CPSC625-600 Midterm Exam (10/18/2002, Fri)

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

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

Subject	Score
AI General	/10
Search	/39
Game Playing	/25
Propositional Logic	/26
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 12 pages, including this cover. **Before starting, count the pages and see if you have all twelve.**
- This is a closed-book, closed-note exam.

1 AI in General (Total: 10 points)

1. Do you think AI is possible? If so, what do you think would be the key conceptual breakthrough? If not, what do you think will be the fundamental obstacle? Answer in one short paragraph, i.e. don't spend too much time (i.e. anything goes). (5 points)

2. AI programs usually get the representational design for a given problem from the programmer. This is one of the causes of the rigidity in many AI approaches. What capability and/or property would be required of an autonomous agent to build its own representations as it goes on? Don't spend too much time (i.e. anything goes). (5 points).

3. What is your project topic and who's your partner? (0 points)

2 Search (Total: 39 points)

2.1 Breadth first and depth first search (10 points)

Answer all 5 questions. In all cases, answer in terms of the **worst case** scenario.

1. BFS and DFS **implementations** are basically the same except for one crucial component. What is it? (2 points)

2. There are several different evaluation measures for BFS and DFS (completeness, optimality, space, and time complexity). For which **measure** are the two search methods identical? (2 points)

3. What is the **one** major advantage of DFS over BFS? Answer in terms of the evaluation measures. (2 points)

4. What are the **two** major advantages of BFS over DFS? Answer in terms of the evaluation measures. (2 points)

5. Several search strategies make use of the DFS strategy. List two search methods (except for Minmax/$\alpha-\beta$) employing DFS-style exploration. (2 points)

2.2 A^* and Iterative Deepening A^* (IDA^*) search (20 points)

Answer all 6 questions. Note that the 6th question is 5 points worth and the rest are 3 points each.

1. What is the utility function used in A^* search? (3 points)
   $f(n) = ...$

2. What is the major disadvantage of A^* in terms of the evaluation measures (completeness, optimality, space, and time complexity)? (3 points)

3. How does A^* and BFS differ in terms of node-list update? (3 points)

4. What is the major advantage of IDA^* compared to A^* in terms of the evaluation measures and why? (3 points)

5. Why are larger heuristic functions better than smaller heuristic functions for IDA^*? (3 points)

6. In IDA^* increasing the f-limit in the amount of a fixed value ϵ can sometimes lead to a more efficient search. However, this approach has a drawback. What is this drawback and what nature of IDA^* contributes to it? (5 points).

2.3 Simulated annealing (9 points)

In simulated annealing, to minimize the energy E, the following strategy is used. Suppose a move from state **old** to state **new** caused the energy to change by $\Delta E = E_{\text{new}} - E_{\text{old}}$:

- if $\Delta E \leq 0$, the move is accepted (new state has lower energy than old state).
- 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.

Answer all 3 questions.

1. Hill-climbing has a severe problem which SA can overcome. What is this problem? (3 points)

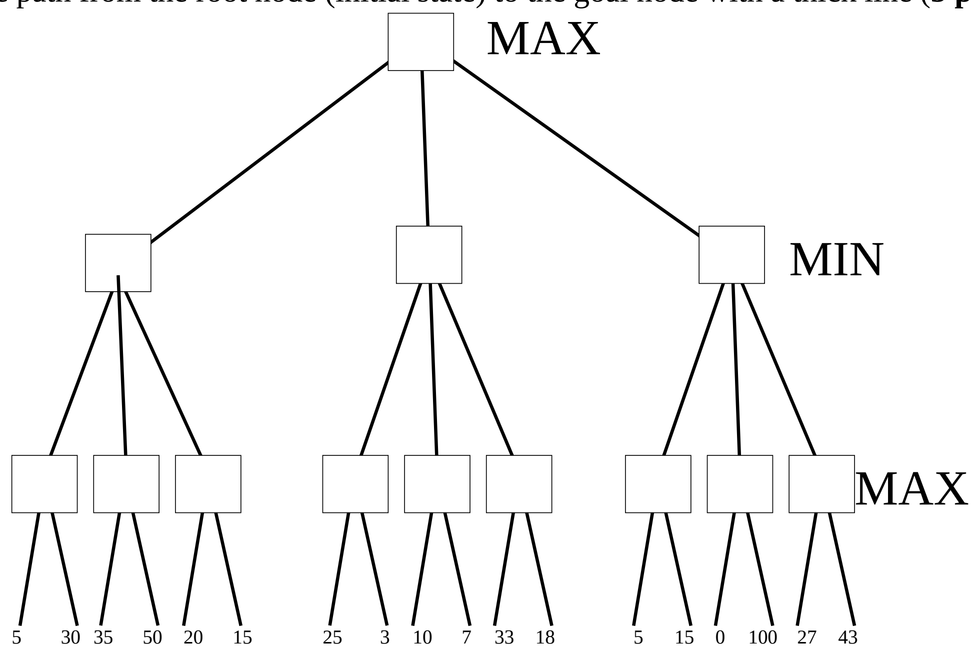
2. Which case above ($\Delta E \leq 0$ or $\Delta E > 0$) contributes to the advantage of SA over regular hill-climbing? (3 points)

3. A typical simulated annealing process begins with a high T and the T is gradually decreased. How does T correlate with the freedom of movement (up and downward the energy landscape)? (3 points)

