Section A: Unit by Unit

OOP

Q1:

Which **two** of the following statements are valid **critiques** about the *design* of the `A` class?

```
public class A {
    private int foo;
    public String bar;
    private double baz;

    public A(int a, String b) {
        foo = a;
        bar = b;
        baz = Math.random();
    }

    public int getFoo() {
        return foo;
    }

    public void setFoo(int newFoo) {
        if (newFoo > foo) {
            foo = newFoo;
        }
    }

}
```

A. The class features a mixture of public and private instance variables

B. The constructor for `A` doesn't take in an input for `baz`.

C. The constructor's assignment operations are missing `this`, which would cause the program to behave incorrectly.

D. `baz` is never used inside the class and is inaccessible outside of the class, making it useless.

Given one of the critiques you selected above, briefly explain (at most ~15 words) how you would fix this problem.

For A: make all of them private (or all of them public) for consistency. For D: write a getter or setter for baz. Or, just delete it!

Q2:

```
public class Counter {
    private int count;
```

```
    public Counter() {
        count = 0;
    }

    public void incr() {
        count++;
    }

    public int show() {
        return count;
    }

    public void reset() {
        count = 0;
    }

    public static void main(String[] args) {
        Counter c = new Counter();
        c.incr();
        c.incr();

        System.out.println(count);
    }
}
```

Would the **main method** compile as written? A. Yes **B.** No

Which of the methods written is functionally a "getter" (accessor) method? A. `public Counter()` B. `public void incr()` **C.** `public int show()` D. `public void reset()`

Which one of the following is an *invariant* of the `Counter` class? (Remember that an invariant is a statement that is always true about the state of the object.)

A. For a given `Counter` object, we know that `count` is always exactly equal to the number of times that `incr()` has been called.

B. The value of `count` can only increase after initialization and it will never decrease.

C. The value of `count` can only decrease when the user calls the `incr()` method with a negative input.

D. For a given `Counter` object, we know that `count` is always less than or equal to the number of times that `incr()` has been called.

Reference Types

Q1:

```
public class Greetable {
    private String name;

    public Greetable(String name) {
        this.name = name;
    }

    public void setName(String newName) {
        this.name = newName;
    }

    public void greet() {
        System.out.println("Hi, I'm " + name);
    }

    public static void main(String[] args) {
        Greetable pilar = new Greetable("Pilar");
        Greetable anselmo = new Greetable("Anselmo");

        anselmo = pilar;
        anselmo.greet();
        pilar.setName("Maria");
        anselmo.greet();
        pilar.setName("Pablo");
        pilar.greet();
        pilar = new Greetable("Jordan");
        anselmo.greet();
    }
}
```

Fill in the blanks to represent what gets printed when we run `java Greetable`.

```
Hi, I'm _________
Hi, I'm _________
Hi, I'm _________
Hi, I'm _________
```

Answer:

```
Hi, I'm Pilar
Hi, I'm Maria
Hi, I'm Pablo
Hi, I'm Pablo
```

Q2:

Inspect the following class and write a reasonable and meaningful implementation of the `equals()` method. There are several valid answers, but at a minimum your answer should behave differently from using `==` ("double equals") to compare two objects.

```
public class B {
    private int uniqueID;   // guaranteed to uniquely identify a "B"
    private String data;    // multiple "B" objects could have the same data

    public B(String data) {
        uniqueID = generateUniqueID(); // implementation omitted, but assume it
exists!
        this.data = data;
    }

    public boolean equals(B other) {
        // your implementation here!



    }
}
```

Answer: A correct answer needs to compare, at minimum, one of `data` or `uniqueID` between the two objects. Keep in mind that data should be compared using `.equals()` while `uniqueID` must be compared using `==`. A `null` check is optional.

```
public boolean equals(B other) {
    return other != null &&
           this.uniqueID == other.uniqueID &&
           this.data.equals(other.data);
}
```

Abstract Data Types

Q1:

Given an interface `Drink` and a class `Soda` that implements the `Drink` interface, select all of the lines below that would compile when written in `main` of `Soda.java`.

