	Course Name:	Artificial Intelligence	Course Code:	CS 401
	Program:	BS (Computer Science)	Semester:	Spring 2019
	Duration:	180 Minutes	Total Marks:	40
	Paper Date:	23-7-2019	Weight	40
	Section:	Retake Exam	Page(s):	
	Exam Type:	Final		

Student Name:
Registration #:

Instructions Calculators: Allowed

Q1. Search Algorithms: **(2 + 2 + 6 Points) [Estimated Time 25 Min]**

Given a list of **n** cities **{C_1, C_2, … , C_n}** a route is a sequence of **n** distinct cities Ci_1, Ci_2, … Ci_n starting at city Ci_1 going to city Ci_2 and ending at city Ci_n. Cost of a route is sum of the costs between successive cities and finally cost of coming back from city Ci_n to city Ci_1.

The travelling salesman problem (TSP) asks the following question:

Given a list of **n** cities **{C_1, C_2, … , C_n}** and the distances between each pair of cities, what is the shortest possible route that starts at some city, visits each city exactly once and returns to the origin city?

In this question we are going to use Hill climbing strategy (i.e. a local search algorithm) to find a optimal/sub-optimal solution of a TSP problem.

Part a) How many different possible ways are there to start at some city and then visit each city exactly once and return to the origin city for a problem of size n (i.e. n cities)? **[2 Point]**

To get full marks give a brief justification of your answer as well

A solution to TSP is a permutation (ordering) of city ids and can be represented as a sequence of city ids stored in an array of array of size n

A simple operator to generate a new solution from an existing solution can be defined as follows

PICK TWO CITIES AT RANDOM AND SWAP THEIR POSITION IN THE SEQUENCE

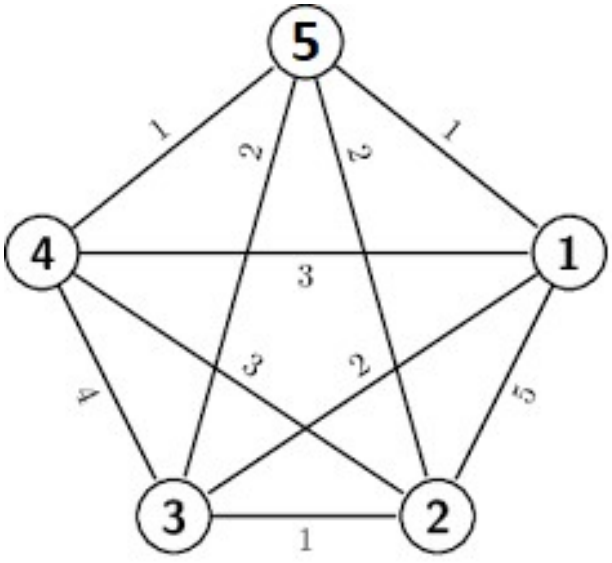
Part b) How Many New Solutions can be generated from an existing solution using this simple operator? Give Reason **[2 Points]**

As defined earlier, the cost of a solution $\mathbf{S_i = (Ci_1, Ci_2, \ldots, Ci_n)}$ is the sum of distances between consecutive cities i.e.

$\mathbf{COST(S_i) = d(Ci_1, Ci_2) + d(Ci_2, Ci_3) + \ldots + d(Ci_{n-1}, Ci_n) + d(Ci_n, Ci_1)}$

Part c) For the following graph consisting of five cities, use hill climbing algorithm with the method of generating successors as given above to find an optimal solution of the problem using the following randomly generated solution as your initial solution. **1, 3, 4, 2, 5 [6 Points]**

You must show all intermediate steps



Intermediate Solutions	Selected Solution

Q 2. Back Propagation [5 points] [Estimate Time 15 Min]

Following is the skeleton of the back propagation learning algorithm for finding weights of a multilayer feed-forward neural network. The last seven statements of the algorithms are given at the end but are somehow mixed up. Your job in this question is to give us correct order these statements.

Mention where each statement resides in the skeleton by **marking/circling the correct choice** for each statement

Backpropagation Learning Algorithm

1 - Create the network and initialize all weights to small random numbers.

