Grad. Comp. Exam: Artificial Intelligence (Fall 2009) Student ID: _____

Answer all questions on the exam. You may use the back for additional space. Total: 100 points. Good Luck.

1. (25 pts) Search:

   (a) For some search algorithms, the solution found might not be the global minimum (with respect to a cost function).

      i. Name and describe one such algorithm.

      ii. Discuss with an example why the algorithm might yield a local minimum.

      iii. Discuss a remedy to reduce the chance for the algorithm to reach a local minimum.

   (b) Consider the problem of solving the 8-puzzle:

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

      i. For A* to be optimal, discuss the necessary property for the h function.

      ii. Describe how to measure cost in this problem.

      iii. Describe an h function that satisfies the property for A* to be optimal.

2. (25 pts) Given the following state of a Tic-Tac-Toe game (where X moves next):

```
 | |X
-----
O| |X
-----
O| |O
```

Trace the recursive function `int alphaBetaPruning(state, alpha, beta)` that implements the Alpha-beta Pruning Algorithm and list:

- the parameters and
- the return value

of each call.

3. (25 pts) CSP

   (a) Describe the elements of a Constraint Satisfaction Problem (CSP).

   (b) Describe an algorithm for solving CSPs.

   (c) The graph coloring problem is to assign a color to each vertex of a graph such that no adjacent vertices (linked by an edge) have the same color. Trace the solver you proposed in (b) for the problem of coloring using three colors a graph having a vertex in each corner of a square, and an edge for each side and for ONE diagonal.

   (d) Can you use A* to solve a CSP? Explain.

4. (25 pts) Resolution inference rule

   (a) What does sound and complete (for an inference rule) mean?

   (b) What is the resolution inference rule?

   (c) Consider:

   - $\forall x, y, z Parent(x, y) \wedge Father(y, z) \Rightarrow Grandfather(x, z)$
   - $\forall x, y, z Parent(x, y) \wedge Mother(y, z) \Rightarrow Grandmother(x, z)$
   - $\forall x, y Parent(x, y) \wedge Male(y) \Rightarrow Father(x, y)$
   - $\forall x, y Parent(x, y) \wedge Female(y) \Rightarrow Mother(x, y)$
   - $Male(Charles)$
   - $Female(Mary)$
   - $Female(Jane)$
   - $Parent(Mary, Jane)$
   - $Parent(Jane, Charles)$

   i. convert each sentence into a conjunctive normal form

   ii. apply resolution (and show your steps) to prove: $Grandfather(Mary, Charles)$