

Question 1. [5 points] Consider the following static method:

```
public static int mystery(int[] arr) {  
    int x = 0;  
    for (int i = 0; i < arr.length; i++) { -N times  
        x += arr[i]; O(1)  
    }  
    for (int i = 0; i < arr.length; i++) { -N times  
        x += arr[i]; O(1)  
    }  
    return x;  
}
```

Let N be the number of elements in the array `arr`. State a worst-case big-O upper bound on the running time of this method in terms of N . Explain your answer briefly.

Both loops are $O(N)$ because the body is $O(1)$ and the number of iterations is N . The overall running time is $O(N)$ because $2 \cdot O(N)$ is $O(N)$ (the 2 is a constant factor, and can be ignored.)

Question 2. [5 points] Consider the following static method:

```
public static int numNegativeRows(int[][] matrix) {  
    int count = 0;  
    for (int i = 0; i < matrix.length; i++) { -N times  
        int rowSum = 0;  
        for (int j = 0; j < matrix[i].length; j++) { -N times  
            rowSum += matrix[i][j]; O(1)  
        }  
        if (rowSum < 0) { count++; }  
    }  
    return count;  
}
```

Assume that the array `matrix` is square (has the same number of rows and columns), and that N is the number of rows/columns. State a worst-case big-O upper bound on the running time of this method in terms of N . Explain your answer briefly.

Overall running time is $O(N^2)$. The body of the inner loop is $O(1)$, the inner loop executes N times, and the outer loop executes N times. $N \cdot N \cdot O(1)$ is $O(N^2)$.

Question 3. [5 points] Consider the following static method:

```
public static boolean isUpperTriangular(double[][] matrix) {  
    for (int i = 0; i < matrix.length; i++) {  
        for (int j = 0; j < i; j++) { 0, 1, 2, 3, ..., N-2, N-1 times  
            if (matrix[i][j] != 0.0) { return false; } O(1)  
        }  
    }  
    return true;  
}
```

Assume that the array `matrix` is square (has the same number of rows and columns), and that N is the number of rows/columns. State a worst-case big-O upper bound on the running time of this method in terms of N . Explain your answer briefly.

The body of the inner loop is $O(1)$. The inner loop is dependent on the outer loop, and over all iterations of the outer loop, it executes

$$\sum_{i=0}^{N-1} i = 0 + 1 + 2 + \dots + (N-2) + (N-1) = \frac{N}{2}(N-1) = \frac{N^2}{2} - \frac{N}{2}$$

times. So, the overall running time is $O(N^2)$.

Question 4. [5 points] What output is printed by the following code (which begins on the left and continues on the right)?

```
public class Q4 {  
    public static void main(  
        String[] args) {  
        List<Integer> list =  
            Arrays.asList(1, 2, 3, 4, 5);  
  
        Iterator<Integer> i =  
            list.iterator();
```

```
        System.out.println(i.next());  
        System.out.println(i.next());  
        if (i.hasNext()) {  
            System.out.println(i.next());  
        }  
        if (i.hasNext()) {  
            System.out.println(i.next());  
        }  
    }  
}
```

1
2
3
4

Question 5. [5 points] Consider the following code:

```
List<Integer> list = Arrays.asList(1, 2, 3, 4, 5);
```

```
Iterator<Integer> i = list.iterator();
```

```
while (i.hasNext()) {
```

```
    System.out.println(i.next());
```

```
    System.out.println(i.next());
```

```
}
```

```
System.out.println("done");
```

*NoSuchElementException
thrown here on 3rd iteration
of while loop*

What output is printed when this code is executed? Explain your answer briefly.

*1
2
3
4
5
[then a NoSuchElementException occurs]*

Question 6. [5 points] Consider the following method:

```
public static void f(String a, String b) {
```

```
    int val = 0;
```

```
    if (a == b) {
```

```
        val = 1;
```

```
    }
```

```
    System.out.printf("[%s] [%s] [%d]\n", a, b, val);
```

```
}
```

(a) When this method is called, is the output [X] [X] [1] possible? Briefly explain why or why not.

Yes: this will happen if a and b are references to the same String object, and that String object contains the character X

(b) When this method is called, is the output [X] [X] [0] possible? Briefly explain why or why not.

