CSE 4308 / 5360 001 – Fall 2018
Exam 1, Monday 09/24/2018

Name: SOLUTION

Student ID:

(Not providing this information: -10 Points)
(Name missing in Individual pages: -5 Points)

Name: ___________________________

Total Exam Points: 100

Score

Question	**Points**	**Max Points**
1		8
2		15
3		10
4		10
5		15
6		12
7		12
8		18
Total		**100**

Name: ______________________

Question 1 – 8 points

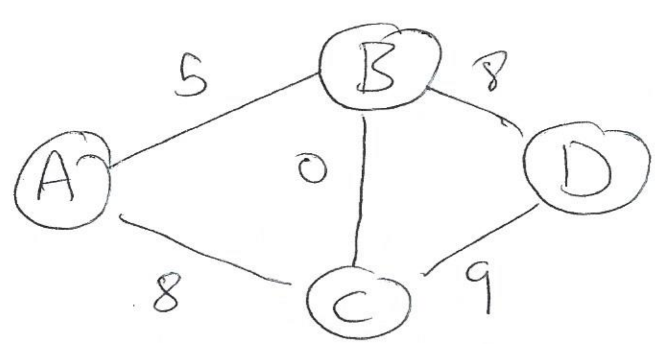
(a) (4 points). Is there a search problem where breadth-first search is guaranteed to find a solution and iterative deepening search will fail to find a solution? If no, justify. If yes, specify an example.

No, Every iteration of IDS will visit every node that BFS will visit at that depth level. So any solution that BFS will find, IDS will find too.

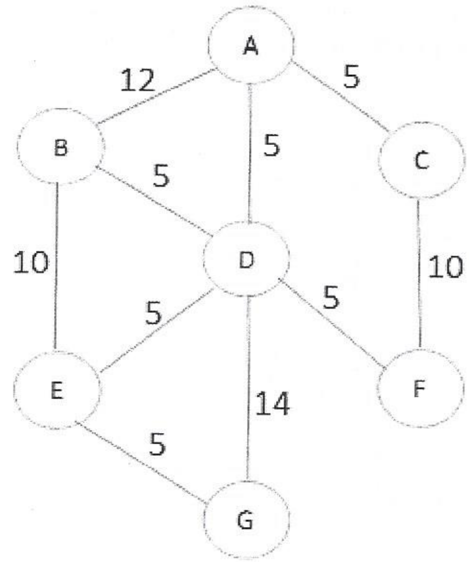
(b) (4 points). Is there a search problem where breadth-first search is guaranteed to find a solution and uniform cost search will fail to find a solution? If no, justify. If yes, specify an example.

Yes, If you have steps with cost 0, UCS will get stuck in a loop while BFS will complete

Ex:



Question 2 – 15 points



Consider the following. The cost of going through a road is simply the length of the road. Let the Start State be **A**.

(a) (10 points) Assuming that the search **does not keep track** of cities already visited, list (in the order in which they are expanded) the nodes **expanded** (not generated) by uniform cost search and iterative deepening search. (NOTE: Multiple answers may be correct here.)

UCS: A(0), C(5), D(5), B(10), A(10), E(10), F(10), A(10), B(12), F(15), D(15), D(15), D(15), D(15), G(15)