2 - A B C D E F

3 - A B C D E F

4 - A B C D E F

5 - A B C D E F

6 - A B C D E F

7 - A B C D E F

Following are the statements which you have to fit in the above algorithm. Here *o* is used for computed *output* and *t* is used for *target/actual output*

A = Update each network weight $w_{i,j}$ by $w_{i,j} = w_{i,j} + \Delta w_{i,j}$ where $\Delta w_{i,j} = \eta \delta_j x_{i,j}$

B = For each hidden unit h do $\delta_h = o_h(1 - o_h) \sum_{k \in outputs} w_{h,k} \delta_k$

C = Until convergence condition is met or max epochs, Do following

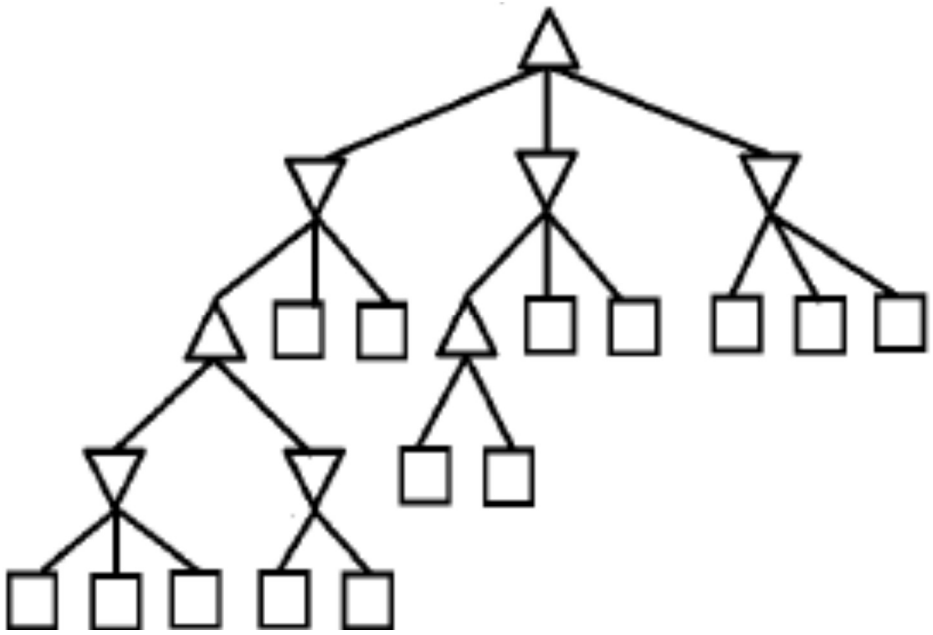
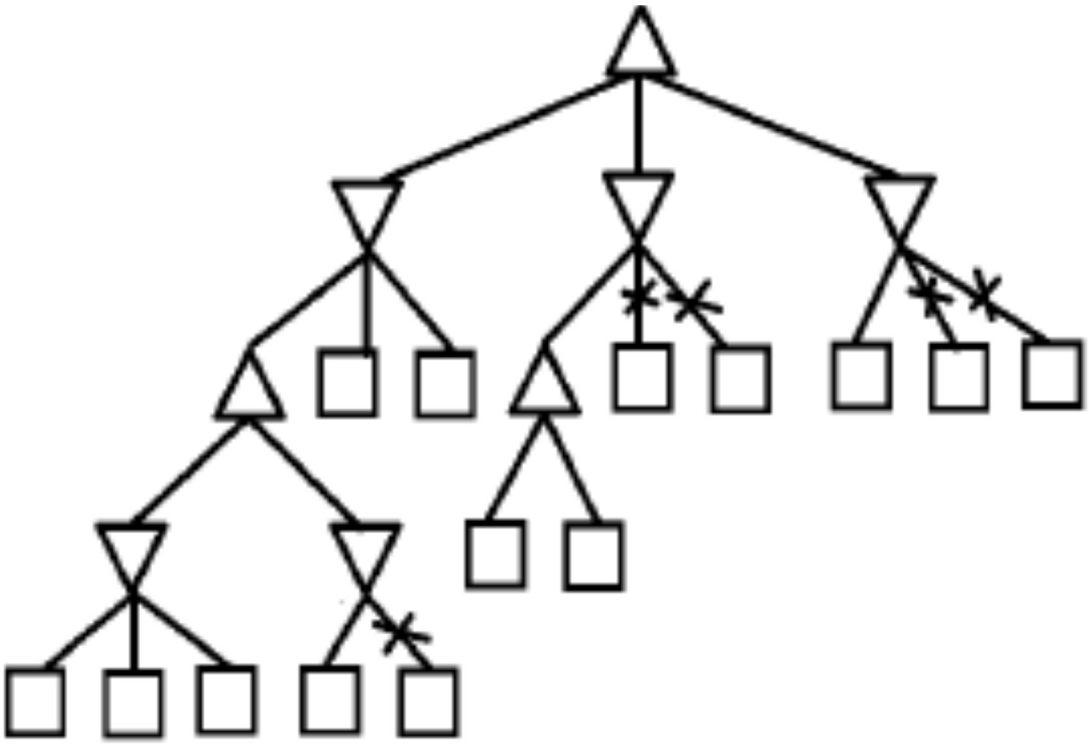
D = Input the training example to the network and compute all intermediate/final outputs o

