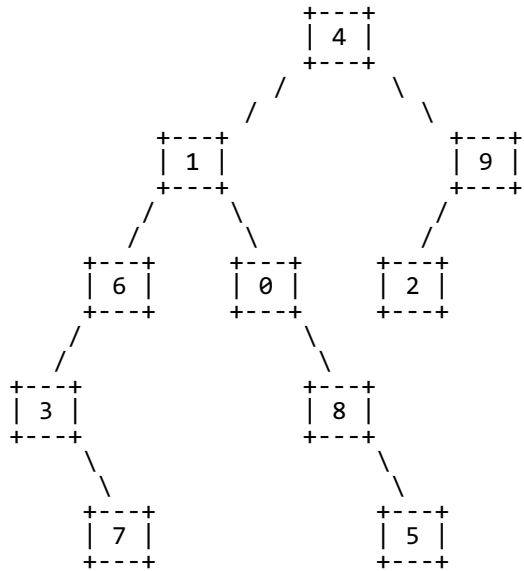


# 1. Binary Tree Traversal

Consider the following tree:



Fill in each of the traversals below :

- Pre-order: \_\_\_\_\_
- In-order: \_\_\_\_\_
- Post-order: \_\_\_\_\_

# 2. Binary Search Tree

Draw a picture below of the binary search tree that would result from inserting the following words into an empty binary search tree in the following order: Facebook, Accenture, Nintendo, Expedia, Amazon, Microsoft, Zillow, Google. Assume the search tree uses alphabetical ordering to compare words.

### 3. Inheritance/Polymorphism Mystery

Consider the following classes:

```
public class Clock extends Bear {
    public void method3() {
        System.out.println("Clock 3");
    }
}

public class Lamp extends Can {
    public void method1() {
        System.out.println("Lamp 1");
    }

    public void method3() {
        System.out.println("Lamp 3");
    }
}

public class Bear extends Can {
    public void method1() {
        System.out.println("Bear 1");
    }

    public void method3() {
        System.out.println("Bear 3");
        super.method3();
    }
}

public class Can {
    public void method2() {
        System.out.println("Can 2");
        method3();
    }

    public void method3() {
        System.out.println("Can 3");
    }
}
```

and that the following variables are defined:

```
Object var1 = new Bear();
Can var2 = new Can();
Can var3 = new Lamp();
Bear var4 = new Clock();
Object var5 = new Can();
Can var6 = new Clock();
```

In the table below, indicate in the right-hand column the output produced by the statement in the left-hand column. If the statement produces more than one line of output, indicate the line breaks with slashes as in "a/b/c" to indicate three lines of output with "a" followed by "b" followed by "c". If the statement causes an error, fill in the right-hand column with either the phrase "compiler error" or "runtime error" to indicate when the error would be detected.

#### Statement

#### Output

var1.method2();

\_\_\_\_\_

var2.method2();

\_\_\_\_\_

var3.method2();

\_\_\_\_\_

var4.method2();

\_\_\_\_\_

var5.method2();

\_\_\_\_\_

var1.method3();

\_\_\_\_\_

var2.method3();

\_\_\_\_\_

var3.method3();

\_\_\_\_\_

var6.method3();

\_\_\_\_\_

((Lamp) var6).method1();

\_\_\_\_\_

((Can) var1).method1();

\_\_\_\_\_

((Can) var1).method2();

\_\_\_\_\_

((Bear) var1).method3();

\_\_\_\_\_

((Clock) var1).method1();

\_\_\_\_\_

((Clock) var4).method2();

\_\_\_\_\_

## 5. Collections Programming

Write a method called `recordDate` that information about a date between two people. For each person, the map records an ordered list of people that person has dated. For example, the map might record these entries for two people

```
Michael => [Ashley, Samantha, Joshua, Brittany, Amanda, Amanda]
Amanda  => [Michael, Daniel, Michael]
```

The dates are listed in reverse order. The list for Michael indicates that he most recently dated Ashley and before that Samantha and before that Joshua, and so on. Notice that he has dated Amanda twice. The list for Amanda indicates that she most recently dated Michael and before that Daniel and before that Michael. All names are stored as string values.

The method takes three parameters: the map, the name of the first person, and the name of the second person. It should record the date for each person and should return what date number this is (1 for a first date, 2 for a second date, and so on). Given the entries above, if we make this call:

```
int n = recordDate(dates, "Michael", "Amanda");
```

The method would record the new date at the front of each list:

```
Michael => [Amanda, Ashley, Samantha, Joshua, Brittany, Amanda, Amanda]
Amanda  => [Michael, Michael, Daniel, Michael]
```

The method would return the value 3 indicating that this is the third date for this pair of people. When someone is first added to the map, you should construct a `LinkedList` object (we use `LinkedList` instead of `ArrayList` because it has fast insertion at the front of the list).

---

## 6. Comparable

Define a class `Donation` that represents donations made to organizations. Each `Donation` object keeps track of an amount, the organization the donation was made to and a `boolean` to indicate whether or not the donation was tax-deductible. Your class must have the following public methods:

Member	Description
<code>public Donation(organization, amount, isDeductible)</code>	constructs a donation object with the given organization, amount and tax-deductible status
<code>public String toString()</code>	returns a <code>String</code> representation of the donation

Your constructor should throw an `IllegalArgumentException` if the amount passed to it is negative or 0.

