Data Structures

Fall 2019, Programming # 1

Due: January 3, 2020

A binary tree can be easily represented in the following way. Start with the root. If there are any children, list them in parentheses. Use - (a dash) for a child that is missing; however do not display a dash or parentheses for a leaf. For example, the tree in Figure 1 is represented as 9(5(3(2 4)7(6 −))13).

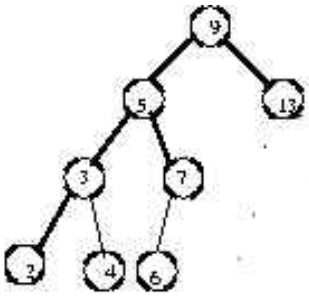

Figure 1: Binary tree represented by 9(5(3(2 4)7(6 -))13)

Suppose we want to support textual printing of the values in the trees. In order to accomplish this, we will logically assign an (x, y) coordinate to each tree node. It is appropriate for the x-coordinate of the node to be proportional to the in-order traversal number of the node in the tree, and for the y-coordinate of the node to be proportional to the the depth of the node in the tree. Therefore, we will need member variables to store these values, and routines to compute the in-order traversal number and depth of each node in the tree (you may choose what to name these). For example, printing the binary search tree 12(- 15(- 76(23 99))) yields

```
12
  15
     76
   23   99
```

Figure 2: Binary tree represented by 12(- 15(- 76(23 99)))

Now consider a binary tree shown in Figure 3, if we look at the tree from the left side, all the nodes you can see will be the sequence 5 10 20 45, which is called the *left boundary* of the tree.

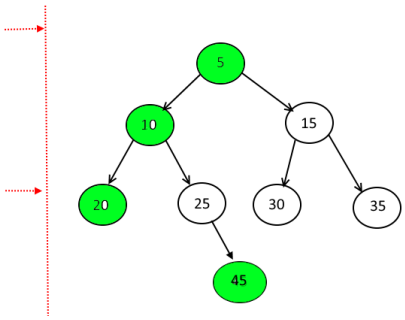

Figure 3: A binary tree whose left boundary is 5 10 20 45.

Things to do

Given a sequence of keys S, insert elements of S into an initially empty

1. "standard" binary search tree, and
2. splay tree [1]

in the given order. Let the resulting trees be $T_{standard}$ and T_{splay}, respectively. Then carry out the following:

(1) Output the parenthesis representation of tree T,

(2) Print T in the way mentioned above, and

(3) Output the left boundary of T.

For example, if $S =$ 12 15 76 23 99, $T_{standard}$ will be the tree resulting from an insertion of 12, followed by an insertion of 15, etc. For $T_{standard}$, the outputs of (1)-(3) above will be

1. 12(- 15(- 76(23 99)))
2. Figure 2
3. 12 15 76 23

In this assignment, read from an input file "tree.txt" in which each line consists of a sequence of numbers to be inserted into an initially empty standard binary search tree. Repeat (1)-(3) above for both $T_{standard}$ and T_{splay} for each line in the file.

[1] To do an insertion in a splay tree, insert the new node to the appropriate position (a leaf) first, then splay the inserted node.