IDS. IT1: A

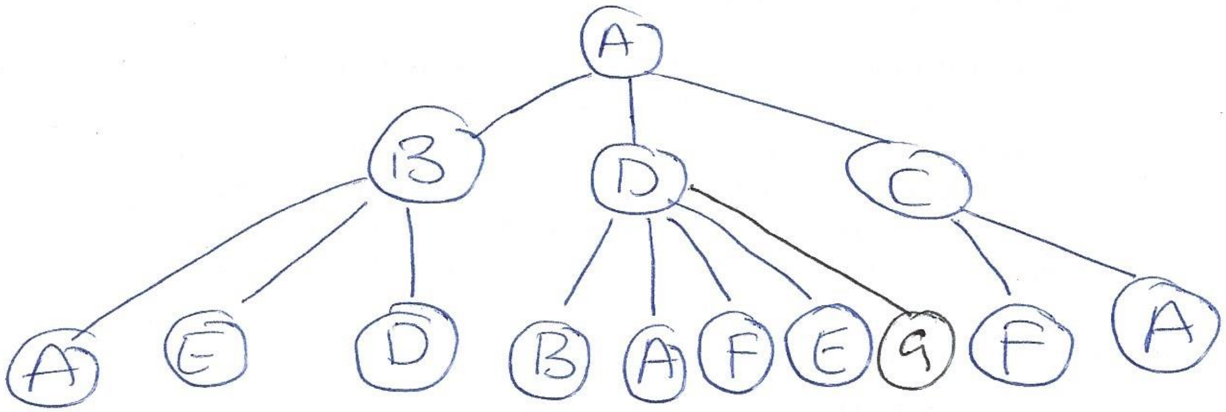
IT2: A B D C

IT3: A B A D E D B A F E G

C A F

Name: ____________________________

(b) (5 points) Draw the first three levels of the search tree. Note: Consider the root to be level 1.



Question 3 – 10 points

The missionary-cannibal problem is defined as follows:

- There are three missionaries and three cannibals on the left bank of the river.
- The goal is to get all six people alive on the right bank of the river.
- There is a single boat, and that boat is the only way to move from one bank to the other.
    - The boat cannot go from one bank to the other without at least one person in it.
    - The boat cannot carry more than two people on the same trip.
- If, at any point, there are more cannibals than missionaries on one bank, the cannibals will kill and eat any missionaries who are on that bank. We do not allow any solution that involves the death of any of the six people.

In this problem, a state is described by specifying four numbers and a Boolean:

- A: number of missionaries on the left bank.
- B: number of cannibals on the left bank.
- C: number of missionaries on the right bank.
- D: number of cannibals on the right bank.
- X (Boolean): true if the boat is on the left side, false if the boat is on the right side.

So, the start state is (3300T) and the goal state is (0033F). A move corresponds to moving one or two people with the boat, from one bank where the boat currently is to the other bank. The goal is to find a sequence of moves that gets all six people (alive) to the right bank.

(a) (5 points). How many states are there in this search space? Exclude states that result in cannibals eating missionaries. Upper bounds on the number of states may receive partial credit (depending on how close the bounds are). Justify your answer.

Initial & Final State : 2.

States with 3 missionaries on left (3_0_T/F): 6

States with 3 missionaries on right (0-3_T/F): 6

States with 2 missionaries on left (2211 T/F) = 2

States with 2 missionaries on right (1122 T/F) = 2

Total 18 states

Name: ______________________

(b) (5 points). What is the branching factor in this search problem? Why? (Branching factor is maximum possible number of actions for a state)

- 2 cannibals from one bank to another.
- 1 cannibal from one bak to another.
- 1 missiony from one bank to another
- 2 missiony frome one bank to another
- 1 cannibal, 1 missiony frome one bank to another.

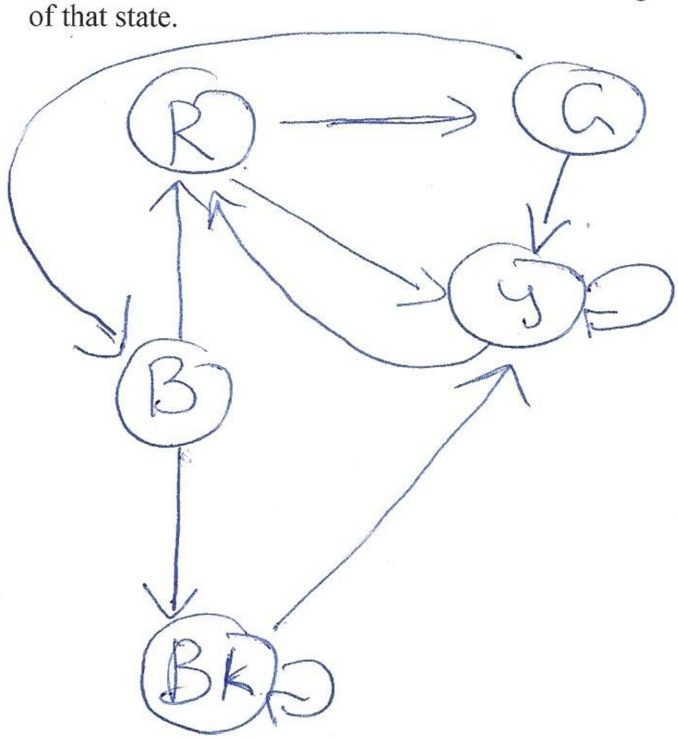
Max possible branches: 5

Question 4 – 10 points

Consider a search space, where each state can be red, green, blue, yellow, or black. **Multiple states may have the same color.** The goal is to reach any **black** state. Here are some rules on the successors of different states, based on their color (these successor functions are unidirectional):

- Red states can only have green or yellow children.
- Blue states can only have red or black children.
- Green states can only have blue or yellow children.
- Yellow states can only have yellow or red children.
- Black states can only have yellow or black children.

