CSCI 4150: Intro. to Artificial Intelligence
Midterm Examination

Tuesday October 19, 1999

Name: _____

Part 1: Blind search	Problem 1 (14)	
	Problem 2 (14)	
	Problem 3 (14)	
Part 2: Heuristic search	Problem 1 (20)	
	Problem 2 (5)	
Part 3: Game search	Problem 1 (7)	
	Problem 2 (20)	
Part 4: Logic	Problem 1 (10)	
	Problem 2 (20)	
Total	(124)	

1 Blind search

The following questions propose a specific problem and ask whether a given search is appropriate to use to solve that problem.

1. (14 points) Route planning: A network of roads connects n cities. You must find a path from a given start city to a given goal city along these roads.

   - *state*: current location (city)
   - *goal test*: are we at the goal city?
   - *operator*: traveling from one city to another along a road in the network
   - *path cost*: total distance traveled

   (a) Depth limited search:

      i. Can this search be used on this problem? If not, why not?

      ii. If so, what is an appropriate depth limit? _____

      iii. Is this search complete for this problem? _____

      iv. Is this search optimal for this problem? _____

   (b) Breadth first search:

      i. Can this search be used on this problem? If not, why not?

      ii. Is this search complete for this problem? _____

      iii. Is this search optimal for this problem? _____

2. (14 points) Missionaries & cannibals problem: 3 missionaries and 3 cannibals are on one side of a river with a boat that can take two people across.

   - *state*: the number of missionaries and cannibals on each side of the river and which side of the river the boat is on.
   - *goal test*: all 6 people are on the other side of the river
   - *operator*: one or two persons ride in the boat to the other side of the river such that the missionaries are never outnumbered by the cannibals (on either side of the river)
   - *path cost*: total number of boat trips

(a) Uniform cost search:

i. Can this search be used on this problem? If not, why not?

ii. Is this search complete for this problem? _____

iii. Is this search optimal for this problem? _____

(b) Iterative deepening:

i. Can this search be used on this problem? If not, why not?

ii. Is this search complete for this problem? _____

iii. Is this search optimal for this problem? _____

3. (14 points) Eight queens problem: place 8 queens on a chess board so that no two queens attack each other.

- *state*: locations of 0 to 8 queens (with no two queens attacking each other)
- *goal test*: 8 queens placed on the board (with none attacked)
- *operator*: place a queen in the left-most empty column such that it is not attacked by any other queen (and does not attack any other queen)
- *path cost*: 0

(a) Depth first search:

i. Can this search be used on this problem? If not, why not?

ii. Is this search complete for this problem? _____

iii. Is this search optimal for this problem? _____

(b) Bidirectional search:

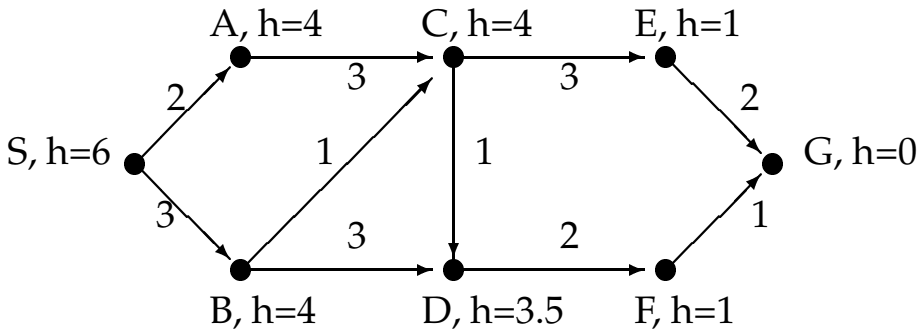
i. Can this search be used on this problem? If not, why not?

ii. Is this search complete for this problem? _____

iii. Is this search optimal for this problem? _____

2 Informed search

1. (20 points) Suppose we want to use the A* algorithm on the graph below to find the shortest path from node S to node G. Each node is labeled by a capital letter and the value of a heuristic function. Each edge is labeled by the cost to traverse that edge.



For this problem:

- Perform the A* algorithm on this graph, filling in the table below. You should not need all the lines in the table. Indicate the f, g, and h values of each node on the queue as shown in the first two rows of the table. You need not write the contents of the (priority) queue in order in the table.