1. `Drink d = new Soda();`
2. `Drink d = new Drink();`
3. `Soda s = new Soda();`
4. `Soda s = new Drink();`

Answer: 1 & 3

Given that `Soda` and `Drink` both compile, that `Soda implements Drink`, and that `Soda.java` contains a method with signature `public void open()`.

True or **False**: We can assume that `Drink.java` must contain an abstract method with the same signature (`public void open()`).

List

For the "appendix"

method signature	purpose
`get(int i)`	return the value at position `i` in the List.
`set(int i, E e)`	set the value at position `i` in the List to be `e`.
`size()`	return the number of values stored in the List.
`remove(int i)`	remove and return the value stored at position `i` in the List.
`add(E e)`	insert the value `e` at the end of the List.
`add(int i, E e)`	insert the value `e` at position `i` in the List. `i` must be between `0` and `size()`.

Q1:

Inspect the following function:

```
public static int mystery(List<Double> ds) {
    int x = 0;
    for (int i = ds.size() - 1; i >= 0; i--) {
        if (ds.get(i) < 0) {
            ds.remove(i);
            x++;
        }
    }
    return x;
}
```

What does the above function *do to the input list*? *Answer: Remove all negative numbers from a given list.*

What does the above function's *return value* represent? *Answer: The number of negative values removed from the list.*

Q2:

Read the following function that creates a copy of an array `A` that repeats itself `k` times and returns this copy:

```
public static String[] loopKTimes(String[] A, int k) {
    String[] output = new String[A.length * k];
    for (int i = 0; i < A.length; i++) {
        for (int j = 0; j < k; j++) {
            output[i + j * A.length] = A[i];
        }
    }
    return output;
}
```

(For example, `loopKTimes(new String[] {"hi", "bye"}, 3)` returns `{"hi", "bye", "hi", "bye", "hi", "bye"}`)

Fill in the following function stub so that the function mimics the behavior of `loopKTimes` but takes in and returns an ArrayList instead. Remember that ArrayLists are *dynamically resizing.*

```
public static ArrayList<String> loopKTimes(ArrayList<String> A, int k) {
    ArrayList<String> output = new ArrayList<String>();

    // Place your code here



    return output;
}
```

ANSWER:

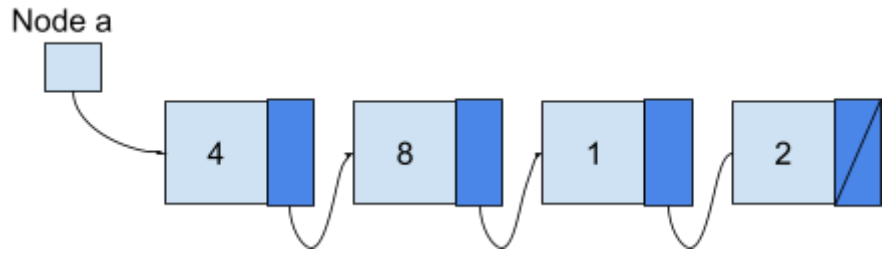
```
public static ArrayList<String> loopKTimes(ArrayList<String> A, int k) {
    ArrayList<String> output = new ArrayList<String>();

    for (int j = 0; j < k; j++) {
        for (int i = 0; i < A.size() i++) {
            output.add(A.get(i));
        }
    }




    return output;
}
```

Nodes

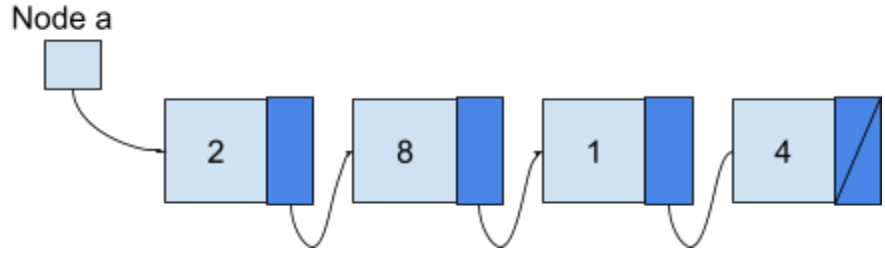
```java
/**
 * This node class will store int values.
 */
public class Node {

  // public instance variables
  public int data;
  public Node next;

  public Node(int data, Node next) {
      this.data = data;
      this.next = next;
  }
}
```

