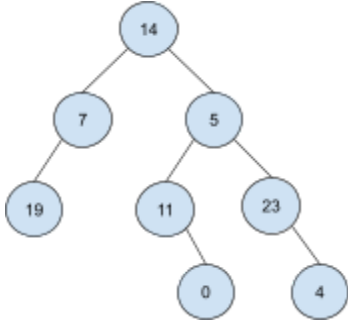
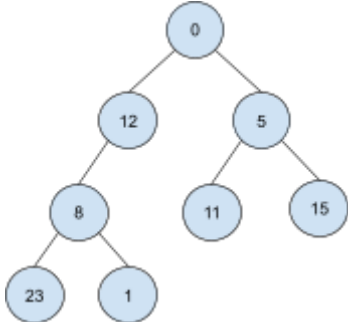
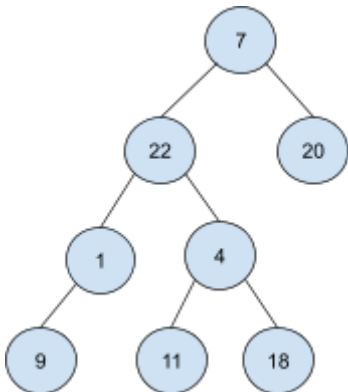


# CSE 123 Spring 2023 Practice Final Exam

## 1. Comprehension

**Part A:** For each of the following binary trees, indicate which type of traversal is shown: pre-order, in-order, or post-order.

	19 7 14 11 0 5 23 4	<input type="checkbox"/> pre-order <input checked="" type="checkbox"/> in-order <input type="checkbox"/> post-order
	0 12 8 23 1 5 11 15	<input checked="" type="checkbox"/> pre-order <input type="checkbox"/> in-order <input type="checkbox"/> post-order
	7 22 1 9 4 11 18 20	<input checked="" type="checkbox"/> pre-order <input type="checkbox"/> in-order <input type="checkbox"/> post-order

**Part B:** Which of these statements are true? (Select all that apply.)

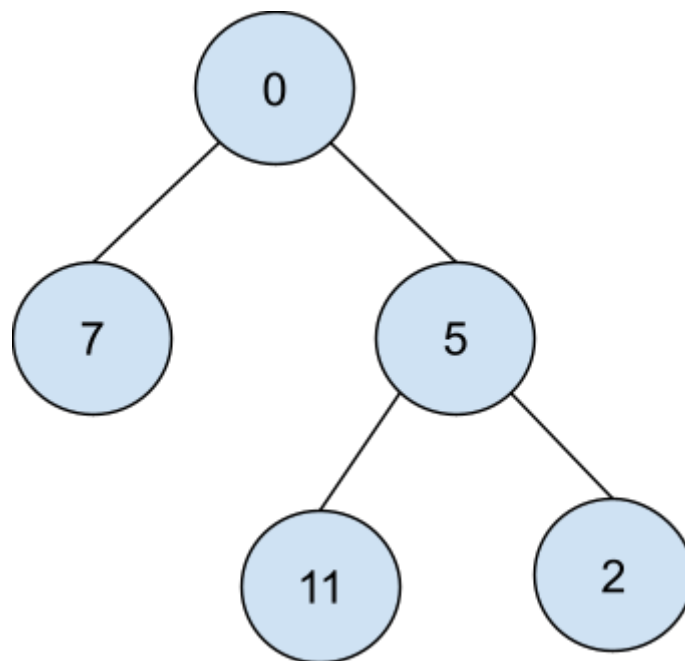
- Abstract classes cannot be instantiated.
- Each class can extend only one base class and implement only one interface.
- A class can call its base class's method using the super keyword.
- If ClassC extends ClassB and ClassB extends ClassA, then an instance of ClassC can be passed as a parameter to a method that expects an instance of ClassA.

