Lecturer:	(Date) 28/07/2020	Approved by:	(Date) 28/07/2020
(Signature and Full name)		(Signature, Position and Full name)	

(The above part must be hidden when copying for exam)

UNIVERSITY OF TECHNOLOGY - VNUHCM FACULTY OF CSE	FINAL EXAM		Semester/Academic year	2	2019-2020
			Exam date		02/08/2020
	Course title	Introduction to Artificial Intelligence			
	Course ID	CO3061			
	Duration	120 minutes	Question sheet code		

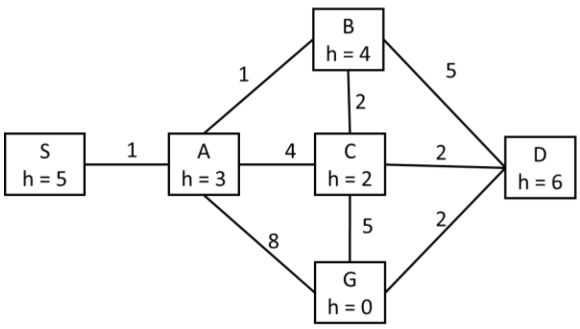
Note: *- Open books, students are allowed to use any paper materials.*
- Students answer the question directly on the exam booklet and return this booklet.

Student ID: Student Name: Score: /100

PART A (L.O.1.2). **UNIFORM SEARCH & INFORMED SEARCH (25 points)**

A1. Given the below graph, where S is the staring state, and G is the goal state. The value h in each node is the heuristic value which is the estimated cost from the current state to the goal state. Write down the **returned path** corresponding to each search algorithm: breadth-first search (BFS), uniform-cost search (UCS), greedy best-first search, and A* search. If there are more than ONE choice, use alphabetical order to break the tie. (**15 points**)

BFS (**3 points**)	S – A – G
UCS (**4 points**)	S – A – B – C – D – G
GBFS (**4 points**)	S – A – G
A* (**4 points**)	S – A – B – C – G



A2. Given a search problem with two **admissible** heuristics $h_1(x)$ and $h_2(x)$. Which following statements are correct? Write **TRUE** or **FALSE** for each statement (**4 points**)

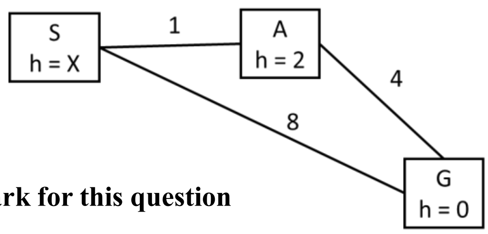
i) $h_1(x) + h_2(x)$ is also an admissible heuristic FALSE

ii) $\min(h_1(x), h_2(x))$ is also an admissible heuristic TRUE

iii) $\max(h_1(x), h_2(x))$ is also an admissible heuristic TRUE

iv) $0.3h_1(x) + 0.7h_2(x)$ is also an admissible heuristic TRUE

A3. Which values of X such that the following heuristic is **admissible** but **not consistent**. (**6 points**)

