Försättsblad till skriftlig tentamen vid Linköpings Universitet

Datum för tentamen	2009-12-22
Sal (1) Om tentan går i flera salar ska du bifoga ett försättsblad till varje sal och ringa in vilken sal som avses	KÅRA
Tid	14-18
Kurskod	TDDD08
Provkod	TEN
Kursnamn/benämning **Provnamn/benämning**	LOGIKPROGRAMMERING
Institution	IDA
Antal uppgifter som ingår i tentamen	9
Jour/Kursansvarig Ange vem som besöker salen	ULF NILSSON
Telefon under skrivtiden	1935/0768601935
Besöker salen ca kl.	15:30
Kursadministratör/kontaktperson (namn + tfnr + mailaddress)	Gunilla Mellheden
Tillåtna hjälpmedel	Inga
Övrigt	Inget
Vilken typ av papper ska användas, rutigt eller linjerat	Valfritt
Antal exemplar i påsen	

Exam in TDDD08/TDDA41 LOGIC PROGRAMMING

Tuesday 22 December, 2009, 14:00–18:00, Room KÅRA

No means of assistance (inga hjälpmedel)!
Grading will rely on the following limits (out of max 36):

Grade	3	4	5
Points	≥ 18	≥ 24	≥ 30

Ulf Nilsson can be reached on phone 1935 or 076–8601935 during the exam.
You may answer in English or in Swedish as you prefer.
REMEMBER TO GIVE MOTIVATIONS TO ALL ANSWERS!!!

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1. Determine which of the following pairs of formulas that are unifiable, and give the mgu in case there is one:

```
| ?- p([], X1, X2) = p(Y1, [Y2 | Y1], Y2).
| ?- p(f(X1), g(X1, X2)) = p(f(Y2), g(Y1, f(Y1))).
| ?- p(X1, g(X1, X2)) = p(f(Y2), g(Y2, f(Y2))).
| ?- p(f(X1), X2, g(X1,X2)) = p(Y1, Y1, g(a, f(b))).
```

(4 points)

2. Assume that ordered binary trees are represented as follows:

`null`	the empty tree
`t(`N`,`L`,`R`)`	a non-empty tree with root N and the subtrees L, R

Write a logic program that takes a tree of integers and computes a new tree with the same structure but where each node is labeled with the least element in the first tree. For instance

```
?- min(t(3, t(4, null, null), t(2, null, null)), X).
```

should give the answer `X=t(2,t(2,null,null),t(2,null,null))`.

(4 points for a program that solves the problem in one tree traversal)

3. Assume that we have an alphabet without function symbols containing the constants $\{a, b, c, d\}$ and the predicate symbols $p/1, q/2, r/1$. Let $\Im$ be the Herbrand interpretation:

$$\{p(a), p(b), p(c), q(a,b), q(b,a), q(a,c), q(c,a), q(d,d), r(c), r(d)\}$$

Which of the following formulas are true in $\Im$?

(a) $\forall X \forall Y (q(X,Y) \rightarrow q(Y,X))$

(b) $\forall X (\neg \exists Y q(X,Y) \vee p(X))$

(c) $\exists X (\neg p(X) \wedge q(X,X))$

(d) $\forall X \forall Y (q(X,Y) \rightarrow (p(Y) \vee r(X)))$

(4 points)

4. Translate the following DCG into a Prolog program (using the approach of most Prolog systems):

```
fib(0) --> [1].
fib(s(0)) --> [1].
fib(s(s(X))) --> fib(s(X)),fib(X).
```

Show by means of the Prolog program that the "string" `[1,1,1,1,1]` is in the language of `fib(s(s(s(s(0)))))`. That is, draw the SLD-refutation (there is no need to draw the whole tree).

(4 points)

5. Consider the following general program P

```
p(X) :- q(X), \+ q(f(X)).
q(X) :- r(X).
q(X) :- s(X), \+ r(X).
r(a).
s(a).
```

Draw the SLDNF-forest of the initial goal `:- p(X)` given that Prolog's computation rule is used. What are the answers produced? What answers would standard Prolog-implementations produce?

(4 points)

6. Every definite program P has a least Herbrand model M_P. Let $M_P \subseteq \Im$. Show that $\Im$ is not necessarily a Herbrand model of P.

(4 points)

7. Consider the following Prolog program:

```
p(X,Z) :- q(X,Y), !, r(Y,Z).
p(a,c).
q(a,b).
q(c,b).
r(X,Y) :- s(X,Y).
s(b,a).
s(b,b).
```

Draw the SLD-tree of the goal `:- p(X,Y)`. What answers are computed? What answers would be obtained if cut (i.e. `!`) is removed from the first clause?

(4 points)

8. Assume that sets are represented as lists possibly containing duplicate elements. That is, the set $\{a, b, c\}$ can be encoded as the list `[a,b,a,c]`. Define the following relations as Prolog programs:

   - `member(X,Xs)`: the element `X` is a member of the set `Xs`.
   - `subset(Xs,Ys)`: the set `Xs` is a subset of the set `Ys`.
   - `equal(Xs,Ys)`: the sets `Xs` and `Ys` are equivalent.
   - `union(Xs,Ys,Zs)`: the set `Zs` is the union of the sets `Xs` and `Ys`.

(4 points for readable and reasonable programs)

9. Let P be a definite program and $\Im$ a Herbrand interpretation. Prove that $\Im$ is a model of P iff $T_P(\Im) \subseteq \Im$.

(4 points)