Birthday: Month: _____ Day: _____

Summer 2010 CS61BL Midterm 1 SOLUTION

You have 110 minutes to finish this test. Your exam should contain 6 problems (numbered 0-5). This is an open-book test. You may consult any books, notes, or other paper-based inanimate objects available to you. Read the problems carefully. If you find it hard to understand a problem, please ask a question. Please write your answers in the spaces provided in the test; if you need to use the back of a page make sure to clearly tell us so on the front of the page.

Good Luck!

0		out of 1 point
1		out of 2 points
2		out of 6 points
3		out of 3 points
4		out of 3 points
5		out of 9 points
Total		out of 24 points

Write your name on the last page

Birthday: Month: _____ Day: _____

Question 1 (2 points)

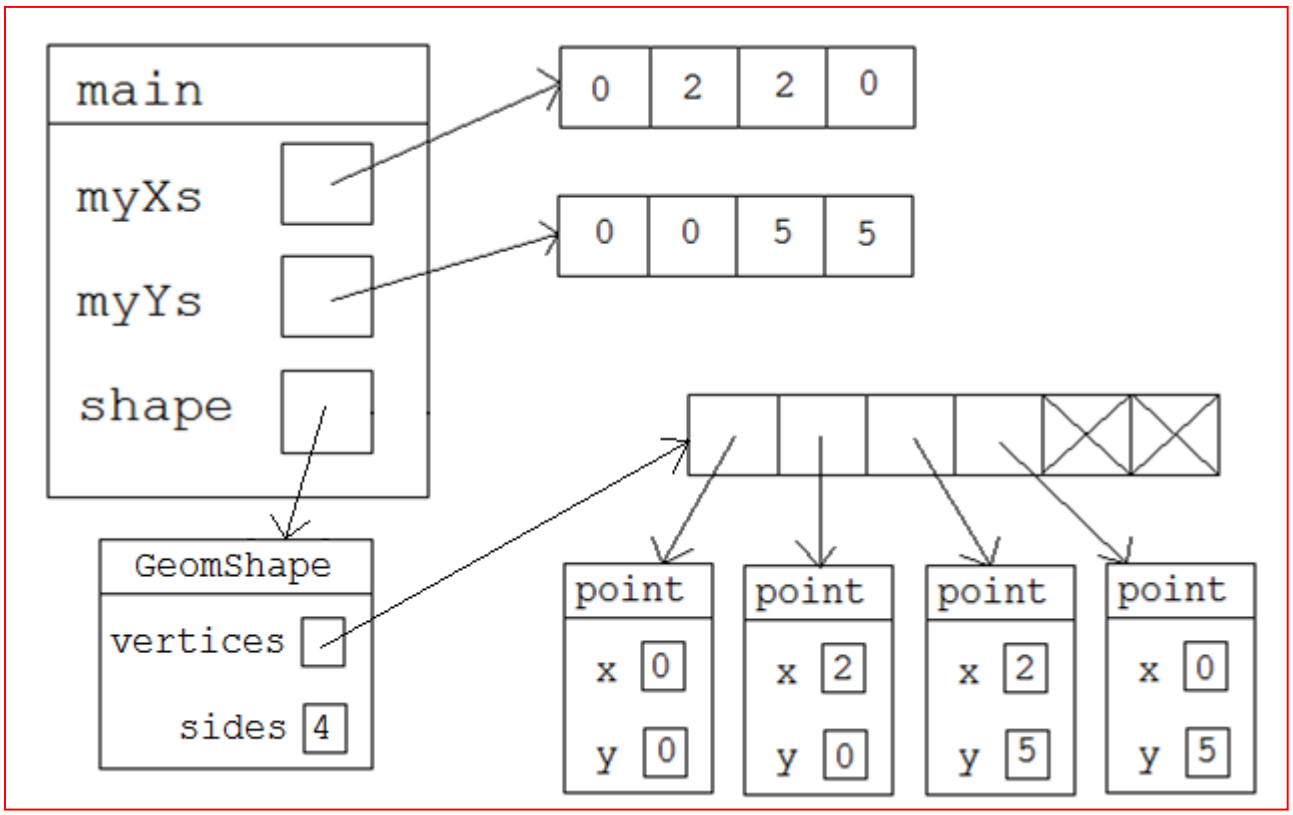
Below is a class that creates a geometric shape. Draw a picture of what memory looks like at the spot indicated in the `main` method. Note: The `Point` class has instance variables `x` and `y` of type `int`.

```
import java.awt.Point;

public class GeometricShape {
      public Point[] vertices;
      int sides;
      public GeometricShape(int[] xValues, int [] yValues) {
            sides = xValues.length;
            vertices = new Point[6];
            for (int i = 0; i < sides; i ++){
                  vertices[i] = new Point(xValues[i], yValues[i]);
            }
      }
      public static void main(String [] args){
            int[] myXs = {0, 2, 2, 0};
            int[] myYs = {0, 0, 5, 5};
            GeometricShape shape = new GeometricShape (myXs, myYs);

            // DRAW A PICTURE OF WHAT MEMORY LOOKS LIKE HERE!!!
      }
}
```

