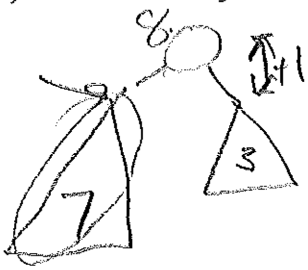
b) If `myTree` is the `BinaryTree` object for the expression: ((4 + 5) * 7), what gets printed by a calls to:

`myTree.inorder()`	`myTree.preorder()`	`myTree.postorder()`	`inorder(myTree)`
4\n	*\n	4	
+\n	+\n	5	
5\n	4\n	+	
*\n	5\n	7	
7\n	7\n	*	

c) If `myTree` is the `BinaryTree` object for the expression: ((4 + 5) * 7), what gets printed by a call to `myTree.printexp()`?

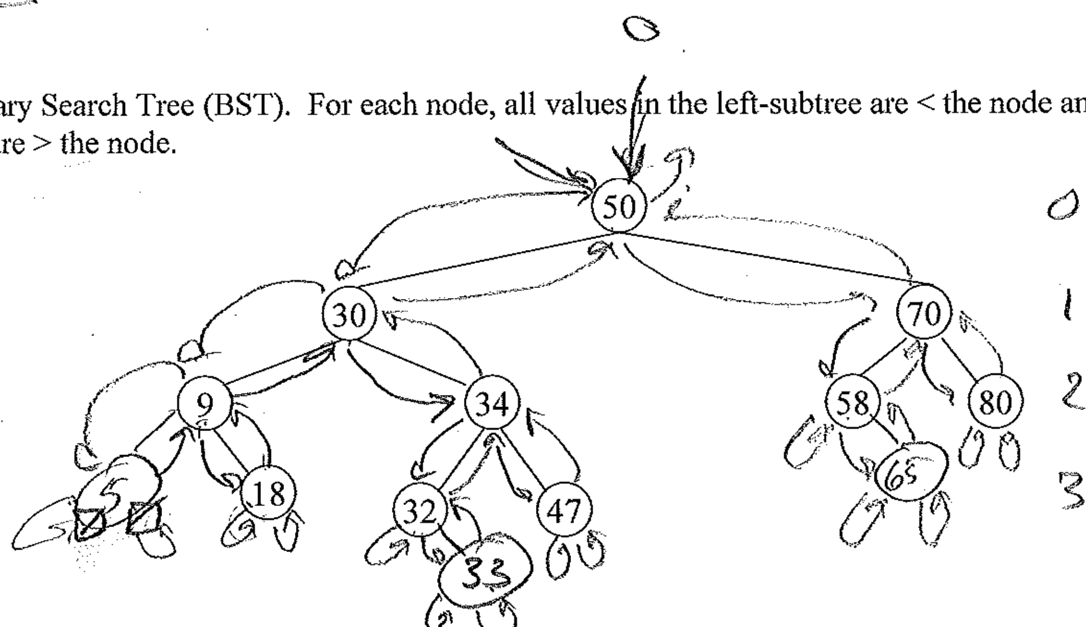
d) If `myTree` is the `BinaryTree` object for the expression: ((4 + 5) * 7), what gets returned by a call to `myTree.postordereval()`?

e) Write the `height` method for the `BinaryTree` class.



1 + max(height left subtree, height right subtree

4. Consider the Binary Search Tree (BST). For each node, all values in the left-subtree are < the node and all values in the right-subtree are > the node.



a. What is the order of node processing in a preorder traveral of the above BST?
50, 30, 9, 5, 18, 34, 32, 33, 47, 70, 58, 65, 80

b. What is the order of node processing in a postorder traveral of the above BST?
5, 18, 9, 33, 32, 47, 34, 30, 65, 58, 80, 70, 50

c. What is the order of node processing in a inorder traveral of the above BST? 5, 9, 18, .. , 80

d. Starting at the root, how would you find the node containing "32"?
right of 50, left of 30, right of 34

e. Starting at the root, when would you discover that "65" is not in the BST?
Walk down branch until at 58 and seeing that 58 has no right child

f. Starting at the root, where would be the "easiest" place to add "65"?
As right child of 58

