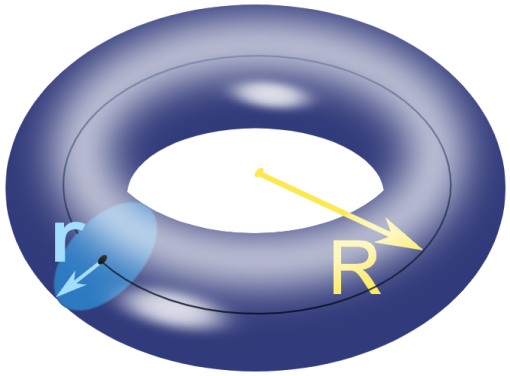
Deliverables

Your project files should be submitted to Web-CAT by the due date and time specified. Note that there is also an optional Skeleton Code assignment which will indicate level of coverage your tests have achieved (there is no late penalty since the skeleton code assignment is ungraded for this project). The files you submit to skeleton code assignment may be incomplete in the sense that method bodies have at least a return statement if applicable or they may be essentially completed files. In order to avoid a late penalty for the project, you must submit your completed code files to Web-CAT no later than 11:59 PM on the due date for the completed code assignment. If you are unable to submit via Web-CAT, you should e-mail your project Java files in a zip file to your TA before the deadline. Your grade will be determined, in part, by the tests that you pass or fail in your test file and by the level of coverage attained in your source file, as well as our usual correctness tests.

Files to submit to the grading system:

- RingTorus.java, RingTorusTest.java

A **ring torus** is made by revolving a small circle with radius ***r*** along a line made by a larger circle with radius ***R*** as shown below.



Variables in formulas:

***R**: radius of large circle (or large radius)*
***r**: radius of small circle (or small radius)*
***A**: surface area*
***V**: volume*
***D**: ring diameter*

$\boldsymbol{D} = 2\,(R + r)$

$\boldsymbol{A} = (2\pi R)\,(2\pi r)$

$\boldsymbol{V} = (2\pi R)\,(\pi r^2)$

Specifications

Overview: In this project, the two files developed in Part 1 are to be extended as follows: (1) RingTorus, which is a class representing a RingTorus object, will implement the Comparable interface and (2) RingTorusTest class, which is a JUnit test class, will be expanded from method coverage to condition coverage for RingTorus. The new items for Part 2 are underlined below for your convenience. *Note that there is no requirement for a class with a main method in this project.*

You should create a new folder to hold the files for this project and add your files from Part 1 (RingTorus.java file and RingTorusTest.java). You should create a new jGRASP project for Part 2 and add RingTorus.java file and RingTorusTest.java to the project; you should see the two files in their respective categories – Source Files and Test Files. If RingTorusTest.java appears in source File category, you should right-click on the file and select "Mark As Test" from the right-click menu.

You will then be able to run the test file by clicking the JUnit run button on the Open Projects toolbar.

- **RingTorus.java** (*new items for this class in Part 2 are underlined*)

  Requirements: Create a RingTorus class that stores the label, small radius, and large radius where the small radius is less than the large radius and both are positive. The RingTorus class also includes methods to set and get each of these fields, as well as methods to calculate the outside diameter, surface area, and volume of a RingTorus object, and a method to provide a String value that describes a RingTorus object. The RingTorus class includes a one static field (or class variable) to track the number of RingTorus objects that have been created, as well appropriate static methods to access and reset this field. And finally, this class provides a method that JUnit will use to test RingTorus objects for equality as well as a method required by Checkstyle. In addition, RingTorus must implement the Comparable interface for objects of type RingTorus.

  Design: The RingTorus class implements the Comparable interface for objects of type RingTorus and has fields, a constructor, and methods as outlined below (last method is new).

  (1) **Fields:** *Instance Variables* - label of type `String`, large radius of type `double`, and small radius of type `double`. Initialize the `String` to `""` and the `double` variables to 0 in their respective declarations. These instance variables should be private so that they are not directly accessible from outside of the RingTorus class, and these should be the only instance variables (fields) in the class.
  Class Variable - count of type int should be private and static, and it should be initialized to zero in the declaration.

