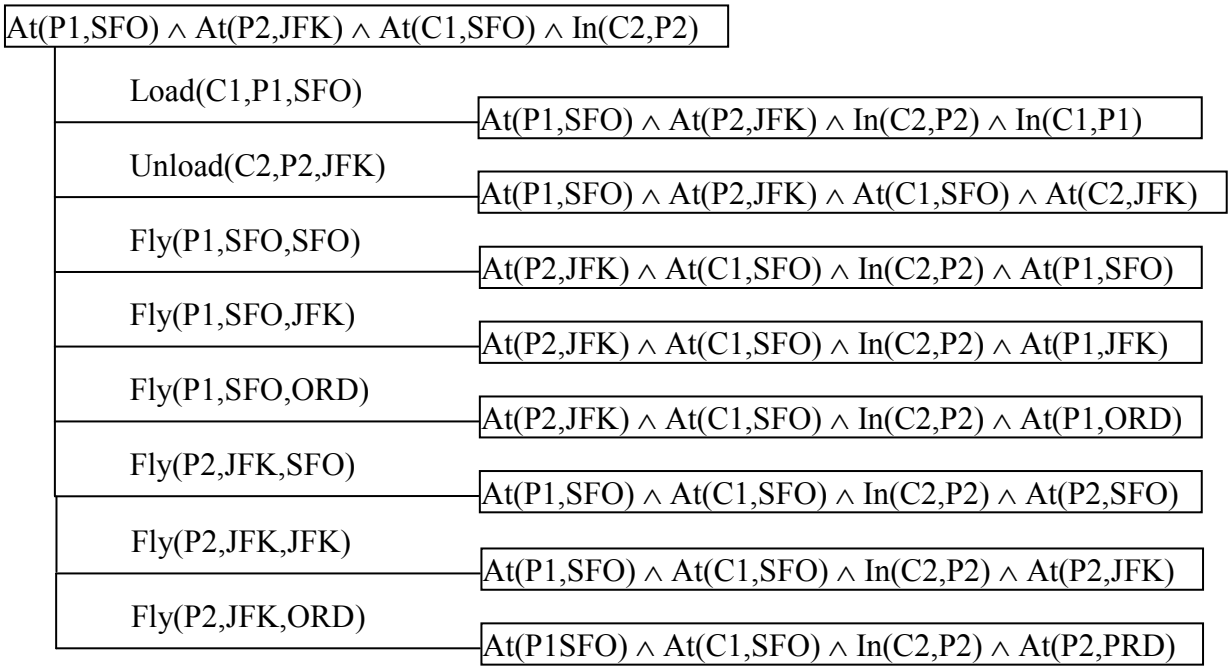
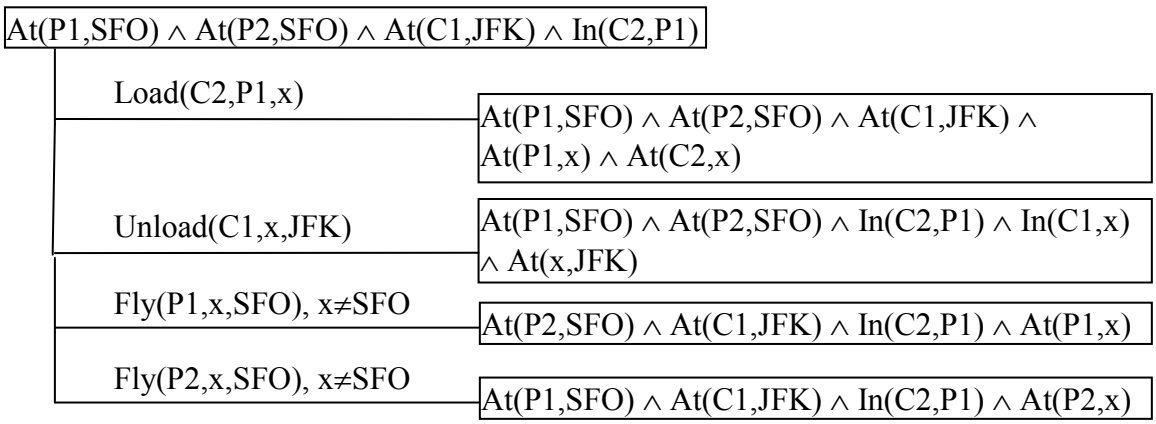
Homework #5: Chapters 11-12

1.

a)



b)



Notes:

