Exercise 1 – Logic Programming – First Term 2009/2010
Deadline: October 5th, 2009, 10.00 WIB at the latest
Submit your paper in the envelope on the door of of R.1203. Late submission will not be accepted.

1. [2+3+2+3=10 points] Given the following description: "The traffic is jammed either if an accident occurred or there are too many private cars on the road. There are too many private cars on the road if car is the most preferred means of transportation. Private car is the most preferred means of transportation whenever public transport is insecure and its capacity is inadequate."

   (a) Write the above description using propositional logic.

   (b) Translate the formula you obtained in (a) into Prolog clauses. Specify also the fact that public transport is insecure and its capacity is inadequate. Note: your program should be ground since it is derived from the translation of propositional logic formulae.

   (c) Give a Prolog query to answer whether the traffic is jammed or not.

   (d) Show the Prolog tree for that query.

2. [4+6=10 points] A natural number can be represented using an atom together with a structure: atom `nil` is used to represent the natural number 0, whereas unary functor `s` is used to construct structures that represent positive natural numbers, i.e. `s(nil)` for 1, `s(s(nil))` for 2, and so on. Using this representation:

   (a) Define a Prolog predicate `more(X,Y)` to test whether a natural number `X` is more than another natural number `Y`. An example of query:

   ```
   ?- more(s(s(nil)), s(nil)).
   Yes.
   ```

   (b) Define a Prolog predicate `divisible_by_4(X)` to test whether a natural number is divisible by 4. An example of query:

   ```
   ?- divisible_by_4(s(s(s(s(nil))))).
   Yes.

   ?- divisible_by_4(s(s(s(s(s(nil)))))).
   No.
   ```

3. [10+10+10=30 points] Use the Martelli-Montanari algorithm *step by step* to unify the following pairs of terms with variables `X`, `Y` and `Z`. For each step, indicate which rule you have used.

   (a) `f(g(Y),X,g(g(a)))` and `f(X,g(g(Z)),g(Z))`

   (b) `f(g(h(a)),g(X),h(a))` and `f(g(h(Y)),Z,h(a))`

   (c) `f(Y,g(X),Z)` and `f(g(g(X)),g(g(Z)),Y)`

4. [5+5+10+10+10=50 points] Consider the following Prolog program P that defines a part of animal taxonomy.

   ```
   % Facts is_member_of/2 represent the fact that
   % an animal class is a member of a larger class.

   is_member_of(aves,animalia).
   is_member_of(mammalia,animalia).
   is_member_of(primata,mammalia).
   is_member_of(hominidae,primata).

   % Rules is_part_of/2 define the generalization of is_member_of/2

   is_part_of(X,Y) :- is_member_of(X,Y).
   is_part_of(X,Y) :- is_member_of(X,Z), is_part_of(Z,Y).
   ```

Answer the following questions:

(a) Give the Herbrand universe $U(P)$ of P.

(b) Give the Herbrand base $B(P)$ of P.

(c) Give an interpretation I, that is also a model of P.

(d) Show by using the consequence operator T_P, that I is indeed a model of P.

(e) Give the declarative meaning of P by computing $T_P \uparrow \omega$.

(f) Give the procedural meaning of P by showing the Prolog tree that covers all the solutions of the query: `is_part_of(X,animalia).` Give also all possible instantiations for `X` derived from the Prolog tree.