# Prelim 1. Solution

**CS 2110, 14 March 2017, 5:30 PM**

| | 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|
| Question | Name | Short answer | OO | Recursion | Loop invariants | |
| Max | 1 | 36 | 33 | 15 | 15 | 100 |
| Score | | | | | | |
| Grader | | | | | | |

## 1. Name (1 point)

Write your name and NetID at the top of **every** page of this exam.

## 2. Short Answer (36 points.)

**(a) 5 points.** Below are five expressions. To the right of each, write its value.

1. (int)'b' == 'b' true. Remember that char is a number type.
2. (char)('a' +3) 'd'
3. new Boolean(false) == new Boolean(false) false. Each new-expression creates a new object, and the pointers to these objects are different.
4. ((Object)(new Integer(3))).equals(3) true
5. k != 0 && 5/k == 8 [note: k is of type int] false. Short-circuit evaluation is used.

**(b) 4 points.** Consider a class $C$ with a method $m$. What are the two consequences of making $C$ and $m$ abstract? Making $C$ abstract means that objects of class $C$ cannot be created. Making $m$ abstract means that any non-abstract subclass must override $m$.

**(c) 5 points.** Function $Integer.parseInt(String\ s)$ returns the int value of the integer that is in String $s$. But if $s$ does not contain an integer, the function throws a $NumberFormatException$. Write a statement that stores in variable $dn$ the value of the function call:

```
Integer.parseInt(somestring)
```

but stores 1 in $dn$ if a $NumberFormatException$ is thrown.

```
try {
    dn= Integer.parseInt(somestring);
} catch (NumberFormatException e) {
    dn= 1;
}
```

**(d) 6 points.** Put a check mark before each of the following sentences that is correct and an X before each that is incorrect.

1. A class can extend only one non-abstract class but any number of abstract classes. false
2. All fields in an abstract class must be public. false
3. An abstract class cannot have a constructor because it cannot be instantiated. false
4. If a class implements an interface, its subclasses must not implement that interface. false
5. A local variable declared at the beginning of a method maintains its value from one call of the method to the next. false
6. Every constructor must start with a call on a super-class constructor. false

**(e) 12 points.** To the right is class `M1` and its subclass `M2`. Below is method `main` of class `M1` —it belongs in class `M1`.

Execute a call on method `main`. Write the value that is printed by each println statement to the right of that println statement.

```
public static void main(String[] p) {
   M1 a= new M1();
   System.out.println(a.x);  //ans: 3
   System.out.println(a.y);  //ans: 100
   System.out.println(a.m());//ans: 6

   M2 b= new M2();
   System.out.println(b.x); //ans: 4
   System.out.println(b.y); //ans: 100
   System.out.println(b.m());//ans: 105
}
```

```
public class M1 {
  public int x= 2;
  public int y= 100;

  public M1(int x) { this.x= x; }

  public M1() { this(3); }

  public int m() {
    return this instanceof M2 ? 5 : 6;
  }
}

public class M2 extends M1 {
  public M2() { super(4); }

  public @Override int m() {
      return 100 + super.m();
   }
}
```

**(f) 4 points.** What is the purpose of a constructor?
What constructor does Java insert into a class $C$ if no constructor is defined in it? The purpose of a constructor is to initialize fields so that the class invariant is true. If no constructor is defined in class C, Java inserts this one: public C(){} .

# 3. Object-Oriented Programming (33 points)

**(a) 5 points**
To the right are classes K1 and K2. Method m() is not overridden in class K2.

Modify class K1 so that a variable will contain the number of times during execution that method m() is called as a method of an object of class K2 (instead of as an object of class K1 only).

Your modifications should consist of inserting a declaration in class K1 and adding code at the beginning of method m().

```
public class K1 {
    //no. times m called in a K2 object
    static int c;

    public void m() {
       if (this instanceof K2) c= c+1;
       ...
    }
}

public class K2 extends K1 { ...  }
```

**(b) 10 points** Below are two class declarations. Complete the bodies of the constructor and function `toString` in class `Surgeon`. Be careful; pay attention to access modifiers.

```
public class Doctor {
   private String name;

   /** A doctor named n.
     * Precond.: no space in n */
   public Doctor(String n) {
         name= n;
   }

  /** Return this doctor's name */
  public String toString() {
      return name;
  }
}
```

```
public class Surgeon extends Doctor {
  private int ops; //no. of ops performed
  /** Constructor: instance with name n
    *              and op operations
    * Precond.: no space in n */
  public Surgeon(String n, int op) {
       super(n);
       ops= op;
  }

  /** Return this surgeon's name, a
    * space, and number of operations. */
  public String toString() {
      return super.toString() + " " + ops;
  }
}
```

**(c) 5 points** Complete the body of method *equals*, which belongs in class `Doctor`.:

```
/** Return true iff ob is a Doctor and
  * ob has the same name as this Doctor. */
public @Override boolean equals(Object ob) {
      if (!(ob instanceof Doctor)) return false;
      return name.equals(((Doctor)ob).name);
}
```

**(d) 5 points** Write down the steps in evaluating a new-expression `new C(args)` .

1. Create (draw) an instance of class C, with default values for the fields;
2. Execute the constructor call C(args);
3. Return as value of the new-expression the name of (pointer to) the created object.

**(e) 8 points**

Consider the interface and class declarations given below. Next to each piece of Java code in the righthand column, write whether it produces no error, a run-time error, or a compile-time error. (Assume that each piece is independent of the others.)

