Objective(s):

a. To be able to implement binary-search-tree insert(int d) method
b. To be able to implement binary tree traversal method
c. To be able to implement binary tree search method

Task 1:

Given TreeNode.java and BST.java, complete insert(int d) and preOrder()

```
public class BST {
  TreeNode root;
  public BST() { root = null; }
  //  public TreeNode getRoot() {
  //    return root;
  //  }
  public void insert(int d) {
    if (root == null) {
        root = new TreeNode(d);
    } else {
        TreeNode cur = root;
        while (cur != null) {
          if (d < cur.data) {
             if (cur.left != null)
                 cur = cur.left;
             else {
                 /* your code 1*/
             }
          } else { //! (d < p.data)
            if (cur.right != null)
                /* your code 2*/;
            else {
                cur.right = new TreeNode(d);
                cur.right.parent = cur;
                        return;
            }
          }
        } //while
    }
  } //insert by iteration
  public void printPreOrder() {
    printPreOrderRecurse(root);
  }
  private void printPreOrderRecurse(TreeNode node) {
        /* your code 3*/
  }
```

```
package code;

public class TreeNode {
    int data;
    TreeNode left, right, parent;

  public TreeNode(int d) {
        data = d;
  }
  @Override
  public String toString() {
  // There are 4 cases no child,
  // left-child-only,
  // right-child-only,
  //and both children
    /* your code 6*/
    return "null<-" + data + "->null";
            // no child
  }
}
```

Note that BST's root cannot be accessed from main, in that case its access modifier should be private and provide getRoot() (commented).

```
public static void demo1() {
  println("-insert and preOrder traversal-");
  int[] dat = { 15, 20, 10, 18, 16,
                12, 8, 25, 19, 30 };

  BST bst = new BST();
  for (int j = 0; j < dat.length; j++)
        bst.insert(dat[j]);

  bst.printPreOrder();
  //8 10 12 15 16 18 19 20 25 30
  System.out.println();
  //demo2(bst);
}
```

Instruction: capture your code for insert(int d) and `printPreOrderRecurse(TreeNode node)`

/* your code 1 and 2 */

```
public void insert(int d) {
    if (root == null) {
        root = new TreeNode(d);
    } else {
        TreeNode cur = root;
        while (cur != null) {
            if (d < cur.data) {
                if (cur.left != null)
                    cur = cur.left;
                else {
                    cur.left = new TreeNode(d);
                    cur.parent = cur;
                    return;
                }
            } else { // d >= cur.data
                if (cur.right != null)
                    cur = cur.right;
                else {
                    cur.right = new TreeNode(d);
                    cur.right.parent = cur;
                    return;
                }
            }
        }
    }
}
```

/* your code 3 */

```
private void printPreOrderRecurse(TreeNode node) {
    if (node != null) {
        printPreOrderRecurse(node.left);
        System.out.print(node.data + " ");
        printPreOrderRecurse(node.right);
    }
}
```

Task 2:

complete `printInOrderRecurse(TreeNode node)` and `printPostOrderRecurse(TreeNode node)`

confirm your output.

Instruction: use the 3 traversal,

draw bst

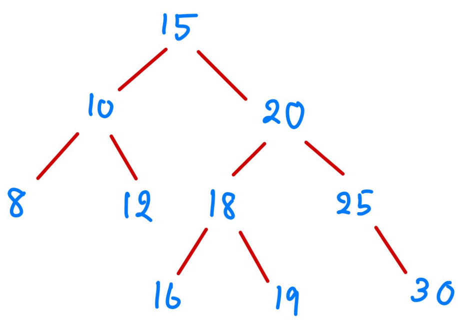
```
//uncomment demo2() invocation inside demo1()
  static void demo2(BST bst) {
    System.out.println("-more traversal---");
    bst.printInOrder();
    System.out.println();
    // 15 10 8 12 20 18 16 19 25 30

    bst.printPostOrder();
    System.out.println();
    // 8 12 10 16 19 18 30 25 20 15

    // demo3(bst);
  }
```

```
    public void printInOrder() {
        printInOrderRecurse(root);
    }
    private void printInOrderRecurse(TreeNode
node) {
        /* your code 4*/
    }
    public void printPostOrder() {
        printPostOrderRecurse(root);
    }
    private void
printPostOrderRecurse(TreeNode node) {
        /* your code 5*/
    }
```

