NAME:
CONTACT PERSON AT K.U.LEUVEN (IN CASE OF ERASMUS STUDENTS):

Examination of
Programming languages and Programming Methodologies
13 January 2017, 9h00 – 13h00

General Guidelines

The examination is **closed book** and takes (at most) 4 hours.
Make sure that your handwriting is **readable**.
Write your name on every sheet you hand in. Write on **one** side of the sheet only.

Questions

1. Do the following Prolog queries succeed or fail? In case of success, give the bindings of the variables in the query. In case of failure, explain why.

   1) `?- [X | T] = [ [Z,4], [b, X] ].`
   2) `?- g(3 + Y, 7) = g(A, B), Y = 4, A = B .`
   3) `?- X = L - T, L = [a, [b, [1,2]]| T], L = [a,B].`
   4) `?- X = [1 | Y], Z = [Y | 1], Z = X.`

2. Consider the following Prolog program.

```
drop(_E,[],[]).
drop(X,[X|T1],T2) :- drop(X,T1,T2).
drop(X,[H|T1],[H|T2]) :- drop(H,T1,T2).
```

   Do the following queries succeed or fail? Sketch their execution by Prolog (e.g. by giving an execution tree). In case of success, indicate how many times it succeeds and give the bindings of the variables (if any) in the query. In case of failure, explain why.

   1) `?- drop(1,[2,3,3],P).`
   2) `?- drop(1,[1,1],P).`

3. The week before the Christmas break was made varied by a series of special lectures, one each day (Monday through Friday). The lectures had the following topics: bioinformatics, physical hygiene, modern art, nutrition, and study habits. The lecturers were two women named Alice and Bernadette, and three men named Charles, Duane, and Eddie. The last names of the lecturers were Felicidad, Garber, Haller, Itakura, and Jeffreys. You also know the following facts:

   1) Alice lectured on Monday.
   2) Charles's lecture on physical hygiene wasn't given on Friday.
   3) Dietician Jeffreys gave the lecture on nutrition.
   4) A man gave the lecture on modern art.
   5) Miss Itakura and the lecturer on proper study habits spoke on consecutive days, in one order or the other.
   6) Haller gave a lecture sometime after Eddie did.
   7) Duane Felicidad gave his lecture sometime before the modern art lecture.

   Write a program to determine for each day the lecturer (first and last name) and the topic. Indicate clearly whether you are using CLP or just normal Prolog. Also indicate which lines in your program are encoding each of the 7 facts.

4. After the exams of January, Ann has the scores of the students for the courses. For example, student Danny obtained a 20 on FAI and a 15 on PLPM, Toon obtained a 18 on PLPM, a 14 on FAI, and a 4 on UAI.

   1) Represent this information in two different ways: by Prolog facts and by Prolog terms. Use your 2 representations to represent the above example.
   2) Define for both representations the predicate `topscore` that determines for a given course the student with the top score. You may assume that for each course there is exactly 1 student with a top score.
      In the above example, Danny is the student with the top score for FAI, whereas for UAI it is Toon.

5. You have a machine with registers r_1 up to r_n, which are organised in a ring, so that you can only copy the contents of a register from

r_i to r_{i+1} for $1 \leq i < n$ and from r_n to r_1, with the instruction *copy*(i) $(1 \leq i \leq n)$. Note that *copy*(i) does not change the contents of register i for $1 \leq i \leq n$. And you can also swap the contents of any two registers, with the *swap*(i, j) instruction where $1 \leq i < j \leq n$. You are given the initial contents of all the registers and the desired final contents of all the registers. We are interested in a sequence of copy/1 and swap/2 instructions that transforms the initial into the final state, or fails if this is impossible.

As an example, consider the initial state where register 1 contains "a", register 2 "b", register 3 'c" and register 4 "d", which we denote by the shorthand **a b c d**, and the final state **a d a b**. A sequence of instructions that effectuates the transition is as follows: first by copy(2) we obtain **a b b d**, next by copy(1) we obtain **a a b d**, next by swap(2,3) we obtain **a b a d**, and finally by swap(2,4) we obtain **a d a b**.

1) Define a data structure to represent a set of **n** registers. Use your representation to represent for the above example with 4 registers, namely **a b a d**.
2) How do you represent a sequence of instructions?
3) Write a predicate that for a given set of registers and a given *copy*(i) instruction $(1 \leq i \leq n)$, computes the resulting set of registers. For example for **a b a d** and copy(2) it should compute **a b b d**.
4) Write a predicate that for a given set of registers and a given *swap*(i, j) instruction $(1 \leq i < j \leq n)$, computes the resulting set of registers.
5) Write a predicate that for a given set of registers generates all the instruction sequences of a given length **l**.
6) Write a predicate that checks whether a given instruction sequence transforms a given initial set of registers into a given final set of registers.
7) Now suppose that you are interested in finding the shortest instruction sequence for transforming an initial set into a final set using iterative deepening. Write a predicate for this.

Good luck.

Gerda Janssens