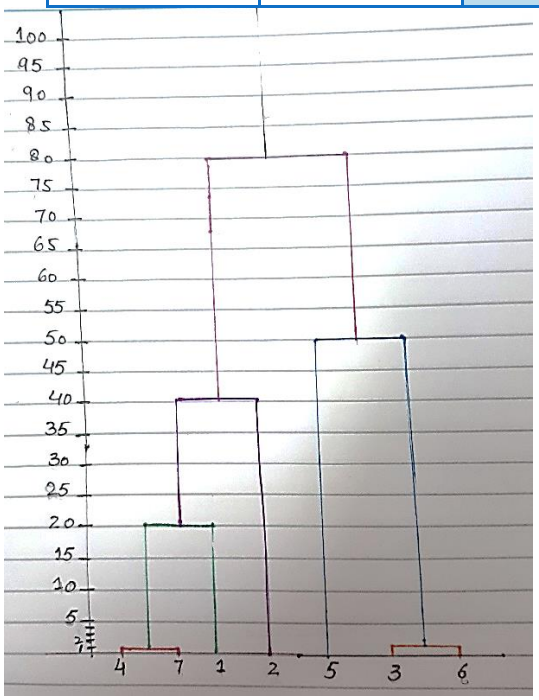
	1	2	(3,6)	(4,7)	5
1	0	60	140	**20**	190
2	60	0	80	40	130
(3, 6)	140	80	0	120	50
(4,7)	20	40	120	0	170
5	190	130	50	170	0

	(1, (4, 7))	2	(3,6)	5
(1, (4, 7))	0	**40**	120	170
2	40	0	80	130
(3, 6)	120	80	0	50
5	170	130	50	0

	((1, (4, 7)), 2)	(3,6)	5
((1, (4, 7)), 2)	0	80	130
(3, 6)	80	0	**50**
5	130	50	0

	((1, (4, 7)), 2)	((3,6), 5)
((1, (4, 7)), 2)	0	**80**
((3, 6), 5)	80	0

	(((1, (4, 7)), 2)((3,6), 5))
(((1, (4, 7)), 2), ((3, 6), 5))	0



QUESTION 6:

Part a. (3)

A manufacturing company wants to optimize the production process of a particular product. The production process involves several parameters such as **temperature**, **pressure**, and **duration**. The company wants to find the optimal combination of these parameters that maximizes the yield of high-quality products. Your task is to apply a genetic algorithm to solve this optimization problem.

Design a chromosome for the above problem. What encoding scheme will you use?

A real value-based encoding can be used to represent the value of every gene of chromosome as follows.

Temperature	Pressure	Duration
32.35	18.6	2

Part b. (3)

In Genetic algorithm if we use only crossover and not mutation then does it make any hurdle in finding our desired solution or not? Give reason to support your answer?

If we use only crossover and not mutation, we run the risk of creating a **homogeneous population**, where the individuals are very similar to each other. This can **limit the exploration** of the search space and lead to a suboptimal solution.
Therefore, it is generally recommended to use both crossover and mutation in genetic algorithms to ensure the **diversity** of the population and increase the chances of finding the desired solution.

~~**Part c. (4)**~~

~~Differentiate forward and backward chaining in expert system with an example.~~

Rough Work