CS188	Intro to AI	
Spring 1993	Stuart Russell	Midterm 2

You have exactly 1 hour. The exam is open-book, open-notes.
You will not necessarily finish all questions, so do your best ones first.
This exam is almost all multiple-choice or true/false. Multiple choice questions may have more than one answer. Give all correct answers. Credit will be assigned so as to render random guessing valueless on average.
Write your answers in blue books. Hand them all in.

60 points total (1 point per minute). Panic not.

1. (12 pts.) Situation calculus and STRIPS

Consider the following five action descriptions, for the domain of manipulating cards (and perhaps other things) on a table (note: stacking A on B is supposed to move all of the other cards above A also, unlike PutOn in the blocks world):

- i) $\forall s c Card(c) \Rightarrow FaceUp(c, Result(s, LookAt(c)))$
- ii) $\forall s c Card(c) \wedge FaceDown(c, s) \Rightarrow FaceUp(c, Result(s, Rotate(c)))$
  $\forall s c Card(c) \wedge FaceUp(c, s) \Rightarrow FaceDown(c, Result(s, Rotate(c)))$
- iii) $\forall s t c Card(c) \wedge Result(UnStack(c), s, t) \Rightarrow OnTable(c, t)$
- iv) $\forall s c d Card(c) \wedge Card(d) \wedge Clear(d, s) \wedge \neg AnywhereAbove(d, c, s) \Rightarrow$
  $On(c, d, Result(s, Stack(c, d)))$
- v) $\forall s c Card(c) \wedge FaceDown(c, s) \Leftrightarrow FaceUp(c, Result(s, Rotate(c)))$

(a) (5 pts) *Multiple choice*: Which are correct (although perhaps not complete) situation calculus descriptions of some action?

(b) (3 pts) *Multiple choice*: Which of ii, iii, and iv would require an additional frame axiom for one of the predicates in the precondition?

(c) (1 pt) *True/false*: *Rotate* can be described by a STRIPS axiom

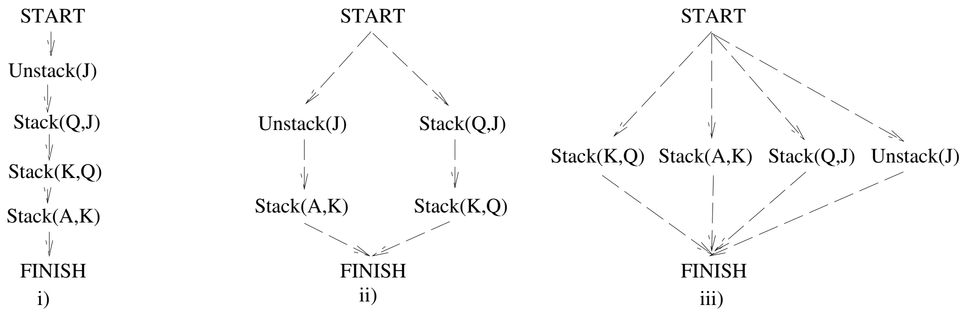
(d) (3 pts) *Multiple choice*: Suppose that in S_0 there are four cards $A\spadesuit$, $K\diamondsuit$, $Q\heartsuit$, $J\clubsuit$ on the table, and we wish to stack them up in that order (ace on top). Which of the following queries will return a plan for this given the above axiom for *Stack* (and any necessary frame axioms)?

i. $On(A\spadesuit, K\diamondsuit) \wedge On(K\diamondsuit, Q\heartsuit) \wedge On(Q\heartsuit, J\clubsuit)$
ii. $Result(s, On(A\spadesuit, K\diamondsuit) \wedge On(K\diamondsuit, Q\heartsuit) \wedge On(Q\heartsuit, J\clubsuit))$
iii. $On(A\spadesuit, K\diamondsuit, s) \wedge On(K\diamondsuit, Q\heartsuit, s) \wedge On(Q\heartsuit, J\clubsuit, s)$

2. (18 pts.) Nonlinear planning

(a) (4 pts) *True/false*: Consider the problem of achieving goals that are conjunctions of $On(x, y)$ conditions in the card domain. The stacking operator in the previous question is less restricted than the standard $PutOn(x, y)$ operator which requires that both x and y be clear. Can we get away with a linear planner for all such goals if we use stacking and unstacking?

