Information page for written examinations at Linköping University

Examination date	2012-04-10
Room (1) If the exam is given in different rooms you have to attach an information paper for each room and mark intended place	TER2
Time	14-18
Course code	TDDD08
Exam code	TEN1
Course name **Exam name**	Logikprogrammering Skriftlig tentamen
Department	IDA
Number of questions in the examination	9
Teacher responsible/contact person during the exam time	Ulf Nilsson
Contact number during the exam time	076 8601935
Visit to the examination room approx.	15
Name and contact details to the course administrator (name + phone nr + mail)	Gunilla Mellheden
Equipment permitted	Inga
Other important information	
Which type of paper should be used, cross-ruled or lined	
Number of exams in the bag	

Exam in TDDD08 LOGIC PROGRAMMING

Tuesday 10 April, 2012, 14:00–18:00, Room TER2

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 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, sketch 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. Let P be a definite program and $\Im_1, \Im_2$ Herbrand models of P. Prove that also $\Im_1 \bigcap \Im_2$ must be a Herbrand model of P.

(4 points)

7. Consider the following Prolog program:

```
p(X) :- q(Y), r(Y, X).
p(X) :- r(X, X).

q(X) :- s(X).

r(a, b).
r(a, c).
r(b, a).
```

```
r(d, d).

s(a).
s(b).
s(c).
```

Draw the SLD-tree of the goal `:- p(X)` assuming that Prolog's computation rule is used. What branches of the tree are not explored if the first clause is replaced by the following one?

```
p(X) :- q(Y), !, r(Y, X).
```

(4 points)

8. The following Prolog program is based on the insertion sort algorithm:

```
% isort(A,B)
% B is a sorted version of A
isort([],[]).
isort([X|Xs],Ys) :- isort(Xs,Zs), insert(X,Zs,Ys).

% insert(A,B,C)
% C is the sorted list obtained by inserting A into
% the sorted list B
insert(X,[],[X]).
insert(X,[Y|Ys],[X,Y|Ys]) :- X =< Y.
insert(X,[Y|Ys],[Y|Zs]) :-X > Y, insert(X,Ys,Zs).
```

Rewrite the program so that it becomes tail-recursive (i.e. so that the procedure is completed when the recursive call is completed). The new program should run in standard Prolog implementations.

(4 points for a correct and reasonable solution)

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)