KOÇ UNIVERSITY
COLLEGE OF ENGINEERING

COMP 341: INTRODUCTION TO ARTIFICIAL INTELLIGENCE

MIDTERM 1

FALL 2018, 04/11/2018
DURATION: 120 MINUTES

Name: Solutions

ID: 00110001 00110000 00110000

- This exam contains 8 pages including this cover page and 6 questions. Check to see if any pages are missing. Put your initials on the top of every page, in case the pages become separated.
- By submitting this exam, you **agree** to fully comply with Koç University Student Code of Conduct, and accept any punishment in case of failure to comply. If you do not submit this exam on time, you will receive 0 credits.
- The exam is **closed book** and **closed notes**. You are **not** allowed to use any additional material including any electronic equipment such as computers and mobile phones.
- You are expected to be provide clear and concise answers. Do your best to make sure that your writing is legible (visibly readable).
- Read each question carefully and make sure to follow instructions. The written instructions take precedence over an answer that the instructor might give you during the exam, unless the instructor makes a class wide announcement.
- Do not write in the table below.
- Good luck!

Question:	1	2	3	4	5	6	Total
Points:	20	20	20	18	10	12	100
Score:							

1. (20 points) True or False :

False ____ To solve a problem, we have to describe its state as detailed as possible.

True ____ In a tree search problem, iterative deepening depth first search algorithm is guaranteed to find a solution if one exists.

False ____ Minimax and alpha-beta does not always return the same solution.

False ____ In a fair game involving chance, an agent with an exact evaluation function always wins.

False ____ On a chess-board, a king can move to any of its 8-neighbors. Manhattan distance is an admissible heuristic for this king to move between two squares.

True ____ It is possible to have optimal reflex agents.

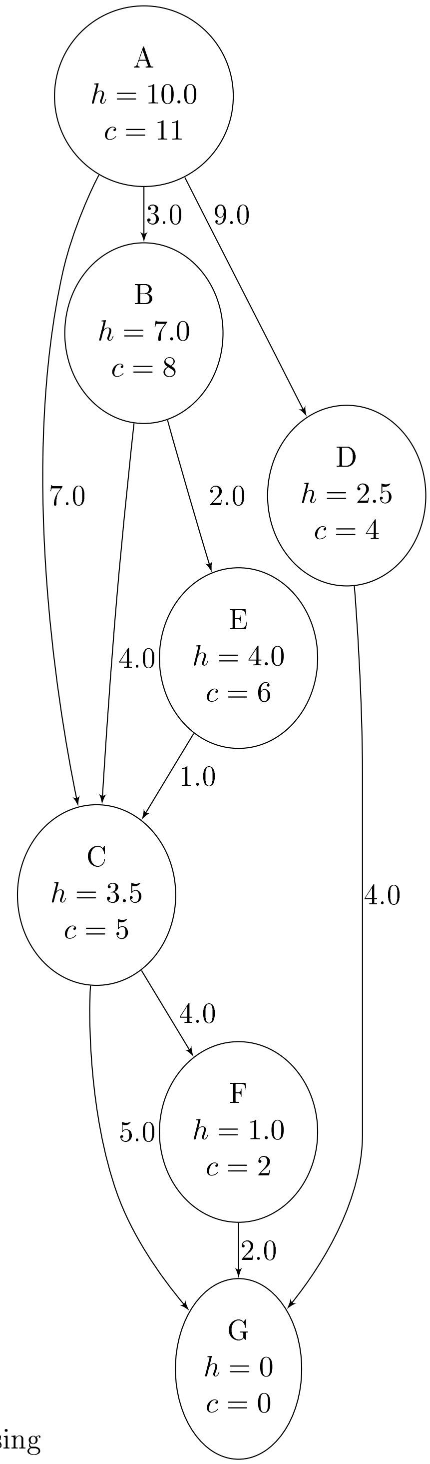
True ____ Local search does not always find the best possible solution.

False ____ Arc consistency can detect all the inconsistent future assignments.

False ____ There are 20^2 number of rows in a joint distribution of 20 boolean variables

True ____ $P(Z|X,Y) = P(Z|X)$ implies $P(Y|X,Z) = P(Y|X)$.

