CS533
Intelligent Agents and Decision Making
Homework 2, Winter 2011

1. Exercise 10.16 (Keep answers concise.)

   For part b you can interpret "spurious" as a solution that either does not achieve the goal or one that achieves the goal but then moves away from the goal.

2. We say that a layered plan for a STRIPS problem P is layer-optimal if no other layered plan has fewer layers. We say that a layered plan is action-optimal if no other layered plan uses fewer total actions. Given an example of a STRIPS planning problem where there is no layer-optimal plan that is also action-optimal. This provides an example of a problem where systems such as GraphPlan, which search for layer-optimal plans, are not ideal if one cares most about minimizing the total number of actions.

3. Consider the CNF formula constructed in class for the simple 2 location robot world. Call this formula F. We showed that this formula was constructed from four distinct subformulas F1, F2, F3, F4 which respectively described the "initial state", "goal", "action effects/preconditions", and "explanatory frame axioms". This exercise is intended to convince you that each of the subformulas are necessary.

   For each of the subformulas, consider removing it from F and give a satisfying truth assignment of the resulting formula that does not correspond to a valid plan. That is, for each formula, F-F1, F-F2, F-F3, F-F4 give a satisfying truth assignment that does not correspond to a legal plan. (F-Fi is simply the formula F with the subformula Fi removed.)

   By legal plan we mean the following. From a truth assignment we can extract a totally ordered or layered plan, given by the sequence of action fluents that are true in the assignment at each level. We can also extract a sequence of states, where the state corresponding to level i contains all facts that correspond to true fluents at level i. We say that a truth assignment corresponds to a legal plan iff it satisfies the following three conditions:

   (a) The first state of the extracted state sequence is equal to the initial state of the planning problem.

   (b) The final state of the extracted state sequence satisfies the goal of the planning problem.

   (c) The plan and state sequence are consistent in that actions at level i can be executed in the level i state and produce exactly the state at level i+1.

4. Given a STRIPS planning problem P, we defined the corresponding relaxed problem $R(P)$ to be identical to P, except that $R(P)$ ignores the negative effects of P. Prove that the length of a shortest solution to $R(P)$ is an admissible heuristic for P. That is, prove that optimal relaxed plans are admissible heuristics.

5. Consider a simple STRIPS problem that encodes a single robot moving in a simple $N \times N$ grid. The robot can move in any neighboring grid cell to the north, south, east, or west. The initial state starts the robot at an arbitrary grid position and the goal is to reach a specified grid condition. Consider the relaxed-plan heuristic for this problem. In particular, decide which of the following best describe the heuristic for this problem:

   (a) It is a perfect heuristic. That is, it returns the exact distance (# of actions) to the goal.

(b) It is a trivial heuristic. That is, it offers little, if any, information about the distance to the goal.

(c) Somewhere in between the above two extremes.

Justify your answer.