E = For each training example, Do following

F = For each output unit k do $\delta_k = o_k (1 - o_k) (t_k - o_k)$

Q 3. Minimax: **(8 Points) [Estimated Time 20 Min]**

Consider the two game trees shown below. For each of the graphs shown below you must **specify the values of utility function** for each of the terminal node (square nodes) that will cause the minimax algorithm prune the indicated branches.

No Pruning	
Pruning	

Q4. Part a) Probability and Bayes Nets: [3 Points] [Estimated Time 15 Min]

Consider the following Bayes Net consisting of five random variables along with the associated conditional probability distributions.

A	J	P(J|A)
+a	+j	0.9
+a	-j	0.1
-a	+j	0.05
-a	-j	0.95

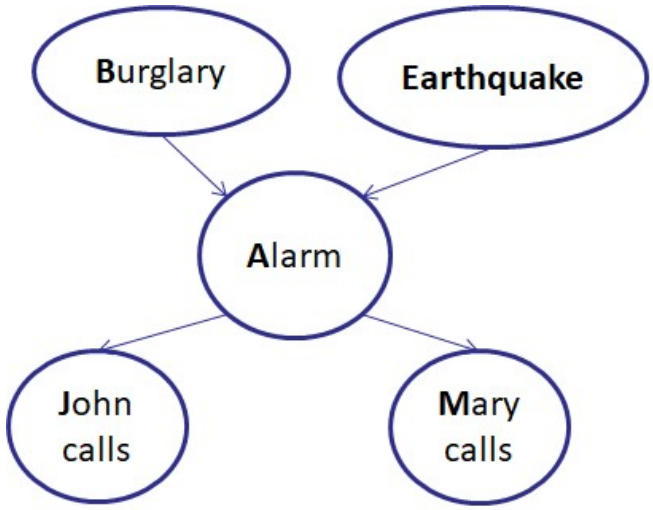
A	M	P(M|A)
+a	+m	0.7
+a	-m	0.3
-a	+m	0.01
-a	-m	0.99

B	E	A	P(A|B,E)
+b	+e	+a	0.95
+b	+e	-a	0.05
+b	-e	+a	0.94
+b	-e	-a	0.06
-b	+e	+a	0.29
-b	+e	-a	0.71
-b	-e	+a	0.001
-b	-e	-a	0.999

B	P(B)
+b	0.001
-b	0.999

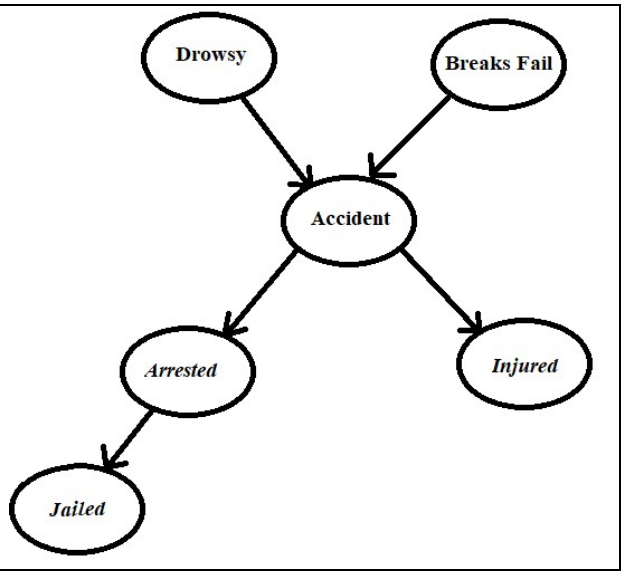
E	P(E)
+e	0.002
-e	0.998

Compute the P (B- | M+, J-) by the method of enumeration.



