Försättsblad till skriftlig tentamen vid Linköpings Universitet

Datum för tentamen	2010-04-06
Sal (1) Om tentan går i flera salar ska du bifoga ett försättsblad till varje sal och ringa in vilken sal som avses	
Tid	8-12
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.	9:30
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 6 April, 2010, 8:00–12:00

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 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. Assume that the standard definition of append/3 is given:

```
append([], Xs, Xs).
append([X|Xs], Ys, [X|Zs]) :- append(Xs, Ys, Zs).
```

Define each of the following relations using exactly one definite clause (i.e. you are not allowed to use disjunction or negation):

`last(X, List)`	`X` is the last element in `List`.
`member(X, List)`	`X` is a member in `List`.
`copies(List)`	`List` contains several occurrences of some element.
`prefix(L, List)`	`L` is a prefix of `List`.

(4 points for reasonable solutions)

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

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

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

(a) $\forall X(p(X) \leftrightarrow q(X,X))$.
(b) $\forall X(p(X) \vee \exists Y q(Y,X))$.
(c) $\exists X \forall Y(p(X) \wedge q(X,Y))$.
(d) $\forall X \exists Y(q(X,Y) \rightarrow p(Y))$.

(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 Prolog program:

```
p(X) :- q(X), r(X).        %  (*)
p(X) :- q(X).
q(X) :- s(X).
q(X) :- t(X).
r(X) :- t(X).
r(X) :- u(X).
s(a).
t(b).
u(c).
```

In what places in the clause marked `(*)` can we put a cut so that only one solution to the goal `:- p(X)` is found?

(4 points)

6. Consider the following general program:

$p(X) \leftarrow \neg q(X)$.
$q(X) \leftarrow \neg r(X)$.
$q(X) \leftarrow s(X), t(X)$.
$r(X) \leftarrow u(X)$.
$r(X) \leftarrow t(X)$.
$s(f(X)) \leftarrow t(X)$.
$t(a)$.

Draw the SLDNF-forest of the goal $\leftarrow p(X)$ given that Prolog's computation rule is used.

(4 points)

7. Every definite program P has a least Herbrand model M_P. Let $\Im$ be a Herbrand interpretation of P such that $M_P \subseteq \Im$. Is it true that $\Im$ must be a Herbrand model of P? Provide a proof or a counter-example.

(4 points)

8. Write a Prolog program that defines a predicate `between(X,Y,Z)` which holds if the arguments are integers and $\mathtt{X} \leq \mathtt{Y} \leq \mathtt{Z}$. 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. A Datalog program P is a definite program without any function symbols. That is, terms are either constants or variables. Demonstrate that there must be some natural number n such that

$$T_P^n(\emptyset) = T_P^{n+1}(\emptyset).$$

(4 points)