Q1:

Given the following state of nodes:



rearrange the nodes so that it looks like:



NOTE:
you are not allowed to access or modify the value in any nodes `data` instance variable, and you are not allowed to allocate a `new node` (e.g. the code you write should not contain the `` `new Node(..., ...)` `` in it.
You are allowed to create Node reference variables with something like: `` `Node temp = a` ``

```
public static void foo() {
	// start:
	//
	//   +---+    +---+---+    +---+---+    +---+---+    +---+---+
	// a | --+--> | 4 | --+--> | 8 | --+--> | 1 | --+--> | 2 | / |
	//   +---+    +---+---+    +---+---+    +---+---+    +---+---+

	Node a = new Node(4, null);
	a.next = new Node(8, null);
	a.next.next = new Node(1, null);
	a.next.next.next = new Node(2, null);

	// end:
	//
	//   +---+    +---+---+    +---+---+    +---+---+    +---+---+
	// a | --+--> | 2 | --+--> | 8 | --+--> | 1 | --+--> | 4 | / |
	//   +---+    +---+---+    +---+---+    +---+---+    +---+---+

	// TODO: put your code here:


	Node four = a;
	Node eight = a.next;
	Node one = a.next.next
	Node two = a.next.next.next;

	a = two;
	two.next = eight;
	one.next = four;
	four.next = null;
}
```

Q2:
Complete the following function:

```
/* Given a reference to the start of a chain of linked nodes
 * and a integer we are searching for
```

```
 * return true if the target is found in the chain,
 * and false if it is not found.
 */
public static boolean search(Node head, int target) {
    // TODO
```

}

Sorting

For both questions below, consider the following (broken) implementation of selection sort

Line Number	Code

0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
	`public static void selectionSort(String[] array) {`
	`    for (int i = 0; i < array.length - 1; i++) {`
	`        int indexOfSmallest = i;`
	`        for (int j = 0; j < array.length; j++) {`
	`            if (array[indexOfSmallest].compareTo(array[j]) < 0) {`
	`                indexOfSmallest = j;`
	`            }`
	`        }`
	
	`        String temp = array[indexOfSmallest];`
	`        array[indexOfSmallest] = array[i];`
	`        array[i] = temp;`
	`    }`
	`}`

As mentioned, the code above does not work (though, it still compiles).

Q1.

Consider we had the following array:
`String[] names = {"Michelle", "Lena", "Davis", "Becca"};`
What if we were to pass this array into the function (e.g. `selectionSort(names)`), what would the `names` array look like after `selectionSort(names)` returns?

Hint: if it was properly sorting, `names` would look like:
`{"Becca", "Davis", "Lena", "Michelle"}`
The code shown above will NOT leave `names` in sorted order

Q2.

Let's try to fix the `selectionSort` code above so that it works properly. For each line that needs to be changed, list its line number and then what the code should be changed to be. You do not have to use all of the rows below:

Line Number	Revised Code

2D Arrays

Q1:

Fill in the contents of the 2D array as initialized by this code here:

```
int[][] output = new int[2][3];
for (int row = 0; row < output.length; row++) {
    for (int col = 0; col < output.length; col++) {
        if (row <= col) {
            output[row][col] = row + col;
        } else {
            output[row][col] = row - col;
        }
    }
}
```

output	col 0	col 1	col 2

row 0
row 1

ANSWER:

output	col 0	col 1	col 2
row 0	0	1	0
row 1	1	2	0

Comparing Objects

Q1:

For the following questions, consider the following `Treasure` class:

```
public class Treasure {
    public int value;
    public Treasure(int value) {
        this.value = value;
    }

    /* Other methods omitted */
}
```

While there are many valid implementations of a `compareTo()` method for `Treasure`, any valid implementation should have the following properties:

1. The method should compile!
2. `x.compareTo(y)` should return a negative number if `x` has a `value` less than `y`'s `value`.
3. `x.compareTo(y)` should return a positive number if `x` has a `value` greater than `y`'s `value`.
4. `x.compareTo(y)` should return `0` if `x` and `y` have the same `value`.