2. (20 points) Consider the graph below where **A** is the initial and **G** is the goal state. The directional arcs represent the possible state transitions and cost of each transition is given next to the arcs. The heuristic values are given inside the states with h. For the given algorithms, write the expansion (i.e. popping from the frontier) order of the nodes, breaking ties alphabetically, and the resulting solution path. Use the graph search versions of the algorithms.



(a) (4 points) Depth First Search:

Expanded Nodes In Order:
Both the recursive and the stack based solution are accepted
A-B-C-F-G OR
A-D-G

Resulting Path:
A-B-C-F-G OR
A-D-G

(b) (6 points) Iterative Deepening Depth First Search:
Expanded Nodes In Order:
Multiple answers are possible based on how you handle the visited nodes in this search and whether you used recursive or stack based solution
A, A-B-C-D, A-B-C-E-D-G OR
A, A-D-C-B, A-D-G

Resulting Path:
A-D-G in both cases

(c) (7 points) A* Search:
Expanded Nodes In Order:
A-B-E-C-F-G

Resulting Path:
A-B-E-C-G

(d) (3 points) Is this heuristic admissible? Justify your answer by using the optimal cost and the heuristic value for each state.

The graph has been updated with the optimal costs to reach to G with c. The updated graph shows that all the heuristic values under estimate the cost to goal thus this heuristic is admissible. However, it is not consistent! Just looking at B and E is enough to see this but there are other examples as well.

3. (20 points) You are given six variables, A, B, C, D, E, F each with the domain $\{1, 2, 3, 4, 5, 6\}$. You are also given the the following constraints on the variables:

   1. All variables must take different values
   2. $A > 3$
   3. B is either 5 or 6
   4. $A > B$
   5. C is even
   6. E is not 1 or 6
   7. $|E - F| = 1$
   8. $|A - C| = 2$

   (a) (2 points) On the grid below cross out the values from each domain that are eliminated by enforcing **unary constraints** (i.e. constraints containing only a single variable).

A	~~1~~	~~2~~	~~3~~	4	5	6
B	~~1~~	~~2~~	~~3~~	~~4~~	5	6
C	~~1~~	2	~~3~~	4	~~5~~	6
D	1	2	3	4	5	6
E	~~1~~	2	3	4	5	~~6~~
F	1	2	3	4	5	6

   0.5 per correctly applied unary constraint (2,3,5 and 6)

   (b) (1 point) According to the Minimum Remaining Value (MRV) heuristic, which variable should be assigned to first? Use the degree heuristic as a first and alphabetical order as a second tie-breaker.

   B since it only has 2 values remaining in its domain

   (c) (1 point) Based on the state of the problem in part (a), What value would you assign to the variable E based on the Least Constraining Value (LCV) heuristic? Take the smallest value in case of a tie.

   3 since selecting it rules out the least number of values from the other variables.

   (d) (6 points) In addition to enforcing unary constraints (part (a)), now also run the arc consistency constraint propagation algorithm (AC3) on the initial problem. Cross out the values that are eliminated. Use the space if needed.

A	~~1~~	~~2~~	~~3~~	~~4~~	~~5~~	6
B	~~1~~	~~2~~	~~3~~	~~4~~	5	~~6~~
C	~~1~~	~~2~~	~~3~~	4	~~5~~	~~6~~
D	1	2	3	~~4~~	~~5~~	~~6~~
E	~~1~~	2	3	~~4~~	~~5~~	~~6~~
F	1	2	3	~~4~~	~~5~~	~~6~~

   (e) (1 point) Give a complete assignment to values that does not violate any constraints.

A	B	C	D	E	F
6	5	4	1,3,1	2,2,3	3,1,2

(f) (2 points) Instead of running backtracking search, you decide to start over and run local search (iterative improvement). What would be your objective function and would you want to maximize it or minimize it?