Define a maximally admissible heuristic that assigns a value to each state based only on the color of that state.



$h(R) = 3$

$h(B) = 1$

$h(G) = 2$

$h(Y) = 4$

$h(Bk) = 0$

Name: ______________________

Question 5 – 15 points

In the 8-puzzle, there are 8 pieces, labeled with the numbers from 1 to 8, placed on a 3x3 grid. At each move, a tile can move up, down, left, or right, but only if the destination location is currently empty. For example, in the start state shown above, there are three legal moves: the 8 can move down, the 7 can move right, or the 6 can move up. The goal is to achieve the goal state shown above. The cost of moving a tile is 1. So, the cost of a solution is the number of moves it takes to achieve that solution.

Example state

4	2	8
3	7	
1	5	6

Goal state

1	2	3
4	5	6
7	8	

Suppose that we have a table where, for every possible state of the 8-puzzle, we have the best move to make from that state. Obviously, it can take a lot of time to compute the best move for each state, so assume that has already been done and we have the results. Then, we define a search algorithm called TABLE-SEARCH, which figures out the next move for any state in constant time using this table that we have created.

(a) (5 points) Make a rough estimation of the memory requirements of TABLE-SEARCH. Explain the assumptions for your estimation. Are the memory requirements realistic for a modern computer? Justify your answer.

If n is number of nodes, then memory requirements are $O(n)$.

Here $n = 9!$

So Memory req is $O(9!)$

Which is realistic for a modern computer

(b) (5 points) Among depth-first search, breadth-first search, iterative deepening search and uniform cost search, which algorithms are more **memory-efficient** than TABLE-SEARCH? Why?

Since we dont track visited states DFS has infinite memory req. The other methods will have memory requirements less than or equal to TABLE-SEARCH.

(c) (5 points) Among depth-first search, breadth-first search, iterative deepening search and uniform cost search, which algorithms are more **time-efficient** than TABLE-SEARCH? Why?

TABLE-SEARCH is a table lookup. As mentioned in the question, it has constant time algorithm. This is better than all the other algorithms.

