Homework 4 (Relational Modeling)
Due Date: Feb 22, 2000

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Question 1 (30 points):
Part a: Express the relations given in Figure 1 using the relations given in class and operators (of course!). Please give a short justification for your answer.
Part b: Let `CousinsFatherSide`(n), `CousinsMotherSide`(n), and `Cousins`(n) be the set of cousins that are separated by n-steps on the father's side, mother's side, and father or mother's side. Write a recursive expression for these relations, i.e., express the relations with parameter n in terms of relations with parameter $n-1$ and the the basic relations introduced in the class.

Question 2 (20 points): Establish whether the following equations between relations are true or not. Please justify your answer. You should enter these equations in *ladybug* and play around with them. Assume that the relations have appropriate types.

$$(P;Q)^{\top} = Q^{\top};P^{\top}$$
$$(P \subseteq Q) \Rightarrow (P;P \subseteq Q)$$
$$(Q \neq \emptyset) \Rightarrow (\texttt{Un};Q;\texttt{Un} = \texttt{Un})$$

`Note`: The symbol $\emptyset$ denotes the empty relation.

Question 3 (50 points): In this question you will write a specification for

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FatherInLaw : People $\leftrightarrow$ Males
SisterInLaw : People $\leftrightarrow$ Females
FirstCousinsFatherSide : People $\leftrightarrow$ People
FirstCousinsMotherSide : People $\leftrightarrow$ People
FirstCousins : People $\leftrightarrow$ People
SecondCousinsFatherSide : People $\leftrightarrow$ People
SecondCousinsMotherSide : People $\leftrightarrow$ People
SecondCousins : People $\leftrightarrow$ People

Figure 1: Some relations

the problem described. Our aim is to model a library. There are two types PERSONS and BOOKS. There is a function issued : BOOKS $\rightarrow$ PERSONS and a set Library : *Set* BOOKS. If book b is issued to person p, then issued$(b) = p$. Library represents the set of books in the library. There is also a set of books on reserve given by the set Reserve : *Set* BOOKS. The operations are:

- *Issue a book*
  This operation issues a book to a person. A book on reserve or already issued cannot be issued.

- *Return a book*
  This operation models the act of a person returning a book.

- *Adding a book to the library*
  This operations models a new book being added to the library.

- *Putting a book on reserve*
  This operations models a book being put on reserve. A book which is currently issued cannot be put on reserve.

- *Taking a book of reserve*
  This operation models a book being taken off reserve.

The claims are:

- Issuing a book and then returning it results in the same state.

- If a book is on reserve, it should never be issued. This claim should be true before and after every operation.

Part a: Write a mathematical description for all the operations and claims and explain your answer.
Part b: Now write the specification in *ladybug*.