CSE560 Fall 2004 Final Exam

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Semantics

Question 1 (1 marks)

Give formal semantics for what $\neg\alpha$ means (in terms of an interpretation)

Answer:
$\neg\alpha$ is true in interpretation I if α is false in the interpretation.

Question 2 (1 marks)

Give formal semantics (in terms of an interpretation) for equality: $t_1 = t_2$, where t_1 and t_2 are any arbitrary terms without variables.

Answer:
$\phi(t_1) = \phi(t_2)$

Question 3 (1 marks)

Assume we have constants a and b, 1-ary predicate $girl$, variable X, and that our domain has 4 objects w, x, y and z. Explain the conditions under which $\forall X girl(X)$ is true in an interpretation.

Answer:
girl must be true of w, x, y or z

Question 4 (1 marks)

Under what conditions is a knowledge base unsatisfiable (in terms of interpretations)?

Answer:
There is no interpretation that makes it true.

Question 5 (1 marks)

Give an example KB that is unsatisfiable.

Answer:
KB has a and $\neg a$ in it

Question 6 (2 marks)

Convert the following clauses into conjunctive normal form (which is a disjunction of positive or negative literals). Show all of your steps.

$a(X, Y) \leftarrow \forall Z b(X, Y, Z)$

Answer:
a(X,Y) ∨ ¬∀ Z b(X,Y,Z)
a(X,Y) ∨ ∃ ¬Z b(X,Y,Z)
a(X,Y) ∨ ¬b(X,Y,f(X,Y)) where f is a skolem function

less(X,Z) ← *less(X,Y)* ∧ *less(Y,Z)*

Answer:
less(X,Z) ∨ ¬(less(X,Y) ∧ ¬less(T,Z))
less(X,Z) ∨ (¬less(X,Y) ∨ ¬less(Y,Z))
less(X,Z) ∨ ¬less(X,Y) ∨ ¬less(Y,Z)

Question 7 (1 marks)

Let *childless(X,Y)* be true if the couple X-Y do not have any children. Let *havechild(X,Y,Z)* be true if Z is the child of X and Y. Write the following in a logical form. *A couple is childless if they do not have any children.* Make sure you clearly show all quantifiers. Make sure you show all bracketing.

Answer:
∀ X (∀ Y (childless(X,Y) ← (¬(∃ Z havechild(X,Y,Z)))))

Question 8 (1 marks)

When written in conjunctive normal form, what do we call clauses if they have exactly one positive literal.

Answer:
datalog

When they have at most one positive literal?

Answer:
horne

When they have an arbitrary number of positive and negative literals?

Answer:
This was a trick question, as we never gave it a formal name

Proof Procedures

Question 9 (1 marks)

Give the resolution rule for clauses in disjunctive normal form. Make your rule as general as possible. (Do not assume that one of the clauses is an answer clause nor a unit clause. But do assume that either clause can have variables and/or function symbols in it.)

Answer:
Let $A = \{\alpha_1, ..., \alpha_a\}$ where each α_i is a literal
Let $B = \{\beta_1, ..., \beta_b\}$ where each β_i is a literal
Let α_i unify with $\neg\beta_j$ with MGU σ
The $A' = A - \{\alpha_i\}$
The $B' = B - \{\beta_j\}$
The resolvent is $A'\sigma \cup B'\sigma$

Question 10 (2 marks)

Use a bottom-up proof procedure to find the set of minimal truths for the following KB. Show all of your steps.

¬f(X) ∨ ¬g(Y) ∨ h(X,Y)	(1)
f(a)	(2)
g(b)	(3)
h(a,b) ∨ h(b,a)	(4)

Answer:
We start our consequent set with the original KB.

¬g(Y) ∨ h(a,Y)	(5)	From resolving (1) & (2)
¬f(X) ∨ h(X,b)	(6)	From resolving (1) & (3)
h(a,b)	(7)	From resolving (5) & (3)
Prune (4)		Implied by (7)

Final set has (1), (2), (3), (5), (6), (7) & (8)

Question 11 (1 marks)

Using your bottom-up proof from the previous question, why or why not does does $h(a, b) \vee h(d, f)$ follow from the above KB.

Answer:
A subset $h(a, b)$ of the query is in the set of minimum truths

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Question 12 (2 marks)

Consider the following KB.

poor(X) ← student(X)	(1)
student(john) ∨ student(tim)	(2)

What is the answer for $?poor(X)$ Show the derivation using a top-down proof procedure.

Answer:
First convert KB to disjunctive normal form.

poor(X) ∨ ¬student(X)	(1)
student(john) ∨ student(tim)	(2)

Then write the query in disjunctive normal form and add to KB

yes(X) ← poor(X)
yes(X) ∨ ¬poor(X) (3)

Start with query

yes(X) $\vee$ $\neg$poor(X)	(3)	
yes(X) $\vee$ $\neg$student(X)	(4)	resolved with (1)
yes(john) $\vee$ student(tim)	(5)	resolved with (2)
yes(john) $\vee$ poor(tim)	(6)	resolved with (1)
yes(john) $\vee$ yes(tim)	(7)	resolved with (3)

Question 13 (1 marks)

What is unit resolution?

Answer:
Unit resolution where one of the clauses just has one literal.

