Name:____

CSE331 Spring 2015, Midterm Examination
May 6, 2015

Please do not turn the page until 10:30.

Rules:

- The exam is closed-book, closed-note, etc.
- **Please stop promptly at 11:20.**
- There are **TO DO points**, distributed **unevenly** among **TO DO** questions (many with multiple parts):

Question	Max	Earned
1		
2		
3		
4		
5		
6		
7		
8		
9		

Advice:

- Read questions carefully. Understand a question before you start writing.
- **Write down thoughts and intermediate steps so you can get partial credit. But clearly indicate what is your final answer.**
- The questions are not necessarily in order of difficulty. **Skip around.** Make sure you get to all the questions.
- If you have questions, ask.
- Relax. You are here to learn.

Name:____

1. (points) Consider this code with the indicated initial precondition where `arr` is an `int[]`:

```
{arr != null /\ arr.length > 1}
int p = arr[0];
int i = 1;
while(i < arr.length - 1) {
    int t = arr[i];
    arr[i] = (p + t + arr[i+1]) / 3;
    p = t;
    i = i+1;
}
```

(a) In 1–2 English sentences, what is the post-condition for this code? Discuss only the final contents of `arr` (not other variables), referring to the original contens of `arr` as needed. Note you need to describe some of the array contents differently from the rest.

(b) Now give a formal mathematical description of the post-condition you described in English in part (a). Use this notation as needed:

- Use `arr[i]pre` to mean the contents of `arr[i]` before any of the code executes.
- Use `x..y` to mean the range of numbers from `x` to `y`, *including* `x` and *excluding* `y`. (If $\mathtt{y} \leq \mathtt{x}$, then this means the empty range.)

(c) Now give a proof in Hoare logic that the code is correct given your answer in part (b), by writing:

- An assertion between each statement
- A clearly identified loop invariant

Do not change the code. You may find it easiest to rewrite the code with your assertions and invariant in the right places, but you can also use arrows into places in the code above. Pay particular attention to getting the loop invariant correct.

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2. (points)

   (a) What is wrong with this method specification?

   ```
   /** @requires p != null and x > 0
    * @returns square root of (max(p.y, x))
    * @modifies p
    * @effects decrements p.y
    * @throws NullPointerException if p == null
    */
   double m(SomeClassWithPublicFieldY p, int x) {...}
   ```

   (b) What is wrong with this method specification?

   ```
   /**
    * @effects adds 7 to every element in arr
    */
   void m(int[] arr) {...}
   ```

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3. (points) This problem considers an ADT for a *non-decreasing finite sequence of ints*. An abstract value is a sequence of integers where each number is no less than the preceding one. An example would be -1, -1, 17, 19, 34, 34, 34, 40. It is a mutable ADT where numbers can be added only to the large end of the sequence.

   Our concrete representation uses an `ArrayList<IntPair>` where for each `IntPair`, `count` indicates how many times `num` is in the sequence. This representation can be particularly efficient when a sequence has numbers repeated many times.

   Our representation invariant includes the following:

   - The `ArrayList` is *sorted* by `num`: The `num` field of any element is greater than the `num` field of all preceding elements.
   - The `ArrayList` is as short as possible. In particular, no `num` field is repeated (instead there is just a higher `count` value for that number).

   Here is a partial implementation:

```
class IntPair {
    public int num;
    public int count;
    public IntPair(int n, int c) { num=n; count=c; }
}

public class Sequence {
    private ArrayList<IntPair> arr;

    public Sequence(int i) {
        arr = new ArrayList<IntPair>();
        arr.add(new IntPair(i,1));
    }

    public String toString() { // for simplicity has extra " " at end
        // algorithm is inefficient but simple
        String ans = "";
        for(IntPair p : arr) {
            for(int c = p.count; c > 0; c--)
                ans += p.num + " ";
        }
        return ans;
    }

    ... more methods ...
}
```

   See the next page for questions.

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(a) Can two instances of the ADT with different array-list contents (i.e., there is one or more `i` such that the objects have a different value for `arr.get(i).num` or `arr.get(i).count`) represent the same abstract value? If yes, give an example. If no, no explanation needed.

(b) Write a `checkRep` method for this implementation. Note the "short as possible" invariant may require checking some properties not explicitly mentioned on the previous page.

(c) Write a public observer method `mostCommon` that returns an `IntPair` containing the number that appears most often in the sequence and the number of times that number appears. Resolve ties however you want.

(d) Does your implementation of `mostCommon` suffer from representation exposure? If so, identify the exposure. If not, identify what you did to avoid it.