Here's a hint: First draw an object.

```
interface I1 {...}
interface I2 {...}
interface I3 extends I1 {...}
class C1 implements I1 {...}
class C2 implements I2 {...}
class C3 implements I3 {...}
class C4 extends C3
        implements I2 {...}
```

```
(a) I2 a= new I2(); // Compile-time error

(b) I2 b= new C2(); // no error

(c) C3 c= new C4(); // no error

(d) C2 d= new C4(); // Compile-time error

(e) C4 e= new C3(); // Compile-time error

(f) C4 f= (C4)(new C3()); // Runtime error

(g) I1 g1= new C1(); // no error
    C4 g2= new C4(); // no error
    g1= g2;          // no error

(h) I1 g1= new C4(); // no error
    I2 g2= new C2(); // no error
    g2= g1;  // Compile-time error
```

# 4. Recursion (15 Points)

(a) Write the body of recursive function $nf$, whose specification and header appear below. Do not use loops. Use only recursion. Here is a restriction, which should help you hone in on a simple solution: The only *String* functions you should use are *charAt*, *length*, and *substring*.

```
    /** Return the number of times the first
      * char of s appears at the beginning of s.
      * Precondition: s is not null and contains at least 1 char.
      * Example: nf("bbbcb$b") = 3.
      * Example: nf("bcb$bbb") = 1. */
    public static int nf(String s) {


        if (s.length() == 1) return 1;
        if (s.charAt(0) != s.charAt(1)) return 1;
        return 1 + nf(s.substring(1));
}
```

(b) Below is function comfy. It is complete except for the base-case if-condition. Circle all possible expressions from the list below that could be used for the base-case if-condition.

1. $s.length() < 3$ no
2. $s.length() \leq 3$ yes
3. $s.length() == 3$ no
4. $Integer.parseInt(s) < 1000$ yes
5. $s.length() == 0$ no

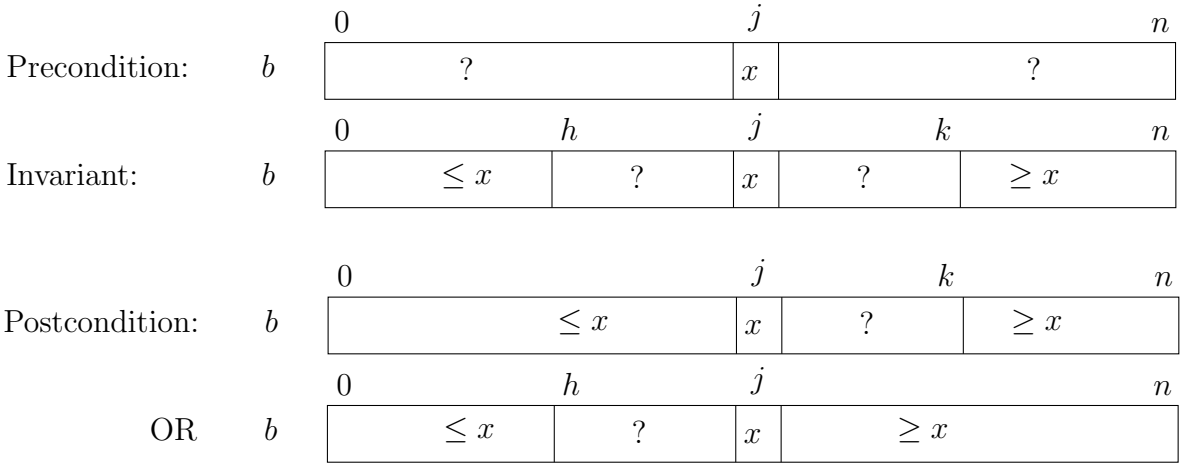
```
/** Return s formatted by adding a comma before every third digit.
   * E.g. 1000 is formatted as 1,000, 56 is 56, and 1234567 is 1,234,567.
   * Precondition s is a non-signed integer and the leftmost digit is not 0. **/
public String comfy(String s) {
 if ( base-case if-condition )  return s;
 return comfy(s.substring(0,s.length()-3)) + ',' + s.substring(s.length()-3);
}
```

# 5. Loop Invariants (15 points)

**(a) 2 points** State the formula for the number of values in array segment $b[h..k-1]$.

$k - h$ // it's Follower − First

**(b) 13 points** Consider the following precondition, invariant, and postcondition. The postcondition has two alternatives —either section $b[h..j-1]$ or section $b[j+1..k]$ is empty (the other one might be, but it is not necessary).




Write a loop with initialization that uses the invariant given above to implement the comment given below. Thus, the loop should continue as long as both ? sections are non-empty. Assume that $b$, $j$, and $n$ are already initialized. Identifier $x$ can't be used in the program; it just stands for the value in $b[j]$. Don't declare variables, but do assign appropriate values to $h$ and $k$ wherever necessary. To swap $b[i]$ and $b[j]$, just say, "Swap $b[i]$ and $b[j]$." Your grade depends only on how well you use the four loopy questions to write the code.

```
// Given the Precondition as shown above, swap values of array
// segment b[0..n] so that the Postcondition holds.
int h= 0;
int k= n;
while (h < j && j < k) {
    if (b[h] <= b[j]) h= h+1;
    else { Swap b[h] and b[k]; k= k - 1; }
}
```