- *it is acceptable to use only constants if all possible legal combinations are enumerated. That is, Load(C2,P1,ORD),Load(C2,P1,JFK),Load(C2,P1,SFO), Unload(C1,P1,JFK), Unload(C1,P2,JFK), Fly(P1 ORD,SFO), Fly(P1,JFK,SFO), Fly(P2,JFK,SFO), and Fly(P2,ORD,SFO).*
- *Technically, we can't simply have Load(C2,P2,ORD) or Unload(C1,P1,JFK) because the planner doesn't know that P1/P2 cannot be at JFK/ORD and another airport at the same time.*

2. *There was an error in the problem description. Technically, any variables mentioned in the preconditions must appear in the actions parameter list (as specified on p. 377). Therefore, it should be Go(x,y,r), Push(b,x,y,r), TurnOn(s,x,b) and TurnOff(s,x,b). However, since the error was mine, we will not take points off if the parameter list is missing the extra variable. To indicate a variable that can be optionally included, I put brackets around it, as in "[, v]"*

a)

Action(Go(x, y *[, r]*),
Pre: At(Shakey, x) ∧ In(x, r) ∧ In(y, r) ∧ ShakeyOn(Floor)
Eff: At(Shakey,y) ∧ ¬At(Shakey, x))
Action(Push(b, x, y *[, r]*),
Pre: At(Shakey, x) ∧ At(b, x) ∧ Box(b) ∧ ShakeyOn(Floor) ∧ In(x, r) ∧ In(y, r)
Eff: At(Shakey, y) ∧ At(b, y) ∧ ¬At(Shakey, x) ∧ ¬At(b, x))
Action(ClimbUp(b, x),
Pre: At(Shakey, x) ∧ At(b, x) ∧ Box(b) ∧ ShakeyOn(Floor)
Eff: ¬ShakeyOn(Floor) ∧ ShakeyOn(b))
Action(ClimbDown(b, x),
Pre: ShakeyOn(b) ∧ Box(b) ∧ At(b, x) ∧ At(Shakey, x)
Eff: ¬ShakeyOn(b) ∧ ShakeyOn(Floor))
Action(TurnOn(s, x *[, b]*),
Pre: At(Shakey, x) ∧ At(s, x) ∧ Switch(s) ∧ Box(b) ∧ At(b,x) ∧ ShakeyOn(b)
Eff: SwitchOn(s))
Action(TurnOff(s, x *[, b]*),
Pre: At(Shakey, x) ∧ At(s, x) ∧ Switch(s) ∧ Box(b) ∧ At(b,x) ∧ ShakeyOn(b) ∧ SwitchOn(s)
Eff: ¬SwitchOn(s))

b)

Box(Box1) ∧ Box(Box2) ∧ Switch(Switch1) ∧ Switch(Switch2) ∧
SwitchOn(Switch2) ∧ ShakeyOn(Floor) ∧ In($L_{ShakeyStart}$, Room1) ∧ In(L_{Door1}, Room1) ∧
In(L_{Door1}, Corridor) ∧ In(L_{Door2}, Room2) ∧ In(L_{Door2}, Corridor) ∧ In($L_{Switch1}$, Room1) ∧
In($L_{Box1Start}$, Room2) ∧ In($L_{Box2Start}$, Room2) ∧ In($L_{Switch2}$, Room2) ∧ At(Shakey, $L_{ShakeyStart}$) ∧
At(Box1, $L_{Box1Start}$) ∧ At(Box2, $L_{Box2Start}$) ∧ At(Switch1, $L_{Switch1}$) ∧ At(Switch2, $L_{Switch2}$)

c) *Note, as above, bracket syntax is used to indicate parameters that should be really present, but which are considered optional for the purpose of grading.*