The `toString` method returns a `String` composed of a dollar sign (\$), followed by the amount donated, followed by a colon and the name of the organization. If the donation is tax-deductible, an asterisk (\*) is added to the beginning of the `String`. You must exactly reproduce the format of the examples given below.

**Make `Donation` objects comparable to each other using the `Comparable<E>` interface.** `Donation` objects that are tax-deductible are considered "less" than donations that are not tax-deductible. In other words, all tax-deductible donations go before donations that are not tax-deductible. Then, they are sorted by amount in ascending order, breaking ties by organization in ascending alphabetical order. For example, if the following objects are declared:

```
Donation uw1 = new Donation("University of Washington", 600.75, true);
Donation uw2 = new Donation("University of Washington", 40, true);
Donation sj = new Donation("Snap Judgment", 30, false);
Donation tal = new Donation("This American Life", 40, true);
Donation mc = new Donation("Microphone Check", 99.99, false);
```

Printing them in sorted order would result in the following output:

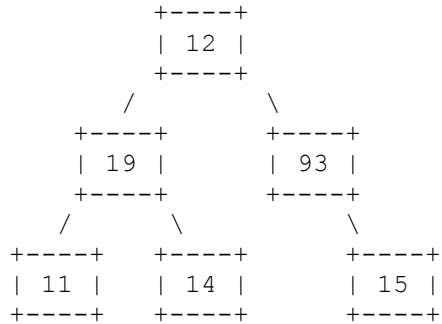
```
* $40.0: This American Life
* $40.0: University of Washington
* $600.75: University of Washington
$30.0: Snap Judgment
$99.99: Microphone Check
```

*(You may also write on the next page.)*

**6. Comparable (writing space)**

## 7. Binary Tree Programming

Write a method called `printLevel` that takes an integer `n` as a parameter and that prints the values at level `n` from left to right. By definition the overall root is at level 1, its children are at level 2, and so on. The table below shows the result of calling this method on an `IntTree` variable `t` storing the following tree.



call	output
<code>t.printLevel(1)</code>	nodes at level 1 = 12
<code>t.printLevel(2)</code>	nodes at level 2 = 19 93
<code>t.printLevel(3)</code>	nodes at level 3 = 11 14 15
<code>t.printLevel(42)</code>	nodes at level 42 =

Notice that if there are no levels at the level (eg level 42), your method should produce no output after the equals sign. You must exactly reproduce the format of this output. Your method should throw an `IllegalArgumentException` if passed a value for level that is less than 1.

You are writing a public method for a binary tree class defined as follows:

```
public class IntTreeNode {
    public int data;           // data stored in this node
    public IntTreeNode left;  // reference to left subtree
    public IntTreeNode right; // reference to right subtree

    <constructors>
}

public class IntTree {
    private IntTreeNode overallRoot;

    <methods>
}
```

You are writing a method that will become part of the `IntTree` class. You may define private helper methods to solve this problem, but otherwise you may not call any other methods of the class. You may not construct any extra data structures to solve this problem.

