Artificial Intelligence - Midterm Examination

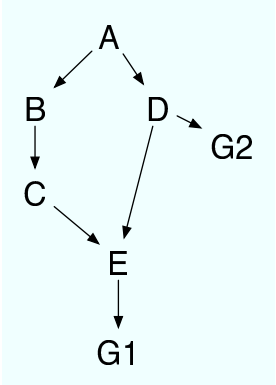
Fall 2006

NAME:
STUDENT ID:

Please answer the questions in the space provided.

1. **Search**

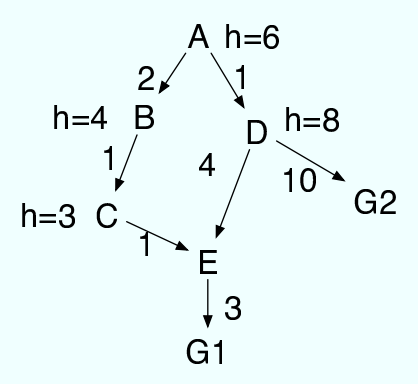
   (a) [5 points] Consider the graph in the figure below, where A is the start state and G1 and G2 are goal states.



   Suppose you are performing breadth-first search on this graph, with the ordering of nodes being left to right (if necessary). The search stops when the first goal state is found. Draw the search tree that you obtain in this case.

(b) [5 points] For the same problem, draw the search tree obtained by depth-first search

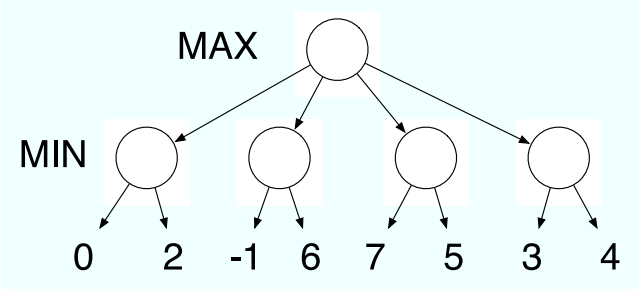
(c) [5 points] Consider the graph below where now we have costs and heuristic values filled in. Is the heuristic below admissible or not? Justify your answer in one sentence. If your answer is no, make a *minimal change* to the heuristic so that it becomes admissible.



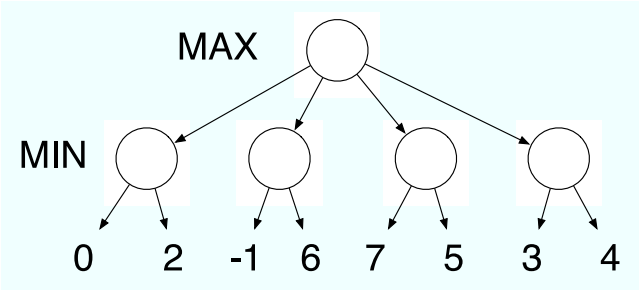
(d) [5 points] Taking into account your previous answer, provide a trace of A^* on this problem.

2. **Game tree search**

(a) [5 points] For the game tree below, write in the circles the values of the respective choices as determined by the minimax algorithm. Mark on the tree the best move for MAX.



(b) [5 points] For the same game tree (depicted again below), shade the nodes that would NOT be expanded by the $\alpha - \beta$ algorithm. Mark again on the tree the best move for MAX. Note that you are not required to trace how the values of α and β change for different nodes as the algorithm runs.



3. **Problem formulation**

You have been hired by a scientific computing center to help them manage the requests they get. Presently, m scientists have each submitted a list of n computations that they would like to complete. The center has 3 machines: a parallel supercomputer, a quantum computer and a cluster of regular computers. Each scientist submits, with each job, a list of the computers that would be suitable to execute it. There are $m \leq k < mn$ days on which to perform computations before the center closes for Christmas. To be fair, at least one computation from each scientist's list has to be performed. Each computation takes exactly one day. Each computer can only do one computation on any given day.

(a) [10 points] Describe this as a constraint satisfaction problem. Clearly specify what are the variables, the domains of the variables and the constraints.

(b) [4 points] Your manager also wants to minimize the total time in which the machines are idle (keeping all the same constraints as above). What kind of problem do you have? Specify one suitable solution method and motivate your choice in one sentence.

4. **Short questions**

(a) [4 points] Alice and Bob are both taking the AI class, and for their first assignment they had to implement breadth-first search. They are both convinced that they have no bugs in the code at all, yet when they run their code on the same problem, their implementations expand different numbers of nodes. Is this possible? Justify your answer.

(b) [4 points] You are given a search problem with a very large branching factor, but where the goal can always be found with a relatively short sequence of actions (whose exact length is unknown). All the actions have the same cost. What search algorithm would you use to find the optimal solution? Justify your answer.

(c) [4 points] You are given a search problem with a very large branching factor, but where the goal can always be found with a relatively short sequence of actions (whose exact length is unknown). The actions have very different costs. What search algorithm would you use to find the optimal solution? Justify your answer.

(d) [4 points]

A search algorithm performs best-first search with the function:

$$f(n) = (c - w)g(n) + wh(n)$$

where $g(n)$ is the cost so far, $h(n)$ is a heuristic function, and c and w are constants. Is there any value of w which guarantees the solution to be optimal?

5. **Logic**

(a) [14 points] Translate the following sentences in first-order logic.

i. [2 points] Star Trek, Star Wars and The Matrix are science fiction movies.

ii. [2 points] Every AI student loves Star Trek or Star Wars.

iii. [2 points] Some AI students do not love Star Trek.

iv. [2 points] All AI students who love Star Trek also love The Matrix.

v. [2 points] Every AI student loves some science fiction movie.

vi. [2 points] No science fiction movie is loved by all AI students.

vii. [2 points] There is an AI student who loves all science fiction movies.

(b) [6 points] Based on the knowledge base above, prove formally that there exists some AI student who loves Star Wars.

6. **Unification**

For all the following sentences, specify whether they unify or not. If yes, give the appropriate substitution.

(a) [2 points] $P(x, y)$ and $P(A, F(A))$

(b) [2 points] $P(x, A)$ an $P(A, F(x))$

(c) [2 points] $P(x, A)$ and $P(F(y), y)$

7. **STRIPS**

(a) [8 points] You can make a pizza if you have tomato sauce, cheese and dough. Making a small pizza requires 1 unit of each. Making a large pizza requires two units of each. Describe this domain in STRIPS, i.e. specify the operators, with their preconditions and postconditions.

(b) [3 points] You currently have 1 tomato sauce can, 1 cheese bag and 1 dough pack. Give a plan that would get you a pizza of some sort. Give the initial state, goal state and plan.

(c) [3 points] Suppose that you would like to state the goal that you want a large or a small pizza. Can you do this in STRIPS? If yes, give the goal state. If no, justify why not.