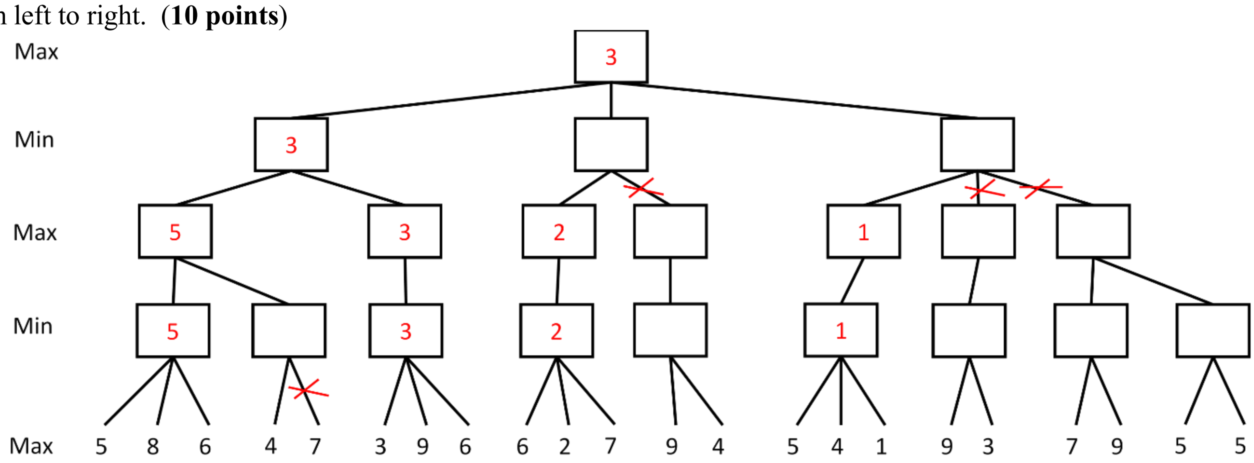


Admissible: $0 \le X \le 5$
Not consistent: $X > 3$ or $X < 1$
Therefore, $3 < X \le 5$ or $0 \le X < 1$

But if your answer is 3<X≤5, it is also acceptable and you get full mark for this question

PART B (L.O.2.1). **ADVERSARIAL SEARCH (15 points)** A=-inf; B=-inf

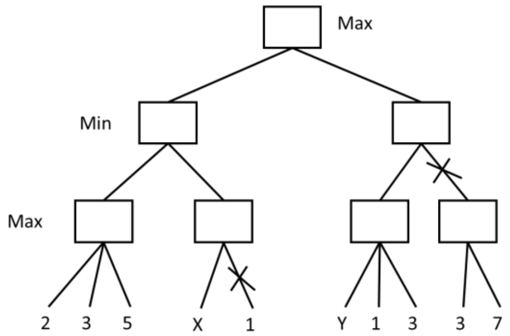
B1. Pruning the below minimax tree using Alpha-Beta Pruning algorithm, assuming that the algorithm traverses the tree from left to right. (**10 points**)



B2. Which values of X and Y such that the minimax tree is pruned as shown below when applying Alpha-Beta Pruning? (**5 points**)

$X \geq 5$

$Y \leq 5$



PART C (L.O.2.1). **CONSTRAINT SATISFACTION PROBLEMS (10 points)**

C1. Solve the following sudoku in the left figure. In sudoku, the objective is to fill a 9×9 grid with digits so that each column, each row, and each of the nine 3×3 subgrids that compose the grid (also called "boxes", "blocks", or "regions") contain all of the digits from 1 to 9. (**10 points**)

Note that the figure in the right is the same with the one shown in the left. It is used as a backup in case that you messed up in the left figure.

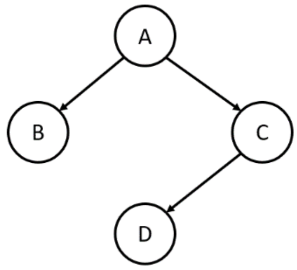
5	3	6	4	7	2	8	1	9
4	2	1	6	9	8	5	7	3
7	8	9	1	5	3	4	6	2
8	6	3	9	2	4	1	5	7
1	7	5	8	3	6	9	2	4
2	9	4	5	1	7	6	3	8
3	1	8	2	4	5	7	9	6
9	4	7	3	6	1	2	8	5
6	5	2	7	8	9	3	4	1

PARTD D (L.O.3.2). **BAYES NETS (25 points)**

D1-D4: Given the Bayesian network as shown in the right figure

A	B	P(B|A)
+a	+b	0.7
+a	-b	0.3
-a	+b	0.2
-a	-b	0.8

A	P(A)
+a	0.6
-a	0.4



A	C	P(C|A)
+a	+c	0.4
+a	-c	0.6
-a	+c	0.7
-a	-c	0.3

C	D	P(D|C)
+c	+d	0.6
+c	-d	0.4
-c	+d	0.2
-c	-d	0.8

D1. Compute P(-a, -c) (**2 points**)

0.12

D2. Compute P(-a |-d) (**3 points**)