**Part C:** Consider the following method in the IntTree class:

```
public int mystery(int limit) {  
    return mystery(limit, overallRoot);  
}  
  
private int mystery(int limit, IntTreeNode root) {  
    if (root == null) {  
        return 0;  
    }  
  
    int result = 0;  
    if (root.data <= limit) {  
        result = 1;  
    }  
  
    result += mystery(limit, root.left);  
    result += mystery(limit, root.right);  
    return result;  
}
```

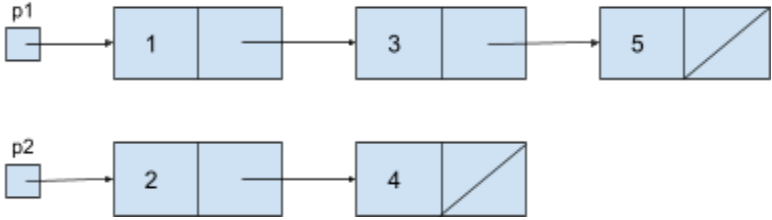
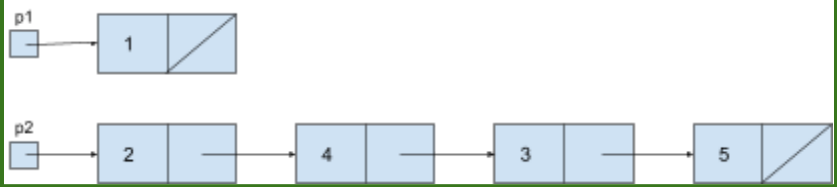
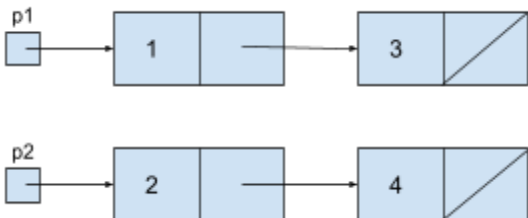
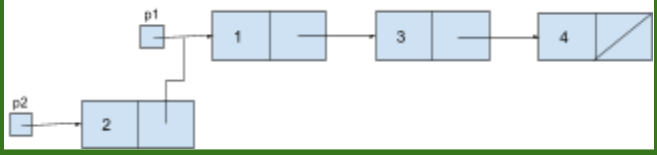
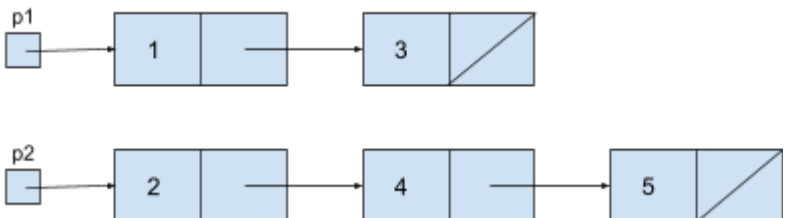
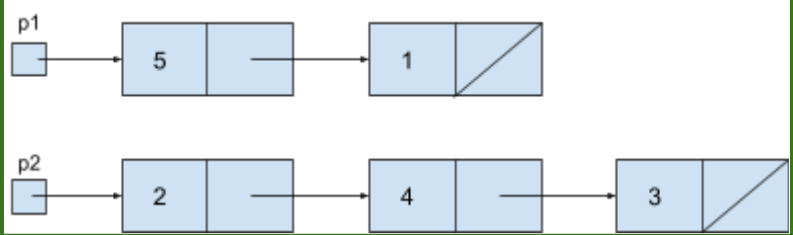
Draw a binary tree such that, if it were stored in the variable tree, the call tree.mystery(10) would return 4.

*One possible solution:*



## 2. Code Tracing

**Part A:** For each of the following, draw the linked lists that result from starting with the lists shown on the right and executing the code provided.