  Assume that if you find a path to a node already on the queue that you update its cost (using the lower f value) instead of adding another copy of that node to the queue.
- Show the path found by the A* algorithm on the graph above.

iteration	node expanded	priority queue at end of this iteration
0		S = 0 + 6 = 6 (i.e. S = g(S) + h(S) = f(S))
1	S	A = 2 + 4 = 6; B = 3 + 4 = 7
2		
3		
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6		
7		
8		
9		
10		

2. (5 points) You may want to skip over this problem and come back to it later as it is worth only 5 points and is harder than other problems on this examination. For this problem, a "yes" or "no" answer without an explanation is worth 0 points.

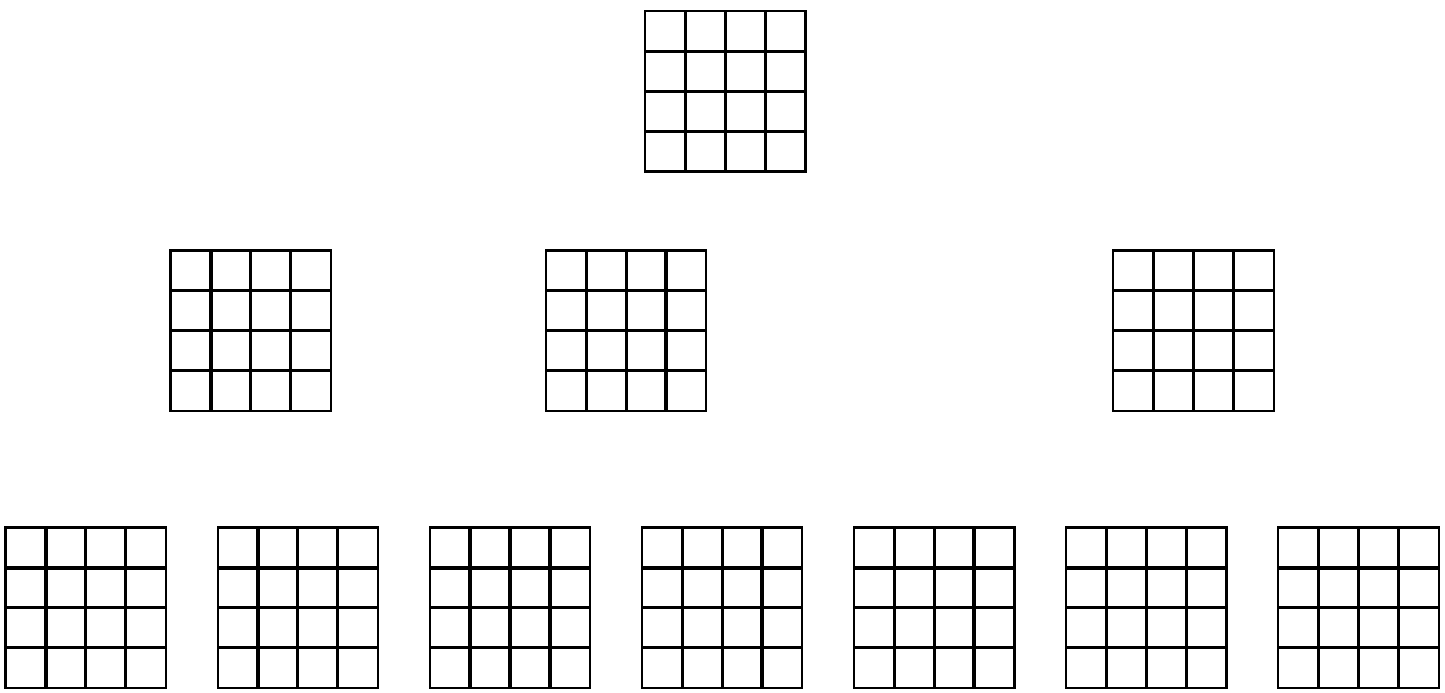
   Suppose we run the A* algorithm using a heuristic that is admissible but not monotonic. Assume that we do not use the pathmax equation. Is A* still optimal? Why? If it is still optimal, then why do we care about monotonic heuristics?

