Programming Languages I:G221.2110
HW 4, November 20 1995

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Due in **two** weeks

Note:
You are required to include a printout of a session showing a run of your program on some general testdata.

Problem 1. [2pts] Write a Common Lisp function called `POWERSET` that takes a set and computes the power set of that set. Recall that a power set of a set S is the set of all subsets of S:

$$\texttt{POWERSET}(S) = \{T : T \subseteq S\}.$$

```
(POWERSET '())              ==>     (())
(POWERSET '(A B))           ==>     (() (A) (B) (A B))
```

Problem 2. [8pts] In this problem you will write some functions to operate on a genealogy database represented as LISP property list. The test file will create many father and mother properties on symbols that name various people. For the purposes of the examples given here, assume that:

The `FATHER` property of `GEORGE` is `FRED`.
The `FATHER` property of `FRED` is `EDWARD`.
The `MOTHER` property of `GEORGE` is `JANE`.
The `MOTHER` property of `JANE` is `VIRGINIA`.
The `FATHER` property of `VIRGINIA` is `ARTHUR`.
The `MOTHER` property of `ALEX` is `SHARON`.
The `MOTHER` property of `BUFFY` is `SHARON`.
The `MOTHER` property of `ELLEN` is `BUFFY`.
The `MOTHER` property of `SHARON` is `VIRGINIA`.

(a) Write a function named `ANCESTORS` that takes the name of a person and traces all `FATHER` and `MOTHER` properties recursively to find all ancestors of the given person. The result should be a list of pairs, where each pair is a list of the name of an ancestor and the *distance* of that ancestor from the original person. A parent is at distance 1, a grandparent at distance 2, and so on. The given person should be considered to be his own ancestor at distance 0. The order of the pairs within the list doesn't matter. For example, the result of
`(ANCESTOR GEORGE)`
might be

```
((FRED 1) (EDWARD 2) (JANE 1) (VIRGINIA 2) (GEORGE 0) (ARTHUR 3))
```

(b) Write a function `INSTALL-CHILDREN` that takes the name of a person and recursively traces all `FATHER` and `MOTHER` properties of that person. For every child-parent pair observed during this recursive trace, the child should be added to the `CHILDREN` property of the parent, which is a list of names; but the child should not be added to the list if already present. As an example, after the two calls
`(INSTALL-CHILDREN 'GEORGE)` and `(INSTALL-CHILDREN 'BUFFY)`,
one should have the following situation:

The CHILDREN property of FRED is (GEORGE).
The CHILDREN property of EDWARD is (FRED).
The CHILDREN property of JANE is (GEORGE).
The CHILDREN property of VIRGINIA is (SHARON JANE).
The CHILDREN property of ARTHUR is (VIRGINIA), and not (VIRGINIA VIRGINIA).
The CHILDREN property of SHARON is (BUFFY).

(c) Write a function named COUSIN-TEST, which takes the names of two persons and determines whether they are *generalized cousins*. Two people are generalized cousins if one is an ancestor of another or they share a common ancestor. If this happens, there will be a *most recent common ancestor*. In the example above, ARTHUR is a common ancestor of GEORGE and ELLEN, but not the most recent common ancestor, because both chains of ancestry go through VIRGINIA, who is the most recent common ancestor.

Suppose persons a and b are generalized cousins by most recent common ancestor c. Let d_{ac} be the distance of c from a, and let d_{bc} be the distance of c from b. Then the *cousin number* $C_{ab/c}$ and the *removedness number* $R_{ab/c}$ are defined to be

$$C_{ab/c} \equiv \min(d_{ac}, d_{bc}) - 1 \quad \text{and} \quad R_{ab/c} \equiv |d_{ac} - d_{bc}|.$$

In our example, the distance from GEORGE to VIRGINIA is 2 and the distance from ELLEN to VIRGINIA is 3; so the cousin number is $\min(2,3) - 1 = 1$ and the removedness number is $|2 - 3| = 1$, meaning GEORGE and ELLEN are first cousin once removed. Further examples, people with common grandparents are first cousins (not at all removed); people with common great-grand parents are second cousins (not at all removed); an uncle or an aunt is a zeroth cousin once removed; a brother or a sister is a zeroth cousin (not at all removed); a great-uncle or a great-aunt is a zeroth cousin twice removed.

If two people are not cousins in any way, COUSIN-TEST should return NIL. If they are cousins, however, COUSIN-TEST should return a list two numbers—the cousin number and the removedness number.

(Notice that it is possible for two people to be cousins in more than one way, if cousins marry. In this case, there will be more than one "most recent" common ancestor, and you must choose the "best" one in some sense.)