CLP in SICStus Exercise Sheet 1

Constraint Programming in SICStus

Goals:

– Introduction to Constraint Programming

1. Sets of numbers

a) Implement ***sum_equals_product(+Sup, -A, -B, -C)***, that determines sets of three distinct numbers ***A***, ***B***, and ***C*** between 0 and ***Sup*** such that their sum equals their product.

b) Implement ***three_squares(+Sup, -A, -B, -C)***, that determines sets of three distinct numbers ***A***, ***B***, and ***C*** between 0 and ***Sup*** such that their sum results in a perfect square, and the product of any two numbers, when added to the third one results also in a perfect square. Try to avoid symmetries in the obtained solutions.

For instance, for Sup = 100, the values 4, 12 and 33 are an admissible solution: 4+12+33 = 49 (7^2); 4*12+33 = 81 (9^2); 4*33+12 = 144 (12^2); 12*33+4 = 400 (20^2)

c) Implement ***solve_digits(-A, -B)***, that finds two numbers of three digits each such that:

- The six digits that compose the two numbers are all distinct, and none of them is 0;
- The first digit of B equals half the last digit of A;
- In both numbers, the digits are ordered in an increasing manner;
- The sum of the digits in A equals the sum of the digits in B;
- The multiplication of the digits of A, added to 12, equals to the multiplication of the digits of B.

  For instance, A = 378 and B = 459 is a solution to the problem.

2. Magic Square

A magic square is square of NxN spaces, filled with numbers between 1 and NxN (each number appearing exactly once), such that the sum of the numbers in each of its lines, columns and main diagonals is the same.

a) Solve the 3x3 version of the magic square.

b) Solve the generic NxN version of the problem.

3. Magic Hexagon

The numbers from 1 to 19 can be placed in a hexagonal pattern as the one below, such that the sum of the values in each row and diagonal is the same. Implement ***magic_hexagon(-L)***, which solves the magic hexagon problem, returning the list of values in the order by which they appear in the image below.

```
  A B C
 D E F G
H I J K L
 M N O P
  Q R S
```

4. N-Queens

The N-Queens problem consists of placing N queens on a chessboard with NxN places, in such a way that no one queen is attacking any other queen. A queen attacks another piece if it is located in the same row, columns or diagonal.

a) Solve the 4x4 version of the problem.

b) Solve the generic NxN version of the problem.

5. Cryptograms

A cryptogram is a problem that consists in replacing letters by digits in such a way that the respective operation is valid. A known example is the SEND MORE MONEY problem, as shown below, with the respective solution:

```
    S E N D          9 5 6 7
  + M O R E        + 1 0 8 5
  ---------        ---------
  M O N E Y        1 0 6 5 2
```

Implement the predicates to solve the following puzzles (the first argument of the predicate is a puzzle identifier).

a) `crypto(1, [0,S,E,N,D], [0,M,O,R,E], [M,O,N,E,Y]).`

b) `crypto(2, [D,O,N,A,L,D], [G,E,R,A,L,D], [R,O,B,E,R,T]).`

c) `crypto(3, [0,C,R,O,S,S], [0,R,O,A,D,S], [D,A,N,G,E,R]).`

d) Can you think of two different ways to solve this problem?

e) Implement ***crypto/3*** to solve any generic cryptogram.

6. Sudoku

Sudoku is a popular puzzle, where a 9x9 board is given with some spaced filled. The goal is to fill every space with numbers from 1 to 9, such that there is no repeated number in any line, column or 3x3 block in the board. Implement ***sudoku(Matrix)***, that receives as argument the semi-instantiated matrix, as in the example below, filling the board with the missing values.

```
M =[ [_,7,_,   _,_,1,   _,_,_],          sudoku(M).
     [6,_,_,   2,9,_,   _,_,7],          5 7 3 8 4 1 6 2 9
     [_,_,_,   _,_,5,   _,4,_],          6 4 1 2 9 3 5 8 7
     [1,_,_,   4,3,_,   9,_,_],          8 9 2 7 6 5 1 4 3
     [_,_,7,   _,_,_,   8,_,_],          1 8 6 4 3 7 9 5 2
     [_,_,4,   _,8,2,   _,_,6],          2 3 7 6 5 9 8 1 4
     [_,2,_,   5,_,_,   _,_,_],          9 5 4 1 8 2 7 3 6
     [7,_,_,   _,2,4,   _,_,5],          3 2 9 5 1 6 4 7 8
     [_,_,_,   3,_,_,   _,9,_] ]         7 1 8 9 2 4 3 6 5
                                         4 6 5 3 7 8 2 9 1
```

7. Old purchase invoice

James found an old invoice for the purchase of his small terrain of seventy-two square meters. The unit price is not visible in the invoice, and neither are the first and last digits of the four-digit total price. Knowing only that the total price of the terrain is in the format –67–€, and that both the unit cost and total price are integer numbers, implement a predicate that determines the price per square meter of the terrain.

8. Grocery purchase

John went to the grocery store to buy potatoes, carrots, onions, and spaghetti. The old grocer says the total is 7.11€. John pays and is leaving when the grocer calls him back, saying he made a mistake and multiplied the prices instead of adding them. However, it turns out the result is also 7.11€. Knowing that the prices of two of the products are multiples of 10 cents, onions are the cheapest product, and that spaghetti was more expensive than the carrots, which were more expensive than the potatoes, what was the price of each product?

9. Inherited cellar

Three brothers inherited a cellar from their uncle Donald. The older brother was entitled to 5/12 of the bottles; the middle one to 30% of the bottles; and the third one to the remaining 187 bottles. Implement a predicate to determine the total amount of bottles in the cellar.

10. Detergent Poll

A detergent is sold in liquid form and as powder. A poll was conducted to determine the preferred type. Based on the known facts below, how many people were inquired in total?

- A third of the inquired people do not use powder;
- Two sevenths of the inquired people do not use liquid;
- 427 people use both liquid and powder;
- A fifth of the inquired people don’t use the product at all.

11. Zebra Puzzle

This a traditional type of logic problem. There are five different houses in a row. In each house lives a person of different nationality, with a favorite drink, cigar brand and animal. We know the following about the houses:

- The Englishman lives in the red house.
- The Spanish has a dog.
- The Norwegian lives in the first house from the left.
- The owner of the yellow house smokes Marlboro.
- The man who smokes Chesterfields lives in the house next to the man who has a fox.
- The Norwegian lives next to the blue house.
- The man who smokes Winston has an iguana.
- The man who smokes Luky Strike drinks orange juice.
- The Ukrainian drinks tea.
- The Portuguese smokes SG Lights.
- The man living in the house next to the one where there is a horse smokes Marlboro.
- The favorite drink of the man who lives in the green house is coffee.
- The green house is immediately to the right of the white house.
- The man living in the house in the middle drinks milk.

In which house does the zebra live? In which house does the man drink water?

12. Car line

Four cars, painted yellow, green, blue and black, with four different sizes, are waiting at a traffic light. We know that the car immediately behind the blue car is smaller than the car immediately in front of the blue car; the green car is the smallest; the green car is ahead of the blue car; the yellow car is ahead of the black car. What is the color of the first car in line?