g. Where would we add "5" and "33"? see above

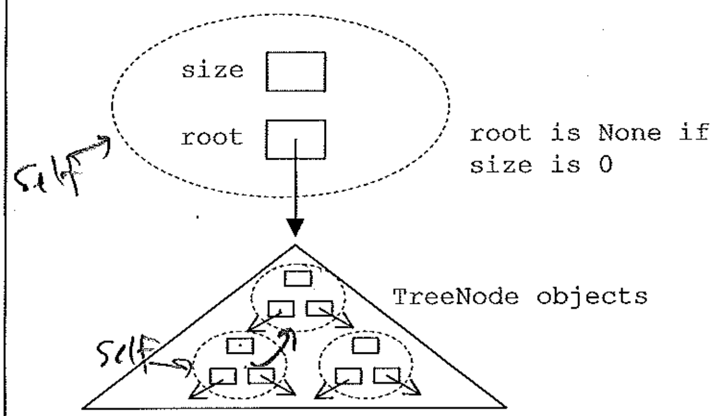
1. Consider the partial TreeNode class and partial BinarySearchTree class.

```
class TreeNode:
   def __init__(self,key,val,left=None,right=None,
                                              parent=None):
        self.key = key
        self.payload = val
        self.leftChild = left
        self.rightChild = right
        self.parent = parent

    def hasLeftChild(self):
        return self.leftChild

    def hasRightChild(self):
        return self.rightChild

    def isLeftChild(self):
        return self.parent and \
               self.parent.leftChild == self

    def isRightChild(self):
        return self.parent and \
               self.parent.leftChild == self

    def isRoot(self):
        return not self.parent

    def isLeaf(self):
      return not (self.rightChild or self.leftChild)

    def hasAnyChildren(self):
        return self.rightChild or self.leftChild

    def hasBothChildren(self):
        return self.rightChild and self.leftChild

    def replaceNodeData(self,key,value,lc,rc):
        self.key = key
        self.payload = value
        self.leftChild = lc
        self.rightChild = rc
        if self.hasLeftChild():
            self.leftChild.parent = self
        if self.hasRightChild():
            self.rightChild.parent = self

    def __iter__(self):
       if self:
          if self.hasLeftChild():
             for elem in self.leftChild:
                yield elem
          yield self.key
          if self.hasRightChild():
             for elem in self.rightChild:
                yield elem
```

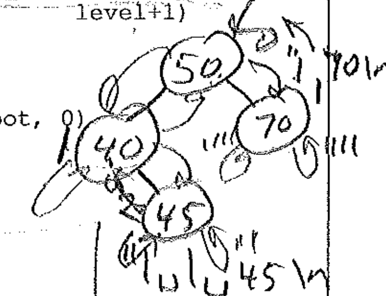
recursive call to __iter__ for left subtree

recursive call for right subtree

A BinarySearchTree object




```
class BinarySearchTree:
  def __init__(self):
      self.root = None
      self.size = 0

  def length(self):
      return self.size

  def __len__(self):
      return self.size

  def __iter__(self):
      return self.root.__iter__()

  def __str__(self):
   """Returns a string representation of the tree
      rotated 90 degrees counter-clockwise"""

    def strHelper(root, level):
       resultStr = ""
       if root:
          resultStr += strHelper(root.rightChild,
                                 level+1)
          resultStr += "|  " * level
          resultStr += str(root.key) + "\n"
          resultStr += strHelper(root.leftChild,
                                 level+1)

       return resultStr

   return strHelper(self.root, 0)
```



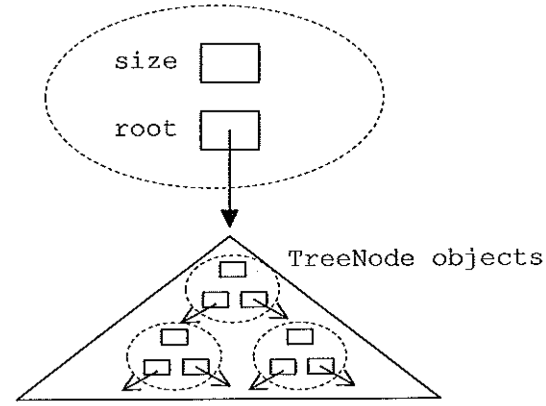
| 70\n
50\n
| | 45\n
| 40\n

a) How do the BinarySearchTree __iter__ and __str__ methods work?