Q4. Part b): [4 + 1 + 1 Points] [Estimated Time 20 Min]

You have spent weekend with your friends and now you are driving back to your home. Its late night and you may be drowsy. You have the following belief network, about accidents, in mind that captures probabilistic relationship between the following binary random variables.

Brake Failure: Whether your break fails of not. *Drowsy*: Whether you are drowsy or not. *Accident*: Its possible values are yes, no. *Arrested*: Whether you get arrested or not. *Injured*: Whether you get injured or not. *Jailed*: Whether you go to jail for a traffic offense.	

Answer the following questions about this belief network

I. Are the following pair of variables independent? Give a short reason in each case

i) Injured and Arrested given you are Accident

ii) Break Fail and Drowsy Given Accident

iii) Break Fail and Jailed Given Injured

iv) Break Fail and Drowsy Given you had an Accident

II. Which conditional probability distribution tables must be specified to use this belief network for computing probability of any event?

III. How would write the joint probability distribution as product of conditional probability distributions given in part b?

Q4. Part c) [1 + 1 + 2] [Estimated Time 10 Min]

Suppose there are n Boolean random variables $X_1, X_2, \ldots, X_n$. Suppose that the Joint Probability Distribution Table of these variables contains one single term i.e. each probability value given in the distribution table is the same. Now answer the following questions

1. What is the value of each entry in distribution table?

2. What is $P(X_1 = \text{true})$? Give argument.

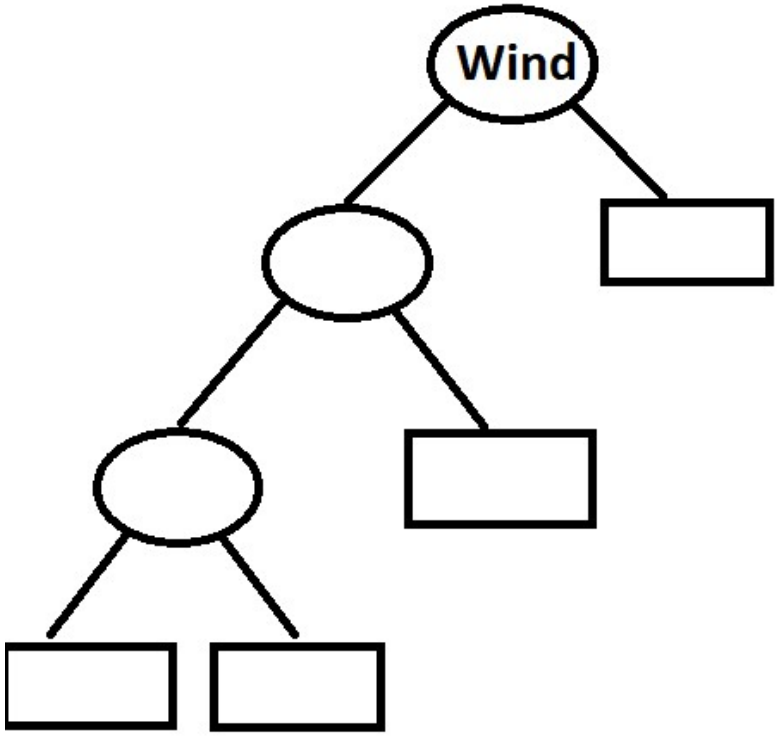
3. For any distinct i, j $\leq$ n, **is the following statement true; X_i is independent of X_j? G**ive reason in favor or against.

Q5. Decision Trees [4] [Estimated Time 20 Mins]

We need to create a decision tree using ID3 learning algorithm from the following training data. Here **Outlook, Humidity and Wind** are input features and **Play Tennis** is the output value.

Outlook	**Humidity**	**Wind**	**Play Tennis**
Rain	High	Weak	Yes
Rain	Normal	Weak	Yes
Rain	Normal	Strong	No
Sunny	High	Weak	No
Sunny	Normal	Weak	Yes
Sunny	Normal	Weak	Yes
Sunny	Normal	Strong	No
Rain	High	Strong	No

Construct a final decision tree of the following form, assuming that **Wind** has already been chosen as root of the decision tree. Show all calculations of appropriate information gains as computed by the ID3 algorithm.



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