ICS 171 — Final Exam — Spring Quarter, 2000

1. (4 pts) NAME AND EMAIL ADDRESS:________________________________

YOUR ID:________ ID TO RIGHT:________ ROW:______ NO. FROM RIGHT:______

2. (1 pt each, 5 pts total) This is a classic brain-teaser puzzle:

> A man is traveling to market with a fox, a goose, and a bag of oats. He comes to a river. The only way across the river is a boat that can hold the man and exactly one of the fox, goose or bag of oats. The fox will eat the goose if left alone with it, and the goose will eat the oats if left alone with it. How can the man get all his possessions safely across the river?

We will call states where something gets eaten "illegal" and consider them as part of the state space, but from which there is no return; i.e., there is no way to go to any other state (including back to the previous state) from such an illegal state.

One way to represent this problem is as a state vector with components (M,F,G,O) where M=man, F=fox, G=goose, and O=oats are binary variables that are 0 if the man/fox/goose/oats are on the **near** bank, and 1 if on the **far** bank. Note that the boat is always on the same side of the river as the man. Thus the start state is (0,0,0,0).

2.a. What is the goal state (using the (M,F,G,O) notation)? **(1,1,1,1)**

2.b. How many states (both legal and illegal) in this state space? $2^4 = 16$

2.c. What is the maximum branching factor in this state space counting BOTH legal and illegal states as children? **4**

2.d. What is the maximum branching factor in this state space counting ONLY legal states as children? **3**

2.e. List all the legal states that can be reached in one step from the start state.

(1,0,1,0)

3. (10 pts maximum, -1 pt each wrong answer but not negative) Consider a general class of search problems where the cost of going from one state to another is some positive number C and is the same for all operators. There is a single goal state for each problem at some unknown but finite depth d in the search tree. The branching factor is some unknown number b, and is at least 2.

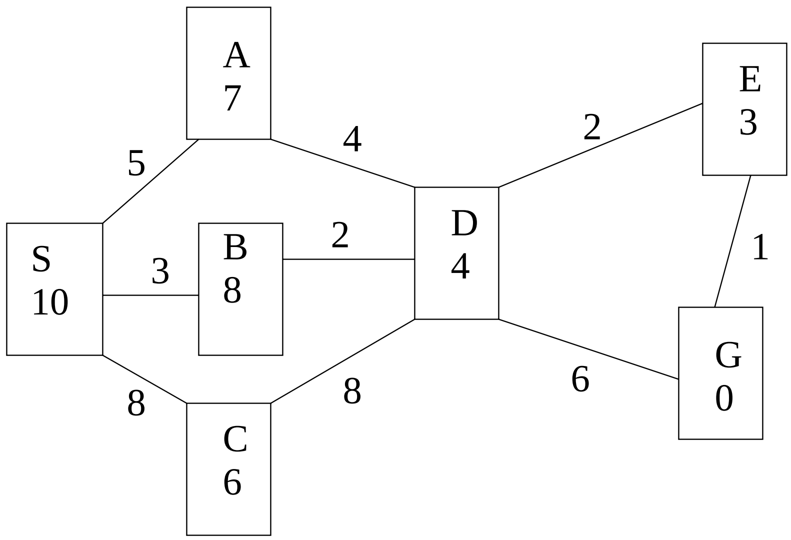
For each of the following algorithms please give its time and space complexity, and indicate whether it is complete or optimal for all problems in this general class. Assume that none of the algorithms does loop-checking of any kind.

Please give the time and space complexity using $\mathcal{O}()$ notation. Please indicate complete or optimal using Y=yes and N=no. Please write neatly; if we cannot read your answer, you will not get credit.

	Time Complexity	Space Complexity	Complete?	Optimal?
Breadth-first	$\mathcal{O}(b^d)$	$\mathcal{O}(b^d)$	Y	Y
Depth-first	$\mathcal{O}(b^d)$	$\mathcal{O}(bd)$	N	N
Uniform Cost	$\mathcal{O}(b^d)$	$\mathcal{O}(b^d)$	Y	Y
Depth-limited (L=limit)	$\mathcal{O}(b^L)$	$\mathcal{O}(bL)$	N	N
Iterated Deepening	$\mathcal{O}(b^d)$	$\mathcal{O}(bd)$	Y	Y

4. (5 pts each, 15 pts total, -1 for each error, but not negative) Problem 4 asks about this graph. Assume that children of a node are returned in alphabetical order whenever the node is expanded. IN THIS PROBLEM, THE PARENT OF A NODE IS *NOT* INCLUDED IN THE RETURNED CHILDREN (I.E., A PARENT-CHECK IS DONE ON THE CHILDREN, AND THE PARENT IS DELETED FROM THE CHILDREN).

