Stanford University
Computer Science Department

Fall 2002 Comprehensive Exam in Artificial Intelligence

1. **Closed Book:** no notes, textbooks, laptops, Internet access, etc.
2. **Write only in the Blue Books: No credit** for answers written on these exam pages.
3. **Write Magic number** on the cover of **EACH blue book**.
4. **The exam is timed for one hour.**

The following is a statement of the Stanford University Honor Code:

A. The Honor Code is an undertaking of the students, individually and collectively:

1. that they will not give or receive aid in examinations; that they will not give or receive unpermitted aid in class work, in the preparation of reports, or in any other work that is to be used by the instructor as the basis of grading;

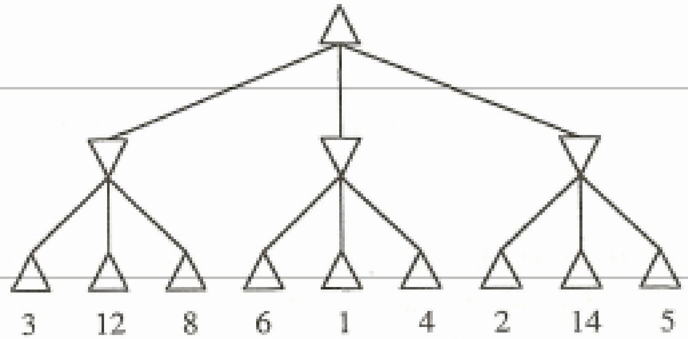
2. that they will do their share and take an active part in seeing to it that others as well as themselves uphold the spirit and letter of the Honor Code.

B. The faculty on its part manifests its confidence in the honor of its students by refraining from proctoring examinations and from taking unusual and unreasonable precautions to prevent the forms of dishonesty mentioned above. The faculty will also avoid, as far as practicable, academic procedures that create temptations to violate the Honor Code.

C. While the faculty alone has the right and obligation to set academic requirements, the students and faculty will work together to establish optimal conditions for honorable academic work.

2002 Comprehensive Examination
Artificial Intelligence

1. Search. (20 points) Consider the game tree shown below. Upward-facing triangles are maximizing nodes, and downward-facing triangles are minimizing nodes.



(a) Use Minimax search to solve this problem. Write the backed up values next to the nodes. What is the best first move for the maximizing player (left middle, or right)? What is the best response for the minimizing player (left middle, or right)?

(b) Now solve the problem using α-β pruning search. Mark the nodes that are *not* evaluated by the algorithm.

2. Logic. (20 points) Let Γ and Δ be sets of sentences in first-order logic, and let φ and ψ be individual sentences in first-order logic. State whether each of the following statements is true or false. (No explanation is necessary.)

(a) If $\Gamma \models \varphi$ and $\Delta \models \varphi$, then $\Gamma \cup \Delta \models \varphi$.

(b) If $\Gamma \models \varphi$ and $\Delta \models \varphi$, then $\Gamma \cap \Delta \models \varphi$.

(c) If $\Gamma \models \varphi$ and $\Delta \models (\varphi \Rightarrow \psi)$, then $\Gamma \cup \Delta \models \psi$.

(d) If $\Gamma \models \varphi$ and $\Delta \models (\varphi \Rightarrow \psi)$, then $\Gamma \cap \Delta \models \psi$.

(e) If $\Gamma \models \varphi$ and $\Delta \models \neg\varphi$, then $\Gamma \cup \Delta \models (\varphi \Rightarrow \neg\varphi)$.

3. Automated Reasoning. (20 points) Use the resolution refutation method to prove $\forall x.p(x,x)$ from the following premises.

$$\forall x.\exists y.(p(x,y) \wedge p(y,x))$$
$$\forall x.\forall y.\forall z.(p(x,y) \wedge p(y,z) \Rightarrow p(x,z))$$

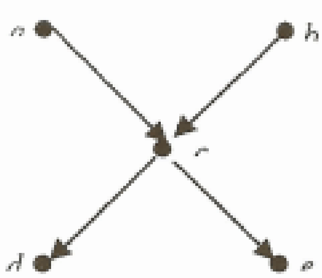
Note that this is a question about resolution. You will get zero points for proving it in any other way.

4. Probability. (20 points) Adapted from Nilsson's *Artificial Intelligence: A New Synthesis*. Suppose that colored balls are distributed in three indistinguishable boxes, B1, B2, and B3, as shown in the following table.

	B1	B2	B3
Red	2	4	3
White	3	2	4
Blue	6	3	3

A box is selected at random from which a ball is selected at random. The ball is red. What is the probability of the box selected being B1? Unreduced fractions are okay.

5. Belief Networks. (20 points) Consider the belief network shown below.



What is the joint probability of *-a*, *-b*, *c*, *d*, *e*? You may assume that p(a)=0.1, p(b)=0.2, p(c|a,b)=0.9, p(c|a,-b)=0.9, p(c|-a,b)=0.3, p(c|-a,-b)=0.1, p(d|c)=0.9, p(d,-c)=0.1, p(e,c)=0.7, p(e,-c)=0.1.