Homework #4: Chapters 11-13

The following exercises are due at the beginning of class on Wednesday, April 13.

1. *[20 points]* Consider the STRIPS actions defined for the air cargo problem in Figure 11.2 on page 380 of the book, and the problem instance described below:

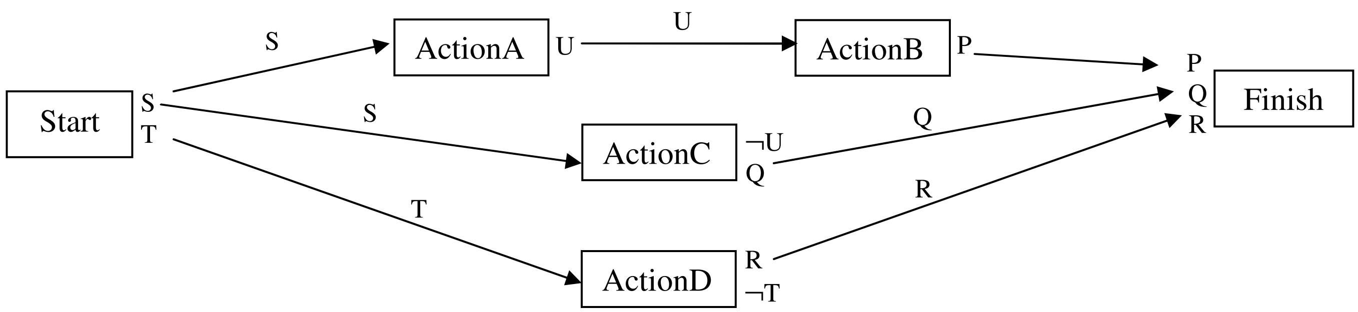
   Initial State: At(P1,LAX) ∧ At(P2,JFK) ∧ At(C1,LAX) ∧ In(C2,P2) ∧ Plane(P1) ∧ Plane(P2) ∧ Cargo(C1) ∧ Cargo(C2)∧ Airport(JFK) ∧ Airport(LAX)
   Goal: At(P1,LAX) ∧ At(P2,LAX) ∧ At(C1,JFK) ∧ In(C2,P1)

   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 not make sense, 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 and consistent with 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 problems 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*
   - *Box*(*o*): object *o* is a box
   - *On*(*x*,*o*): *x* is on object *o*

   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 box from one place to another, *ClimbUp* onto or *ClimbDown* from a box, and *Grasp* or *Ungrasp* an object. The monkey may only push or climb on a box 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 STRIPS-style definitions of the six actions.
   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.

3. *[15 points]* Consider the inconsistent partially ordered plan given on the reverse of this page. Identify the conflicts in this plan and show all ways of resolving them that follow the principle of least commitment. For each solution, draw the new partially ordered plan, and list all of its linearizations.



4. *[15 points]* Consider the following actions, written using the extension to STRIPS that supports disjunctive and conditional effects.
   Action(A, PRECOND: R, EFFECT: $\neg Q \wedge$ (when P:S))
   Action(B, PRECOND: $P \wedge Q$, EFFECT: when R:T)
   Action(C, PRECOND: P, EFFECT: $Q \wedge (\neg P \vee S)$)
   Use an AND-OR graph to show the applicable actions and resulting successor states for the state with description $P \wedge R$. Do not show any actions beyond the immediate successor states.

5. *[10 points]* Why can't conditional planning deal with unbounded indeterminacy, while continuous planning can?

6. *[15 points]* 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	0.10	0.01	0.05	0.20
$\neg a$	0.20	0.04	0.15	0.25

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

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