"S" is the start node, and "G" is the only goal node. The number inside each node is an estimate of the remaining distance to any goal from that node. The number next to each arc is the operator cost for that arc. The goal node is recognized when the goal node would have been expanded.



Write the order in which nodes are expanded for each type of search.

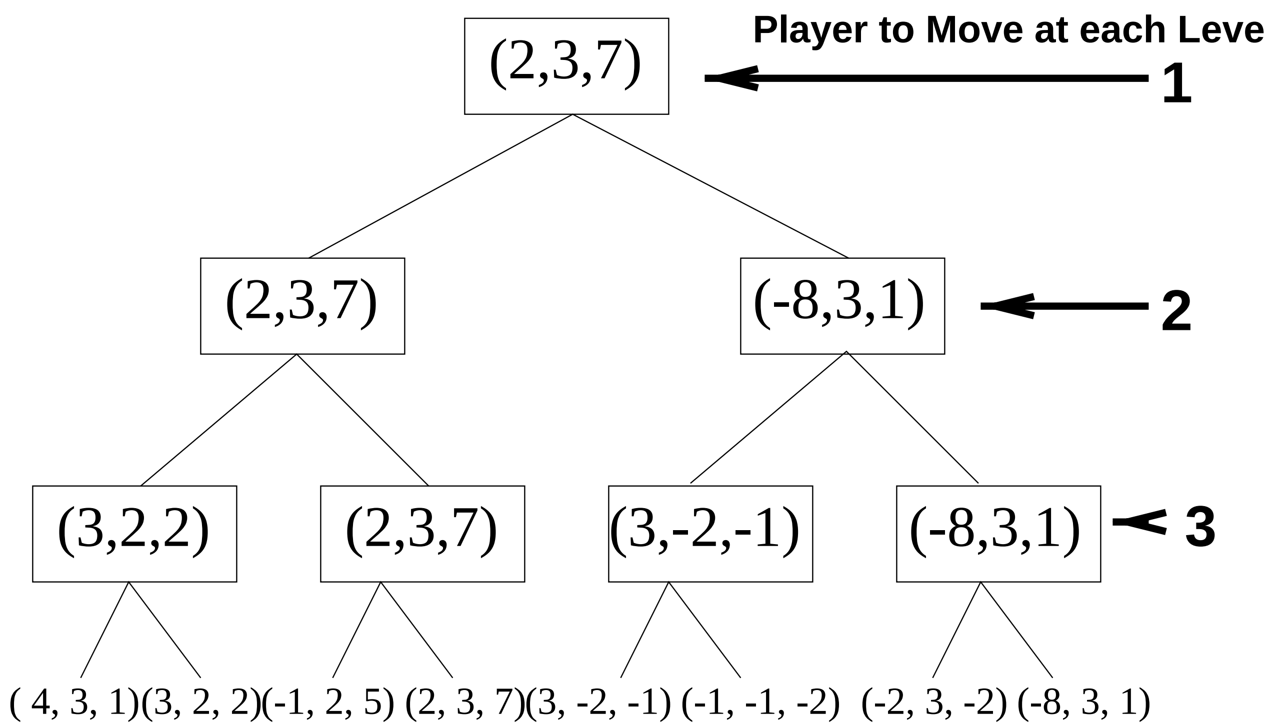
4.a. Best-first (sort by $f(n) = g(n) + h(n)$) **S** **B** **D** **E** **G** ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

4.b. Greedy (sort by $h(n)$) **S** **C** **D** **G** ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

4.c. Iterated Deepening **S** **S** **A** **B** **C** **S** **A** **D** **B** **D** **C** **D** **S** **A** **D** **B** **C** **E** **G**