Suppose we have an initial state where $J\clubsuit$ is on $A\spadesuit$ and the other cards are on the table. The goal is the same as in question 1. Consider the following three plans for achieving the goal:



(b) (3 pts) *Multiple choice*: Which of the three plans will necessarily achieve the goal?

(c) (3 pts) *Multiple choice*: Which of the three plans will possibly achieve the goal?

(d) (3 pts) *Multiple choice*: Which of the three plans is nonlinear?

(e) (5 pts) (OPEN-ENDED: DO THIS ONE LAST!!): In the above we assumed that the agent knew where each card was so that the stack operation was straightforward. Suppose that some or all of the cards are face down so that a stacking operation cannot necessarily be carried out directly, because the execution component can't see which is which. Discuss how planning can be done to achieve goals under these circumstances.

3. (12 pts.) Basic probability

(a) (6 pts) *Multiple choice*: Suppose we wish to calculate $P(H|E_1, E_2)$, and we have no conditional independence information. Which of the following sets of numbers are sufficient for the calculation? (Assume that $P(X|Y)$ means the conditional probabilities for all possible values of X and Y.)

i. $P(E_1, E_2)$, $P(H)$, $P(E_1|H)$, $P(E_2|H)$

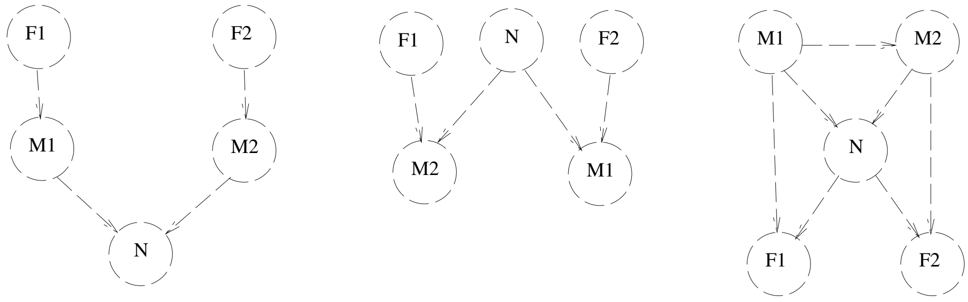
ii. $P(E_1, E_2)$, $P(H)$, $P(E_1, E_2|H)$

iii. $P(H)$, $P(E_1|H)$, $P(E_2|H)$

(b) (6 pts) *Multiple choice*: Suppose we know that $P(E_1|H, E_2) = P(E_1|H)$ for all values of H, E_1, E_2. Now which of the above three sets are sufficient?

4. (18 pts.) Belief networks

Two scientists, in different parts of the world, make measurements M_1 and M_2 of the number of stars N in some small region of the sky, using their telescopes. Normally there is a smallish possibility of error by up to 1 star. Each telescope can also (with a slightly smaller probability) be badly out of focus (events F_1 and F_2) in which case the scientist will undercount by 3 or more stars. Consider the following three networks:



i) ii) iii)

(a) (6 pts) *Multiple choice*: Which of the following belief networks correctly (but not necessarily efficiently) represent the above information?

(b) (3 pts) *Multiple choice*: Which is the best network?

(c) (4 pts) Give a reasonable conditional probability table for the values of $P(M_1|N)$ (for simplicity, consider only the possible values 1,2,3 in this part).

(d) (2 pts) Suppose $M_1 = 1$, $M_3 = 3$. What are the possible numbers of stars?

(e) (3 pts) Of these, which is the most likely number?

5. (0 pts.) Decision theory

(But be honest!) How much would you pay to play Bernoulli's game?