208/592 = 13/37 = 0.3514 P(-a;-d)

d-separate

D3. Compute P(+b, |-a, -d) (**5 points**)

= P(+b|-a) = 0.2

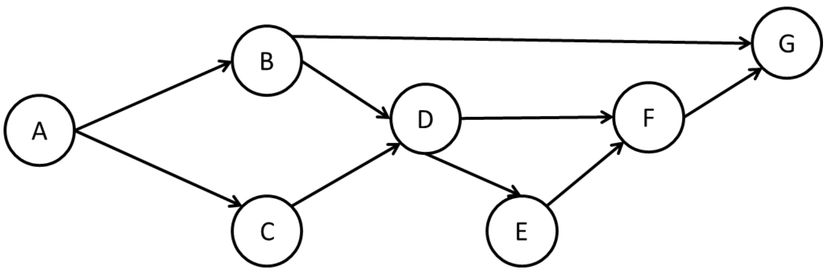
D4. Compute P(-b|-c,+d) (**5 points**) sigma A P(-b;-c;+d;A)

= P(-b|-c) = 0.425 ----------

P(-c;+d)

*Câu D5: Given the Bayesian network as below, which below statements are **TRUE** or **FALSE**? (**10 points**)*

Where **X $\perp\!\!\!\perp$ Y | Z** means that X is independent with Y given Z**.**



Example: A $\perp\!\!\!\perp$ D | B FALSE

A $\perp\!\!\!\perp$ F | D TRUE

E $\perp\!\!\!\perp$ G | F FALSE

A $\perp\!\!\!\perp$ G | B FALSE

C $\perp\!\!\!\perp$ G | D FALSE

B $\perp\!\!\!\perp$ C | A, G FALSE

B $\perp\!\!\!\perp$ E | F FALSE

A $\perp\!\!\!\perp$ E | G FALSE

A $\perp\!\!\!\perp$ D | B, F FALSE

E $\perp\!\!\!\perp$ G | B, F TRUE

A $\perp\!\!\!\perp$ F | D, G FALSE

PART E (L.O.4.2). **MACHINE LEARNING (25 points)**

E1. (Decision Tree) Given the labelled data as shown in the right figure, compute the information gain for each attribute. Based on this information, which attribute should be used as the root of the decision tree? (**15 points**)

Sample	A_1	A_2	A_3	Y
x_1	0	0	1	1
x_2	0	0	1	1
x_3	0	1	0	1
x_4	0	1	0	0
x_5	0	1	1	0
x_6	1	1	0	0
x_7	1	1	1	0
x_8	1	0	0	0

Entropy(Y) = 0.9544

InfoGain(Y, A_1) = 0.3476

InfoGain(Y, A_2) = 0.1589

InfoGain(Y, A_3) = 0.0488

The attribute should be chosen first: A_1

E2. (Perception) Filling the below table using the weight update algorithm to construct a perceptron which can correctly classify the samples showed in the right figure. (**10 points**)

Sample	x_1	x_2	y
1	0	0	1
2	0	1	1
3	1	0	1
4	1	1	0

Hint: starting with the initial weight is [0, 0, 0]. Your task is to loop through these sample and update the weights until they are converged. Note that you need to insert the value 1 (which is corresponding to bias) for each sample

Step	Sample	w_0 (bias)	w_1	w_2
0		0	0	0
1	[1, 0, 0]	0	0	0
2	[1, 0, 1]	0	0	0
3	[1, 1, 0]	0	0	0
4	[1, 1, 1]	-1	-1	-1
5	[1, 0, 0]	0	-1	-1
6	[1, 0, 1]	1	-1	0
7	[1, 1, 0]	1	-1	0
8	[1, 1, 1]	0	-2	-1
9	[1, 0, 0]	0	-2	-1
10	[1, 0, 1]	0	-2	-1
11	[1, 1, 0]	1	-1	-1
12	[1, 1, 1]	1	-1	-1
13	[1, 0, 0]	1	-1	-1
14	[1, 0, 1]	1	-1	-1
15	[1, 1, 0]	1	-1	-1

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