I would choose number of violated constraints as my objective function and try to minimize it

(g) (7 points) Given the table below with the initial assignments, run local search until you have found a solution or hit a local minima. Use value swap between two variables as your successor function. You are only allowed to do one swap per step. Number of steps is not an indicator for the length of the solution

	A	B	C	D	E	F	Obj. Func.
Init	5	6	4	2	1	3	4/7
Step 1	6	5	4	2	1	3	2/3
Step 2	6	5	4	1	2	3	0/0
Step 3							
Step 4							
Step 5							
Step 6							
Step 7							
Step 8							

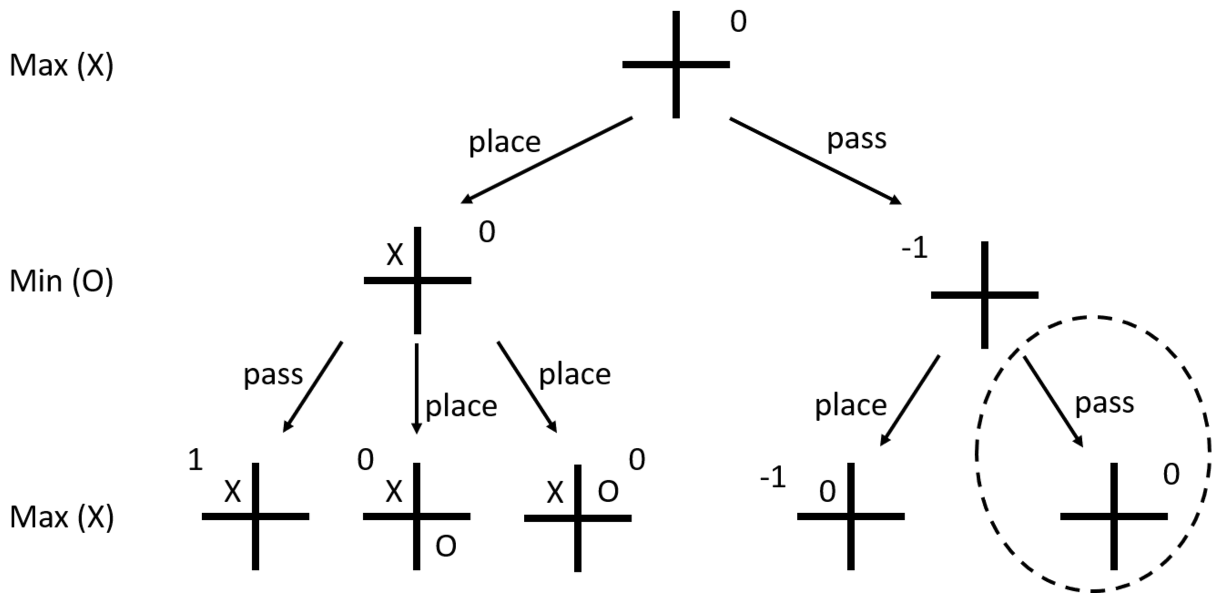
Init: 4, 6, 7 and 8 are violated. I will also accept answers where binary constraints are counted twice based on the answer to the previous part (the objective function values to the right)

Steps 1 and 2: There are two moves that decrase the objective function by two, namely swapping $A-B$ and swapping $E-D$. After applying these two swaps (order does not matter since they do not interact), we find the solution. I am showing one alternative above but will accept the other.

Note that if binary constraints are counted as 2, then the only solution is the one provided above.

4. (18 Points) Consider a game of 2×2 tic-tac-toe (aka X-O-X) where each player has the additional option of *passing* (i.e. not marking any square) and that X goes first. Note that there are only 4 squares in such a game instead of the usual 9.

   (a) (6 points) Draw the full game tree down to depth 2. You do not need to show nodes that are rotations or reflections of siblings already shown. (Your tree should have five leaves.)



   (b) (4 points) Suppose the evaluation function is the number of Xs minus the number of Os and that the agent which plays X is the maximizer. Mark the values of all leaves and internal nodes on the map.

   See the tree (to the top sides of the nodes)

   (c) (2 points) Circle any node that would not be evaluated by alpha-beta during a left-to-right exploration of your tree. If there is nothing to be pruned explicitly say so.

   See the tree (dashed ellipse)

   (d) (6 points) Suppose we wanted to solve the game to find the optimal move (i.e., no depth limit). Explain why alpha-beta with an appropriate move ordering would be much better than minimax. How can you modify the minimax algorithm to work? (Hint: These are tree-search algorithms)

   Minimax will never terminate due to *passing* but alpha-beta pruning would prune the nodes if the neighbors are expanded in a certain order. Note that alpha-beta would also never terminate if the passing is always evaluated first. To make these algorithms work, we would need to keep track of previously visited nodes and not evaluate them further, similar to the graph search ideas.