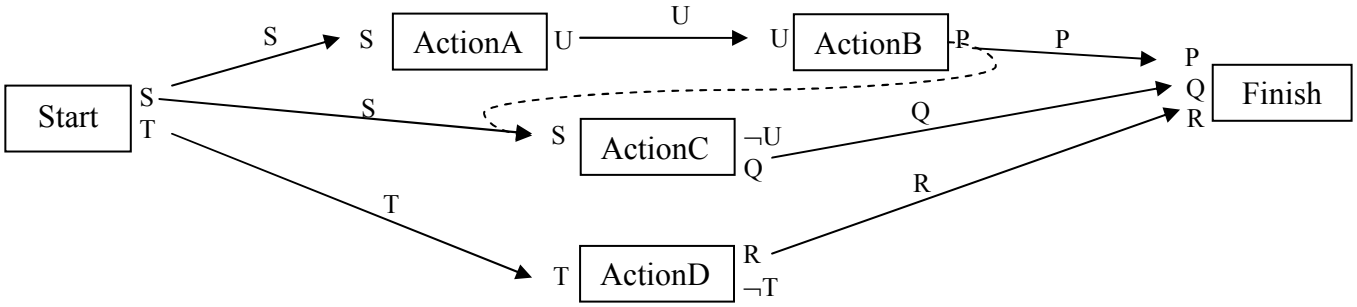
Go($L_{ShakeyStart}$, L_{Door1} *[, Room1]*)
Go(L_{Door1}, L_{Door2} *[, Corridor]*)
Go(L_{Door2}, $L_{Box1Start}$ *[, Room2]*)
Push(Box1, $L_{Box1Start}$, $L_{Switch2}$ *[, Room2]*)
ClimbUp(Box1, $L_{Switch2}$)
TurnOff(Switch2, $L_{Switch2}$ *[,Box1]*)

3.

Conflict:

- ActionC negates U, which is the causal link from ActionA to ActionB.

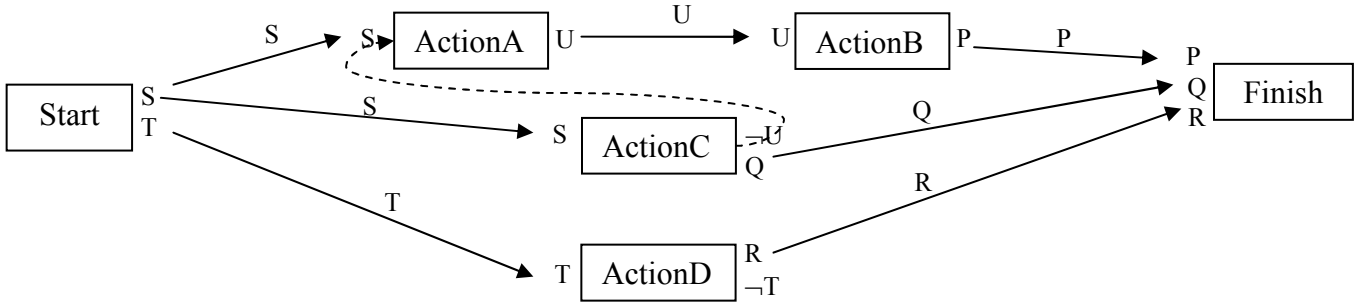
Resolution 1: Add ordering constraint ActionB < ActionC



Linearizations of Resolution 1: (ActionA abbreviated as A, and so on…)

A, B, C, D
A, B, D, C
A, D, B, C
D, A, B, C

Resolution 2: Add ordering constraint ActionC < ActionA



Linearizations of Resolution 2: (ActionA abbreviated as A, and so on…)

C, A, B, D
C, D, A, B
C, A, D, B
D, C, A, B

4. There are many possible answers to this question. The examples from the book and class (which should not be repeated) are:

   Bounded indeterminacy:

   - flipping a coin – it will either come up heads or tails

   Unbounded indeterminacy:

   - driving, economic planning, military strategy (however, a sufficiently detailed example is acceptable, since the book does not go into detail).

   Sample acceptable answers are:

   Bounded indeterminacy:

   - a single die roll – there are 6 possible results (1-6)
   - choice to hit or stay in Black Jack. Although there are 52 cards the player could receive, these can be divided into 11 equivalence classes (ace, digits 2-10, and face cards) in terms of impact on the game.

   Unbounded indeterminacy:

   - a real robot's "turn 90 degrees" action – The robot might turn 89 degrees, or 91 degrees, the motor might fail altogether, the robot might get stuck against an obstacle, it might lose traction on the floor, a person might be blocking it, etc. We could continue to list reasons why the turn was not precise or didn't occur at all.
   - predicting the weather – Although, we could discretize the possible events (e.g., rain, sun, snow, cloud), a good prediction should involve temperature and amount of precipitation as well (which are continuous values). Also, there are many factors (pressure, temperature, moisture conditions at various locations, geographic effects, etc.) that determine the weather, and many of these may be unknown. Note, this is indeterminacy regarding the state of the world, as opposed to the effects of actions.
   - developing a business plan – there are simply too many economic, market and production factors to consider all possible eventualities. Although one can plan for the most likely or most serious contingencies, there will always be unexpected circumstances that must be dealt with when they arise.