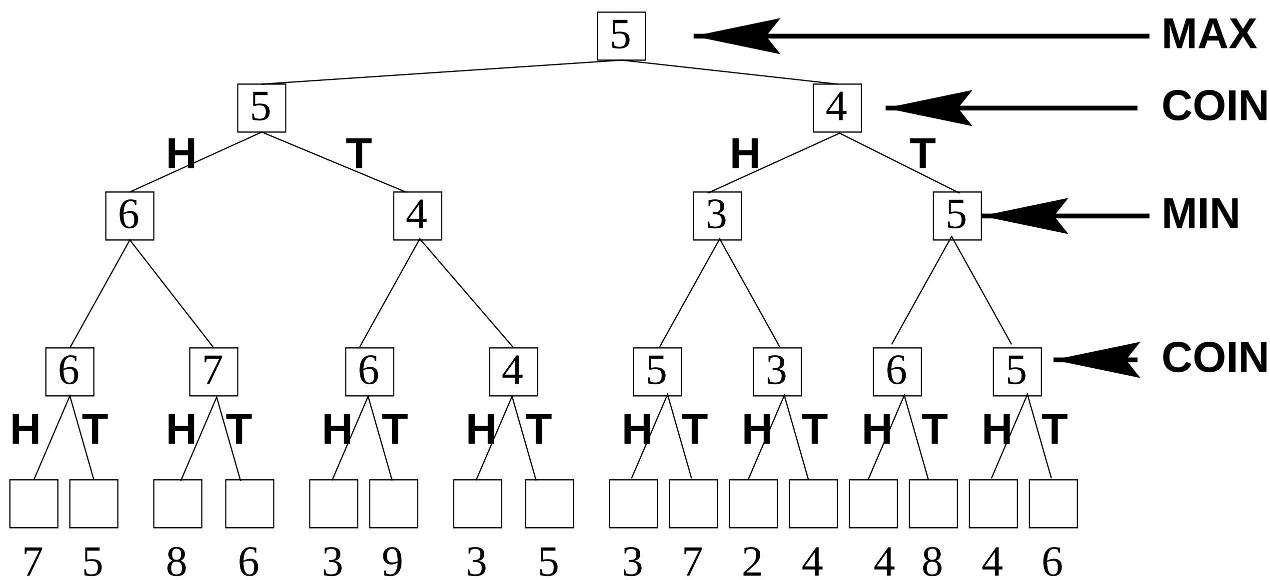
5. (10 pts max, -1 for each error, but not negative) The following problem asks about MINI-MAX search in game trees with THREE PLAYERS. All three players are playing independently trying to win the game. This is just like MINI-MAX, but the evaluation functions are 3-component vectors — the first component is player 1's value, the second component is player 2's value, and the third component is player 3's value. For example, (3,5,7) is worth 3 to player 1, 5 to player 2, and 7 to player 3. Please think carefully about how MINI-MAX will work for a 3-player game before working this problem.

The game tree below illustrates one position reached in the game. It is PLAYER 1's turn to move. Below the leaf nodes are the 3-component vectors of estimated scores of each resulting position returned by the heuristic static evaluator. FILL IN ALL BRANCH NODES WITH THE VALUES PASSED UPWARDS FROM THE LEAF NODES.

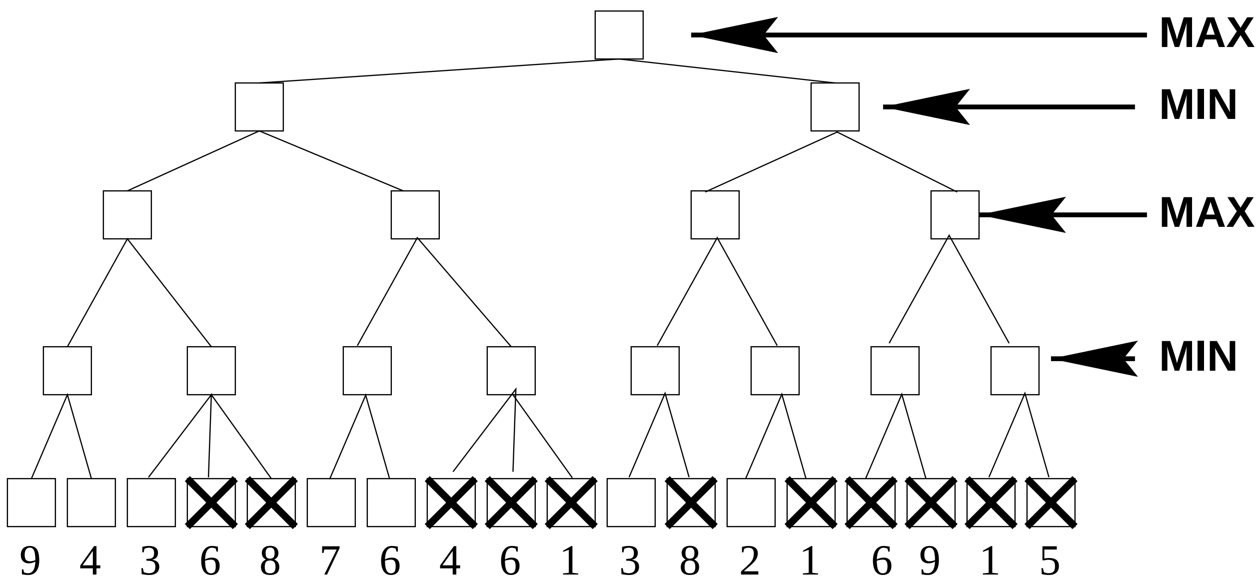


6. (10 pts max, -1 for each error, but not negative) The following problem asks about MINI-MAX search in game trees with chance (also called EXPECTI-MAX search). This is just like MINI-MAX, but there is a coin flip ("COIN") between each player's move. If the coin turns up heads, the path labeled "H" is taken; if it turns up tails, the path labeled "T" is taken. The value passed upward from the COIN level is the probabilistic weighted average (the expected value) of the two paths "H" and "T". Assume a fair coin, i.e., P(H)=P(T)=0.5. Please think carefully about how to pass values upwards from the COIN level before working this problem.