 <p>p1 → 1 → 3 → 5</p> <p>p2 → 2 → 4</p>	<pre>p2.next.next = p1.next; p1.next = null;</pre>
 <p>p1 → 1</p> <p>p2 → 2 → 4 → 3 → 5</p>	
 <p>p1 → 1 → 3</p> <p>p2 → 2 → 4</p>	<pre>p1.next.next = p2.next; p2.next = p1;</pre>
 <p>p1 → 1 → 3 → 4</p> <p>p2 → 2</p>	
 <p>p1 → 1 → 3</p> <p>p2 → 2 → 4 → 5</p>	<pre>ListNode temp = p2.next.next; p2.next.next = p1.next; temp.next = p1; p1.next = null; p1 = temp;</pre>
 <p>p1 → 5 → 1</p> <p>p2 → 2 → 4 → 3</p>	

**Part B:** Consider the following classes:

```
public class Shape {
    public void method1() {
        System.out.println("Shape 1");
        method3();
    }

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

public class Circle extends Shape {
    public void method2() {
        System.out.println("Circle 2");
    }

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

```
public class Rectangle extends Shape {
    public void method3() {
        System.out.println("Rect 3");
        super.method3();
    }
}

public class Square extends Rectangle {
    public void method2() {
        System.out.println("Square 2");
    }

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

Assume the following variables have been defined:

```
Shape var1 = new Rectangle();
Square var2 = new Square();
Shape var3 = new Circle();
Rectangle var4 = new Square();
```

For each of the following statements, Indicate what the output would be. If the statement would result in an error, write "error" instead. (You may use a slash to indicate line breaks. For example, "line1/line2" indicates two lines of output: "line1" and "line2.")

var1.method1();	Shape 1 / Rect 3 / Shape 3
var2.method3();	Square 3
var3.method1();	Shape 1 / Circle 3
var4.method2();	Error

**Part C:** Consider the following method:

```
public static void mystery(int n, int m) {  
    if (n > 0 && m > 0) {  
        mystery(n / 10, m / 10);  
    }  
  
    if (n % 10 == m % 10) {  
        System.out.print("=");  
    } else {  
        System.out.print("!");  
    }  
}
```

For each of the following statements, indicate what the output would be.

mystery(0, 90)

=

mystery(12, 22)

!=

mystery(582, 1522)

!!=

### 3. Linked List Debugging

Consider a method in the `LinkedList` class called `mergeWith` that takes a `LinkedList` as a parameter and moves the values in the parameter into this list. Assuming both this list and the parameter list are in sorted order, after `mergeWith` executes, this list will contain the values from both lists in sorted order and the parameter list will be empty.

For example, suppose the variables `list1` and `list2` contain the following lists:

```
list1 = [-3 2 5 9 12]
list2 = [0 1 8 9 22]
```

After the call `list1.mergeWith(list2)` executes, the variables `list1` and `list2` would contain:

```
list1 = [-3 0 1 2 5 8 9 9 12 22]
list2 = []
```

On the other hand, if the lists were in their original state as above, then after the call `list2.mergeWith(list1)` executes, the variables `list1` and `list2` would contain:

```
list1 = []
list2 = [-3 0 1 2 5 8 9 9 12 22]
```

Consider the following buggy implementation of `mergeWith`:

```
1     public void mergeWith(LinkedList other) {
2         if (front == null) {
3             front = other.front;
4         } else if (other.front != null) {
5             ListNode curr = front;
6             while (curr.next != null && other.front != null) {
7                 if (curr.next.data > other.front.data) {
8                     ListNode temp = curr.next;
9                     curr.next = other.front;
10                    other.front = other.front.next;
11                    curr.next.next = temp;
12                }
13                curr = curr.next;
14            }
15
16            if (other.front != null) {
17                curr.next = other.front;
18            }
19        }
20        other.front = null;
21    }
```

This implementation contains a bug that is causing it to not work as intended. For example, given `list1` and `list2` as above, `list1.mergeWith(list2)` would produce the correct results, but `list2.mergeWith(list1)` would result in the following:

```
list1 = []
list2 = [0 -3 1 2 5 8 9 9 12 22]
```

*(continued on next page...)*

Annotate (write on) the code below to indicate how you would fix the bug. You may add (using arrows to indicate where to insert), remove (by crossing out), or modify (with a combination) any code you choose.