(e) Write a public mutator method `addToEnd` that adds a number to the sequence. It should throw the checked exception `NotLargeEnoughException` if the number is too small to be added. Assume the class for this exception is already defined.

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4. (points) This problem continues the previous problem. We consider implementing the same ADT, still with an `ArrayList<IntPair>`, but with a different representation invariant. We no longer maintain that the `ArrayList` is as short as possible: We allow (adjacent) array elements to have the same `num` value. We still require it to be sorted.

   (a) Can two instances of the ADT with different array-list contents (i.e., there is one or more `i` such that the objects have a different value for `arr.get(i).num` or `arr.get(i).count`) represent the same abstract value? If yes, give an example. If no, no explanation needed.

   (b) Is the new representation invariant *weaker*, *stronger*, or *incomparable* to the one in the previous problem? No explanation needed.

   (c) Given the new representation invariant, does the implementation of `toString` need to change? No explanation needed.

   (d) Given the new representation invariant, does the implementation of `addToEnd` need to change? No explanation needed.

   (e) Given the new representation invariant, does the implementation of `mostCommon` need to change? No explanation needed.

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5. (points)

   (a) For any ADT, we recommend writing a Java method that checks the representation invariant. Give two distinct reasons why we recommend writing this code (rather than only describing the representation invariant in comments).

   (b) Why should the Java method for checking a representation invariant be private?

   (c) For any ADT, there should be an abstraction function, but we do not recommend writing a Java method for it. Why not?

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6. (points) Consider these two class definitions:

```
public class Fruit {
    public String color;
    public double weight;

    public Fruit(String c, double w) { color=c; weight=w; }

    public boolean equals(Object o) {
        if(!(o instanceof Fruit))
            return false;
        Fruit f = (Fruit) o;
        return this.color.equals(f.color); // only compare colors
    }
    // other methods...
}

public class Apple extends Fruit {
    public boolean isShiny;

    public Apple(String c, double w, boolean s) { super(c,w); isShiny=s; }

    public boolean equals(Object o) {
        if(!(o instanceof Fruit))
            return false;
        boolean ans = true;
        ans = ans && super.equals(o);
        ans = ans && ((Fruit) o).weight == this.weight;
        if(o instanceof Apple) {
            Apple a = (Apple) o;
            ans = ans && this.isShiny == a.isShiny;
        }
        return ans;
    }
    // other methods...
}
```

(a) Do these `equals` methods provide the *reflexivity* property of Java's equals contract? If yes, just say so. If not, provide an example violating reflexivity.

(b) Do these `equals` methods provide the *symmetry* property of Java's equals contract? If yes, just say so. If not, provide an example violating symmetry.

(c) Do these `equals` methods provide the *transitivity* property of Java's equals contract? If yes, just say so. If not, provide an example violating transitivity.

There is room on the next page for your answsers, if needed.

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Room for answers from previous page.

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7. (points) Consider this method:

```
int m(boolean a, boolean b, boolean c, boolean d) {
    int ans = 1;
    if (a) {
        ans  = 2;
    } else if (b) {
        ans = 3;
    } else if (c) {
        if(d) {
            ans = 4;
        }
    }
    return ans;
}
```

No explanations are required below, but explanations will be needed for partial credit for wrong answers.

(a) What number of tests do you need to *exhaustively test* this method?

(b) What is the minimum number of tests needed to achieve full *statement coverage* for this method?

(c) What is the minimum number of tests needed to achieve full *branch coverage* for this method?

(d) Which of the questions above can be answered while using only a black-box testing methodology?

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8. (points)

Suppose `FooException` is a checked exception. Consider this code:

```
/**
 * @throws FooException if x > 0
 */
void m(int x) throws FooException {
    System.out.println(x);
}

void n() {
    m(17);
}
```

Does this code typecheck (assuming it is in some class)? If so, indicate what happens when `n` is called. If not, describe two changes where either one would cause the program to typecheck.

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9. (points) Short answer related to assigned readings

   (a) Yes or no: Did the class readings recommend creating strong-as-possible specifications for all classes and methods before beginning implementation?

   (b) If a subclass overrides a method defined in a superclass, how should the specification of the subclass method related to the specification of the superclass method? (Circle one.)

   - The specification for the subclass method should be stronger (or at least no weaker).
   - The specification for the subclass method should be weaker (or at least no stronger).
   - The specification for the subclass method should be either weaker or stronger.
   - The specification for the subclass method should be neither weaker nor stronger.

   (c) What is the return type of the `compareTo` method in the `Comparable` interface?