Question 14 (1 marks)

Under what two conditions is unit resolution guarenteed to always halt and halt with false if the knowledge base is inconsistent.

Answer:
All clauses are horne and no function symbols.

Question 15 (1 marks)

How would you use a refutation proof to prove that something follows from a knowledge base.

Answer:
Add its negation to the knowledge base and see if you can prove false. If you can, then it is true.

Question 16 (1 marks)

What is paramodulation used for, and how does it work with a proof procedure? Does it have any disadvantages?

Answer:
It is used to reason about equality. Equality statements in a KB are viewed as rewrite rules to rewrite the term on the left by the term on the constant on the right. The rewriting is done to the original kb and can be done at any step in a proof if a left-hand side is seen. This approach is sound but is not always complete (depends on your KB).

Question 17 (2 marks)

Consider the following KB.
mother(leslie,mary)
mother(mary,nancy)
mother(nancy,oprah)
mother(oprah,patty)

Besides asking if someone is someone's mother, we might also want to know if someone is not someone else's mother. For instance, we might want to ask $\neg mother(leslie, patty)$. Without adding extra facts into the knowledge base or using an abduction or default reasoning, what technique can you use? Explain how the technique works. Does it have any disadvantages?

Answer:
Negation as failure. Whenever you have to prove $\neg\phi$, you do an embedded proof of ϕ. If ϕ cannot be proved, you

assume that ϕ is true. Not guarenteed to be sound, and depends on form that the rules are written in.

Planning

Let the two actions be go(From,To) for going from From to To and buy(At,Thing) for buying Thing at At.

The static relations are sells(At,Thing) meaning that place At actually does sell Thing. The primitive relations are at(X) meaning the person is at X and has(X) which means the person has X.

Question 18 (1 marks)

Using Strips notation, give the definition of the initial world where the person is at home, and store sells milk. Give the definition of the goal where the person is at home and has milk.

Answer:
Initial world: at(home) sells(store,milk)
Goal world: at(home) have(milk)

Question 19 (2 marks)

Write the Strips action operators for 'go' and 'buy.'

Answer:
Action Definitions:

Header	go(From,To)
Preconditions	at(From)
Delete list	at(From)
Add list	at(To)
Header	buy(At,Thing)
Precondition	at(At) sell(At,Thing)
Delete list	
Add list	have(Thing)

Question 20 (2 marks)

For situation semantics, give the definition of **poss(Action,State)**, which encodes which actions are possible to execute in which states. Do not use knowledge of the initial world in your definition (i.e. don't take advantage of there only being one thing that is sold).

Answer:
poss(buy(At,Thing),S) $\leftarrow$ at(At,S) $\wedge$ sells(At,Thing)
poss(go(From,To),S) $\leftarrow$ at(From,S)

Question 21 (2 marks)

For situation semantics, give the axioms to define the primitive relations. Indicate which ones are frame axioms. Do not use knowledge of the initial world in writing the axioms (i.e. don't take advantage of there only being one thing that is sold).

Answer:
have(X,do(buy(At,X),S)
have(X,do(Action,S)) $\leftarrow$ have(X,S)   frame axiom

at(X,do(go(From,X),S)
at(X,do(Action,S)) ← at(X,S) ∧ ¬∃ Y Action = go(X,Y)   frame axiom

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Question 22 (2 marks)

For situation semantics, write a world state (using the **do** function) that achieves the goal.

Answer:
do(go(store,home),do(buy(store,milk),do(go(home,store),init)))

Question 23 (2 marks)

Write the plan as it would be found by a partial order planner. Show all effects (add/delete list) of each action, all causal links and any extra ordering constraints that are needed that are not already implied by the causal links.

Answer:

```
    ---------
    | START |
    ---------
at(home) sell(store,milk)
V                  V
V                  V
V                   V
at(home)             V
------------------   V
| go(home,store) |   V
------------------   V
at(store) !at(home)  V
V  V                 V
V   V                V
V    V               V
V  at(store)  sell(store,milk)
V   -------------------
V   | buy(store,milk) |----
V   -------------------   |
V        have(milk)       |
V              V          |
V               V         | Only ordering constraint
V                V        | needed not implied by a
V                 V       | causal link
at(store)          V      |
------------------  V     |
| go(store,home) |--V------
------------------  V
at(home) !at(store) V
V                  V
V                 V
V                V
at(home)   have(milk)
   ----------
   | FINISH |
   ----------
```

Assumption-Based Reasoning

Question 24 (1 marks)

Consider the following KB.
mother(leslie,mary)
mother(mary,nancy)
mother(nancy,oprah)
mother(oprah,patty)

Consider again the above knowledge base. We again want to reason about whether $\neg mother(leslie, patty)$ is true. We can use default reasoning, where our set of facts is the knowledge base above. What would H be, which is the set of assumptions that we are prepared to make? (Hint: you only need a single clause.)

Answer:
¬mother(X,Y)

Question 25 (2 marks)

Suppose we have the following knowledge base F.

cough ← *flu*
cough ← *cold*
high-temperature ← *flu*
runny-nose ← *cold*

Also, assume that our set of assumables, H, is { flu, cold }.

Give all explanations that will explain *cough*. Indicate which ones are minimum.

Answer:
flu, cold
flu
cold

Only the last two are minimum.