CORRECT ANSWER:



RUBRIC:

CODE	Deduction	Description
A	-1	Not showing the integers within boxes (there is a maximum of 1 point taken off no matter how many times this mistake is made.)
B	-0.5	Leaving out the sides instance variable inside of the geometric shape object
C	-1	The last two elements actually point to objects.
D	-1	The shape array only has 4 elements.
E	-1	If the integer values are not in the correct order or are generally wrong.
F	-1	If shape points directly to the array of Points, instead of to an object with instance variables vertices and sides.
G	-1	If the GeometricShape object has instance variables xValues and yValues
H	-0.5	Not drawing the X's in the last two spots in the array vertices.
I	-1	Sides instance variable is null
J	-0.5	No arrow from shape to geometricShape object

Things we didn't take off points for:

- **The Point objects do not need to be labeled "Point".**
- **Drawing all arrays as an object that then points to the thing that we typically draw arrays as.**
- **Putting something inside the array like (0, 2) is fine for each of the points. The array should really have an arrow that points to a separate object but we weren't picky.**
- **Geometric shape object does not need to be labeled "Geometric shape"**
- **Constructor stack frame drawn**

Question 2 (6 points)

The next three problems deal with the class `Set` from lab and shown below.

Taking advantage of inheritance, define a class `ExpandableSet` that behaves just like the `Set` except that, when `insert` is called with a value to be inserted larger than the `Set` can currently hold, the `Set` doubles in size until the value can be added. `ExpandableSet` should have a no argument constructor that makes the initial size of the `Set` be 1.

```
public class Set {
     // Represent a set of nonnegative ints from 0 to maxElement-1
     // for some initially specified maxElement.
     // contains[k] is true if k is in this set, false if it isn't
     protected boolean[] contains;

     // Initialize a set of ints from 0 to maxElement-1.
     public Set(int maxElement) {
          contains = new boolean[maxElement];
     }
     public void insert(int k) {
```

```
            contains[k] = true;
      }
      public void remove(int k) {
            contains[k] = false;
      }
      public boolean member(int k) {
            return contains[k];
      }
}

/*
 * JUnit has the following relevant methods (for Questions 3 and 4)
 */

static void assertTrue(boolean b)

static void assertFalse(boolean b)

static void assertEquals(String message, Object expected, Object actual)

static void fail()
```

Please write your solution to Question 2 here:

CORRECT ANSWER (multiple correct solutions possible):

```
public class ExpandableSet extends Set{

      public ExpandableSet() {
            super(1);
      }
      public void insert(int k){
            if (k >= contains.length)
            {
                  int origSize = contains.length;
                  int newSize = origSize * 2;
                  while (newSize <= k) {
                        newSize = newSize * 2;
                  }
                  boolean[] biggerVersion  = new boolean[newSize];
                  for (int i = 0; i < origSize; i++) {
                        biggerVersion[i] = contains[i];
                  }
                  contains = biggerVersion;
            }
            super.insert(k);
      }
}
      public void insert(int k){
```

```
        if (k >= contains.length)
        {
            boolean[] biggerVersion = new boolean[contains.length * 2];
            for (int i = 0; i < contains.length; i++) {
                biggerVersion[i] = contains[i];
            }
            contains = biggerVersion;
            insert(k);
        }
        super.insert(k);
    }
```

RUBRIC:

CODE	Deduction	Description
A	-1	Not including the line `public class ExpandableSet extends Set{`
B	-1	Not including a constructor that calls super(1); We take off this point for explicitly saying this.contains = new boolean[1]; b/c the compiler forces you to call super in this case b/c there is not a no argument constructor provided.
C	-1	Not including the insert method header (written exactly as: `public void insert(int k)`)
D	-0.5	Not calling super.insert(k) when k < contains.length (assuming that they do something like contains[k] = true;
E	-1	Forgetting to actually insert the value into the array
F	-1	Off by one error in checking k and contains.length. (If k == contains.length they need to expand).
G	-2	Writing to contains.length (which is not modifiable). For example: `contains.length = contains.length * 2;`

