CS-390
Fundamental Programming Practices
Final Exam SOLUTIONS

Name: _____ ID: _____

I (16)	II (16)			III (24)		SCI (3)

Part I. Multiple Choice & True/False Questions. (2 points each) For multiple choice, circle the best answer; circle *only one* answer in each problem. For True/False, mark it either 'T' or 'F'.

1. Which of the following statements is true?
   a. Use `ArrayList` when a lot of insertions and removals are needed.
   b. There is no need to shift elements when we remove elements from `ArrayList`.
   c. `LinkedList` implements `RandomAccess`.
   d. Resizing is not necessary for a `LinkedList` when a lot of insertions are done.

   Answer: d

2. Suppose a list mylist contains objects that do not have a natural ordering. (Note: Integers and Strings have a natural ordering but Persons and Employees do not.) Assume the following line of code compiles and runs without error:

   ```
   Collections.sort(mylist)
   ```

   Which of the following statements is *not necessarily* true?
   a. The type of `mylist` is a subtype of `List`
   b. The type of `mylist` is a subtype of `Iterable`
   c. The type of `mylist` is a subtype of `Comparable`
   d. The type of each element of `mylist` is a subtype of `Comparable`

   Answer: c

3. Suppose you create your own kind of `List` class in which you plan to store `String`s in sorted order. Which Java interface(s) *must* you implement in order to be sure that the method call

   ```
   Collections.binarySearch(<your list>, <your string>)
   ```

   will run properly and use the fast binary search algorithm on your `List` in searching for your test `String`? Circle the best answer.

   a. The `List` interface is enough
   b. The `Iterable` interface is enough
   c. Both the `List` interface and the `RandomAccess` interface
   d. The `RandomAccess` interface is enough

   Answer: c

4. _T__(True/False) Suppose you create a class `Key` in which you override `equals` and `hashCode`. Suppose that your way of overriding `hashCode` is the following:

```
hashCode() {
   return 1;
}
```

If you use instances of `Key` as keys in a `Hashmap`, the `Hashmap` operations of `put`, `get`, `remove` will be no more efficient than the corresponding operations of adding, getting, and removing elements in a linked list.

5. _T_(True/False) In-order traversal will visit nodes in a binary search tree in sorted order.

6. _F_(True/False) The following code is a full implementation of an `Employee` class and includes an implementation, as an inner class, of the `Comparator` interface. Is the implementation shown consistent with equals?

```
public class Employee  {
   private String name;
   private double salary;
   public Employee(String name, double salary) {
      this.name = name;
      this.salary = salary;
   }
   class NameComparator implements Comparator<Employee> {
      @Override
      public int compare(Employee e1, Employee e2) {
         if(e1.name.equals(e2.name)) return 0;
         else return e1.name.compareTo(e2.name);
      }
   }
   public boolean equals(Object ob) {
      if(ob == null) return false;
      if(!(ob instanceof Employee)) return false;
      Employee e = (Employee)ob;
      Return e.name.equals(name) && e.salary == salary;
   }
}
```

7. The new `forEach` method that was introduced in Java 8 is an example of which of the following (circle the best answer)
   a. A static method in an interface
   b. A default method in an interface
   c. A new implemented method in the Iterator interface
   d. None of the above

   Answer: b

8. When the `main` method is run in the `Main` class (shown below), which of the following is output to the console? Circle only one answer.

a. true
001:data

b. true
null

c. false
001:data

d. false
null

Answer: b

```
public class Main {
    HashMap<Key, Record> map = new HashMap<>();
    Key defaultKey = new Key("secret");
    public Main() {
        map.put(defaultKey, new Record("001", "data"));
    }
    public static void main(String[] args) {
        Main m = new Main();
        Key k = new Key("secret");
        System.out.println(k.equals(m.defaultKey));
        Record recFound = m.map.get(k);
        System.out.println(recFound);
    }
}
```

```
public class Key {
    private String key;
    public Key(String k) {
        this.key = k;
    }

    @Override
    public boolean equals(Object ob) {
        if(ob == null) return false;
        if(!(ob instanceof Key)) return false;
        Key theKey = (Key)ob;
        return key.equals(theKey.key);
    }
}

public class Record {
    private String recordId;
    private String data;
    public Record(String id, String data) {
        this.recordId = id;
        this.data = data;
    }
    public String getRecordId() {
        return recordId;
    }
    public String getData() {
        return data;
    }

    @Override
    public String toString() {
        return recordId + ":" + data;
    }
}
```

Part II. Short Answer

1. [3 points] What is the output when the `main` method of `Test` class is run? (You may safely assume that no compiler errors will occur.)

```
class Test {
   public static void test() throws Exception {
        try {
             throw new Exception("Exception thrown");
        }
        catch (Exception x){
            System.out.println(x.getMessage());
        }
        finally {
            System.out.println("In finally block!");
        }
        System.out.println("In test method");
    }

   public static void main(String[] args){
        try{
            test();
        }
        catch(Exception x){
            System.out.println(x.getMessage());
      }
    }
}
```

Answer:

Exception thrown
In finally block
In test method

2. [5 points] Many data structures are implemented using the composition pattern, relying on some kind of background data structure to perform its operations. Below, several such data structures are listed (a – e). Match the data structure to the type of structure most often used as its background data structure (choose from 1 – 5).

Note. It is possible to use data structures in the right column more than once.

Grading
1 point for each correct answer.

