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):

![Tree Diagrams](image)

**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:

```lisp
(setq tree1 '(a (b (c nil nil) nil) (d (e nil nil) (f (g (h nil nil) (i nil nil)) nil)))
)
```

Define tree2:

```lisp
(setq tree2 '(a (b (f) (g)) (c (h (i))) (d (j) (k) (l))
            (e (m (n (p))(o))))
)
```

Define function searchb:

```lisp
(defun searchb (tree node)
  (cond ((null tree) nil)
         (t (or (eq (car tree) node)
                (searchb (cadr tree) node)
                (searchb (caddr tree) node)))))
```

Define function search:

```lisp
(defun search (tree node)
  (cond ((null tree) nil)
         (t (or (eq node (car tree))
                (search (cdr tree) node)))))
```
Define functions searchs\textit{ons}:

\begin{verbatim}
(defun searchs\textit{ons} (sonlist node)
  (cond ((null sonlist) nil)
         ((search (\text{car} sonlist) node) t)
         (t (searchs\textit{ons} (\text{cdr} sonlist) node))))
\end{verbatim}

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:

\begin{verbatim}
(trace search\text{b} search searchs\textit{ons})
(pp search\text{b} search searchs\textit{ons} tree1 tree2)
\end{verbatim}

You are now ready to run \text{search\text{b}} on tree\text{1} and \text{search} on tree\text{2}. Type:

\begin{verbatim}
(search\text{b} tree1 'g)
\end{verbatim}

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

\begin{verbatim}
(search\text{b} tree1 'x)
(search\text{b} tree2 'k)
(search\text{b} tree2 'x)
\end{verbatim}

Finally, either exit LISP by typing:

\begin{verbatim}
(exit)
\end{verbatim}

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

\begin{verbatim}
^D (control D)
\end{verbatim}

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 \textit{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 \textit{tree2} in LISP. Write the tree in Figure 4 in this notation.

3. What does \textit{search\text{b}} do? Identify the recursion relations and the termination test.

4. What does \textit{search} do? Identify the recursion relations and the termination test.

5. What does \textit{searchs\textit{ons}} do? At entry, what is \textit{sonlist}?
6. Why is it necessary to have two distinct recursive functions, `search` 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`.

7. `searchb`, `search` 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.