Försättsblad till skriftlig tentamen vid Linköpings Universitet

Datum för tentamen	2013-10-25
Sal (1) Om tentan går i flera salar ska du bifoga ett försättsblad till varje sal och ringa in vilken sal som avses	U15
Tid	8-12
Kurskod	TDDD08
Provkod	TEN1
Kursnamn/benämning **Provnamn/benämning**	Logikprogrammering Skriftlig tentamen
Institution	IDA
Antal uppgifter som ingår i tentamen	10
Jour/Kursansvarig Ange vem som besöker salen	Włodek Drabent
Telefon under skrivtiden	(013 28) 89 29
Besöker salen ca kl.	8.40 och 10.00
Kursadministratör/kontaktperson (namn + tfnr + mailaddress)	Liselotte Lundberg 281278 liselotte.lundberg@liu.se
Tillåtna hjälpmedel	Ett papper med valfria anteckningar – 1 sida A4 eller 2 sidor A5. Anteckningarna ska signeras och bifogas tentamen vid inlämnandet.
Övrigt	
Vilken typ av papper ska användas, rutigt eller linjerat	rutigt
Antal exemplar i påsen	

Exam in TDDD08 Logic Programming

Friday 2013-10-25, 8:00-12:00, U15

Means of assistance (hjälpmedel): A sheet of notes – 2 sided A5 or 1 sided A4. The notes should be signed in the same way as the exam sheets and returned together with the exam.

You may answer in English or Swedish.

Grade limits: 3: 18 p, 4: 24 p, 5: 30 p (for total 36 p).

Remember to give motivations to all answers!

GOOD LUCK!

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1. Determine which of the following pairs of terms that are unifiable, and provide a most general unifier (mgu) in case there is one.

   a) $p(f(X), g(X,Y))$
      $p(f(Z), g(V, f(V)))$

   b) $q(X, Z, g(X), Z)$
      $q(f(Y), g(Y), g(f(a)), g(f(a)))$

   c) $p([X|Y], f(Y))$
      $p([Z], f(Z))$

   d) $q(X, f(W,V), W)$
      $q(f(Y,Z), Y, f(a,Y))$

   (4 points)

2. Write a logic program defining a predicate `palindrome/1` which is true if the argument is a list which is a palindrome.

   A palindrome is a list which is the same after reversal, i.e. $[e_1, \ldots, e_n]$ where $n \geq 0$ and $e_{1+i} = e_{n-i}$ for $i = 0, \ldots, n-1$.

   For a full score your program should work in linear time with respect to the length of the list. (4 points)

3. Assume that a tree (represented by a term) is either a leaf *nil*, or a node with two subtrees: $n(\mathit{Value}, \mathit{Subtree}_1, \mathit{Subtree}_2)$. Write a program that replaces all the *Values* in the tree by the rightmost *Value* in the tree.

   The rightmost value can be defined as follows: The rightmost value of a tree $n(\_, \_, \mathit{Subtree}_2)$ is the rightmost value of $\mathit{Subtree}_2$ if $\mathit{Subtree}_2$ is not *nil*; the rightmost value of $n(V, \_, \mathit{nil})$ is V; tree *nil* does not have its rightmost value.

   For a full score your program should traverse a tree only once, and should not use negation. You should describe the relation defined by each predicate; an informal description is sufficient.

   Hint: here is a program that replaces all the *Values* in the nodes by a single term.

```
% rep(T1,V,T2) - T2 is T1 with the value in each node
%                 replaced by V.
rep( nil, _, nil ).
rep( n(_,L,R), V, n(V,L1,R1) ) :-
        rep( L, V, L1 ), rep( R, V, R1 ).
```

(5 points)

4. Consider the following definite program P:

$$q(f(a)).$$
$$q(f(X)) \leftarrow q(Y), r(Y,X).$$
$$r(f(X), g(X)).$$
$$r(X,Y) \leftarrow q(g(X)), r(Y,X).$$

Assume that the vocabulary $\mathcal{A}$ contains one constant a and two function symbols f, g. What is the Herbrand universe $\mathbf{U}_{\mathcal{A}}$ corresponding to $\mathcal{A}$?

Give two atoms (atomic formulae) which are logical consequences of P, but are not instances of the unary clauses of P. Does there exist such atom which is nonground?

Provide the set $PTR(P)$ of atomic logical consequences of P. Alternatively, provide the least Herbrand model of P.

(5 points)

5. For the previous program and a chosen query build two SLD-trees (using different selection rules) – one finite and one infinite.

(2 points)

6. The program

$$split([\,],[\,],[\,]).$$
$$split([X|Xs],[X|Ys],Zs) \leftarrow split(Xs,Zs,Ys).$$

is intended to split a list into two lists of similar lengths. Describe (informally) the relation defined by the predicate split/3. What is the difference between the lengths of the two produced lists? Provide a formal specification describing these lengths and prove that the program is correct w.r.t. this specification.

(4 points)

7. Translate the following DCG into a Prolog program (using a standard approach)

```
a(0,M) --> b(M).
a(f(N),M) --> [0], a(N,M).
b(M) --> [1], a(M).
b(M) --> [1].
```

Show that $[0,0,1]$ is a member of the language of $a(f^2(0), f^2(0))$, by presenting a successful SLD-derivation. (Here $f^2(0)$ abbreviates $f(f(0))$.)

(4 points)

8. Is this Prolog program tail recursive? Consider initial queries of the form $perm(l, X)$ where l is a ground list.

$$
\begin{array}{l}
perm([\,],[\,]).\\
perm(Xs,[Z|Zs]) \text{ :- } select(Z, Xs, Ys), perm(Ys, Zs).\\
select(X,[X|Xs],Xs).\\
select(X,[Y|Ys],[Y|Zs]) \text{ :- } select(X, Ys, Zs).
\end{array}
$$

(1 point)

9. Consider the following general program (the subset program from the lectures, with abbreviations: s for subset, ns for non-subset, and m for member).

$$
\begin{array}{l}
s(L, M) \leftarrow \neg ns(L, M).\\
ns(L, M) \leftarrow m(X, L), \neg m(X, M).\\
m(X,[X|L]).\\
m(X,[Y|L]) \leftarrow m(X, L).
\end{array}
$$

Draw an SLDNF-forest for query $Q = s([V, W], [a, b, c])$. (The choice of the selection rule is yours.) Mark which trees are finitely failed, which leaves are floundered, which branches are successful derivations, and what are their answers (or answer substitutions).

Use the fact that the SLD-tree for a query $m(Z, [t_1, \ldots, t_n])$, where $[t_1, \ldots, t_n]$ is a ground list, is finite and has n ground answers. (When such a tree appears in your forest just draw its root and mention the answers.)

Which results would Prolog produce for query Q (with $\neg$ implemented as \+)?

(4 points)

10. Choose three from the notions below and explain them.

Your explanation should be short but precise, and should show that you understand the notions. The chosen notions should not be explained in your sheet of notes.

(a) Herbrand interpretation.

(b) Logical consequence (of a set of formulae).

(c) Answer (i.e. correct answer) of a definite clause program.

(d) Proof tree.

(e) Least Herbrand model.

(f) Specification.

(g) Correctness (of a program).

(h) Completeness (of a program).

(i) Solution of a constraint.

(j) Closed world assumption (CWA).

(3 points)