

## Final Exam

**Wednesday December 22**  
**120 minutes == 120 points**  
**open book and notes**

1. *40 points*

Write one STRIPS-like operator schema for grabbing objects and one for carrying the grabbed objects (if any) from a location to another. The *Grab* operator should specify that to grab an object  $o$  you and the object have to be at the same location. The *Carry* operator should specify that to carry objects from  $x$  to  $y$  you and the grabbed objects have to be at  $x$ . As a result, you and all the objects that have been carried will be at  $y$ . The *Carry* operator has to work for carrying any number of objects.

- (a) write an operator schema for *Grab* and one for *Carry*;
- (b) describe the extensions (if any) to STRIPS that your operators require;
- (c) using the operators you defined and the following initial state  
 $At(Me, Grocery) \wedge At(Egg, Grocery) \wedge At(Orange, Grocery)$   
 $\wedge At(Ketchup, Grocery) \wedge Item(Egg) \wedge Item(Orange) \wedge Item(Ketchup)$   
 show a plan to achieve the goal  
 $At(Me, Home) \wedge At(Orange, Home) \wedge At(Egg, Home)$
- (d) write the operators using the successor state axiom notation.

2. *40 points*

Use predicate calculus and resolution refutation for this question.

- (a) Represent the following set of axioms in predicate calculus:
  1. Anyone who has any pet loves it.
  2. Anyone who has a bird does not have any cat.
  3. Cats and birds are pets.
  4. John has a cat who ate a bird.
  5. John does not love pets who eat birds.
- (b) Convert each of the statements above to conjunctive normal form, skolemizing as needed.
- (c) Of the given set of statements, is there a subset of statements that is contradictory? If not, then what minimum facts you need to add to the above to get a subset of statements that is contradictory? In either

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case, identify this subset, and then prove the unsatisfiability of this subset of clauses by using resolution with refutation.

3. *10 points*

Show a simple example of a game tree where alpha-beta pruning removes at least one branch.

4. *30 points*

Answer these questions briefly but precisely.

- (a) Why iterative deepening A\* requires less space than A\*?
- (b) When would you use simulated annealing?
- (c) Is it possible to use min-max in a non-zero sum game?
- (d) Is it true that resolution refutation always terminates either by finding a contradiction and by failing to find a contradiction?
- (e) Why frame axioms are needed in situation calculus?
- (f) Can semantic networks be used to represent non-binary relations?