

**Graduate Comprehensive Exam  
Artificial Intelligence  
Spring 2000**

Answer all questions on the exam; you may use the back for additional space. Total: 100 points. Good Luck.

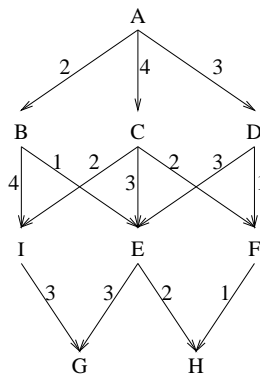
1. (30 pts) Given the following problem:

Consider an arithmetic problem represented in letters, as shown in an example below. Assign a decimal digit to each of the letters in such a way that the sum of the addition is correct. If the same letter occurs more than once, it must be assigned the same digit each time. No two different letters may be assigned the same digit.

$$\begin{array}{r} \text{SEND} \\ + \text{MORE} \\ \hline \text{MONEY} \end{array}$$

- (a) Formulate it as a state-space search problem (representation of a state, start state, goal test, operators, and path cost).
- (b) How many possible states are there? Explain your answer.
- (c) Perform breadth-first search to find a path that reaches the goal. In the interest of time, you may stop if the goal is not reached after two levels (beyond the start state). Show the order of visited states and the solution path if found.

2. (30 pts) Given the following state space:



provide the order of states visited, the path found and the path cost for:

- (a) uniform-cost search (aka branch and bound)
- (b) A\*
- (c) hill climbing (on path cost)

The initial state is A and the goal state is G. The heuristic value for A is 3, B,C,D is 2, I,E,F is 1, H is 10, and G is 0. If a tie occurs, states are visited in alphabetical order.

3. (40 pts) Logical reasoning

(a) Translate the following into predicate calculus:

- i. John likes all kinds of food.
- ii. Apples are food.
- iii. Chairs are not food.
- iv. Anything anyone eats and isn't killed by is food.
- v. Bill eats peanuts and is still alive.
- vi. Sue eats everything Bill eats.
- vii. Bill doesn't like some kind of food.

and prove that John likes peanuts (indicate how the variables are unified).

(b) Convert the following into clause(s):

$$\forall x\{Hate(x, Caesar) \vee \forall Y\exists Z[Hate(y, z) \Rightarrow Thinkcracy(x, y)]\}$$