# CPSC420-500 Midterm Exam (10/12/2006, Thu)[1]

Last name: _____, First name: _____

Time: **12:45pm–2:00pm (75 minutes + $\alpha$)**, Total Points: **100**

| Subject | Score |
|---|---|
| AI General | /10 |
| Search | /35 |
| Game Playing | /24 |
| Propositional Logic | /31 |
| **Total** | /100 |

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

- Be as **succinct** (i.e., brief) 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 Appendix at the end. **Before starting, count the pages and see if you have all 10.**

- 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 AI, in General

**Question 1 (5 pts):** Pick one of the academic disciplines related to AI and explain how it is related. [Don't spend too much time on this question! No more than one paragraph please.]

**Question 2 (5 pts):** Do you think AI is possible? Explain why or why not. [This is an open question. Any reasonable answer will be fine. Don't write more than one paragraph.]

## 2 Search

**Question 3 (4 pts):** Why does queuing order (and/or sorting) affect the behavior of different search algorithms? Explain in terms of the operations performed on the node list.

**Question 4 (5 pts):** Explain why *Iterative Deepening Depth-First Search* (IDS) can be better than Breadth-First Search and also Depth-First Search? Explain in terms of one or more of the four evaluation criteria.

**Question 5 (7 pts):** Why is A* superior to Greedy search? Explain in terms of one or more of the four evaluation criteria.

**Question 6 (5 pts):** Iterative Deepening A\* (IDA\*) is superior to A\* in one crucial way, but it can be disadvantageous in another. Identify what are these two, in terms of one or more of the four evaluation criteria, and explain why.

**Question 7 (4 pts):** Why does relaxing the constraint on legal moves usually result in an admissible heuristic? Explain in terms of the 8-puzzle.

**Question 8 (4 pts):** What is the main drawback of hill-climbing or gradient-based iterative improvement algorithms?

**Question 9 (6 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 (rather than being rejected) only in two cases depending on the $\Delta E$ 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. Assume the temperature $T$ is fixed.

# 3  Game Playing

**Question 10 (6 pts):**  Using the following figure, explain how $\alpha - \beta$ pruning works. (1) Show each stage of the search and $\alpha/\beta$ 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 $v$, $\alpha$, and $\beta$), and which comparison should be used ($\leq$ or $\geq$). For example $v \leq \alpha$. Note that $v$ is the returned utility value for each child.
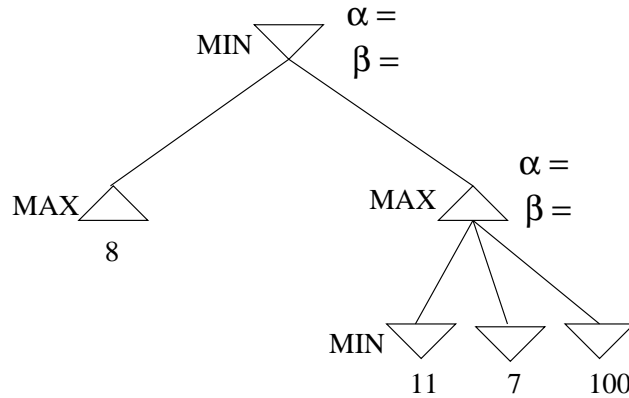


**Question 11 (6 pts):**  For the following tree, repeat the same subquestions in Question 10 above.
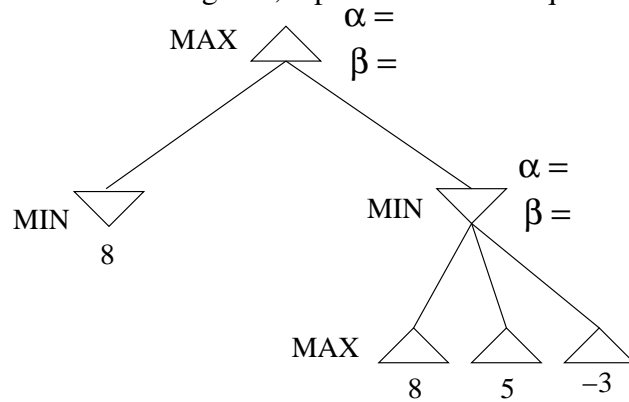
**Question 12 (4 pts):** What assumption is necessary for the results of $\alpha - \beta$ pruning to be the same as minmax search? Explain in terms of the MIN and MAX players' general characteristics.

**Question 13 (4 pts):** Why is node ordering important in $\alpha - \beta$ pruning?

**Question 14 (4 pts):** Is the MIN-MAX algorithm similar to BFS or to DFS? Explain why.

# 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 15 (6 pts):** Convert $\neg\left[(P \vee Q) \rightarrow \neg(S \rightarrow (R \wedge \neg P))\right]$ to conjunctive normal form. Show every step of the derivation.

**Question 16 (6 pts):** Given axioms $F_1, F_2, ..., F_n$ and a conclusion $G$, why is deriving **False** in resolution equivalent to showing that $(F_1 \wedge F_2 \wedge ... \wedge F_n) \rightarrow G$ is valid?

**Question 17 (8 pts):**   Using **resolution**, show that:
$(P \lor S)$ is a logical consequence of

1. $X \lor Q$

2. $Q \rightarrow (R \lor S)$

3. $\neg R \lor P$

4. $\neg X \lor R.$

First, convert the problem into a form suitable for resolution. Then, show every step of the derivation.

**Question 18 (6 pts):**   Choose one: Resolution is domain (1) independent or (2) dependent. Explain why that particular property is both an advantage and a disadvantage.

**Question 19 (5 pts):**   What is the limitation of propositional logic, in terms of its representational power?

# 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.

- $P \lor Q = Q \lor P$,
  $P \land Q = Q \land P$ (commutative)

- $(P \lor Q) \lor H = P \lor (Q \lor H)$,
  $(P \land Q) \land H = P \land (Q \land H)$,(associative)

- $P \lor (Q \land H) = (P \lor Q) \land (P \lor H)$,
  $P \land (Q \lor H) = (P \land Q) \lor (P \land H)$ (distributive)

- $P \lor \mathbf{False} = P, P \land \mathbf{False} = \mathbf{False}$

- $P \lor \mathbf{True} = \mathbf{True}$
  $P \land \mathbf{True} = P$

- $P \lor \neg P = \mathbf{True}$
  $P \land \neg P = \mathbf{False}$

- $\neg(P \lor Q) = \neg P \land \neg Q$,
  $\neg(P \land Q) = \neg P \lor \neg Q$ (DeMorgan's law)

- $P \to Q = \neg Q \to \neg P$ (contrapositive)

- $P \to Q = \neg P \lor Q$

These are the common inference rules:

- Modus Ponens:

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

- Unit Resolution:

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

- Resolution:

$$\frac{F \lor G, \neg G \lor H}{F \lor H} \quad or\ equivalently \quad \frac{\neg F \to G, G \to H}{\neg F \to H}$$