More partial TreeNode class and partial BinarySearchTree class.

```
class BinarySearchTree:
    . . .
    def __contains__(self,key):
        if self._get(key,self.root):
            return True
        else:
            return False

    def get(self,key):
        if self.root:
            res = self._get(key,self.root)
            if res:
                return res.payload
            else:
                return None
        else:
            return None

    def _get(self,key,currentNode):
        if not currentNode:
            return None
        elif currentNode.key == key:
            return currentNode
        elif key < currentNode.key:
            return self._get(key,currentNode.leftChild)
        else:
            return self._get(key,currentNode.rightChild)

    def __getitem__(self,key):
        return self.get(key)

    def __setitem__(self,k,v):
        self.put(k,v)

    def put(self,key,val):
        if self.root:
            self._put(key,val,self.root)
        else:
            self.root = TreeNode(key,val)
        self.size = self.size + 1

    def _put(self,key,val,currentNode):
        if key < currentNode.key:
            if currentNode.hasLeftChild():
                self._put(key,val,currentNode.leftChild)
            else:
                currentNode.leftChild = TreeNode(key,val,parent=currentNode)

        elif key > currentNode.key:
            if currentNode.hasRightChild():
                self._put(key,val,currentNode.rightChild)
            else:
                currentNode.rightChild
                    = TreeNode(key,val,parent=currentNode)

        else:
            currentNode.payload = val
            self.size -= 1
```

A BinarySearchTree object



b) The `_get` method is the "work horse" of BST search. It recursively walks `currentNode` down the tree until it finds `key` or becomes `None`

In English, what are the base and recursive cases?

Base cases:
1) Walk off branch of BST
2) Find node with key

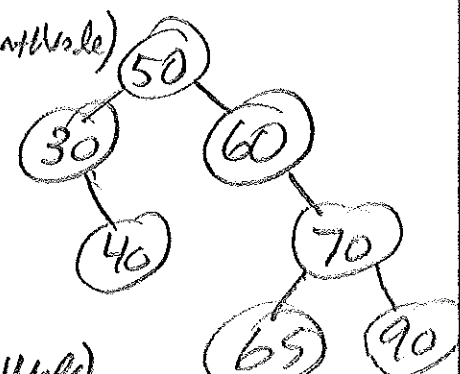
Recursive:
(1) search left subtree
(2) search right subtree

c) What is the `put` method doing?

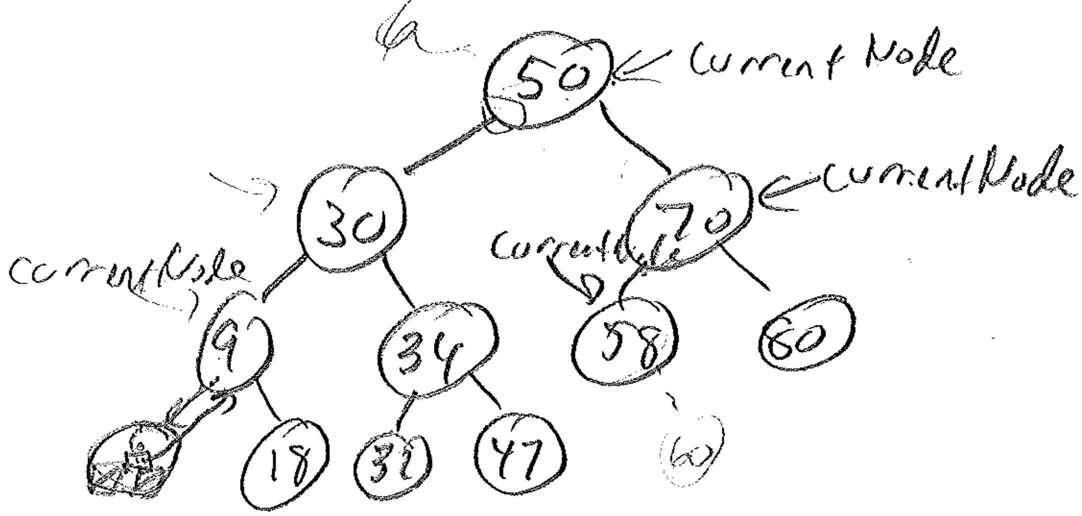
Check for

d) Complete the recursive `_put` method.

e) Draw the "shape" of the BST after `put`s of: 50, 60, 30, 70, 90, 40, 65



f) If "n" items are in the BST, what is `put`'s: Best-case $O(1)$? Worst-case $O(n)$? Average-case $O(n)$?



50
current Node
30
70
current Node
current Node
current Node
9
34
58
60
18
32
47
60