

# CS343 Artificial Intelligence: Midterm Exam

March 8, 2007

NAME: \_\_\_\_\_

1. (22 points) Consider the following 8-puzzle problem. Assume the operators are moves of the blank: R, L, D, U (Right, Left, Down, Up).

Start:

```
+---+---+---+
| 1 | 4 | 2 |
| 8 |   | 3 |
| 7 | 6 | 5 |
+---+---+---+
```

Goal:

```
+---+---+---+
| 1 | 2 | 3 |
| 8 |   | 4 |
| 7 | 6 | 5 |
+---+---+---+
```

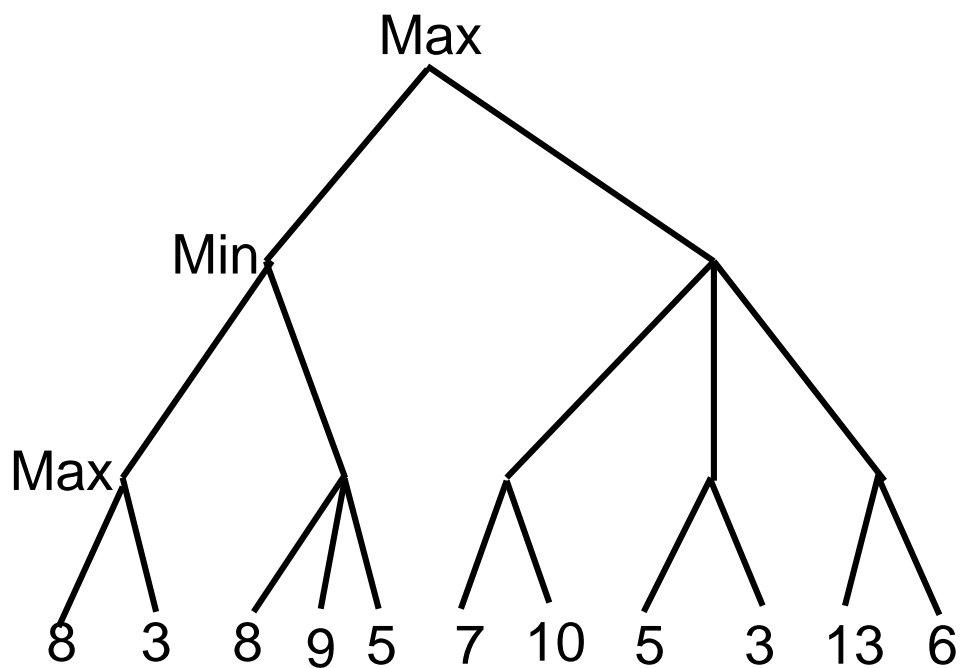
On the following blank page, show the search tree generated when performing A\* search using the *number of misplaced tiles* heuristic. For each node, compactly show the board configuration and the evaluation score in the form  $g + h = f$ . Number the nodes in order of their **expansion**. Assume successor nodes are always generated in the order: R, L, D, U; and that the earliest generated node is always preferred when breaking ties in the evaluation function. Assume that nodes that create a path from the root that revisits the same state (a loop) are removed. Did A\* find the shortest solution?

Would the search tree be different if hill-climbing (without backtracking and with the same heuristic) was used instead of A\*? If so, circle the earliest generated node in your search tree that would have been expanded by hill-climbing but was not expanded by A\*.

Would hill-climbing find the shortest solution?

## Search Tree for Problem 1

2. (16 points) Consider the following simple game tree showing the utility (or heuristic evaluation) of each of the leaves. Assume alpha-beta search is used to pick the best move for Max at the top level and that siblings are explored in left to right order. Circle each leaf node that is actually evaluated and show each updated bound and exact value established for the utility of any intermediate nodes. Number each step in order. What is the best move for Max (left or right)?



3. (18 points) Represent the following in first-order logic. Make sure to use a reasonable set of primitive predicates that capture the basic concepts. Explain any predicates and their arguments that are not obvious.

Every religion has some extremist members that hate all members of all other religions.

Every female candidate for president has a husband who won a presidential election against a parent of another president.

4. (23 points) Given the following KB in first order logic

“Every person has a parent”

$\forall x(\text{Person}(x) \Rightarrow \exists y \text{Parent}(y, x))$

“Every person is either male or female”

$\forall x(\text{Person}(x) \Rightarrow (\text{Male}(x) \vee \text{Female}(x)))$

“A female child is a daughter”

$\forall x \forall y (\text{Parent}(x, y) \wedge \text{Female}(y) \Rightarrow \text{Daughter}(y, x))$

“Pat is a person”

$\text{Person}(\text{Pat})$

“Pat is nobody’s daughter”

$\neg \exists x \text{Daughter}(\text{Pat}, x)$

Use resolution to prove:

“Pat is male”

$\text{Male}(\text{Pat})$

Show the conversion to clause form and clearly indicate each resolution used in the proof.  
The straightforward proof contains 6 resolutions.

5. (21 points) Provide short answers (1-3 sentences) for each of the following questions:

In what way is iterative deepening better than depth-first search? In what way is it better than breadth first?

In what way is hill-climbing better than best-first search? In what way is best-first search better than hill-climbing?

Define in detail the specific condition that a heuristic must satisfy in order for A\* to be guaranteed to return an optimal solution.

Clearly define the terms *soundness* and *completeness* for a logical inference system.

(Extra credit) How did Kurt Gödel, who proved the famous completeness and incompleteness theorems for first-order logic, die?

In what way is resolution theorem proving better than both forward and backward chaining?  
In what way are both forward and backward chaining better than resolution?

Name and clearly describe the distinct type of logic that is required to model inheritance with exceptions.

What are *frame axioms* in the situation calculus, the logical formalism used in AI planning?