CS 188	Introduction to AI	
Fall 1993	Stuart Russell	Midterm 2 Solutions

1. (14 pts.) Situation calculus and STRIPS

(a) (6 pts) The axioms describe a single action $Eat(p, x)$, which results in the object being inside the person doing the eating and no longer being held:

$$\begin{array}{rl} Action: & Eat(p,x) \\ Preconds: & [Edible(x) \wedge Holding(p,x)] \\ AddList: & [Inside(x,p)] \\ DeleteList: & [Holding(p,x)] \end{array}$$

The frame axioms need not be preresented at all in the schema because they are implicitly respected by the planning algorithm using the schema.

(b) (2 pts) No, all the frame axioms are present (assuming that $Inside$ and $Holding$ are the relevant predicates. No frame axiom is needed for $Edible$ because is has no situation argument. Unfortunately this means that something is still edible after it has been eaten.

(c) (6 pts) $barf$ is very much like Eat except that only one predicate ($Inside$) is affected:

$$\begin{array}{l} \forall sxp\ Inside(x,p,s) \Rightarrow \neg Inside(x,p,Result(Barf(p,x),s)) \\ \forall sxyp\ Holding(p,y,s) \wedge y \neq x \Leftrightarrow Holding(p,y,Result(Barf(p,x),s)) \\ \forall sxyp\ Inside(y,p,s) \wedge y \neq x \Rightarrow Inside(y,p,Result(Barf(p,x),s)) \\ \forall sxyp\ \neg Inside(y,p,s) \Rightarrow \neg Inside(y,p,Result(Eat(p,x),s)) \end{array}$$

Note that if we have nonselective $Barf$ing, the delete list would have to be a universal quantification (everything inside is now outside), which would be outside the scope of STRIPS notation.

2. (10 pts.) Nonlinear planning

(a) (2 pts) Only F is unordered, and it has four possible places to go, so there are four linearizations.

(b) (2 pts) A step possibly threatens a causal link if there is some ordering in which the link is clobbered. Both E and F possibly threaten the link.

(c) (2 pts) E is currently ordered betwen B and C, so it necessarily threatens the link.

(d) (2 pts) F can be promoted or demoted, between Start and B or between C and finish.

(e) (2 pts) The status of g is only possibly true, because if F is put between C and Finish it will undo g.

3. (7 pts.) Basic probability

In this question we consider a set of n Boolean random variables $X_1 \ldots X_n$. Suppose that the joint distribution for $X_1 \ldots X_n$ is uniform (all entries identical).

(a) (3 pts) The probability $P(X_1 = True)$ is given by the sum of all entries with $X_1 = True$; similarly for $P(X_1 = False)$. Since there are the same number of entries of each type, we must have $P(X_1 = True) = P(X_1 = False) = 0.5$.

(b) (2 pts) $\mathbf{P}(X_i|X_j) = \mathbf{P}(X_i, X_j)/\mathbf{P}(X_j)$. Since each of the four entries in $\mathbf{P}(X_i, X_j)$ must be equal, by the above argument, we have $\mathbf{P}(X_i|X_j) = 0.25/0.5 = 0.5 = \mathbf{P}(X_j)$; that is, all the variables must be independent of each other.

(c) (2 pts) Since the entries sum to 1, each must be $1/2^n$.

4. (13 pts.) Independence in networks

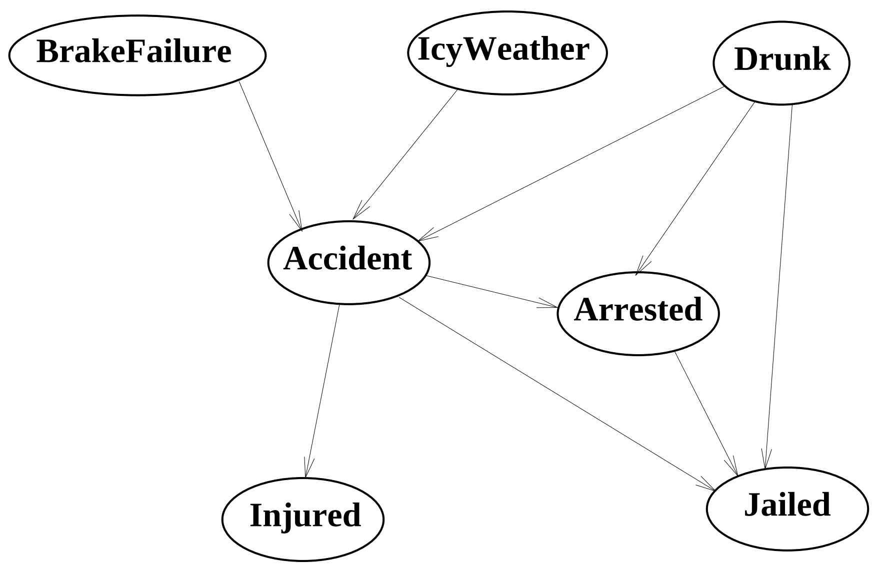
(a) (10 pts)

	i	ii	iii	iv
1. $\mathbf{P}(C\|A,B) = \mathbf{P}(C\|A)$	Y			
2. $\mathbf{P}(C\|A,B) = \mathbf{P}(C\|B)$			Y	
3. $\mathbf{P}(B\|A) = \mathbf{P}(B)$		Y		
4. $\mathbf{P}(B,C\|A) = \mathbf{P}(B\|A)\mathbf{P}(C\|A)$	Y			

(b) (3 pts) True. Even a fully-connected network can have a set of conditional probability tables that represent complete independence (uniform tables), or any other independence relation. The topology itself does not rule out any independence relation.

5. (16 pts.) Belief network design

(a) (8 pts) A good ordering (root causes to final symptoms) might be *Drunk*, *BrakeFailure*, *IcyWeather*, *AccidentSeverity*, *Arrested*, *Injured*, *Jailed*. The topology would look something like this:



(b) (3 pts) See figure

(c) (4 pts) The main things are: *Jailed* is only possible if *Arrested* is true. It is more likely if *Drunk*, and if not *Drunk* then unless *AccidentSeverity* is high the probability of *Jailed* is low or zero. It should increase with *AccidentSeverity* for drunks.

(d) (1 pt) The net is not singly-connected, because of multiple paths from *Drunk* to *Jailed*.