/* BST */



/* Output */

```
-insert and preOrder traversal-
8 10 12 15 16 18 19 20 25 30
-more traversal---
15 10 8 12 20 18 16 19 25 30
8 12 10 16 19 18 30 25 20 15
```

/* your code 4 */

```
private void printInOrderRecurse(TreeNode node) {
    if (node != null) {
        System.out.print(node.data + " ");
        printInOrderRecurse(node.left);
        printInOrderRecurse(node.right);
    }
}
```

/* your code 5 */

```
private void printPostOrderRecurse(TreeNode node) {
    if (node != null) {
        printPostOrderRecurse(node.left);
        printPostOrderRecurse(node.right);
        System.out.print(node.data + " ");
    }
}
```

Task 3:

In fact, processing TreeNode in main is cumbersome (as we preferred encapsulation). However, we'll leave search(int d) to return TreeNode as is. We'll check the search result in the method.

```
println("-search recursive---");
println(bst.search(20)); // 18<-20->25
println(bst.search(25)); // null<-25->30
println(bst.search(12)); // null<-12->null
println(bst.search(1));  // null
println(bst.searchRecurse(10
                , bst.getRoot()));
//if searchRecurse and getRoot is available

println("-search iterative---");
println(bst.searchIter(20));
println(bst.searchIter(25));
println(bst.searchIter(12));
println(bst.searchIter(1));
```

```
public TreeNode search(int d) {
  TreeNode result = searchRecurse(d, root);
  return result;
}
public TreeNode searchRecurse(int d, TreeNode n) {
  if (n == null) return null;
  if (d == n.data) return n;
  /* your code 7*/
  return searchRecurse(d, n.right);
}
```

```
public TreeNode searchIter(int key) {
  if (root.data == key)
      return root;
  TreeNode current = root;
  while (current != null) {
      if (key < current.data) {
          if (current.left != null)
              current = current.left;
      } else {
          if (current.right != null)
              current = current.right;
      }

      if (current.data == key)
          return current;

      /* your code 8 */
  } //while
  return null;
}
```

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Instructions:

Complete /* your code 6 */ in TreeNode.java so that we can check the search result.

Complete /* your code 7 */ and /* your code 8 */

(The result commented is to confirm your work correctness.)

Capture your demo3()'s output.

/* your code 6 */

```
@Override
public String toString() {
    String leftString = (left != null) ? String.valueOf(left.data) : "null";
    String rightString = (right != null) ? String.valueOf(right.data) : "null";

    return leftString + "<-" + data + "->" + rightString;
}
```

/* your code 7 */

```
public TreeNode searchRecurse(int d, TreeNode n) {
    if (n == null)
        return null;
    if (d == n.data)
        return n;
    if (d < n.data) {
        return searchRecurse(d, n.left);
    } else {
        return searchRecurse(d, n.right);
    }
}
```

/* Output demo3() */

```
-search recursive---
18<-20->25
null<-25->30
null<-12->null
null
-search iterative---
18<-20->25
null<-25->30
null<-12->null
null
```

/* your code 8 */

```
public TreeNode searchIter(int key) {
    if (root.data == key)
        return root;
    TreeNode current = root;
    while (current != null) {
        if (key < current.data) {
            if (current.left != null)
                current = current.left;
        } else {
            if (current.right != null)
                current = current.right;
        }
        if (current.data == key)
            return current;
        if (current.left == null && current.right == null)
            return null;

    } // while
    return null;
}
```

Submission: MyStackA_XXYYYY.java and MyRPN_XXYYYY.java

Due date: TBA