MSc/ICY Introduction to Artificial Intelligence
Homework 1
Due Date: Monday 22nd February 2016, 23:59 GMT
Late Penalty: -5 points per day (not including weekends and holidays).

This homework is marked out of 100 points and is worth 10% of the entire module mark. This homework covers material from Lectures 1-8 and Chapters 3 and 5 of the Russell Norvig book.

You must hand in your assignment electronically in PDF FORMAT ONLY via Canvas: https://canvas.bham.ac.uk/.
Type out all your answers using a text editor or word processor. I will only accept handwritten answers for the grid questions (#1-3), tree questions (6,8-9), or if you want to draw a figure as part of an explanation.

1. (10 points)
On the square grid on the last page of this assignment, the agent needs to find a path from the starting location (Blue Marker) to the goal (Green Marker). In each square, the agent has up to four actions: move 1 space North, East, South, or West. Red indicates barriers which the agent cannot enter (Cannot generate a node in the points covered in red).

Show how the search for the solution will proceed, first by using the Breadth First Search Algorithm.

Make the following assumptions: When expanding a node, assume that its children are discovered in the following clockwise order: 1. North, 2. East, 3. South, 4. West. (Note this is the order the nodes are meant to be added to the data structure in the algorithm).

In the grid, the starting space is labeled 0. For every other space, write its order of discovery by number on the space, e.g. 1,2,3… up to 18. If a space is never discovered, leave it blank. Indicate the final path chosen by the algorithm with arrows on the grid. Submit a scanned or a clearly photographed copy of your grid sheet.

2. (10 points)
Repeat question 1, but with the Depth First Search Algorithm. Use a new grid sheet.

3. (10 points)
Repeat question 1, but with the A* search algorithm, and the “Manhattan Distance” heuristic. Use a new grid sheet.

4. (4 points)
If problem is changed to 8-step (Diagonal movement allowed)
Is Manhattan still suitable to provide an optimal solution? Explain your reasons why? If it is not suitable then provide an alternative heuristic.

5. (10 points)
In lectures we explained that the complexity of Breadth-First Search is $O(b^d)$ (for both time and space), and Depth-First Search is $O(b^m)$ for Time and $O(bm)$ for Space. Here, b is the tree's branching factor, d is the depth of the shallowest solution, and m is the maximum possible depth of the search tree.

a. In the worst case scenario how many steps will the iterative deepening search take on a tree of depth m and a branching factor of b?
b. What is the time complexity of iterative deepening search from part a in big O notation?
c. What is the space complexity of iterative deepening and why?
d. Describe a situation where iterative deepening search performs worse than depth-first search. (e.g. has a complexity of $O(n^2)$ rather than $O(n)$)

6. (20 points)
The missionaries and cannibals problem is a famous AI problem posed in Amarel 1986.
The problem will be posed as follows:
There are 3 missionaries and 3 cannibals on one side of a river with a boat that can carry two people at most. You need to find a way to get everyone to the other side of the river, however, you cannot leave any missionaries outnumbered by the cannibals for obvious reasons and the boat must have at least one person to travel between the different banks (the boat cannot move by itself) and can only pick up people from the bank it is currently on. Cannibals can be left alone together.
Using the following notation:

Left Bank	Boat Location	Right Bank
	R	M M M C C C

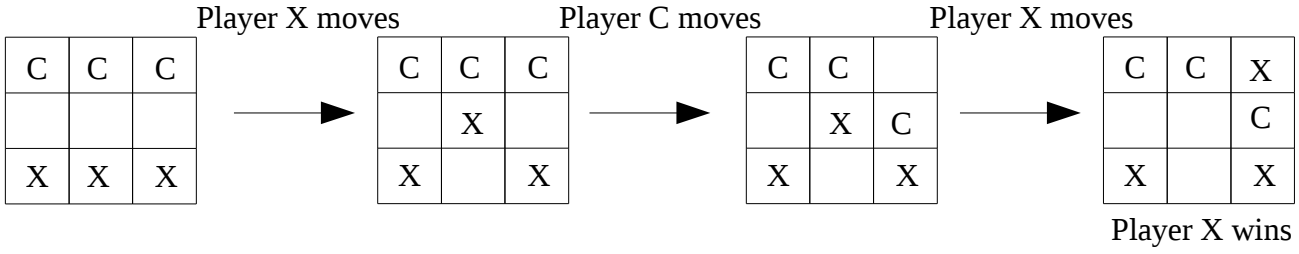
Where M is a missionary and C is a cannibal. The boat can either be at R (Right Bank) or L (Left Bank). The boat can only pick up passengers from the bank it is located.
An example of one trip across the river is as follows:

Left side	Boat Location	Right Side
M C	L	M M C C
C	R	M M M C C

The states are generated so that the minimal number of people that can travel on the boat are generated first.
By hand using one of the optimal search algorithms solve this problem and draw the search tree generated. (Illegal states can be left out)

7. (6 points)
For each of the following statements write down whether the statement is true or false and provide a brief explanation why.
a) The heuristic function h(n) = 0 is an admissible heuristic for the graph problem presented in question 1.
b) Uniform cost search is complete even if zero step costs are allowed given a finite graph.
c) Assume that a rook can move on a chessboard any number of squares in a straight line, vertically or horizontally, but cannot jump over other pieces. Manhattan distance is an admissible heuristic for the problem of moving the rook from square A to square B in the smallest number of moves.

