FINAL EXAMINATION

Course: Artificial Intelligence	
Time: 120 minutes	Term: 3 – Academic Year: 2018-2019
Lecturer: Châu Thành Đức – Nguyễn Hải Minh – Nguyễn Ngọc Thảo	
Student Name:	Student ID:

(Notes: Neither books nor laptops, phones allowed)

Write your answer directly in this test paper

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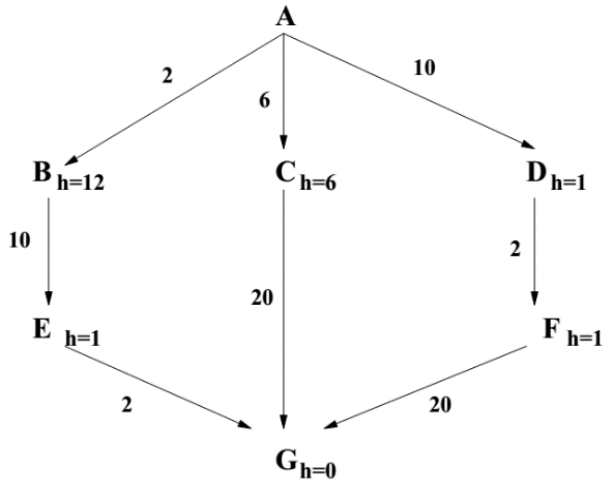
PART I: Obligatiory Section

Question 1 (2.0pts): Consider the following graph, which is a representation of a search problem. S is the start node and G is the goal node. Heuristic function $h(n)$ is also denoted in the graph. Perform A* algorithm on this graph and answer the following questions:



a. (1.0pt) Draw the search tree, calculate the value of evaluation function for each state during the expanding process.

b. (0.5pt) Show the list of expanded states:.....

c. (0.25pt) The returned path is:.....

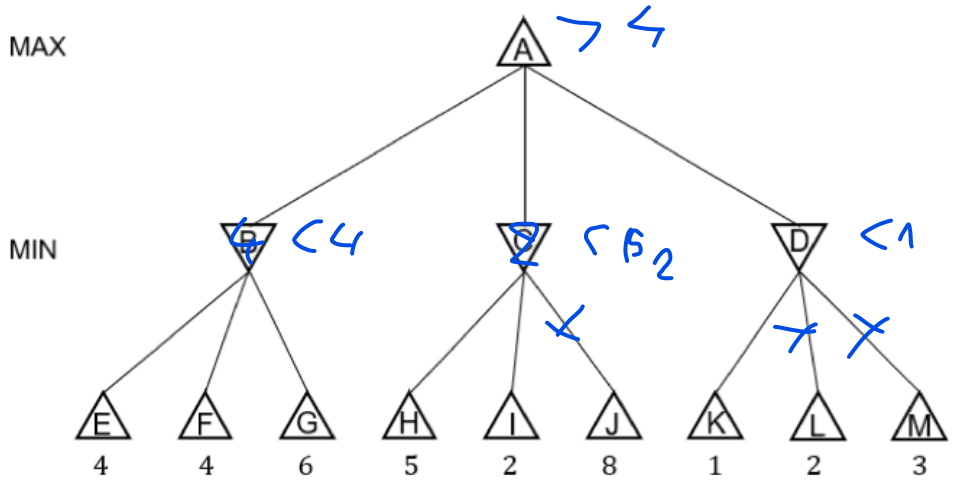
d. (0.25pt) Is this the shortest path from *S* to *G*? Why?.....

.....

.....

.....

Question 2 (2.0pts): Run the algorithm α-β pruning on the following 2-ply game tree. The utility value is for MAX. Will any nodes be pruned? Explain your answer. (You can write minimax value directly on the game tree)



Question 3 (2.0pts):

a. (0.5pt) Consider the following KB consisting of 4 sentences. Prove via resolution that KB entails the sentence R.

$$\neg(\neg P \wedge Q), P \rightarrow (\neg T \vee R), Q, T$$

Rewrite the sentences in KB and the query in appropriate format for resolution. For every new clause, show the indices of the pair of clauses being resolved. You do not have to enumerate all new clauses, just consider some clauses that you think they might be useful.

b. (1.0pt) For each English sentence below, write the FOL sentence that best expresses its intended meaning using only the following given predicates:

- MEMBER(x, y) for "x is a member of y".
- STUDENT(x) for "x is a student".
- UNIFORM(x) for "x wears uniform".
- STAFF(x) for "x is a staff".

1. Every staff has to wear uniform.

$\forall x \; Staff(x) \Rightarrow Uniform(x)$

2. Not every student has to wear uniform.

$\neg \forall x \; Student(x) \Rightarrow Uniform(x)$

3. Every member of University of Science can be either a staff or a student (but not both).

$\forall x (Member(x, US) \Rightarrow (Staff(x) \Leftrightarrow \neg Student(x))$

4. There is exactly one staff who does not wear uniform.

$\exists x \; Staff(x) \wedge \neg Uniform(x) \wedge (\forall y \; Staff(y) \wedge \neg Uniform(y) \Rightarrow y = x)$

c. (0.5pt) Every problem that can be solved with resolution can be solved with forward/backward chaining and vice versa. Is this statement TRUE or FALSE? Explain briefly.

False because to solve we need the sentences to be in horn clause form

Question 4 (2.0pts):

a. (0.5pt) Machine learning methods are often categorised in three main types: supervised, unsupervised and reinforcement learning methods.

- Explain the given terms in not more than one sentence each.

