

**Final Exam – Tuesday May 12**  
**120 minutes == 120 points**  
**open book and notes**

1. [25 points] You are given the following set of axioms in propositional calculus:
  1.  $Humid \Rightarrow \neg(Hot \wedge \neg Sticky)$
  2.  $\neg Hot \wedge Sunny \Rightarrow Pleasant$
  3.  $Sunny \wedge Humid$
  4.  $Sunny \vee \neg Pleasant$
  1. Convert them to conjunctive normal form.
  2. Prove by resolution with refutation “ $Sticky \vee Pleasant$ .”
  3. Try to prove “ $Sticky \wedge Pleasant$ .” If you fail to prove it, what can you conclude?
  
2. [20 points]
  1. Represent the following sentences in predicate calculus, using the predicates  $Cat(x)$ ,  $Bird(y)$ ,  $Person(z)$ ,  $InVillage(x)$ ,  $Eat(x, y)$ , and  $Hate(x, y)$ .
    1. There are at least two cats in the village.
    2. There are some people who hate cats who eat birds.
    3. Felix is a cat.
    4. Felix ate a bird.
  2. Convert each of them to conjunctive normal form, skolemizing as needed.
  3. Prove by resolution that “there is someone who hates Felix.”
  
3. [20 points] Suppose you have a (magic) card for an Automated Teller Machine (ATM) that gives you money any time you use it in an ATM machine. You need money to get food and you are left with food but no money. You have an ATM card and no food. Your goal is to have food.
  1. Write action schemas for the problem described above.
  2. Show the levels  $S_0$ ,  $A_0$ , and  $S_1$  of the corresponding planning graph. Mark the mutexes.
  3. At what level can you achieve the goal to have food?
  4. If instead your goal is to have food and have money, at what level can you achieve it?

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4. [15 points] Represent the following information using a semantic network with the notation shown in the textbook: “Clyde crossed the Alps with Hannibal to fight against the Romans. Hannibal is a commander from the city of Carthage. Clyde is an elephant. Elephants are grey. They can carry large loads.”
5. [10 points] Show a simple example of a game tree where alpha-beta pruning removes at least one branch.
6. [10 points] Suppose you decide to modify A\* as follows. You use an admissible heuristic (i.e. a heuristic that is an underestimate), but you do not use at all the  $g(\cdot)$  value in computing the  $f(\cdot)$  value of the nodes you expand. To be precise, you use  $f(n) = h(n)$ . Is this modified algorithm admissible? Why (or why not)?
7. [20 points]

Answer the following questions briefly but precisely. Justify your answers.

1. Is it possible for alpha-beta pruning and minimax to return different results on the same problem?
2. Can semantic networks be used to represent non-binary relations? How?
3. Why does iterative deepening A\* require less memory than A\*?
4. What are the main factors that affect the computational complexity of the GRAPHPLAN planning algorithm?
5. Why in an ontology it is important to distinguish objects like “butter” from objects like “table”?