Information page for written examinations at Linköping University

Examination date	2011-08-20
Room (1) If the exam is given in different rooms you have to attach an information paper for each room and mark intended place	TER3
Time	8-12
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.	10
Name and contact details to the course administrator (name + phone nr + mail)	Gunilla Mellheden, 070 5979044, gunilla.mellheden@liu.se
Equipment permitted	None
Other important information	
Which type of paper should be used, cross-ruled or lined	Any

Exam in TDDD08 LOGIC PROGRAMMING

Saturday 20 August, 2011, 8:00–12:00, Room TER3

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 terms that are unifiable, and provide the mgu in case there is one:

```
| ?- p(f(X),X,f(Y)) = p(Y,f(Z),Z).
| ?- p(f(X),f(Y),X) = p(Z,Z,W).
| ?- p(X1,X2,X3) = p(f(X2,X2),f(X3,X3),a).
| ?- [X,Y|X] = [f(Z),X,X].
```

(4 points)

2. 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) and still is executable by Prolog.

(4 points for a correct and reasonable solution)

3. Consider the following definite program P:

$p(X) \leftarrow q(X).$
$p(f(X)) \leftarrow p(X).$
$q(a).$
$q(g(a)).$

Which of the following Herbrand interpretations are models of P?

$$\begin{aligned}
\Im_1 &= \{q(t) \mid t \in U_P\} \\
\Im_2 &= \{q(t) \mid t \in U_P\} \cup \{p(f^n(a) \mid n \geq 0\} \\
\Im_3 &= \{q(t) \mid t \in U_P\} \cup \{p(f^n(t)) \mid t \in \{a, g(a)\}, n \geq 0\} \\
\Im_4 &= \{q(t) \mid t \in U_P\} \cup \{p(t) \mid t \in U_P\}
\end{aligned}$$

Hint: The notation $f^3(a)$ is a shorthand for $f(f(f(a)))$ and $f^0(a)$ is a shorthand for a.

(4 points)

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

```
p(N) --> a(N,M),b(M,0).
a(N,N) --> [].
a(s(N),M) --> [a],a(N,M).
b(N,N) --> [].
b(s(N),M) --> [b],b(N,M).
```

Show that the string `[a,a,b]` is contained in the language of `p(s(s(s(0))))`, using the resulting program.

(4 points)

5. Consider the following general program:

```
p(X) :- \+ s(X).
p(X) :- q(X).
q(X) :- r(X,Y).
q(X) :- r(Y,X).
r(b,c).
s(X) :- \+ q(X), t(X).
t(x) :- \+ r(X,X).
```

Draw the SLDNF-forest of the goal `:- p(a)` given that Prolog's computation rule is used.

(4 points)

6. 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)

7. Consider the following general logic program:

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

Prove that the program does not have a least Herbrand model.

(4 points)

8. Write a Prolog program that defines a predicate `between(X,Y,Z)` which holds if the arguments are integers and $X \leq Y \leq Z$. Given the goal `:- between(1,N,5)` the program should generate (one-by-one) all integers in the closed interval $1-5$.

(4 points for a reasonable program)

9. Consider the immediate consequence operator T_P of a definite program P. Prove that an Herbrand interpretation I cannot be a model of P unless $T_P(I) \subseteq I$.

(4 points)