CSCI 3202 Introduction to Artificial Intelligence
Instructor: Hoenigman
Midterm Review

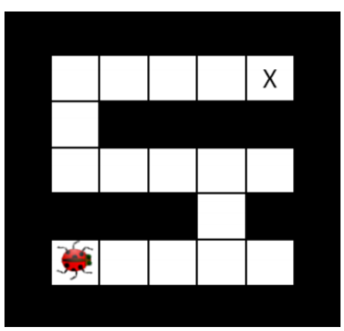
Your midterm is on Friday October 17 at 3pm.

The exam is open notes and open books, but you will not have access to your computer, cell phone, or any other electronic device connected to the internet during the exam.

Practice Problems

1. You control one or more insects in a rectangular maze-like environment with dimensions M × N, as shown below. At each time step, an insect can move into an adjacent square if that square is currently free, or the insect may stay in its current location. Squares may be blocked by walls, but the map is known. Optimality is always in terms of time steps; all actions have cost 1 regardless of the number of insects moving or where they move. For each of the following scenarios, precisely but compactly define the state space and give its size. Then, either evaluate the provided heuristics or supply your own, as indicated. Your answers should follow the format of the example case below. Full credit requires a minimal state space (i.e. do not include extra information), but you should answer for a general instance of the problem, not simply the map shown.

   Lonely Bug
   You control a single insect as shown in the maze below, which must reach a designated target location X. There are no other insects moving around.



State space description: A tuple (x,y) encoding the position of the insect.

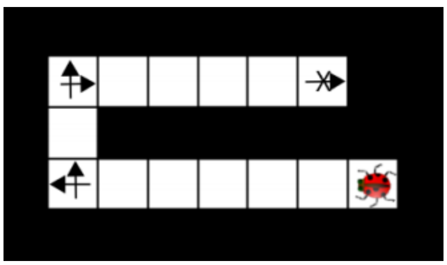
State space size: MxN

Which of the following is an admissible heuristic, if any?

1. The Manhattan distance from the insect's location to the target.
2. The Euclidean distance from the insect's location to the target.
3. Both 1 and 2 are admissible.

2. **Jumping Bug**

   Your single insect is alone in the maze, and this time it has super legs that can take it as far as you want in a straight line in each time step. The disadvantage of these legs is that they make turning slower, so now it takes the insect a time step to change the direction it is facing. Moving *v* squares requires that all intermediate squares passed over, as well as the v^{th} square, currently be empty. The cost of a multi-square move is still 1 time unit, as is a turning move. As an example, the arrows in the maze below indicate where the insect will be and which direction it is facing after each time step in the optimal (fewest time steps) plan (cost 5):



State space description:

State space size:

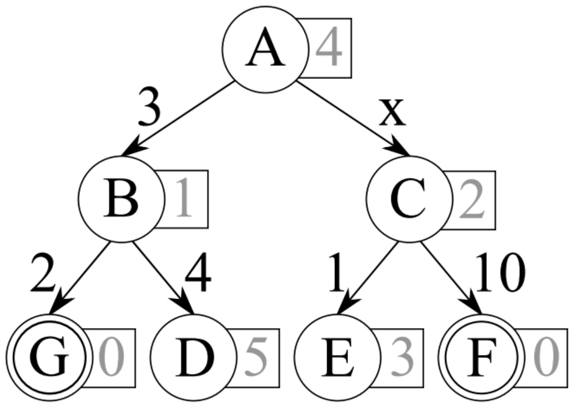
Which of the following is an admissible heuristic, if any?

1. Cost of path to hive in lonely bug problem in Question 1, without special jumping ability or turning cost.
2. Number of turns in the optimal path in the lonely bug problem.
3. Number of dimensions, (0,1,2) in which the current position differs from the goal.

3. Tree search

   Consider the following graph, where you start at A, and there are two states that pass the goal test: G and F. The numbers next to edges are action costs, and the numbers in boxes are the heuristic values for the nodes they are attached to.

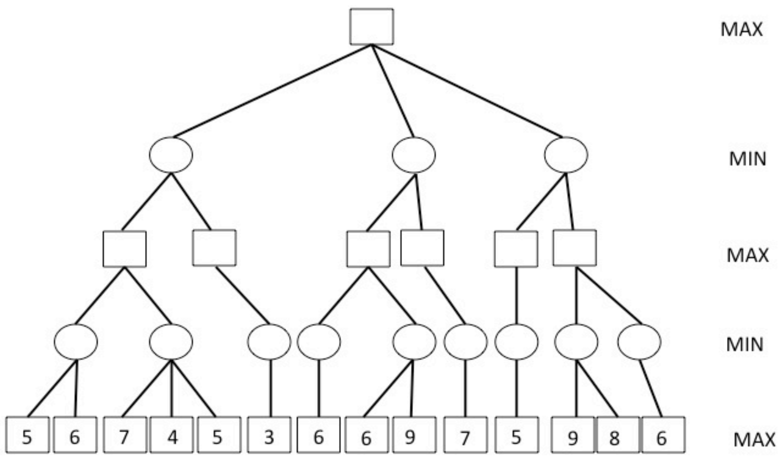
Assume ties are broken by expanding the alphabetically earlier node first (so distinctions between < and ≤ are meaningful). You may assume that all edge costs are positive integers and all heuristic values are non-negative integers.



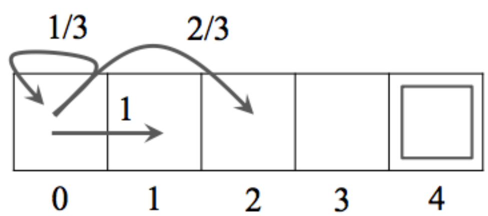
What range of values for the missing edge weight will lead Uniform Cost search to expand node C?

What range of values for the missing edge weight will lead A* search to expand node C?

4. In the following tree, what is Max's utility using minimax search? Which branches and nodes would be pruned from the tree using alpha-beta search?



5. Consider an MDP with states {0,1,2,3,4}, where 0 is the starting state and 4 is a terminal state. In the terminal state, there are no actions that can be taken. In states *k <= 3,* you can *Walk (W)* and *T(k, W, k+1) = 1*. In states *k <= 2*, you can also *Jump (J)* and *T(k, J, k+2) = 2/3, T(k, J, k) = 1/3* (usually jumping is faster, but sometimes you trip and don't make progress). The reward *R(s,a,s')* = $(s-s')^2$ for all (s,a,s'). Use a discount gamma = ½.



Consider the policy π that chooses the action Walk in every state.

Compute $U^{\pi}(2)$ after one iteration of value iteration. Start in state k = 0.