CS 540-1: Introduction to Artificial Intelligence

Exam 1: 7:15-9:15pm, October 11, 1995

CLOSED BOOK

(one page of notes allowed)

Write your answers on these pages and show your work. If you feel that a question is not fully specified, state any assumptions you need to make in order to solve the problem. You may use the backs of these sheets for scratch work.

Write your name on this and all other pages of this exam. Make sure your exam contains six problems on seven pages.

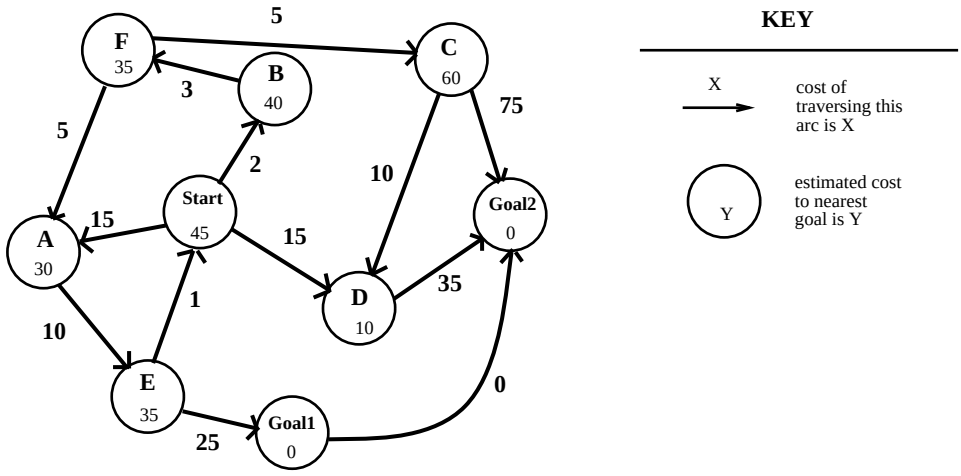
Name _____

Student ID _____

Problem	**Score**	**Max Score**
1	_____	25
2	_____	20
3	_____	7
4	_____	15
5	_____	18
6	_____	15
Total	_____	100

PROBLEM 1 - Basic Search Strategies (25 points)

Consider the state-space graph drawn below; the start and goal states are labeled. *Note that arcs are directed.* For each of the search strategies listed below, indicate which goal state is reached (if any) and list, in order, the states expanded. (A state is *expanded* when it is *removed* from the OPEN list.) Assume that all search strategies use an OPEN and a CLOSED list, and that best-first search checks for shorter paths to nodes. *When all else is equal, nodes should be expanded in alphabetical order.*



Breadth-First Search

Goal state reached: _____ States expanded: _____

Iterative Deepening

Goal state reached: _____ States expanded: _____

Uniform-Cost Search (implemented as best-first search with $f=g$)

Goal state reached: _____ States expanded: _____

Best-First Search (using $f=g+h$)

Goal state reached: _____ States expanded: _____

Hill Climbing (using the h function only)

Goal state reached: _____ States expanded: _____

PROBLEM 2 - Heuristic Functions (20 points)

Part A. When using the cost function specified in HW2 for agent moves, ‘‘straight-line’’ (Euclidean) distance to the nearest goal is an *admissible h* function.

Would this *h* function still be *admissible* if diagonal moves (i.e., NE, SE, SW, and NW) cost 10 times as much as non-diagonal moves (i.e., N, E, S, W)? Briefly explain your answer.

Would *h* still be admissible if diagonal moves cost *the same* as non-diagonal ones? Again, briefly explain your answer.

Part B. Assume you are given three *admissible h* functions for a given search problem; for simplicity, call them *h1*, *h2*, and *h3*.

For each of the following combinations, explain whether or not the resulting *h* function is admissible.