Be sure to clearly indicate *where* you would add/remove/change code in addition to what changes you would make. (Incorrect or incomplete attempted fixes in the correct place *may* still earn an S.)

```
1     public void mergeWith(LinkedList other) {
2         if (front == null) {
3             front = other.front;
4         } else if (other.front != null) {
5             if (other.front.data < front.data) {
6                 ListNode temp = front;
7                 front = other.front;
8                 other.front = other.front.next;
9                 front.next = temp;
10            }
11            ListNode curr = front;
12            while (curr.next != null && other.front != null) {
13                if (curr.next.data > other.front.data) {
14                    ListNode temp = curr.next;
15                    curr.next = other.front;
16                    other.front = other.front.next;
17                    curr.next.next = temp;
18                }
19                curr = curr.next;
20            }
21
22            if (other.front != null) {
23                curr.next = other.front;
24            }
25        }
26        other.front = null;
27    }
```

## 4. Inheritance Programming

Consider the following class:

```
public class Beverage {
    private double size;

    public Beverage(double size) {
        this.size = size;
    }

    public String toString() {
        return getSize() + "oz beverage";
    }

    public double getSize() {
        return size;
    }
}
```

Write a new class called `CoffeeDrink` that represents a beverage containing coffee. `CoffeeDrink` should extend `Beverage` but differ in the following ways:

- `CoffeeDrink` has a caffeine content (in mg) specified in the constructor as an integer
- `CoffeeDrink` has a `getCaffeine()` method that returns the caffeine content of the drink
- `CoffeeDrink` has an `isCaffeinated()` method that returns `true` if the drink contains at least 10mg of caffeine and `false` otherwise
- If a `CoffeeDrink` is *not* caffeinated, the string representation of the drink ends with (decaf)
  - The rest of the string representation is the same as any other `Beverage`
- `CoffeeDrink` implements the `Comparable` interface; `CoffeeDrinks` are compared first by size (smaller drinks are “less than” bigger drinks) then by caffeine content (less caffeine is “less than” more caffeine)

To earn an E on this problem, your `CoffeeDrink` class must not duplicate any code from the `Beverage` class.

Write your solution on the next page.



Write your solution to problem #4 here:

One possible solution:

```
public class CoffeeDrink extends Beverage implements Comparable<CoffeeDrink> {
    private int caffeine;

    public CoffeeDrink(double size, int caffeine) {
        super(size);
        this.caffeine = caffeine;
    }

    public boolean isCaffeinated() {
        return caffeine >= 10;
    }

    public int getCaffeine() { return caffeine; }

    public String toString() {
        String result = super.toString();
        if (!isCaffeinated()) {
            result += " (decaf)";
        }
        return result;
    }

    public int compareTo(CoffeeDrink other) {
        if (this.getSize() > other.getSize()) {
            return 1;
        } else if (this.getSize() < other.getSize()) {
            return -1;
        } else {
            return this.getCaffeine() - other.getCaffeine();
        }
    }
}
```

## 5. Recursive Programming

Write a *recursive* method called `waysToClimb` that takes two integer parameters, `steps` and `max`, and computes all possible ways to climb a set of `steps` by taking strides of at least 1 and at most `max` stairs at once. Your method should print out each possible way of climbing the stairs and return the total number of ways that are found.

For example, the call `waysToClimb(3, 3)` would produce the following output:

```
[1, 1, 1]
[1, 2]
[2, 1]
[3]
```

This call would return the value 4, since there are four possible options. Notice that order matters in the possibilities– `[1, 2]` and `[2, 1]` are considered different. Options should only consist of strides of at least 1 step– do not include 0 or negative steps.

As another example, the call `waysToClimb(5, 2)` would produce the following output:

```
[1, 1, 1, 1, 1]
[1, 1, 1, 2]
[1, 1, 2, 1]
[1, 2, 1, 1]
[1, 2, 2]
[2, 1, 1, 1]
[2, 1, 2]
[2, 2, 1]
```

This call would return the value 8.