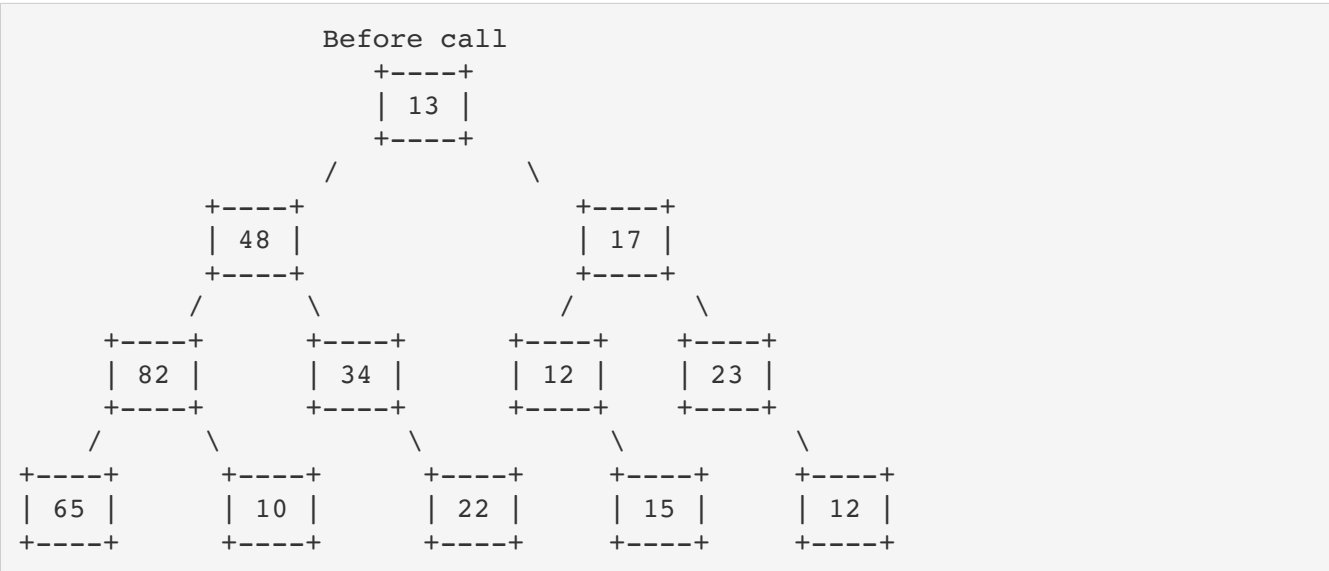
*(Write your answer on the next page.)*

---

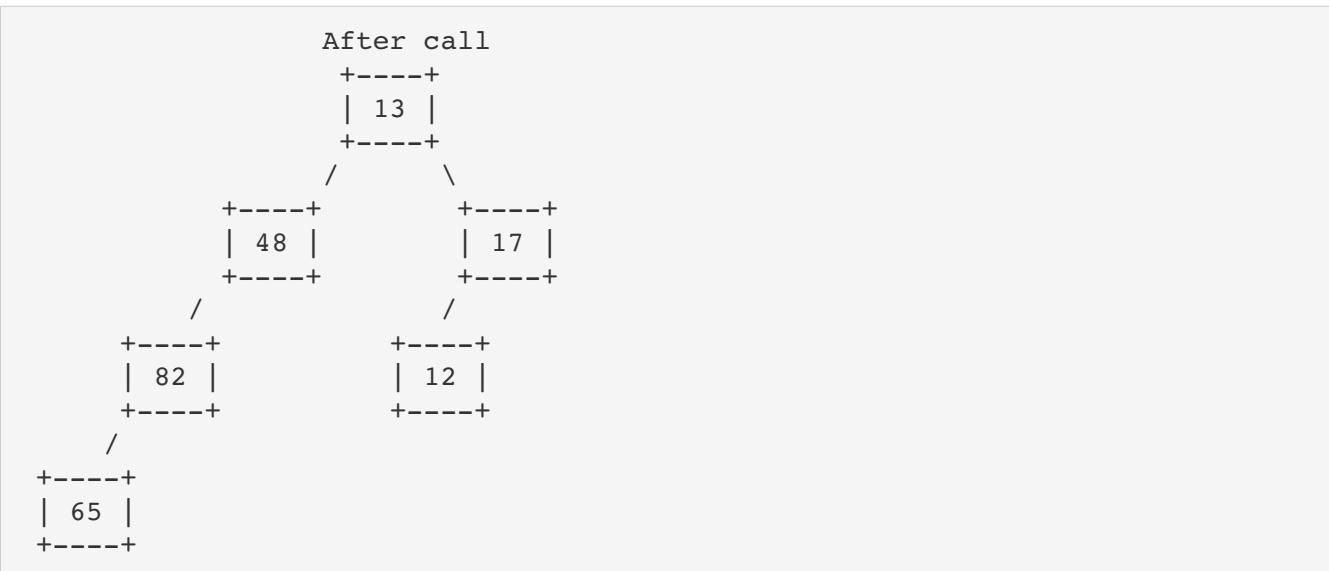
**8. Binary Tree Programming (writing space)**

## 8. Binary Tree Programming

Write a method called `removeRightLeaves` that removes right leaves from the tree until it has no right leaves remaining. A right leaf is a leaf that is a right child of some other node. For example, suppose a variable `t` stores a reference to the following tree:



The right leaves of this tree are the nodes that store 10, 22, 15 and 12. If we make the call `t.removeRightLeaves();` then these four nodes will be removed. But notice that once these four nodes have been removed, we are left with new right leaves storing 34 and 23. These also are removed leaving the tree below.



The overallRoot would never be a right leaf because it has no parent.



**8. Binary Tree Programming (writing space)**

## 9. Linked List Programming

Write a method called `rotate3` that rotates each successive sequence of 3 values in a list of integers (moving the first value to the last position). For example, suppose that a variable called `list` stores the following sequence of values:

```
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15]
```

and we make the following call:

```
list.rotate3();
```

Afterwards the list should store the following sequence of values:

```
[2, 3, 1, 5, 6, 4, 8, 9, 7, 11, 12, 10, 14, 15, 13]
```

The first sequence of 3 values (1, 2, 3) has been rotated to be (2, 3, 1). The second sequence of 3 values (4, 5, 6) has been rotated to be (5, 6, 4). And so on. If the list has extra values that are not part of a sequence of 3, those values are unchanged. For example, if the list had instead stored:

```
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17]
```

The result would have been:

```
[2, 3, 1, 5, 6, 4, 8, 9, 7, 11, 12, 10, 14, 15, 13, 16, 17]
```

Notice that the values (16, 17) are unchanged in position because they were not part of a sequence of three values.

These examples purposely used sequential integers to make the rearrangement clear, but you should not expect that the list will store sequential integers.

Your method should not change the list if it has fewer than three values.

## 9. Linked List Programming (writing space)