For each of the following `compareTo()` methods, decide if it is valid or invalid. If it is invalid, explain why with reference to the above properties.

Option 1:

```
public int compareTo(Treasure o) {
    if (this == o) {
        return 0;
    } else if (this < o) {
        return -1;
```

```
    } else {
        return 1;
    }
}
```

Option 2:

```
public int compareTo(Treasure o) {
    if (this.value == o.value) {
        return 0;
    } else if (this.value < o.value) {
        return -1 - (int) (Math.random() * 10);
    } else {
        return 1 + (int) (Math.random() * 10);
    }
}
```

Option 3:

```
public int compareTo(Treasure o) {
    return o.value - this.value;
}
```

Answers: Option 1 is not valid because it does not compile (this and o can't be compared with <). Option 2 is valid. Option 3 is not valid because it does not return a negative number if `this.value` is less than `o.value`.

Writing Files

Q1:

Here's a function that takes a 2D array and prints it out with a space between each entry and a new line after each row.

```
public static void print2DArray(int[][] A) {
    for (int row = 0; row < A.length; row++) {
        for (int col = 0; col < A[0].length; col++) {
            System.out.print(A[row][col] + " ");
        }
        System.out.println();
    }
}
```

Write a function that takes a 2D array of integers and writes it to a file. The file should have a space between each entry and a new line after each row. The function should not return anything.

```
public static void write2DArray(int[][] A, String filename) {
    Out outStream = new Out(filename);
```

```
    // your code here

    outStream.close();
}
```

Answer:

```
public static void write2DArray(int[][] A, String filename) {
    Out outStream = new Out(filename);
    for (int row = 0; row < A.length; row++) {
        for (int col = 0; col < A[0].length; col++) {
            outStream.print(A[row][col] + " ");
        }
        outStream.println();
    }
    outStream.close();
}
```

Directories:

For the "appendix"?

method signature	purpose
`File(String path)`	Constructor, takes in a `path` to a file to the file to represent.
`isFile()`	Method that tests if the `File` called on is a regular file, `true` if it is, `false` otherwise
`isDirectory()`	Method that tests if the `File` called on is a directory, `true` if it is, `false` otherwise
`listFiles()`	Method that returns a `File[]`. If the `File` the method is called on is a directory, the array contains all files in the directory. If the `File` the method is called on is not a directory, it returns `null`.

Q1:

Complete the following function:

```
/* Given a path, determine if that path specifies a parent directory
 * A parent directory satisfies two conditions:
 * - it is a valid directory
 * - it contains at least one directory inside of it
 */
```

```
public static booleanisParentDirectory(String path) {
   // TODO: Your Code Here
   File f = new File(path);



}
```

Map

Throughout this course, we have been storing data in arrays and ArrayLists. In both cases, we index into the data structure using an integer. In other words, we can access the elements in those containers by specifying an integer index that uniquely identifies a value in the array or ArrayList.

The goal of the following question will be for you to write a class that allows you to index data using a String as a key instead of an integer. Computer scientists refer to this data structure as a *Map*, so that's what we'll call the class.