H	-3	They don't copy values from the old array into the new array. For example if they don't include something like this:
		`for (int i = 0; i < contains.length; i++) {`
		`  biggerVersion[i] = contains[i];`
		`}`
		OR if they write over contains before they have copied the values. For example.
		`contains = new boolean[contains.length * 2];`

I	-2	Tries to write to this.
J	-2	Don't point contains to the newly constructed array
K	-3	`Doesn't correctly increase the size by a factor of 2.`

L	-2	They don't handle the case where the array needs to expand to more than 2 times the size. In the first example solution this is done with the following loop:
		`while (newSize <= k) {`
		`  newSize = newSize * 2;`
		`}`
		In the second example this is done by recursively calling `insert`.

M	-3	Tries to implicitly write over this by calling super within the insert method, this sometimes overlaps with H. Don't double count., calls this() on insert
N	-1	Provided additional unnecessary methods
P	-3	Treating an expandable set as an array – type mismatch issues etc.

Q	**-1**	**Uses maxElement instead of contains.length**
R	**-1**	**Loop condition never fails – infinite loop**
S	**-1**	**Calls insert(k) instead of super.insert(k)**
T	**-0.5**	**Return inside of insert**
U	**-0.5**	**Misc. compile time errors**

Question 3 (3 points)

Now we are going to test `ExpandableSet` using `JUnit`. When we change the `length` of `ExpandableSet`, we want it to become exactly the `length` we expect. For example, if the `ExpandableSet` should have doubled in length we want it to be exactly double the length, no more, no less.

a) However in the JUnit file we can't just check the `length` of the array. Explain why.

Example 1 point answer: The code is not inside the Set class, nor a subclass of the Set class so we can't access the protected variable `contains`
Example 0.5 point answer: The variable is protected so we can't access it.
Example 0 point answer: Not mentioning protected – for example: The length can change so we can't access it. JUnit can't work with arrays.

- Note: Saying that there are no getter methods for the length does not increase or decrease a score on this question.

b) Complete the helper method below to appear in your `JUnit` file `ExpandableSetTest`. This method will return `true` if the length of the `ExpandableSet es` is equal to the `int expectedSize`. You may not write any additional methods. Hint: It will be helpful to use the concept of Exceptions.

```
public class ExpandableSetTest extends TestCase {

    private boolean sizeCheckHelper(ExpandableSet es, int expectedSize){
```

CORRECT ANSWER:

```
try {
   es.member(expectedSize - 1)
}
catch (ArrayOutOfBoundsException e) {
  return false;
}
try {
   es.member(expectedSize )
   return false;
}
catch (ArrayOutOfBoundsException e) {
  return true;
}
```

- 1 point for checking that it is big enough,
- 1 point for checking that it isn't too big.

Errors:
A – you only check if it is big enough
B – you only check if it is too big.

1. No points off if the name of the exception isn't exactly correct but the idea is correct
2. 0/2 if missing the idea that calling es.member(x) might throw an exception
3. 0/2 if doing something like es.length
4. No points off if es.contains(x) is called instead of es.member(x)
5. 0.5 off if the logic is sound but the wrong exception is caught (Null Pointer)
6. -1 for using insert instead of member

Question 4 (3 points)

Fill in the table below with a convincing set of JUnit test methods for the `insert` method in `ExpandableSet`. You should test 1 important thing about `insert` in each test method. You may use your method `sizeCheckHelper`.

`public class ExpandableSetTest extends TestCase {`	**Description of what this tests**
`public void test1()` `}`	

`public void test2() {`
 	
`}`	

`public void test3() {`
 	
`}`	

Solution

```
// NONE
// Test that the size doesn't increase unnecessarily
ExpandableSet e = new ExpandableSet();
e.insert(0);
assertTrue (sizeCheckHelper(e, 1));

// ONE
// Test that the size doubles when necessary
ExpandableSet e = new ExpandableSet();
e.insert(1);
assertTrue (sizeCheckHelper(e, 2));

// MANY
// Test that the size is 8 times as large when necessary.
ExpandableSet e = new ExpandableSet();
e.insert(4);
assertTrue (sizeCheckHelper(e, 8));
```

RUBRIC:

CODE	Deduction	Description
A	+1	Provides no expansion case
B	+1	Provides single expansion case
C	+1	Provides multiple expansion case
D	+1	Provides a check that the value actually gets set by insert
E	-1	Doesn't create the objects needed, for example – contains no calls to new ExpandableSet();
F	-1	If they used print statements instead of using JUnit asserts.
G	-0.5	SizeCheck helper with incorrect arguments
H	-0.5	Contains[k] check (where k is an incorrect position)
I	-1	Not using sizecheckHelper and using something that doesn't work
J	-1	Treating expandable set as an array

- We didn't take off points if people created a constructor that took in a size and used it in their tests.