_1_ a. Binary Search Tree	1. Node
2 or 4_b. HashMap	2. Entry
_3_ c. TreeSet (from Java library)	3. Binary Search Tree
_1_ d. LinkedList	4. Linked List
_5_ e. HashSet	5. HashMap

3. [4 points] Below is code for a `Circle` class. The constructor accepts input for the size of the circle's radius and intends to validate that the input value for the radius is non-negative. To validate the input, the method `validateRadius` is called. Write the code for the `validateRadius` method. This method should throw an `IllegalClosedCurveException` if the input value of the radius is a negative number. *Hint.* You may need to modify the declaration of the method.

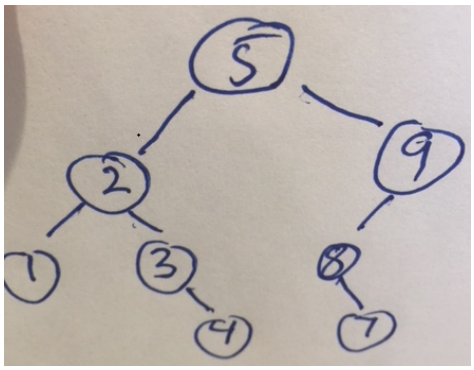
Grading:
2pts: validateRadius throws exception
2pts: body of validateRadius is right

```
public class IllegalClosedCurveException extends Exception {
    public IllegalClosedCurveException() {
        super();
    }
    public IllegalClosedCurveException(String msg){
        super(msg);
    }
    public IllegalClosedCurveException(Throwable t){
        super(t);
    }
}
```

```
public class Circle extends ClosedCurve {
    double radius;
    public Circle(double radius)  throws IllegalClosedCurveException {
        validateRadius(radius);
        this.radius = radius;
    }
    double computeArea() {
        return (Math.PI * radius * radius);
    }
    private void validateRadius(double r) throws IllegalClosedCurveException {
        if(r<=0){
            throw new IllegalClosedCurveException("Illegal input for radius");
        }
    }
}
```

4. [4 points] Draw the binary search tree obtained from successively adding the following integers to an initially empty BST: 5, 9, 2, 3, 1, 4, 8, 7

Grading
-1 point for each incorrect insertion



Part III. Programming Questions.

1. (12 points) Below is a skeleton of a `Stack` implementation based on `Nodes`. The `NodeStack` class has a member inner class `Node` that has already been implemented, and has an instance variable `topNode`. Your task is to implement the three unimplemented stack methods shown in the code below. To implement `pop`, you must replace `topNode` with the next `Node` in the stack, and return the value contained in the original `topNode`. For `peek`, you must return the value stored in `topNode`, but you will not remove it. And for `push`, you will create a new `Node` and set it as the new `topNode`. All changes made by `push`, `pop`, and `peek` must ensure that links from `Node` to `Node` have been defined properly. Write your code in the space provided, below:

Grading:

4 points for each of pop, push, peek.

Code in these methods just needs to work – it does not need to be exactly the same as the code shown here.

```
public class NodeStack {
    private Node topNode = null;
    public void push(String val) {
        if(topNode == null) topNode = new Node(val, null);
        else {
            topNode = new Node(val, topNode);
        }
    }

    public String peek() {
        if(topNode == null) return null;
        else return topNode.data;
    }

    public String pop() {
        if(topNode == null) return null;
        else {
            String retval = topNode.data ;
            topNode = topNode.next;
            return retval;
        }
    }

}
```

2. (12 points) Fully implement the methods in the `SearchForString` class, shown below. The class `SearchForString` has one instance variable `String[] arr`, one constructor with signature

```
SearchForString (String[] arr)
```

and one instance method

```
public boolean search(String s)
```

The constructor should set its value in the instance variable of the class. The method `search` should be a recursive implementation of a search for the input argument `s` in the array `arr`; if `s` is found, the method should return `true`; `false` otherwise.

The method must implement the following recursive strategy:

> Compare `s` to `arr[len-1]` (where `len` is the length of `arr`). If they are equal, return `true`. Otherwise, (recursively) search for `s` in the rest of the array.

You may safely assume that `arr` contains only non-null `Strings` and that the argument `s` passed in to `search` is never null. You *must not* assume that the `Strings` in `arr` are in sorted order.

To complete the problem, complete the work in the class `SearchForString` that has already been partially coded. A `private` instance method `recurSearch`, having two arguments (`s` and an integer argument `upperIndex`) has been included in `SearchForString`; you must make use of this method to do the actual recursion.

Grading:

The only requirement is that recursion is being used

If so, give full credit if the logic and code are correct.

(It is not necessary for them to use both search and recurSearch or if they do, it is not necessary to implement exactly as it is done here.)

```java
public class SearchForString {
    private String[] arr;
    public SearchForString(String[] arr) {
        this.arr = arr;

    }
    public boolean search(String s){
        if(arr == null) return false;
        return recurSearch(s, arr.length - 1);
    }
    private boolean recurSearch(String s, int upperIndex) {
        if(upperIndex < 0) return false;
        if(arr[upperIndex].equals(s)) return true;
        return recurSearch(s, upperIndex - 1);
    }
    public static void main(String[] args) {
        String [] arr = {"Billy", "Steve", "Ralph", "Susan"};
        SearchForString sfs = new SearchForString(arr);
        System.out.println(sfs.search("Billy"));
        System.out.println(sfs.search("Bob"));

    }
}
```

Part IV. SCI (3 points)

Describe a parallel between principles of SCI and principles of computer science that have been discussed in the course. Richer content will be awarded more credit.