You may assume that both `steps` and `max` are greater than 0. You may print the possibilities in any order, but to earn an E, you must print *all* possibilities and you must not print any possibility more than once.

To earn a grade other than N, your method **must** be implemented recursively, though you may also use loops if you like.

Write your solution on the next page.

Write your solution to problem #5 here:

One possible solution:

```
public static int waysToClimb(int steps, int max) {
    return waysToClimb(steps, max, 0, new Stack<Integer>());
}

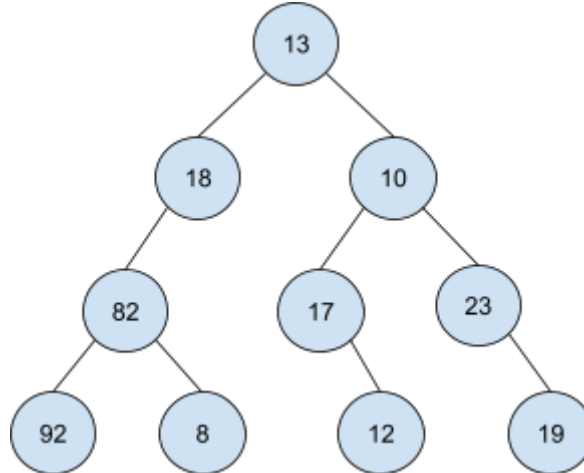
private static int waysToClimb(int steps, int max, int curr, Stack<Integer> plan) {
    if (curr == steps) {
        System.out.println(plan);
        return 1;
    }

    int total = 0;
    for (int i = 1; i <= max; i++) {
        if (curr + i <= steps) {
            plan.push(i);
            total += waysToClimb(steps, max, curr + i, plan);
            plan.pop();
        }
    }
    return total;
}
```

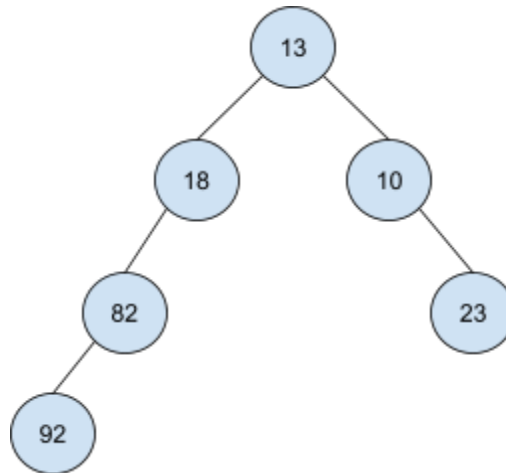
## 6. Binary Tree Programming

Write a method called `limitLeaves` to be added to the `IntTree` class (see the reference sheet). This method takes a single integer parameter, `min`, and modifies the tree so that no leaf node contains a value that is less than `min`.

For example, suppose that the variable `tree` contains a reference to the following tree:



The method call `tree.limitLeaves(20)` would result in `tree` referring to the following tree:



Notice that the leaf nodes containing the values 8, 12, and 19 were removed because they are less than 20. Notice also that removing the node containing 12 created a new leaf node containing 17, which was also removed.

Your method should not create any `IntTreeNode` objects or modify the data field of any existing `IntTreeNode` objects; you should implement your method only by removing nodes from the existing tree. You should not remove any nodes that are not necessary to produce a tree with no leaves less than `min`. Specifically, you should only remove leaf nodes, or nodes that become leaf nodes after removing other nodes.

Write your solution on the next page.

Write your solution to problem #6 here:

*One possible solution:*

```
public void limitLeaves(int min) {
    overallRoot = limitLeaves(min, overallRoot);
}

private IntTreeNode limitLeaves(int min, IntTreeNode root) {
    if (root == null) {
        return null;
    }

    root.left = limitLeaves(min, root.left);
    root.right = limitLeaves(min, root.right);
    if (root.left == null && root.right == null && root.data < min) {
        root = null;
    }
    return root;
}
```