Question 6 – 12 points

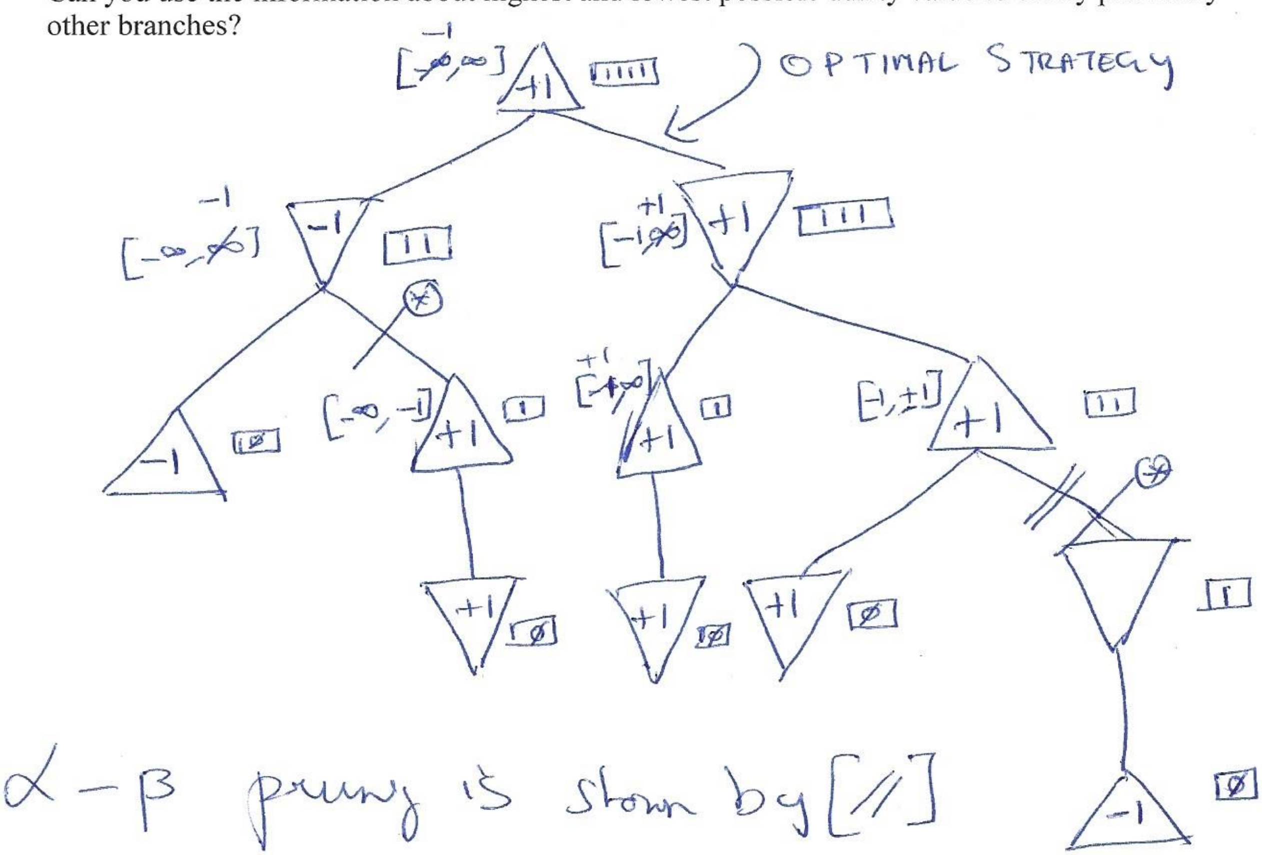
Consider the following 2 –player game

- Start with 4 sticks on the table
- Each player on his/her turn can remove one or two sticks from the table.
- If on the player's turn there are no sticks he/she loses (i.e. if on MAX turn if there are no sticks, he/she loses, and the utility of that state is -1 and vice versa)
- MAX plays first

Draw the full MINMAX search tree (Triangle for MAX, Inverted Triangle for MIN, Left Branch for remove 2 if possible and Right Branch for remove 1 if possible). Indicate utility values for terminal nodes (+1 if MAX wins, -1 if MAX loses). Also compute utility for all other nodes and indicate which action the algorithm will select as an optimal strategy.

Indicate the branches (if any) that can be pruned by ALPHA-BETA pruning.

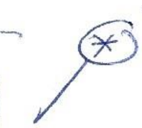
Can you use the information about highest and lowest possible utility value to safely prune any other branches?



Yes we can use maximum and minimum possible utility values to prune additional nodes.

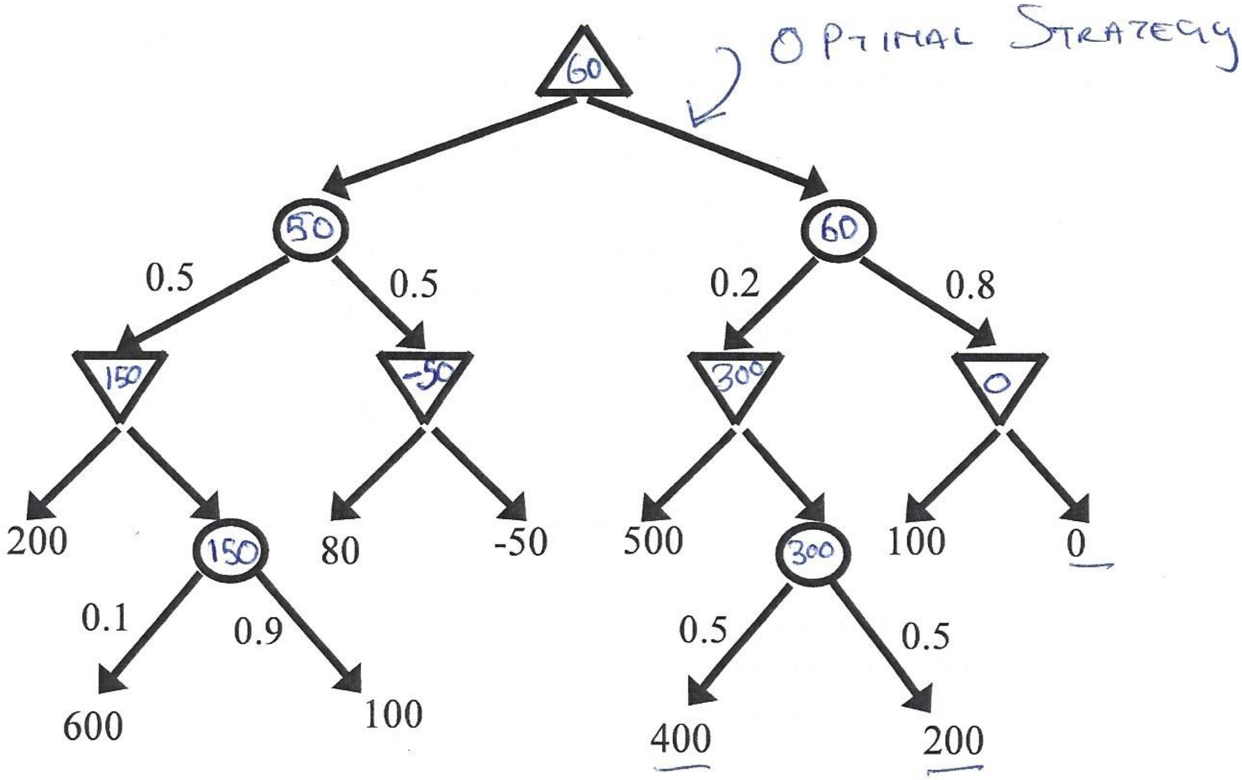
MIN nodes can prune all other successors once it gets successor with utility -1