Yes: this will happen if a and b are references to different string objects, and each one contains the character X

Question 7. [5 points] Consider the following code—the Box class on the left, and a code fragment using it on the right:

<pre> public class Box implements Comparable<Box> { public int x; public Box(int val) { x = val; } public int compareTo(Box m) { return m.x - this.x; } } </pre>	<pre> Box[] boxes = { new Box(3), new Box(1), new Box(2) }; Arrays.sort(boxes); for (Box b : boxes) { System.out.println(b.x); } </pre>
--	--

What output is printed by the code on the right?

3
2
1

reversed comparison:
is < 0 if this.x is greater than m.x
 $= 0$ if this.x equals m.x
 > 0 if this.x is less than m.x

Question 8. [5 points] Consider the following code—the Frob class on the left, and a code fragment using it on the right:

<pre> public class Frob implements Comparator<String> { public int compare(String lhs, String rhs) { return lhs.length() - rhs.length(); } } </pre>	<pre> String[] names = { "Alice", "Bob", "Carl" }; Frob f = new Frob(); System.out.println(f.compare("Alice", "Bob")); Arrays.sort(names); for (String n : names) { System.out.println(n); } </pre>
---	--

} sorts by length

What output is printed by the code on the right?

2
Bob
Carl
Alice

Question 9. [5 points] Consider the following method, which is intended to return the sum of the integers in a collection of integer values:

```
public static int sum(Collection<Integer> coll) {  
    int sum = 0;  
    for (int i = 0; i < coll.size(); i++) {  
        sum += coll.get(i);  
    }  
    return sum;  
}
```

collection does not have a get method,
because for some types of collections (e.g. Sets)
the elements don't have indices

Briefly explain the error in this method and how to fix it. (Hint: consider the parameter's data type.)

Use a for each loop:

```
for (Integer x : coll) {  
    sum += x;  
}
```

Question 10. [5 points] Complete the following generic method. It should return the minimum of the two parameter values. (Hint: note that the type parameter E is guaranteed to implement Comparable.)

```
public static<E extends Comparable<E>> E min(E val1, E val2) {
```

```
    if( val1.compareTo(val2) < 0 ) {  
        return val1;
```

```
    } else {  
        return val2;
```

```
    }
```

```
}
```

Programming Questions

To get started, use a web browser to download the zipfile as specified by your instructor. Import it as an Eclipse project using File → Import... → General → Existing Projects into Workspace → Archive file.

Important: You may use the following resources:

- The textbook
- The lecture notes posted on the course web page
- Your previous labs and assignments

Do not open any other files, web pages, etc.

Question 11. [25 points] Complete the implementation of the `Pokemon` class. The class should have three fields:

1. A primary type, whose data type is `PokemonType`
2. A secondary type, whose data type is `PokemonType`
3. A name, whose data type is `String`

There are two constructors:

- The first takes primary type and name as parameters, storing the parameter values in the corresponding fields, and sets the object's secondary type to `PokemonType.NONE`
- The second takes primary type, secondary type, and name, storing the parameter values in the corresponding fields

There should be getters `getPrimaryType`, `getSecondaryType`, and `getName` which return the value of the appropriate field.

The class should implement the `Comparable<Pokemon>` interface. The `compareTo` method should compare first by primary type, then by secondary type (if the primary types are equal), and finally by name (if the primary *and* secondary types are equal). Note that because `PokemonType` is an enumeration, it implicitly implements `Comparable`, so you can compare `PokemonType` values using the `compareTo` method (as you did with `Suit` and `Rank` values in Labs 9 and 10.)

There are unit tests in the `Q11Test` class: make sure they pass.

Question 12. [25 points] In the `Q12` class, implement the `isSorted` static method. The method takes a `List` of elements of type `E`, and returns true if the list is sorted. A list is sorted if and only if for each element other than the first, the previous element is not greater. Note that `E` is guaranteed to implement `Comparable<E>`, so you can call `compareTo` on values of type `E`.

Note: To receive full credit for your solution, your method must complete in $O(N)$ time, where N

is the number of elements in the list. However, you can expect to receive 80% of full credit if your algorithm is correct, but completes in $O(N^2)$ time. (A slow but correct algorithm will get a much better score than an incorrect algorithm.)

There are JUnit tests in the `Q12Test` class. Make sure they pass. Also be aware that any list that is empty or has exactly one element should be considered to be sorted.