Homework #5: Chapters 10 and 13

The following exercises are due at the beginning of class on Monday, April 2. Note, this homework is continued on the reverse side of the paper.

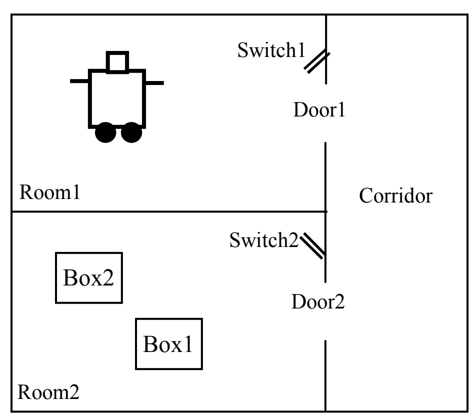
1. *[20 points]* Consider the PDDL actions defined for the air cargo problem in Figure 10.1 on page 369 of the book, and the problem instance described below:

   Initial State: At(P1,SFO) ∧ At(P2,JFK) ∧ At(C1,SFO) ∧ In(C2,P2) ∧ Plane(P1) ∧ Plane(P2) ∧ Cargo(C1) ∧ Cargo(C2) ∧ Airport(JFK) ∧ Airport(SFO) ∧ Airport(ORD)
   Goal: At(P1,SFO) ∧ At(P2,SFO) ∧ 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 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. *[25 points]* Consider the world of Shaky the robot, as described in problem 10.4 on page 397 of the book.

   a) *[15 points]* Using PDDL syntax, define the 6 actions described in the book (Go(x,y,r), Push(b,x,y,r), ClimbUp(x,b), ClimbDown(b,x), TurnOn(s,b), and TurnOff(s,b)). In your action definitions, use only the predicates Box(b) to mean that b is a box, In(x,r) to mean that location x is in room r, At(x,y) to mean that the object x is at location y, ShakyOn(x) to mean that Shaky is on the object x, Switch(s) to mean that s is a switch, and SwitchOn(s) to mean that the switch s is on. Only the constants Shaky and Floor should be used in the action definitions.
   b) *[5 points]* Define the initial state depicted to the right. Use only the constants Box1, Box2, Switch1, Switch2, Floor, Shaky, Room1, Room2, Corridor, L_{Door1}, L_{Door2}, $L_{ShakyStart}$, $L_{Switch1}$, $L_{Box1Start}$, $L_{Box2Start}$, $L_{Switch2}$. Hint: You should have 20 conjuncts in the initial state definition.
   c) *[5 points]* Provide a totally ordered plan for Shaky to turn off Switch2 using the actions defined in part a and the initial state defined in part b. You do not need to use an algorithm to find the plan, nor do you need to show your work.



NOTE: The intended interpretation of the switches drawn is that Switch1 is in the off position and Switch2 is in the on position.

3. *[30 points]* Consider the problem of putting on one's shoes and socks, described as follows:

   Goal(RightShoeOn $\wedge$ LeftShoeOn)
   Init($\varnothing$)
   Action(RightShoe, PRECOND:RightSockOn, EFFECT:RightShoeOn)
   Action(RightSock, PRECOND:$\varnothing$, EFFECT:RightSockOn)
   Action(LeftShoe, PRECOND:LeftSockOn, EFFECT:LeftShoeOn)
   Action(LeftSock, PRECOND:$\varnothing$, EFFECT:LeftSockOn)

   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		$\neg b$	
	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) $P(\neg a)$
   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?