8. (20 points)
This is a 3x3 square game. The rules are as follows:
Two players have three pieces each, marked as C and X. The player with the X pieces takes the first turn. Each turn the player must select one piece to move, this piece can only move forward unless its path is blocked by another piece at which point it can move diagonally. A player wins the game when a piece of theirs reaches the opponents side of the board. An example game is shown below:

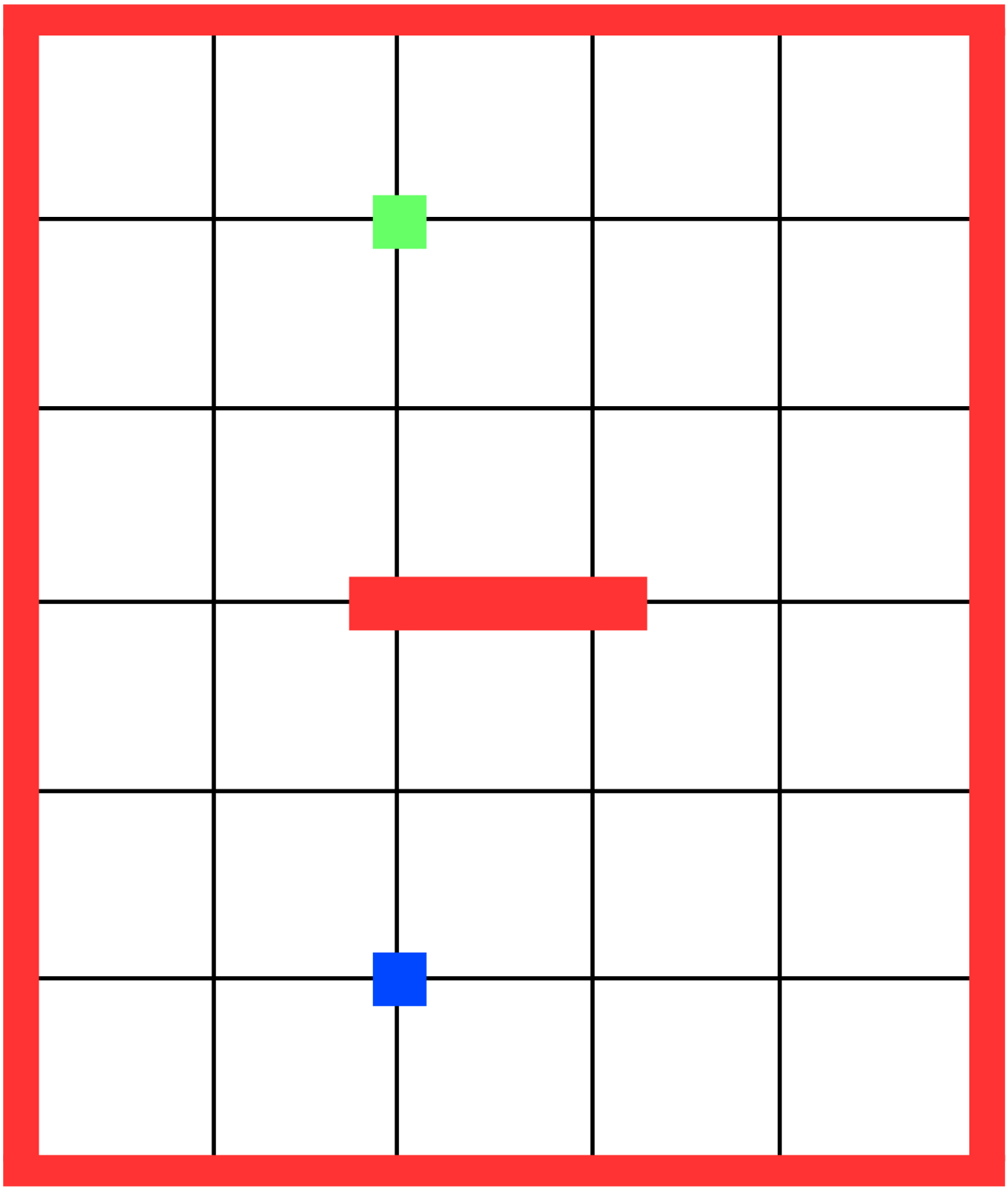


When X wins the game it is given a score of +1 and when C wins the score is -1.
When generating possible moves always start with the left hand most piece of the player then the center piece and then the right piece.

From this game draw the tree generated from the minimax algorithm with all the costs and show which moves are optimal for player X to win against an optimal opponent.

9. (10 points)
Using the tree generated in question 8 circle the nodes or sub-trees that are pruned when using the alpha-beta pruning algorithm.

Bonus Question. (20 points)
On HackerRank.com complete the A* pacman search challenge under the AI domain and the A* subdomain. To be marked for this when you register your account add the University of Birmingham to your school details and provide your username with your submission of this exercise. (Make sure you are properly registered on the website as if you are not you may not show up on the leaderboards which means you will not be marked!)



Circle which Algorithm: BFS DFS A*