MAX nodes can prune all other successors once it gets successor with utility +1

Shown in figure using []

Name: ___________________________

Question 7 – 12 points



Consider the game tree above. States where the MAX player has to play is represented by a triangle, states where MIN player plays is denoted by inverted triangle and random chance is represented by circles. For clarity's sake terminal nodes are represented by just their utility values.

(a) (7 points) Indicate the EXPEXTIMINMAX value of each non-terminal node. (Just indicate the values next to the nodes in the image above). Also indicate which action it will be select.

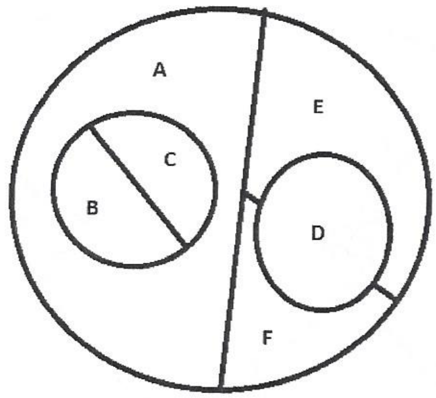
(b) (5 points) After playing the move selected by EXPECTIMINMAX what is maximum and minimum value that the MAX player can win from a single game.

Both player are playig MINMAX so the variation is due to chance.

So for a sigle game MAX can expect to win a Minimum of 0 and max of 400.

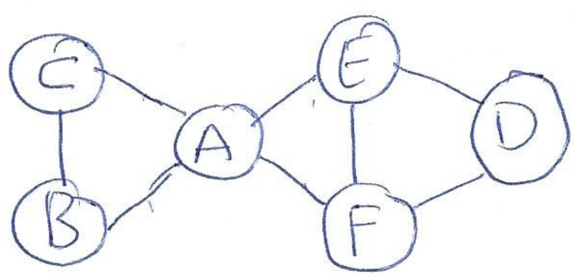
Question 8 – 18 points

Consider the following Map coloring problem where you must color each territory either Red, Green or Blue such that no two adjacent regions have the same color.



(a) **[5 points]**: Draw the constraint graph for this problem.
(b) **[4 points]**: If you are using Backtracking search with MRV and Degree heuristic to select variables, what is the first variable to be selected.
(c) **[5 points]**: Assign the color Red to that variable and show the steps of checking for Arc consistency
(d) **[4 points]**: What will be the next variable to be selected (using the same methods as step b).

(a)



(b) All the nodes have MRV (3) initially.
Of these A has highest degree heuristic
(4)

Choose A

A − B, A − C, A − E, A − F Name: ______________________

(c) A B C D E F

R ~~R~~GB ~~R~~GB RGB ~~R~~GB ~~R~~GB.

B − A, B − C.

A B C D E F

R GB GB RGB GB GB.

C − A, C − B

A B C D E F

R GB GB RGB GB GB

Similarly no changes for E − A, E − D, F − A, F − D

No other arcs left.

(d) There are 4 nodes with MRV (2): B, C, E, F

Of these E, F have highest degree heuristic value (2)

Choose one of them.

Name: ______________________

SCRATCH