CS320 (H) Midterm Exam (3/1/02, Friday)

Last name: _____, First name: _____, ID: _____

Time: **12:40pm–1:30pm (50 minutes** + α), Total Points: **100**

Subject	Score
LISP	/3
AI General	/12
Search	/35
Game Playing	/20
Propositional Logic	/30
Total	/100

- You may use the back of the sheet, but please **prominently mark** on the front in such a case.

- Be as succinct as possible.

- Read the questions carefully to see what kind of answer is expected (*explain blah* **in terms of ...** *blah*).

- Solve all problems.

- Total of 10 pages, including this cover and the blank page at the end. **Before starting, count the pages and see if you have all ten.**

- This is a closed-book, closed-note exam.

1   LISP (Total: 3 points)

Write a **recursive** LISP function that calculates the factorial of an integer ($n \geq 1$). The function should take a single integer as an argument. The factorial of an integer $n \geq 1$ is defined as:

$$
\begin{aligned}
factorial(1) &= 1 \\
factorial(k) &= k \times factorial(k-1)
\end{aligned}
$$

For example, (`factorial 5`) should return 120. (**3 points**)

2 AI General (Total: 12 points)

2.1 AI and related fields (6 points)

There are several academic disciplines with close ties to AI. From these fields of studies, list two fields and explain how each relate to AI: (1) how they can help advance AI and (2) how AI can help advance them. (**6 points**)

2.2 Turing test and Strong and Weak AI (6 points)

The Turing test proposed by Alan Turing (1950) was designed to provide a satisfactory operational definition of intelligence. In this test, the computer is interrogated by a human via a teletype, and passes the test if the interrogator cannot tell if there is a computer or a human at the other end.

Explain what (1) strong AI and (2) weak AI are (one sentence each), and identify which of these two claims can the Turing test be used to verify (i.e. whether the computer has strong AI or not, or whether it has weak AI or not). (**6 points**)

Hint: think in terms of intelligence and/or consciousness.

3 Search (Total: 35 points)

3.1 Breadth first and depth first search (10 points)

Compare and contrast breadth first and depth first search in terms of the following criteria, given the average branching factor b and max depth of goal m. Complexity is for the worst-case.

	Breadth First Search	Depth First Search
space complexity	O( )	O( )
time complexity	O( )	O( )
complete?	(Y , N) Circle one	(Y , N) Circle one
optimal?	(Y , N) Circle one	(Y , N) Circle one
scenario when the strategy works well	When is this strategy better than the other?	When is this strategy better than the other?

3.2 Iterative Deepening A^* (IDA^*) search (10 points)

(1) Describe A^* search in terms of the utility function (or evaluation function used; explain in detail), and how the node list is operated (new node pushed or enqueued? list is sorted or not?). What advantage does A^* have over regular Breadth First Search?(**5 points**)

(2) Define f-contour in IDA^*. How do Iterative Deepening Search and IDA^* search differ in terms of the different bounds that are used? What advantage does IDA^* have over regular A^*? Answer all three questions. (**5 points**)

3.3 Simulated annealing (10 points)

In simulated annealing, to minimize the energy E, the following strategy is used. Suppose a move caused the energy to change by ΔE:

- if $\Delta E \leq 0$, the move is accepted.

- if $\Delta E > 0$, the move is accepted with probability
  $P(\Delta E) = e^{-\frac{\Delta E}{kT}}$, where k is a constant and T is temperature.

(1) Explain what kind of problem in greedy search can Simulated Annealing overcome (pick one that is the most appropriate), and explain why it can overcome the difficulty. (**6 points**)

(2) Circle one within each pair of parentheses below that makes the sentence true (**4 points**, 2 points each).

- It is more probable for a move to be accepted when $\Delta E > 0$, if T is (Higher, Lower). *Circle one*

- It is more probable for a move to be accepted when $\Delta E > 0$, if ΔE is (Higher, Lower). *Circle one*