   5cm

5. (10 points) A school employs 75 teachers. The following table summarizes their length of service (denoted by y) at the school, classified by gender.

Service Length:	$y < 3$	$3 \leq y \leq 8$	$8 < y$
Female	12	20	13
Make	8	15	7

Answer the questions below based on this table. Do not calculate the fractions but feel free to simplify them.

(a) (1 point) Probability of a randomly selected teacher being female:
$(12 + 20 + 13)/75 = 45/75 = 3/5$

(b) (1 point) Probability of a randomly selected teacher being female and having at least 3 years of experience:
$(20 + 13)/75 = 33/75 = 11/25$

(c) (1 point) Probability of a randomly selected teacher being female **given** that the teacher has more than 8 years service:
$13/20$

(d) (4 points) Which event is independent of selecting a female teacher? Justify your answer.
Look at the event of having at least 3 years of experience. Let's call this event E_1 and the event of picking a female teacher E_2. Then:
$P(E_1) = (20 + 15 + 13 + 7)/75 = 55/75 = 11/15$, $P(E_2) = 3/5$ and $P(E_1, E_2) = 11/25$. $P(E_1)P(E_2) = 11/15 \cdot 3/5 = 11/25$.
Thus; $P(E_1, E_2) = P(E_1)P(E_2)$ which imply that the events E_1 and E_2 are independet. You could have found this by examining a total of 6 combinations of events related to service length.

(e) (1 point) Three teachers are selected at random. What is the probability of all three are female with less than 3 years of service?
$12/75 \times 11/74 \times 10/73$
$(12/75)^3$ gets half a point.

(f) (2 points) Three teachers are selected at random. What is the probability of all three being the same gender?
Probability of picking three female teacheers: $45/75 \times 44/74 \times 43/73$.
Probability of picking three male teacheers: $30/75 \times 29/74 \times 28/73$.
The desired probability is then $45/75 \times 44/74 \times 43/73 + 30/75 \times 29/74 \times 28/73$.
$(3/5)^3 + (2/5)^3$ gets a 1 point

6. (12 points) You are on a game show and are given the choice of three doors. Behind one of the doors is a car and nothing behind the others. You initially pick a door. Then the host, who knows the car's location, opens one of the other doors that is empty and gives you the chance of changing your selection. Would changing your selection at this point affect your chances of winning the car? Justify your answer using probability. Your grade will depend on your justification.

Without a loss of generality, let's assume we picked the first door and the host opened the third door. Further let the random variable C denote the location of the car, and the random variable H denote the host's choice. Then:

- $P(C = 1) = 1/3$: The prior probability of car being behind door 1
- $P(H = 3) = 1/2$: The prior probability of host opening door 3. It is $1/2$ because the always opens the empty door which implies he/she knows the car's location and will never open the corresponding door.
- $P(H = 3|C = 1) = 1/2$: Probability of the host opening the door 3, if the car is behind door 1. It is $1/2$ since the host will chose either the door 2 or 3 on random since the car is behind door 1. Note that $P(H = 3|C = 2) = 1$ since the host does not reveal the car and the door 1 is already selected by us!
- $P(C = 1|H = 3)$: The probability of car being behind door 1, if the host opened door 3. If this is lower than $1/2$, we should switch and otherwise stay with our initial door.

Let's apply the Bayes' Rule $P(C = 1|H = 3) = \frac{P(H=3|C=1)P(C=1)}{P(H=3)} = \frac{1/2 \cdot 1/3}{1/2} = 1/3$

Since $1/3 < 1/2$, we should switch to door 2 which will double our chances of winning the car!

There are other ways of coming to this solution. You can enumerate the possibilities and count (12 points), make some intuitive discussion (around 6-9 points) etc. If you have got $1/2$ and say that changing does not matter will get you 3 points. Coming up with 1/2and saying that "I will change my decision since 1/2>1/3" will receive 0 points no matter the justification.