Model that map input and output through training with table data

- Explain in which category does Decision Tree Learning fall and why?

b. **(**1.5pts) Using the decision tree learning algorithm (ID3), draw the decision tree for the following dataset step-by-step

Name	Hair	Height	Weight	Lotion	Result
Sarah	Blonde	Average	Light	No	Sunburned
Dana	Blonde	Tall	Average	Yes	None
Alex	Brown	Short	Average	Yes	None
Annie	Blonde	Short	Average	No	Sunburned
Julie	Blonde	Average	Light	No	None
Pete	Brown	Tall	Heavy	No	None
John	Brown	Average	Heavy	No	None
Ruth	Blonde	Average	Light	No	None

PART II: OPTIONAL SECTION *(Students choose to answer 2 questions from **5, 6, 7**)*

Question 5 (2.0pts): Given a statement as follows:

(1) Every considered object is red, green or blue.
(2) If *x* is to the left of *y* then *x* is not to the right of *y*.
(3) Red objects are to the left of green objects.
(4) Object *a* is to the right of object *b*.
(5) Object *b* is green and object *a* is not green.

The given statement can be represented in first-order logic with the following predicates

- RED(*x*) for "*x* is red"
- GREEN(*x*) for "*x* is green" BLUE(*x*) for "*x* is blue"
- LEFT(*x*, *y*) for "*x* is to the left of *y*"
- RIGHT(*x*, *y*) for "*x* is to the right of *y*"

Answer the following questions:

a. Translate the sentences above into FOL sentences

(1). $\forall x \; Red(x) \vee G(x) \vee B(x)$

(2). $\forall x \forall y \; Left(x,y) \Rightarrow \neg Right(x,y)$

(3). $\forall x,y \; R(x) \wedge G(y) \Rightarrow Left(x,y)$

(4). $Right(a,b)$

(5). $G(b) \wedge \neg G(a)$

b. Convert the FOL sentences in a. into Conjunctive Normal Form

(1). $R(x) \vee G(x) \vee B(x)$

(2). $\neg Left(x,y) \vee \neg Right(x,y)$

(3). $\neg R(x) \vee \neg G(y) \vee Left(x,y)$

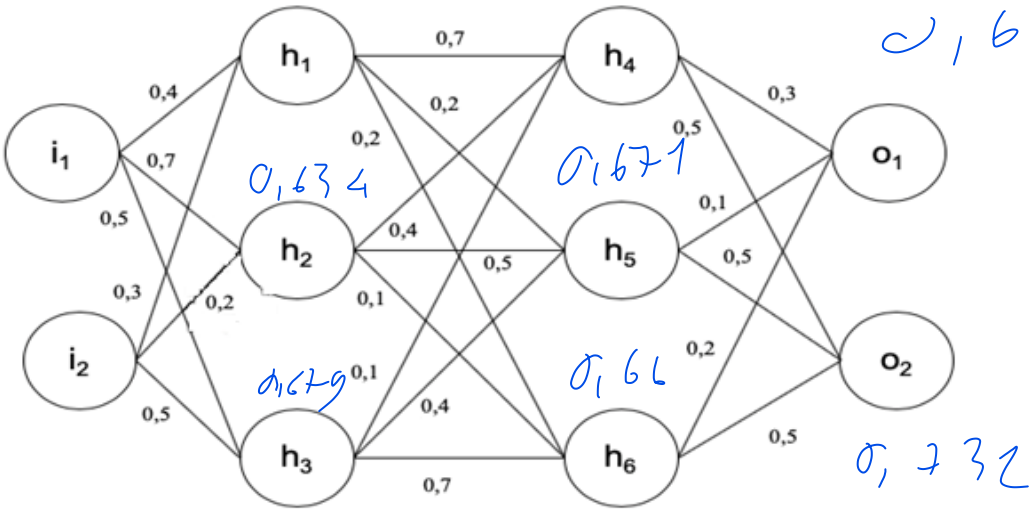
(4). $Right(a,b)$

(5). $G(b)$
$\neg G(a)$

c. Prove via resolution that "Object *a* is blue." For every step, show the new clause, indices of the pair of clauses being resolved, and the corresponding substitutions.

$\neg B(a)$

Question 6 (2.0pts): Given a neural network as follows



In which:
- i_1 and i_2 are input nodes.
- h_1, h_2, h_3, h_4, h_5, h_6 are hidden nodes, and o_1, o_2 are output nodes. Each of them use sigmoid activation function.
- weights are initiated as on the figure.

1. **(1.5pts)** Given the input (i_1, i_2) = (0.5, 1.0). Calculate the results of the network at o_1 and o_2.

2. **(0.5pts)** Given the target output (o_1, o_2) = (0.1, 0.9). Calculate the loss of network, which is defined as follows:

$$Loss_{total} = \sum \frac{1}{2}(target - output)^2$$

Question 7 (2.0pts): Einstein's Riddle: There are 5 houses in five different colors. In each house lives a person with a different nationality. These five owners drink a certain type of beverage, smoke a certain brand of cigar and keep a certain pet. No owners have the same pet, smoke the same brand of cigar or drink the same beverage. Given the following hints:

1. the Brit lives in the red house
2. the Swede keeps dogs as pets
3. the Dane drinks tea
4. the green house is on the left of the white house
5. the green house's owner drinks coffee
6. the person who smokes Pall Mall rears birds
7. the owner of the yellow house smokes Dunhill
8. the man living in the center house drinks milk
9. the Norwegian lives in the first house
10. the man who smokes blends lives next to the one who keeps cats
11. the man who keeps horses lives next to the man who smokes Dunhill
12. the owner who smokes BlueMaster drinks beer
13. the German smokes Prince
14. the Norwegian lives next to the blue house
15. the man who smokes blend has a neighbor who drinks water

Define the the variables and domains of each variable and constraints of the given problem.

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