Homework #5: Chapter 10,13

The following exercises are due at the beginning of class on Tuesday, April 19. 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,ORD) ∧ In(C2,P1) ∧ Plane(P1) ∧ Plane(P2) ∧ Cargo(C1) ∧ Cargo(C2) ∧ Airport(JFK) ∧ Airport(LAX) ∧ Airport(ORD)

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

   a) *[10 points]* Using forward state-space search, draw a search tree to depth 1. Expand the root node, showing 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, you should show all applicable actions, even those that are spurious.
   b) *[10 points]* Now draw the search tree to depth 1, but use backward state-space search. Expand the root node, showing 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.

2. *[25 points]* The monkey-and-bananas problem is faced by a monkey in a laboratory with some bananas hanging out of reach from the ceiling. A box is available that will enable the monkey to reach the bananas if he climbs on it. Assume that your domain predicates are:
   - *At*(*x*,*l*): *x* is at location *l*
   - *Height*(*x*,*h*): *x* has height *h*
   - *Holding*(*x*,*o*): *x* is holding object *o*
   - *On*(*x*,*o*): *x* is on object *o*
   - *Climbable*(*o*): object *o* can be climbed on (such as a box)
   - *Pushable*(*o*): object *o* can be pushed across the floor (such as a box)
   - *Small*(*x*): *x* is small enough to hold in a monkey's hand

   Initially, the *Monkey* is at location *A*, the *Bananas* at *B*, and the *Box* at *C*. The monkey and box have height *Low*, but if the monkey climbs onto the box, he will have height *High*, the same as the bananas. The actions available to the monkey include *Go* from one place to another, *Push* a pushable object from one place to another, *ClimbUp* onto or *ClimbDown* from a box, and *Grasp* or *Ungrasp* a small object. The monkey may only push or climb on a climbable object if it is at the same location as the box. Grasping results in holding the object if the monkey and object are in the same place at the same height.

   a) *[5 points]* Write down the initial state description.
   b) *[15 points]* Write down PDDL-style definitions of the six actions. Be sure your actions schemas have correct parameter lists and that the preconditions and effects capture the semantics of the action as closely as PDDL allows.
   c) *[5 points]* Give a total-order plan that is a solution to the goal *Holding*(*Monkey*,*Bananas*). You do not have to use an algorithm to find this 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 ∧ cleanHands ∧ quiet)
   Goal(dinner ∧ present ∧ ¬garbage)
   Action(Cook, PRECOND: cleanHands, EFFECT: dinner)
   Action(Wrap, PRECOND, quiet, EFFECT: present)
   Action(Carry, PRECOND: ∅, EFFECT: ¬garbage ∧ ¬cleanHands)
   Action(Dolly, PRECOND: ∅, EFFECT: ¬garbage ∧ ¬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. *[15 points, 3 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		*¬b*	
	c	*¬c*	*c*	*¬c*
a	0.01	0.20	0.10	0.25
¬a	0.04	0.05	0.15	0.20

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

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

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?