

Print Your Name: \_\_\_\_\_

**ECS 170 - Intro to Artificial Intelligence (Winter 2003)**

Mid-term Examination (100 points) – February 6, 2003

Time: From 1.40 – 3.00 PM

Open textbook and open notes only

**Give your answers on these sheets. Show your work clearly. Use extra sheets if necessary**

**Problem 1. (15 points) Consider the so-called Cryptarithmic problem shown below.**

```
  S A V E
+ M O R E
-----
  M O N E Y
```

**The problem is to figure out the digits (0 thru 9) that should be assigned to these letters so that the indicated arithmetic operation is valid.**

**Your job is to formulate this as a search problem. Clearly indicate a definition of state, initial state, goal state, operators and define a suitable path cost. Estimate the size of the search tree and draw a small segment of the search tree just to show that you understood the procedure.**

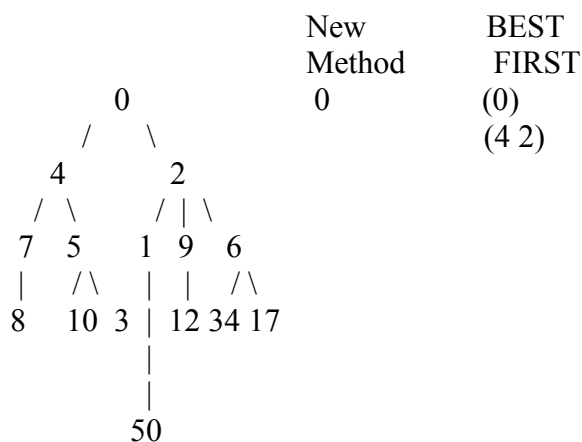
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**Problem 2. (20 points)** The following search tree is given. Your job is to find the maximum number located at one of the leaf nodes of the tree. You are asked to compare a newly discovered heuristic search with the Best First search by actually finding the maximum number using both methods on the given search tree. For each of the methods, your answer should show the list of nodes waiting to be expanded after each step. In each case, what is the answer produced by your search method? What is the correct answer?

First I will describe the new method and next I will help you by re-stating the Best First method, described in your textbook.

**New method:** Follow the path that looks like it's improving the fastest. Keep going as long as the path is improving.

**Best First method:** Continue working from the "best node on the active list so far" as long as its successors are still improving.



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**Problem 3. (25 points)** For each of the following statements below, indicate whether the statement is true or false, and give a brief but precise justification for your answer. Correct answers *with correct justifications* will carry 3 points. No points will be awarded for answers without correct justifications.

Example Question: The time and memory requirements of IDA\* can be improved by using A\* algorithm to do search in individual iterations.

Model Answer: False. Because A\* in the worst case can take as much memory as breadth-first, and thus using A\* in the individual iterations will make IDA\* require exponential memory (instead of linear memory).

A). Breadth-first search is complete if the state space has infinite depth but finite branching factor.

B). Assume that a king can move one square in any of the 8 directions in a chessboard. Manhattan distance is then an admissible heuristic for the problem of moving the king from square A to Square B.

C.) For a uniform tree of depth 10 and branching factor  $b$ , iterative deepening depth-first search will search at most 5 times more nodes than depth-first search, whatever be the value of  $b$ .

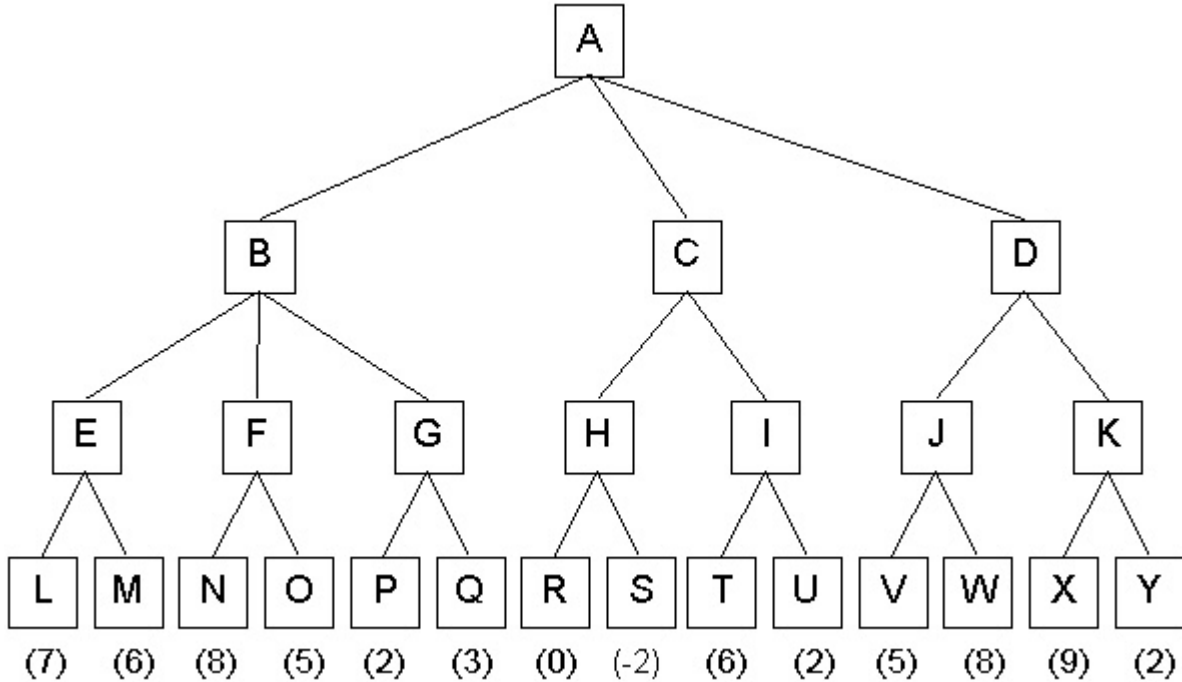
D.) A\* search does  $b^{(d/2)}$  node expansions when searching a uniform tree of branching factor  $b$  and depth  $d$ , using a perfect heuristic.

E.) Consider a uniform search tree of depth  $d$  and branching factor  $b$ , where there are many goal nodes, all of which are uniformly distributed at the leaf level  $d$ . Assuming that memory consumption is not a problem, we are better off using breadth-first search than depth-first search in this scenario.

F.) A\* search with heuristic  $h = 0$  will always have to search the entire tree before finding the optimal solution.

G.) Suppose A\* search uses an evaluation function  $f(n) = (1-w) g(n) + w h(n)$ . For any value of  $w$  between 0 and 1 (inclusive), A\* will terminate and return optimal solution.

H.) If  $h_1$  and  $h_2$  are two admissible heuristics, and  $h_3$  is defined as  $h_3(n) = \max \{h_1(n), h_2(n)\}$ , then A\* search with  $h_3$  is guaranteed to return an optimal solution while expanding as many or fewer nodes than either  $h_1$  or  $h_2$ .



4. (20 points) Consider the game tree shown above in which the static scores are from the first player's point of view.

- Suppose the first player is the maximizing player. What move should be chosen? Justify your answer by showing all work.
- What nodes would not need to be examined using the alpha-beta pruning procedure.

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**5. (20 points) Given the following facts, prove that “Some who are intelligent cannot read.”**

- a. Whoever can read is literate**
- b. Dolphins are not literate**
- c. Some dolphins are intelligent**

**Use the symbols R for Read, L for Literate, D for dolphins and I for intelligent.  
Show clearly all the work.**

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(Blank sheet for your use)