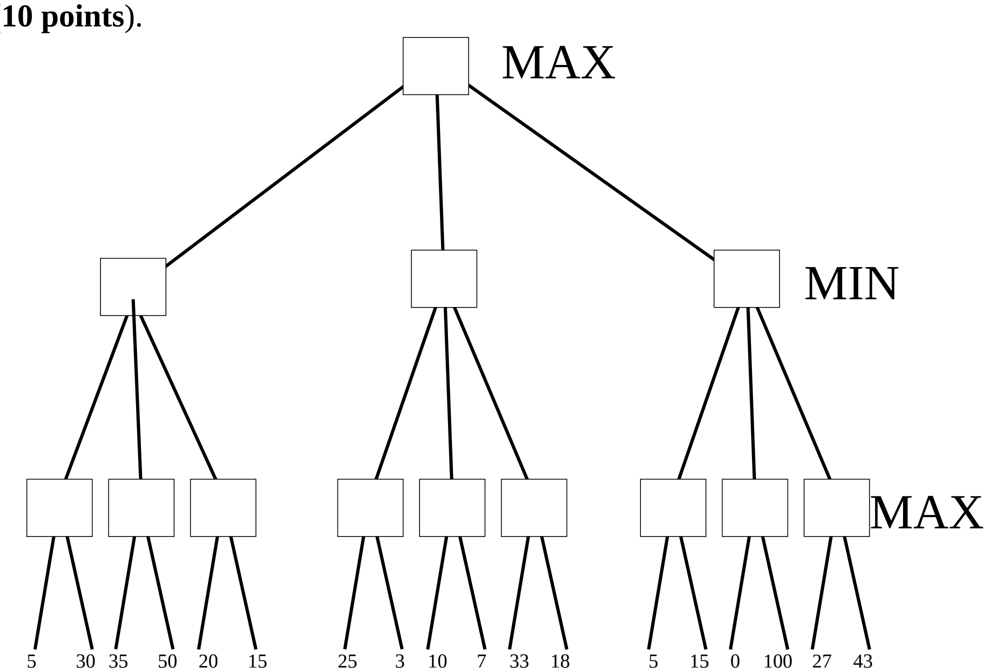
3 Game Playing (Total: 25 points)

Solve all four problems.

1. Consider a MIN-MAX game tree (the two below are the same).
   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 (**5 points**).



2. Cross out the branches that are pruned by α-β pruning. Show the final best estimate values at each node. (**10 points**).



3. In MIN-MAX search, a depth-first strategy is used. What feature of the algorithm makes it a depth-first exploration? Briefly explain in terms of the functions MIN-VALUE and MAX-VALUE. (5 points)

4. Why is α-β pruning a good strategy compared to the regular Min-Max tree approach? Briefly explain. (5 points)

4 Propositional Logic and Theorem Proving (Total: 26 points)

Use the following laws of propositional logic as necessary:

- $P \vee Q = Q \vee P$,
  $P \wedge Q = Q \wedge P$ (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)
- $P \vee \mathbf{F} = P$, $P \wedge \mathbf{F} = \mathbf{F}$ (**F**: False)
- $P \vee \mathbf{T} = \mathbf{T}$
  $P \wedge \mathbf{T} = P$ (**T**: True)
- $P \vee \neg P = \mathbf{T}$
  $P \wedge \neg P = \mathbf{F}$
- $\neg(P \vee Q) = \neg P \wedge \neg Q$,
  $\neg(P \wedge Q) = \neg P \vee \neg Q$ (DeMorgan's law)
- $P \rightarrow Q = \neg Q \rightarrow \neg P$ (contrapositive)
- $P \rightarrow Q = \neg P \vee Q$

Solve all three problems.

1. Convert the following formulas into Conjunctive Normal Form (conjunction of disjunctions). Show all your work. (6 points; 3 points each)

   (a) $\neg(\neg P \vee Q) \rightarrow (\neg R \wedge S)$

   (b) $(P \wedge \neg Q) \vee (R \wedge \neg S)$

2. Convert the following formula into Disjunctive Normal Form (disjunction of conjunctions). Show all your work. (3 points)

   (a) $\neg(\neg P \vee Q) \rightarrow (\neg R \wedge S)$

3. Consider a robot that is able to lift a block if the block is light enough that it is liftable (LIFTABLE), and if the battery power is adequate (BATTERYOK). If both of these conditions are met, then the robot will always lift the block and its arm will move (MOVESARM).

$$BATTERYOK \wedge LIFTABLE \rightarrow MOVESARM$$

We can think of a situation when we know that the battery is okay but the arm did not move. From this we can infer that the block it is holding now is not liftable.

In other words, we want to show $\neg LIFTABLE$ is a logical consequence of the facts below:

(1) $BATTERYOK$
(2) $\neg MOVESARM$
(3) $\neg BATTERYOK \vee \neg LIFTABLE \vee MOVESARM$

Show that $\neg LIFTABLE$ is a logical consequence of the above **using resolution**. Show all your work. (10 points)

4. Horn clauses are clauses with one or less positive literal, for example, $P \vee \neg Q \vee \neg R \vee \neg S$. Horn normal form consists of conjunctions of Horn clauses. This normal form is highly suitable for one kind of theorem proving technique (forward-chaining, backward-chaining, or resolution). Which is it? and why? Explain in terms of the following example (7 points).

   Given:
   (1) $\neg P \vee \neg Q \vee R$
   (2) P
   (3) S
   (4) $\neg S \vee Q$
   we want to prove that R is true.

5.