4 Game Playing (Total: 20 points)

Consider a MIN-MAX game tree (the two below are the same).
(1) Fill in the utility function values at each node (the blank squares) in the MIN-MAX tree below, and mark the path from the root node (initial state) to the goal node with a thick line (**10 points**).
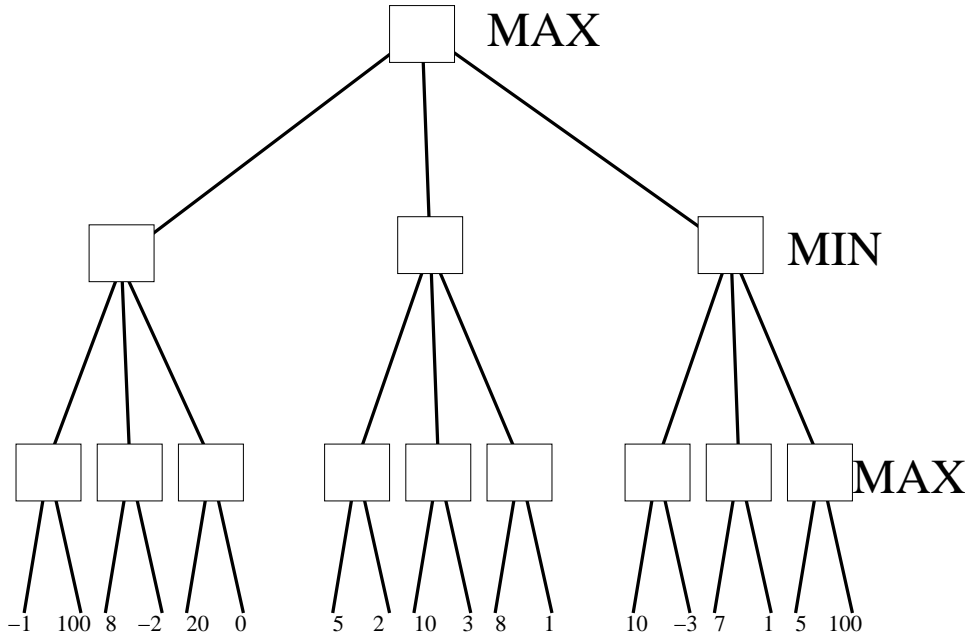
(2) **(2.1)** Cross out the branches that are pruned by α-β pruning. **(2.2)** How many nodes did you **not** have to visit with α-β pruning when compared to the full MIN-MAX search above (count the leaf nodes as well)? Show all intermediate values at each node as they get updated. (**10 points**).
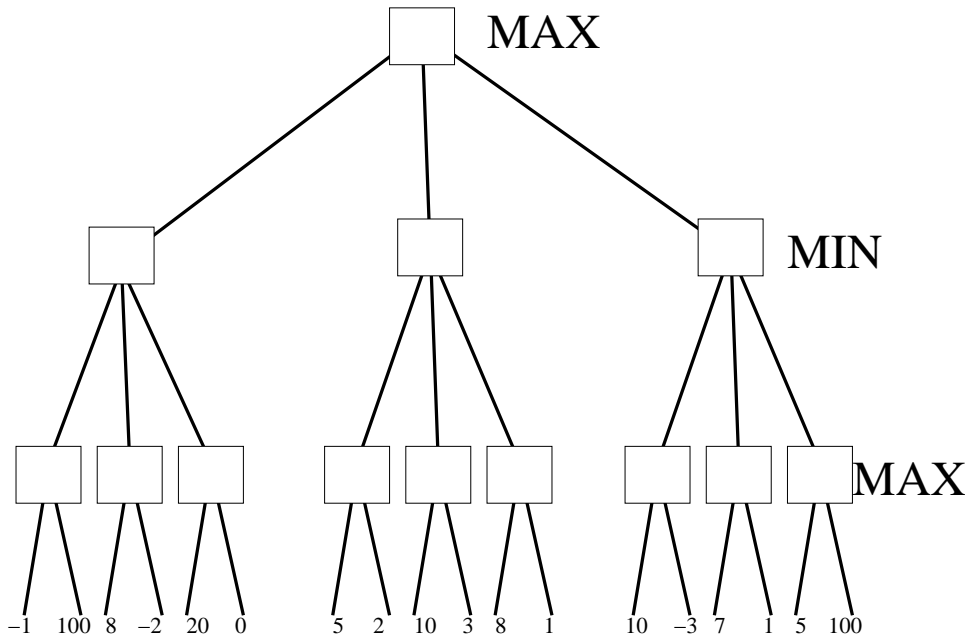
5 Propositional Logic (Total: 30 points)

Given two sentences:

1. Tom cannot be a good student unless <u>he is smart and his father supports him</u>.

2. Tom is a good student only if his father supports him.

Using **resolution**, prove that sentence 2 is a logical consequence of sentence 1. Follow the steps below to accomplish this.

(1) Convert the two natural language sentences into Propositional Logic formulas (**5 points**)

Hint One: G: good student, S: smart, F: father supports.
Hint Two: "A only if B" = "B is a necessary condition of A". **Use connectives:** $\neg, \vee, \wedge, \rightarrow$. Parenthesize all except $\neg$ to disambiguate.

1. _____

2. _____

(2) Modify the two formulas in step (1) so that **resolution** can be used, and then convert the resulting formulas into Conjunctive Normal Form. Recall what we had to do to make a problem a resolution problem when we had $F_1 \wedge ... \wedge F_n$ and G and we wanted to show $F_1 \wedge ... \wedge F_n \rightarrow G$. The result should be a list of clauses that are numbered accordingly. Show all your work. (**10 points**)

More questions on the next page

(3) Use resolution to derive **F**, thus proving that sentence 2 is a logical consequence of sentence 1. Show all your work. As you resolve two clauses, write the parent clause numbers, and number the new clause appropriately for future reference. Show all your work. (**10 points**)

Hint: If you cannot derive **F**, there is something wrong with your English to Propositional Logic translation. Go back to step (1).

(4) Briefly explain (i.e. in one sentence) why resolution works, or in other words, what is the proof technique used in resolution. (**5 points**)

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