Question 5 (9 points)

This question is based upon Project 1. Relevant details of the `Picture class` and `Pixel class` are provided on the next few pages. The goal is to iterate over all `Pixels` in a `Picture` that are within a Circle. The order in which `Pixels` are returned doesn't matter, but all `Pixels` within the circle should be returned. For example, we want to be able to run the following method in the `Picture` class:

```
// Colors the picture with a black circle of radius 10,
// centered at (50, 50)
```

```
    public void blackCircle(){
        this.initIterator(50, 50, 10);
        while (this.hasNext()){
            this.next().setColor(new Color(0, 0, 0, 255));
        }
    }
```

Based upon the comments below, implement the following methods for the `Picture class.` You may only add code within the methods defined below. Any other modifications will result in a score of 0 on this question.

```
public class Picture extends SimplePicture {
    // instance variables - You may NOT define any new instance variables

    int midX;           // the X coordinate of the center of the circle
    int midY;           // the Y coordinate of the center of the circle
    int radius;         // the radius of the circle
    Pixel nextPixel;    // Invariant: always references the next Pixel to
                        //            be returned by next() or null if no
                        //             pixels remain.

// Returns true if there are more pixels to return in the circle
// and false otherwise
public boolean hasNext() {
    // if nextPixel is null, there are no more pixels to return
    return nextPixel != null;
}

// HELPER METHOD
// Returns true if the instance variable nextPixel is within the
// the circle and false otherwise.
private boolean isNextPixelWithinRadius() {
    if (nextPixel == null) {
        return false;
    }
    int x = nextPixel.getX();
    int y = nextPixel.getY();
    return (Pixel.distance(x, y, midX, midY) < radius);
}

// This method should restore the invariant described for nextPixel.
// You must call this method at least once in your code on the next page.
// This method may call the optional helper method getUnexploredPixel
private void restoreInvariant() {


}
// OPTIONAL HELPER METHOD
// If you chose to implement this method you must implement exactly what
```

```
// the comment specifies.
//
// This method should return the next unexplored Pixel based upon the
// argument lastPixel. Unexplored Pixels should be returned regardless of
// whether they are within the circle. This method does not modify
// nextPixel. The method returns the next Pixel to be explored or null
// if no unexplored Pixels remain.
public Pixel getUnexploredPixel(Pixel lastPixel)
{
}
```

CODE	Deduction	Description
A	-4	Missing pixels in the traversal (major)
B	-2	Bad math indexing picture, for example by accessing a pixel that may be outside of the circle (getPixel(x-radius, y-radius) etc.
C	-1	Off by 1 in accessing all of the pixels
D	-2	Really pretty close to all of the pixels but more than an off by 1 error

CODE	Deduction	Description
E	-4	**Invariant not maintained**
F	-2	**Restore invariant does not restore the invariant**
G	-3	**Wrong invariant**

CODE	Deduction	Description
I	-1	Calls new Pixel(…) instead of getPixel(…)
J	-1	Next() doesn't return a pixel/or calls restore invariant after the return.
K	-2	Not constructing a pixel
L	-1	Makes a new picture object

CODE	Deduction	Description
Y	-1	Doesn't save instance variables midX, midY and radius
Z	-1	Doesn't make sure that the invariant is true at the end of the call to initIterator, examples of this include not initializing the pixel, another is calling restore invariant that may cause the initial pixel (0,0) to never be returned by next.

```
// The circle is defined by a radius circleRadius and is centered at
// coordinates (centerX, centerY).
// This method will be called before the first call to hasNext() or next()
SOLUTION
public void initIterator(int centerX, int centerY, int circleRadius) {
          midX = centerX;
          midY = centerY;
          radius = circleRadius;
          nextPixel = this.getPixel(0, 0);
          if (!nextPixelWithinRadius()){
              restoreInvariant();
```

```
        }
```

RUBRIC:

CODE	Deduction	Description
A		Doesn't save instance variables midX, midY and radius
B		Doesn't make sure that the invariant is true at the end of the call to initIterator.

```
}

// return successive Pixels within the circle specified in initIterator
    SOLUTION:
    public Pixel next() {
        Pixel pixelToReturn = nextPixel;
        restoreInvariant();
        return pixelToReturn;
    }
```