The `Map` is implemented using an `ArrayList<Match>`; the `Match` interface, along with an implementing class `SimpleMatch`, is provided for you. The `Match` interface has three methods: `getKey()`, `getValue()`, and `setValue()`. **To allow the indexing to be well-defined, we will enforce the constraint that no two `Match` objects contained in the `ArrayList<Match>` can have the same key.**

Part 1:

Implement the `Map` constructor. This function takes a filename as input and reads in a list of key to value matches from the file. Note that the key is of typeString, and the values are of type double: remember your `readXYZ()` methods from `In.java!` The file format is as follows, where `N` refers to the number of `Match`es represented in the file:

```
N
key1 value1
key2 value2
key3 value3
...
keyN valueN
```

You can assume that the file will be formatted correctly and that it will contain no duplicate keys. The constructor should read in the file and store the key to value matches in the `ArrayList<Match>` instance variable called `matches`.

```
   public Map(String inputFile) {
        this.matches = new ArrayList<Match>();
        // your code here
```

```
}
```

Part 2:

Next, write two tests for the provided `get()` method.

The first test should create a `Map` object from the file `test1.txt` and then call the `get()` method on the `Map` object with the key `"Aditya"`. The test should then check that the value returned by the `get()` method is equal to `63.4` (representing the number of hours he spent in Office Hours this semester!)

`test1.txt`

```
3
Aditya 63.4
Bhrajit 94.5
Sukya 192.3
```

```
    @Test
    public void testGetElementPresent() {
        // your code here
    }
```

The second test should create a `Map` object from the file `test1.txt` and then call the `get()` method on the `Map` object with a key that is not present in the file. The test should then check that the value returned by the `get()` method is `Double.NEGATIVE_INFINITY`.

```
    @Test
    public void testGetElementNotPresent() {
        // your code here
    }
```

Part 3:

Next, implement the `insert()` method. This method takes a key and a value as input and updates our `Map` to match the key with that value. If a `Match` object with the given key already exists in the `ArrayList<Match>`, then the method should **update the existing Match object with that key** and return `false` to indicate that the size of the `Map` has not changed. Otherwise, the method should create a new `Match` object, insert it into `matches`, and return `true`. We have provided two test cases that further demonstrate the intended behavior.

```
@Test
public void insertKeyNotPresent() {
    Map m = new Map("test1.txt");
    boolean result = m.insert("key4", 3423);
    assertTrue(result);
    assertEquals(3423, m.get("key4"), 0.01);
    assertEquals(m.size(), 4);
}
```

```
@Test
public void insertKeyAlreadyPresent() {
    Map m = new Map("test1.txt"); // has a match for “Aditya”
    boolean result = m.insert("Aditya", 100.3);
    assertFalse(result);
    assertEquals(100.3, m.get("key1"), 0.01); // ignore the delta for grading
    assertEquals(m.size(), 3);
}

   public boolean insert(String key, String value) {
        // your code here
    }



public class Map() {
    private ArrayList<Match> matches;


    public Map(String inputFile) {
        matches = new ArrayList<Match>();
        In inStream = new In(inputFile);
        int numMatches = inStream.readInt();
        for (int i = 0; i < numMatches; i++) {
            String key = inStream.readString();
            double value = inStream.readDouble();
            Match m = new SimpleMatch(key, value);
            matches.add(m);
        }
    }

    public double get(String key) {
        for (int i = 0; i < matches.size(); i++) {
            if (m.key.equals(key)) {
                return m.getValue();
            }
        }
        return Double.NEGATIVE_INFINITY;
    }

    public boolean insert(String key, double value) {
        for (int i = 0; i < matches.size(); i++) {
            if (m.key.equals(key)) {
                m.setValue(value);
                return false;
```

```
            }
        }
        Match m = new SimpleMatch(key, value);
        matches.add(m);
        return true;
    }

    public boolean delete(String key) {
        for (int i = 0; i < matches.size(); i++) {
            if (m.key.equals(key)) {
                matches.remove(i);
                return true;
            }
        }
        return false;
    }

    public int size() {
        return matches.size();
    }
}

public interface Match {
    public String getKey();
    public double getValue();
    public void setValue(double value);
}

public class SimpleMatch implements Match {
    private String key;
    private double value;

    public SimpleMatch(String key, double value) {
        this.key = key;
        this.value = value;
    }
    /* Other methods omitted for space; they behave as the
       method names suggest for getters and setters.    */
}
```