3 Game search

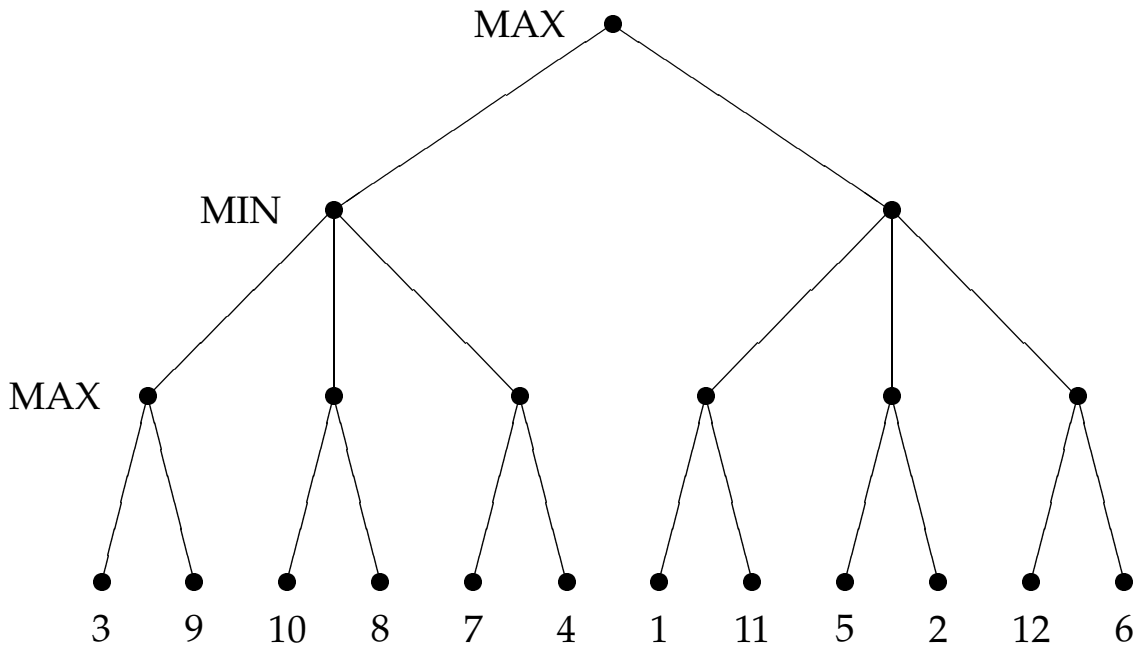
1. (7 points) Suppose we are using minimax search (without alpha-beta pruning) with a depth cutoff of 2 to play a game of Othello on a 4 by 4 board.

   It is O's turn to move; the resulting game tree appears below, along with the value of the evaluation function for each leaf node. Although it is not important for what you need to do in this problem, the evaluation function used here is computed as follows: a score is assigned to each player, giving 1 point for each piece that player has in the middle 4 squares and 2 points for each piece on an edge or in a corner. The evaluation function with respect to a given player is the difference between that player's score and his opponent's score.

   - What value does minimax return on this game tree?
   - Indicate O's best move on the tree below.



2. (20 points) Perform alpha-beta minimax search on the tree below.
   - Indicate which leaf nodes are evaluated by circling the value of the leaf node.
   - What is the value of this tree?
   - Which is the best move from the root node?



4 Logic

1. (10 points) Answer the following questions regarding completeness:

   (a) What does it mean for an inference procedure to be complete?

   (b) Is generalized modus ponens a complete inference procedure? If so, under what conditions (if any)?

   (c) Is generalized resolution a complete inference procedure? If so, under what conditions (if any)?

2. (20 points) For this problem, you will do a resolution proof based on the following situation:

   > Tom and Mike are members of the Mountain club. All members of the Mountain club are skiers or climbers (or both). Climbers don't like rain, and skiers don't like snow. Mike doesn't like anything that Tom likes, and Mike likes everything that Tom doesn't like. Tom likes rain.

   Use the following predicates for this problem:

Member(x)	x is a member of the Mountain club
Skier(x)	x is a skier
Climber(x)	x is a climber
Likes(x, y)	x likes y

(a) Translate the above prose into first order logic sentences.

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(b) Transform the sentences from part (a) into conjunctive normal form

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(c) Using generalized resolution, show that Mike is a climber. Your initial knowledge base is the sentences from part (b). You should not need all the steps in the table below.

For each step, indicate which sentences you are using the generalized resolution rule on by listing the sentence numbers. In the other boxes, show the substitution used and the resulting sentence.

	Sentences combined	Substitution	New sentence added to the knowledge base
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			