This problem reflects the philosophy that one learns fastest and best by doing. In this problem, you will be asked to run a given LISP program and observe and describe its behavior.

For this exercise, we will need two LISP data structures, tree1 (a binary tree), and tree2 (a general tree):

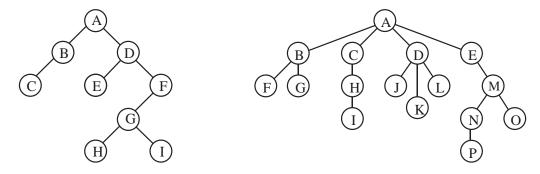


Figure 1: tree1

Figure 2: tree2

We will represent these two trees in LISP parenthesized notation. To begin this exercise type lisp into the command shell. At this point, you will be talking to LISP.

Next, set up this exercise by typing the following five s-expressions:

```
Define tree1:
```

```
(setq tree1 '(a (b (c nil nil) nil) (d (e nil nil)
              (f (g (h nil nil) (i nil nil)) nil)))
 )
Define tree2:
 (setq tree2 '(a (b (f) (g)) (c (h (i))) (d (j) (k) (1))
              (e (m (n (p))(o)))
Define function searchb:
 (defun searchb (tree node)
     (cond ((null tree) nil)
           (t (or (eq (car tree) node)
                   (searchb (cadr tree) node)
                   (searchb (caddr tree) node)))))
Define function searcht:
 (defun searcht (tree node)
     (cond ((null tree) nil)
           (t (or (eq node (car tree))
                   (searchsons (cdr tree) node)))))
```

Define functions searchsons:

Next, turn on the function trace mechanism for the tree functions so that you may observe the sequence of function calls which are about to occur, as well as the function values:

```
(trace searchb searcht searchsons)
```

You are now ready to run searchb on tree1 and searcht on tree2. Type:

```
(searchb tree1 'g)
```

and pause to observe the trace output. Then do the same for:

```
(searchb tree1 'x)
(searcht tree2 'k)
(searcht tree2 'x)
```

Finally, either exit LISP by typing:

```
(exit)
```

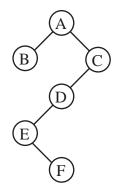
or stick around and play with LISP a while. If you ever get yourself into a state you don't understand, type:

```
^D (control D)
```

until you get to the top level and then exit to the system.

Now for the fun part: the actual problem questions. You may write your answers on the output listing you have obtained. Turn in both the listing and your written answers.

- 1. Describe the notation used to represent binary tree tree1 in LISP parenthesized notation. Write the binary tree in Figure 3 in this notation.
- 2. Describe the notation used to represent the general tree tree2 in LISP. Write the tree in Figure 4 in this notation.
- 3. What does searchb do? Identify the recursion relations and the termination test.
- 4. What does searcht do? Identify the recursion relations and the termination test.
- 5. What does searchsons do? At entry, what is sonlist?
- 6. Why is it necessary to have two distinct recursive functions, searcht and searchsons, to process general tree tree2, while only one recursive function, searchb, is required to process tree1? Draw a simple picture illustrating who calls who in the processing of tree2.



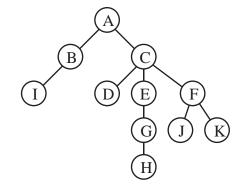


Figure 3: A binary tree

Figure 4: A general tree

7. searchb, searcht and searchsons are really predicates in that they return a logical value, either t or nil. Suppose we want searchb to return a pointer to some part of the binary tree where it now returns only t. What would the appropriate value to return be? Write a modified searchb, searchb1, which would return such a pointer. Run this function if you have time and show its output for some example.