The game tree below illustrates one position reached in the game. It is MAX's turn to move. Below the leaf nodes are the estimated score of each resulting position returned by the heuristic static evaluator. FILL IN ALL BRANCH NODES WITH THE VALUES PASSED UPWARDS FROM THE LEAF NODES.



7. (10 pts max, -1 for each error, but not negative) The following problem asks about alpha-beta pruning in game trees. The game tree below illustrates one position reached in the game. It is MAX's turn to move. Below the leaf nodes are the estimated score of each resulting position returned by the heuristic static evaluator. CROSS OUT EACH LEAF NODE THAT WILL **NOT** BE EXAMINED BECAUSE IT IS PRUNED BY ALPHA-BETA PRUNING.



8. (8 pts total) This question asks about information retrieval of documents from a collection in response to a user query.

8.a. (1 pt each, 5 pts total) The following steps in a "typical IR system" have been scrambled. Please write them in the correct order below.

A. Retrieval B. Feedback C. Query processing
D. Presentation E. Document processing

E **C** **A** **D** **B**

8.b. (1 pt each, 3 pts total) Assume that you have two text documents, D1 and D2, and a text query, Q. Assume that similarity is computed using a simple dot product:
$sim(Q, D) = \sum_{term \in Q} w(term, Q) w(term, D)$

Text document D1 term weights, $w(term, D1)$:
Language(0.1), Java(0.2), Object-Oriented(0.15).

Text document D2 term weights, $w(term, D2)$:
Coffee(0.1), Dining(0.1), Java(0.2)

Text query Q term weights, $w(term, Q)$:
Programming(0.05), Java(0.15), Object-Oriented(0.1)

a. What is $sim(Q, D1)$? **0.045** b. What is $sim(Q, D2)$? **0.03**

c. Which document is selected? **D1**

9. (3 pts each, 18 pts total) Label the following as Y (= yes) or N (= no) depending on whether a perceptron can correctly classify the examples shown. If your answer is Y (= yes), fill in a set of weights that correctly classifies them. Use w_0 as the threshold and w_i as the weight for input x_i. *NOTE: Other weights are OK iff function is correct.* ALL PERCEPTRONS HAVE THREE EXTERNAL INPUTS, x_1, x_2, and x_3.

ANSWERS TO ALL PARTS OF A QUESTION MUST BE CORRECT TO GET CREDIT.

9.a. "At least two inputs are 1."
Correctly classifiable? **Y** If yes, weights are $w_0 =$ **-1.5** ; $w_1 =$ **1** ; $w_2 =$ **1** ; $w_3 =$ **1**

9.b. "Exactly two inputs are 1."
Correctly classifiable? **N** If yes, weights are $w_0 =$ ____ ; $w_1 =$ ____ ; $w_2 =$ ____ ; $w_3 =$ ____

9.c. "At most two inputs are 1."
Correctly classifiable? **Y** If yes, weights are $w_0 =$ **2.5** ; $w_1 =$ **-1** ; $w_2 =$ **-1** ; $w_3 =$ **-1**

9.d. "Input $x_1 = 1$, input $x_2 = 0$, input $x_3 =$anything."
Correctly classifiable? **Y** If yes, weights are $w_0 =$ **-0.5** ; $w_1 =$ **1** ; $w_2 =$ **-1** ; $w_3 =$ **0**

9.e. "IF input $x_1 = 1$ THEN input $x_2 = 0$ ELSE input $x_2 = 1$."
Correctly classifiable? **N** If yes, weights are $w_0 =$ ____ ; $w_1 =$ ____ ; $w_2 =$ ____ ; $w_3 =$ ____

9.f. "Input $x_1 =$ input x_2."
Correctly classifiable? **N** If yes, weights are $w_0 =$ ____ ; $w_1 =$ ____ ; $w_2 =$ ____ ; $w_3 =$ ____

10. (10 pts total) Suppose you are given the following data about soy bean plant diseases:

LEAF	INSECTS	CLASS
moldy	none	healthy
wrinkled	none	healthy
green	none	healthy
moldy	present	diseased
wrinkled	present	diseased
green	present	healthy

10.a. (4 pts) Which choice of root node minimizes the disorder of the children that result from that choice? (L=LEAF, I=INSECTS) **I**

10.b. (6 pts) Using the root node that you chose in 11.a., draw a decision tree that correctly predicts "play outdoors".