Homework #5: Chapters 10 and 13

The following exercises are due at the beginning of class on Tuesday, April 8. Note, this homework is continued on the reverse side of the paper.

1. *[20 points]* Consider the PDDL actions defined for the air cargo problem in Figure 10.1 on page 369 of the book, and the problem instance described below:

   Initial State: At(P1,LAX) ∧ At(P2,JFK) ∧ At(C1,LAX) ∧ In(C2,P1) ∧ Plane(P1) ∧ Plane(P2) ∧ Cargo(C1) ∧ Cargo(C2) ∧ Airport(JFK) ∧ Airport(LAX) ∧ Airport(ORD)

   Goal: At(P1,JFK) ∧ At(P2,ORD) ∧ At(C1,JFK) ∧ In(C2,P2)

   a) *[10 points]* Do the first level of a breadth-first forward state-space search on this problem. You should show all actions that are applicable in the initial state, as well as the successor states that result from these actions. For convenience, your state descriptions may omit literals that use the Plane, Airport, and Cargo predicates. Note, some of the applicable actions may be spurious, but you should show them anyway.
   b) *[10 points]* Do the first level of a breadth-first backward state-space search on this problem. You should show all actions that are relevant to the given goal, and show the predecessor states for these actions. In addition to omitting literals that use the Plane, Airport, and Cargo predicates as above, you may use variables as parameters for the actions, but be careful to specify any constraints that are necessary to maintain relevance.

2. *[30 points]* Consider the problem of devising a plan for cleaning the kitchen. Assume the following:

   - Cleaning the stove or the refrigerator will get the floor dirty.
   - To clean the oven, it is necessary to apply oven cleaner and then to remove the cleaner.
   - Before the floor can be washed, it must be swept.
   - Before the floor can be swept, the garbage must be taken out.
   - Cleaning the refrigerator generates garbage and messes up the counters.
   - Washing the counters or the floor gets the sink dirty.

   a) *[5 points]* Define a set of PDDL predicates for describing states of this problem. Hint: If you use constants to represent the various objects in need of cleaning, then five to seven predicates should be sufficient.
   b) *[15 points]* Define a set of PDDL operators representing all of the actions mentioned in the description above. Be sure that your preconditions and effects accurately capture the information given in this description. You do not need to add any preconditions not mentioned (such as, in order to sweep the floor, you need to own a broom).
   c) *[5 points]* Using PDDL, give a likely initial state for a kitchen in need of cleaning and a goal state that represents the ideal, clean kitchen.
   d) *[5 points]* Provide a plan that is a solution to the problem as you have defined it. You do not need to use an algorithm to find the plan, nor do you need to show your work.

3. *[30 points]* Consider the dinner date problem described below. Note, to keep thing simple the state is described using propositions instead of literals:

   Init(garbage $\wedge$ cleanHands $\wedge$ quiet)
   Goal(dinner $\wedge$ present $\wedge$ $\neg$garbage)
   Action(Cook, PRECOND: cleanHands, EFFECT: dinner)
   Action(Wrap, PRECOND, quiet, EFFECT: present)
   Action(Carry, PRECOND: $\varnothing$, EFFECT: $\neg$garbage $\wedge$ $\neg$cleanHands)
   Action(Dolly, PRECOND: $\varnothing$, EFFECT: $\neg$garbage $\wedge$ $\neg$quiet)

   a) *[25 points]* Construct levels S_0, A_0, S_1, A_1 and S_2 of the planning graph. For each level, provide a table that indicates the pairs of literals (or actions) that are mutex, along with a short justification of why they are mutex (e.g., A and B have inconsistent effects on literal F, or A interferes with B on literal F).
   b) *[5 points]* Estimate the cost of the goal using the max-level, level sum and set-level heuristics.

4. *[10 points, 2 points each]* A full joint distribution for the Boolean random variables A, B, and C is specified below. Assume that the true value of a random variable is the corresponding lower case letter (e.g., $P(b)$ means $P(B=true)$)

	b		$\neg b$	
	c	$\neg c$	c	$\neg c$
a	0.01	0.20	0.10	0.25
$\neg a$	0.04	0.05	0.15	0.20

   Use the distribution to compute the following probabilities. Show your work.

   a) $P(\neg \mathrm{b})$
   b) $\mathbf{P}(C)$
   c) $P(\neg a \wedge \neg b)$
   d) $P(c \vee \neg a)$
   e) $P(a \mid b \wedge \neg c)$

5. *[10 points]* After your annual checkup, the doctor has bad news and good news. The bad news is that you tested positive for a serious disease and that the test is 99% accurate (i.e., the probability of testing positive when you do have the disease is 0.99, as is the probability of testing negative when you don't have the disease). The good news is that this is a rare disease, striking only 1 in 10,000 people of your age. Why is it good news that the disease is rare? What are the chances that you actually have the disease?