CPSC420-502 Midterm Exam (10/16/2003, Thu)[1]

Last name: ________________, First name: ________________, ID (last 5 digit): ______________

Time: **9:35am–10:50am (75 minutes + α)**, Total Points: **100**

Subject	Score
AI General	/10
Search	/40
Game Playing	/25
Propositional Logic	/25
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 11 pages, including this cover and the Appendix at the end. **Before starting, count the pages and see if you have all 11.**
- This is a closed-book, closed-note exam.
- You may rip off the last page (Appendix) to view it while solving the logic problems.

[1] Instructor: Yoonsuck Choe.

1 AI, in General

Question 1 (4 pts): Among many different academic disciplines related to AI, list **two** that **you think** are most important, and briefly explain why.

Question 2 (6 pts): What are the strengths and weaknesses of the Turing test as a test for intelligence? Briefly provide one example for each.

2 Search

Question 3 (4 pts): What role does the queueing function play in a general search algorithm? Explain in terms of the resulting search behavior when the queueing function was altered.

Question 4 (5 pts): Explain why *Iterative Deepening Depth-First Search* can be better than both Breadth-First Search and also Depth-First Search? Explain in terms of the four evaluation criteria (completeness, optimality, space complexity, and time complexity).

Question 5 (6 pts): When you compare the Greedy search and the A^* search algorithm, (1) which feature of the *queueing operation* (i.e., insertion of nodes into the node list) is common in both, and (2) what is different in the two? (3) Why is A^* superior to Greedy search? Explain in terms of the four evaluation criteria.

Question 6 (6 pts): Iterative Deepening A^* is superior to A^* in one crucial way, but it can be disadvantageous in another. Identify what are these two, in terms of the four evaluation criteria, and explain why by contrasting to Depth-First search and Breadth-First search.

Question 7 (5 pts): Explain what a dominant heuristic is and explain why a dominant heuristic is better when used in A^*. Discuss in terms of the concept of f-contours and the number of nodes expanded.

Question 8 (4 pts): What is the major difference between uninformed and informed search methods?

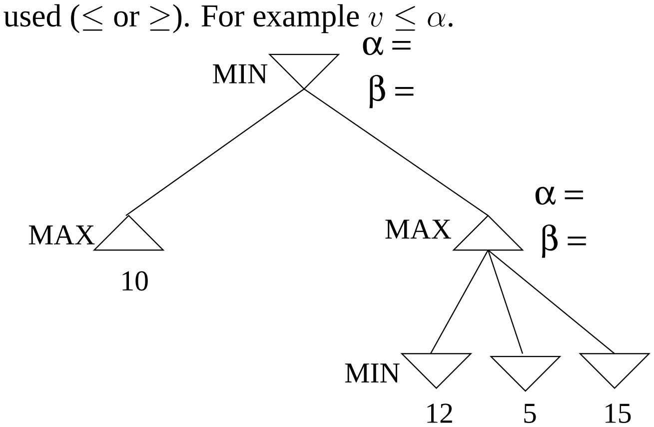
Question 9 (5 pts): Hill-climbing is a local search method without any memory. (1) Explain how hill-climbing differs from Greedy search, and (2) explain what is the major drawback of the hill-climbing method.

Question 10 (5 pts): In Simulated Annealing, the goal is to move from one state to another by applying an operator so that the energy E associated with the state is *minimized*. Given a state, an operator is allowed to be applied only in two cases depending on the ΔE value (the change in energy E in the two states): (1) Explain what are these two cases, and (2) explain why this can help solve the problem of local search methods such as hill-climbing.

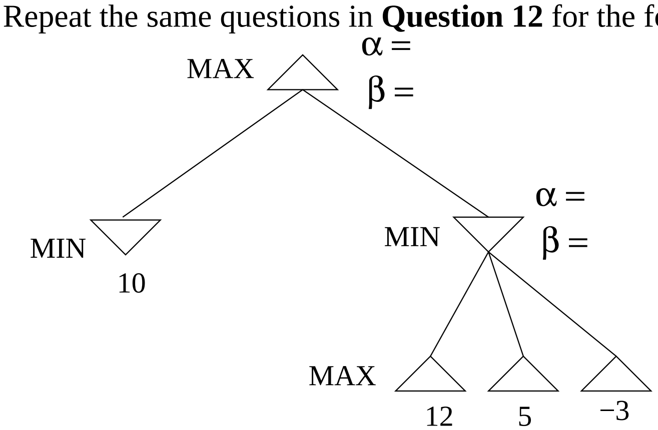
3 Game Playing

Question 11 (3 pts): Minmax search is very similar to one of the uninformed search methods. (1) What is it and (2) why?

