CMSC 671 Homework 4

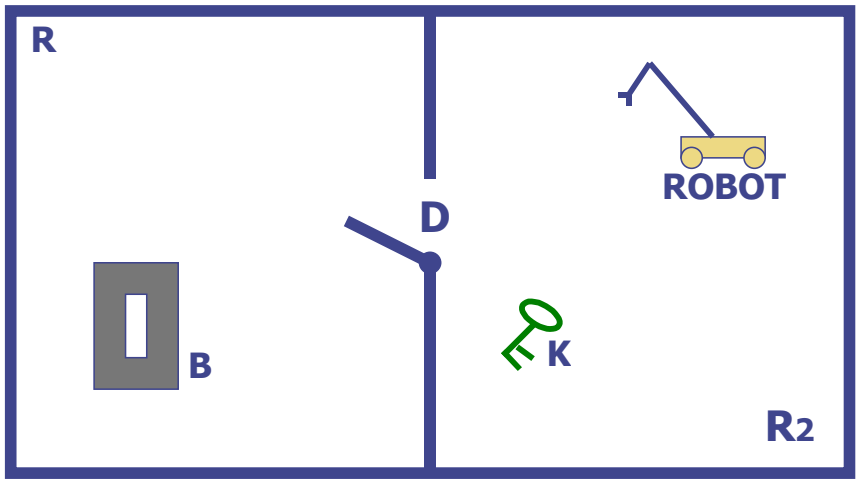
Due Date: Tuesday, November 8, in class

1. **[20 points] STRIPS Planning** Russell & Norvig exercise 11.4.

2. **[20 points] POP**

   A robot ROBOT operates in an environment made of two rooms R1 and R2 connected by a door D. A box B is located in R2 and the door's key is initially in R2. The door can be open or closed (and locked). The figure illustrates the initial state described by:

   IN(ROBOT,R2)
   IN(K,R2)
   OPEN(D)



   The actions are:

   Grasp-Key-In-R2
   Lock-Door
   Go-From-R2-To-R1-With-Key
   Put-Key-In-Box

   defined as follows:

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Grasp-Key-In-R2
P: IN(ROBOT,R2), IN(K,R2)
E: HOLDING(ROBOT,K)

Lock-Door
P: HOLDING(ROBOT,K), OPEN(D)
E: ~OPEN(D), LOCKED(D)

Go-From-R2-To-R1-With-Key
P: IN(ROBOT,R2), HOLDING(ROBOT,K), OPEN(D)
E: ~IN(ROBOT,R2), ~IN(K,R2), IN(ROBOT,R1), IN(K,R1)
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Put-Key-In-Box
P: IN(ROBOT,R1), HOLDING(ROBOT,K)
E: ~HOLDING(ROBOT,K), ~IN(K,R1), IN(K,B)

The goal is:
IN(K,BOX), LOCKED(D)
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Construct a partial-order plan to solve this problem. **Clearly** indicate at each step the modifications made to the plan: the action added, the causal links added and/or the ordering constraints added. Indicate any threats at each step.

3. **[20 points]** **[GraphPlan]** Consider the following (trivial) planning problem. We have a car in London (L) and we wish to drive it to Paris (P). The car has a key that must be in the ignition in order to drive the car. Initially we have the key in our possession, and we wish to have the key at the end of the plan. We have the following grounded operators:

operator	*preconditions*	*add*	*delete*
Drive(P)	*At(Car, L)* *InIgnition(Key)*	*At(Car, P)*	*At(Car, L)*
Drive(L)	*At(Car, P)* *InIgnition(Key)*	*At(Car, L)*	*At(Car, P)*
Insert(Key)	*Have(Key)*	*InIgnition(Key)*	*Have(Key)*
Remove(Key)	*InIgnition(Key)*	*Have(Key)*	*InIgnition(Key)*

The initial state is $At(Car, L) \wedge Have(Key)$ and the goal state is $At(Car, P) \wedge Have(Key)$. Show how GraphPlan would solve this problem. You must show the propositions and actions at every time slice. For each time slice, show the mutual exclusions. For the actions, show which mutual exclusions are implied directly from the definition of the operators, and which were propagated by GraphPlan.

4. **[15 points]** **[Event Probabilities]** Russell & Norvig Exercise 13.5.

5. **[15 points]** **[Marginalizing Over the Joint Distribution]** Russell & Norvig Exercise 13.6.

6. **[10 points]** **[Independence]** Russell & Norvig Exercise 13.14.