

## CS 188 Midterm

11:15am–12:30pm March 22, 1990

Please try to be precise in your answers. The maximum possible score on this exam is 100 points. Good Luck!

### 1 Resolution Proof [20 pts]

Formulate as predicate-calculus expressions the facts given in the following puzzle. Use the resolution method to prove that Cafe-Stanford is criminal. Remember to convert to Conjunctive Normal Form before starting the proof!

1. It is a crime to sell a bad cappucino.
2. All the beverages that Tom drank were purchased by him from either Cafe-Stanford or Cafe-Berkeley.
3. One of the beverages that Tom drank was a bad cappucino.
4. Tom never bought anything from Cafe-Berkeley.

Use the following predicates: Bad ( $x$ ), Cappucino ( $x$ ), Criminal ( $x$ ), Beverage ( $x$ ), Drank ( $x, y$ ) for “ $x$  drank  $y$ ”, Sells ( $x, y, z$ ) for “ $x$  sells  $y$  to  $z$ ”.

### 2 Clause Form [20 pts]

Transform the *negation* of the following well-formed formula to clause form. Is the ( original ) formula valid?

$$[\exists x(p_1(x) \wedge q_1(x))] \Rightarrow [\exists x(p_1(x)) \wedge \exists x(q_1(x))]$$

### 3 Search [20 pts]

1. A knight on an infinite chessboard must be transferred from an initial position of  $(0, 0)$  to a goal position  $(m, n)$  using the minimum number of legal knight moves. Find an admissible heuristic function  $h$  that you could use to solve the problem using the  $A^*$  algorithm.

2. Suppose that for some search problem for which you want to use  $A^*$  search you have found an evaluation function that never overestimates the cost to a goal state by more than  $K$  units. How can you get a guaranteed optimal solution from  $A^*$  search?

#### 4 Lisp [20 pts]

Define a LISP function ALLSUB ( $u, v$ ) that returns a list of all occurrences of a list of atoms  $u$  as a sublist of another list of atoms  $v$ . The occurrence of a particular sublist is represented by a number  $n$  corresponding to the position in the list  $v$  of the beginning of that occurrence. For example

ALLSUB ('(A A) , '(A A A B A A) ) = (1 2 5)

#### 5 Alpha-Beta Search [20 pts]

Explore the tree using the alpha-beta procedure. Assume that the top level is a maximizing level. Cross out all nodes where static evaluation need not occur. Indicate the winning path or paths.