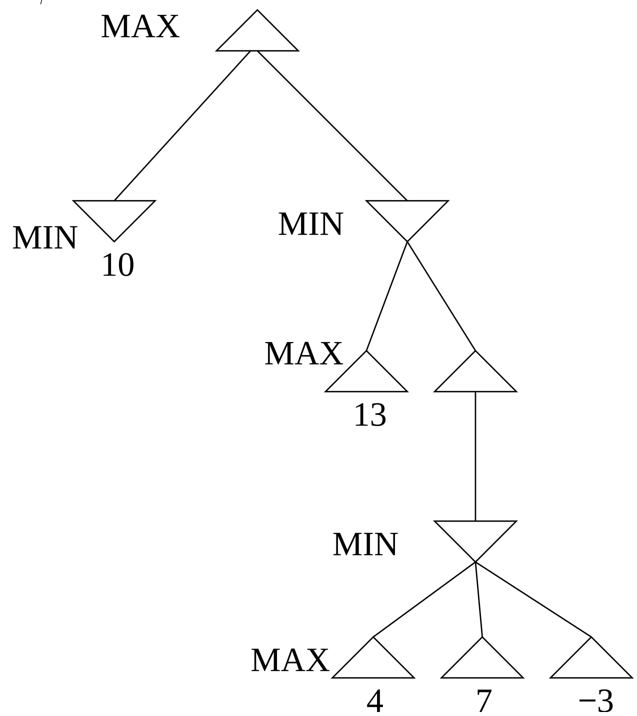
Question 12 (6 pts): Using the following figure, explain how $\alpha - \beta$ pruning works. (1) Show each stage of the search and α/β value updates. (2) Show the cut(s). (3) Show which values should be compared to determine whether or not to cut (i.e., choose a pair from v, α, and β), and the which comparison should be used ($\leq$ or $\geq$). For example $v \leq \alpha$.



Question 13 (6 pts): Repeat the same questions in **Question 12** for the following tree.



Question 14 (6 pts): Using the tree below, (1) explain how an α or β value that was set far above the search tree can affect cuts at deeper depths. (2) Show where a cut can occur. **Hint**: think about how the α and β values from above are handed over to the children and grandchildred.



Question 15 (4 pts): What assumption is necessary for the results from an $\alpha - \beta$ pruning search is the same as Minmax search? Explain in terms of the MIN and the MAX player and the property of their strategy.

4 Propositional Logic

Use the laws of propositional logic at the end of the test as necessary (see the last page). You may detach the last page from the test.

Question 18 (4 pts): Convert $\neg(P \rightarrow (Q \wedge R))$ to disjunctive normal form, i.e., disjunction of terms $(\cdot \wedge \cdots \wedge \cdot) \vee (\cdot \wedge \cdots \wedge \cdot) \vee \cdots$. Show every step of the derivation.

Question 19 (4 pts): Convert $(\neg P \vee S) \rightarrow (P \wedge Q \wedge R)$ to conjunctive normal form, i.e., conjunction of clauses $(\cdot \vee \cdots \vee \cdot) \wedge (\cdot \vee \cdots \vee \cdot) \vee \cdots$. Show every step of the derivation.

Question 20 (3 pts): Why do we want to convert logical formulas into these differnt normal forms? Briefly explain in the perspective of AI.

Question 18 (8 pts): Using **resolution**, show that:

$(P \vee S)$ is a logical consequence of $(P \vee Q) \wedge (\neg Q \vee R \vee S) \wedge (\neg R \vee P)$.

Show every step of the derivation.

Question 19 (3 pts): When using resolution, why is it critical that all axioms (or premises) in the knowledge base is **true**?

Question 20 (3 pts): What is a **Horn clause** and why is it particularly suitable for automated theorem proving? (**Hint:** think about implications $A \rightarrow B$.)

Appendix: Laws of Propositional Logic

Note: There is no exam question on this page.

Use the laws of propositional logic below as necessary. You may detach the last page from the test.

- $P \vee Q = Q \vee P$,
  $P \wedge Q = Q \wedge P$ (commutative)
- $(P \vee Q) \vee H = P \vee (Q \vee H)$,
  $(P \wedge Q) \wedge H = P \wedge (Q \wedge H)$,(associative)
- $P \vee (Q \wedge H) = (P \vee Q) \wedge (P \vee H)$,
  $P \wedge (Q \vee H) = (P \wedge Q) \vee (P \wedge H)$ (distributive)
- $P \vee \textbf{False} = P, P \wedge \textbf{False} = \textbf{False}$
- $P \vee \textbf{True} = \textbf{True}$
  $P \wedge \textbf{True} = P$
- $P \vee \neg P = \textbf{True}$
  $P \wedge \neg P = \textbf{False}$
- $\neg(P \vee Q) = \neg P \wedge \neg Q$,
  $\neg(P \wedge Q) = \neg P \vee \neg Q$ (DeMorgan's law)
- $P \rightarrow Q = \neg Q \rightarrow \neg P$ (contrapositive)
- $P \rightarrow Q = \neg P \vee Q$

These are the common inference rules:

- Modus Ponens:

$$\frac{F \rightarrow G, F}{G}$$

- Unit Resolution:

$$\frac{F \vee G, \neg G}{F}$$

- Resolution:

$$\frac{F \vee G, \neg G \vee H}{F \vee H} \quad or\ equivalently \quad \frac{\neg F \rightarrow G, G \rightarrow H}{\neg F \rightarrow H}$$