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i) $h(n) = h1(n) + h2(n) + h3(n)$ admissible? _____

---

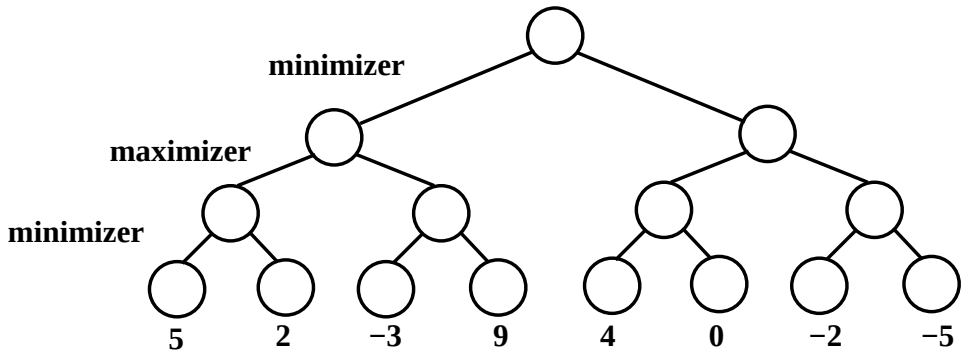
ii) $h(n) = \frac{h1(n) + h2(n) + h3(n)}{3}$ admissible? _____

Part B. (continued)

Propose and justify a combination of *h1*, *h2*, and *h3* that, when used by A* as its *h* function, is guaranteed to lead to the expansion of no more nodes than the smallest number expanded by A* if it *individually* used each of *h1*, *h2*, and *h3*.

PROBLEM 3 - Game Playing (7 points)

Apply the *minimax* algorithm to the game tree below, where it is the *minimizer's* turn to play. Report the estimated values of the intermediate nodes and indicate the proper move of the minimizer.



Indicate, by crossing out, *one* (1) unnecessary call to the static board evaluator. Explain why this call to the board evaluator is unnecessary.

PROBLEM 4 - Propositional Logic (15 points)

Part A. Use a *truth table* to show the following sentence in propositional logic is *valid*.

$$[\ (P \Rightarrow Q) \wedge (P \Rightarrow R)\ ] \Leftrightarrow [\ P \Rightarrow (Q \wedge R)\ ]$$

Part B. Let the following propositional symbols have the following meaning:

A	John was in a car accident.
S	John is sick.
I	John is injured.
D	John needs to see a doctor.

Express each of the following English sentences in propositional logic.

John was in a car accident, but he isn't injured.

John needs to see a doctor if he is sick or injured.

If John wasn't in an accident and isn't sick, then he doesn't need a doctor.

PROBLEM 5 - Miscellaneous Short Answers (18 points)

You are not required to explain your answers to the questions below, but briefly doing so may lead to partial credit.

A. Two *admissible* searches are _____ and _____ .

B. Three searches that may never find a solution, even when one exists, are _____ , _____ , and _____ .

C. A given heuristic function always returns a larger positive value for a particular node than it does for the parent of that node. This heuristic function is (i) admissible, (ii) not admissible, (iii) there is insufficient information to tell whether or not it is admissible: _____

D. An admissible *h* function will never cause *A** to expand more nodes than the number expanded by uniform-cost search (true or false): _____

E. *Iterative deepening* will always find the same solution as *depth-first search* (true or false): _____

F. *Alpha-beta pruning* will often produce better game-playing moves than the simpler *minimax algorithm* (true or false): _____

G. The sentence $(P \wedge Q) \Rightarrow \neg Q$ is syntactically correct in the propositional logic (true or false): _____

H. What will Common Lisp return when the following s-expression is typed to it:

```
(list (cons '(1) '(2)) (first (rest '(1 2 3))))? _____
```

PROBLEM 6 - Common Lisp (15 points)

Part A. Consider the following recursive function definition. It is supposed to replace all the numbers, located anywhere in an s-expression, with the atom XXX. However, it is buggy.

```
(defun X-out-numbers (sexpr)

  "Replace all numbers in this sexpr with the atom XXX."

  (if (numberp sexpr)

      'XXX

    (list

       (if (numberp (first sexpr))

           XXX

         (first sexpr))

       (X-out-numbers (rest sexpr))

    )))
```

Describe below the errors in this function, and write a correct version of the function to the *right* of the code above (you need not rewrite the first two lines).

Part B. Assume the following is typed to a newly started LISP:

```
(setf a '(* 1 3 9))
(setf b '(+ 3 (first (rest a))))
```

What does each of the following return (write ‘‘error’’ if an error condition develops):

i) `b`
returned value =

ii) `(first (rest a))`
returned value =

iii) `(cons 'a a)`
returned value =

(the end)