  (2) **Constructor**: Your RingTorus class must contain a public constructor that accepts three parameters (see types of above) representing the label, large radius, and small radius. Instead of assigning the parameters directly to the fields, the respective set method for each field (described below) should be called since they are checking the validity of the parameter. For example, instead of using the statement `label = labelIn;` use the statement `setLabel(labelIn);`
  After setLabel is called be sure to call setLargeRadius before calling setSmallRadius. The constructor should increment the class variable count each time a RingTorus is constructed.

  Below are examples of how the constructor could be used to create RingTorus objects. Note that although String and numeric literals are used for the actual parameters (or arguments) in these examples, variables of the required type could have been used instead of the literals.

```
RingTorus ex1 = new RingTorus ("Small Example", 9.5, 1.25);

RingTorus ex2 = new RingTorus (" Medium Example ", 35.1, 10.4);

RingTorus ex3 = new RingTorus ("Large Example", 134.28, 32.46);
```

(3) **Methods**: Usually a class provides methods to access and modify each of its instance variables (known as get and set methods) along with any other required methods. The methods for RingTorus, which should each be public, are described below. See the formulas in the figure above and the Code and Test section below for information on constructing these methods.

- `getLabel`: Accepts no parameters and returns a `String` representing the label field.
- `setLabel`: Takes a `String` parameter and returns a `boolean`. If the `String` parameter is not `null`, then the "trimmed" `String` is set to the label field and the method returns `true`. Otherwise, the method returns `false` and the label is not set.
- `getLargeRadius`: Accepts no parameters and returns a `double` representing the large radius field.
- `setLargeRadius`: Takes a `double` parameter and returns a `boolean`. If the `double` parameter is positive and is greater than the current small radius, then the parameter is assigned to the large radius field and the method returns `true`. Otherwise, the method returns `false` and the large radius field is not set.
- `getSmallRadius`: Accepts no parameters and returns a `double` representing the small radius field.
- `setSmallRadius`: Takes a `double` parameter and returns a `boolean`. If the `double` parameter is positive and is less than the current large radius, then the parameter is assigned to the small radius field and the method returns `true`. Otherwise, the method returns `false` and the small radius field is not set.
- `diameter`: Accepts no parameters and returns a `double` representing the diameter of the RingTorus. See formula in figure on page 1.
- `surfaceArea`: Accepts no parameters and returns the `double` value for the surface area of the RingTorus. See formula in figure on page 1.
- `volume`: Accepts no parameters and returns the double value for the volume of the RingTorus. See formula in figure on page 1.
- `toString`: Returns a `String` containing the information about the RingTorus object formatted as shown below, including decimal formatting ("#,##0.0##") for the `double` values. Newline and tab escape sequences should be used to achieve the proper layout within the String but it should not begin or end with a newline. In addition to the field values (or corresponding "get" methods), the following methods should be used to compute appropriate values in the `toString` method: `diameter()`, `surfaceArea()`, and `volume()`. Each line should have no trailing spaces (e.g., there should be no spaces before a newline (\n) character). The `toString` value for `ex1`, `ex2`, and `ex3` respectively are shown below (the blank lines are not part of the `toString` values).

```
RingTorus "Small Example"
   large radius = 9.5 units
   small radius = 1.25 units
   diameter = 21.5 units
   surface area = 468.806 square units
   volume = 293.004 cubic units
```

```
RingTorus "Medium Example"
   large radius = 35.1 units
   small radius = 10.4 units
   diameter = 91.0 units
   surface area = 14,411.202 square units
   volume = 74,938.248 cubic units

RingTorus "Large Example"
   large radius = 134.28 units
   small radius = 32.46 units
   diameter = 333.48 units
   surface area = 172,075.716 square units
   volume = 2,792,788.867 cubic units
```

- `getCount`: A static method that accepts no parameters and returns an int representing the static count field.
- `resetCount`: A static method that returns nothing, accepts no parameters, and sets the static count field to zero.
- `equals`: An instance method that accepts a parameter of type Object and returns false if the Object is a not a RingTorus; otherwise, when cast to a RingTorus, if it has the same field values (ignoring case in the label field) as the RingTorus upon which the method was called, it returns true. Otherwise, it returns false. Note that this equals method with parameter type Object will be called by the JUnit Assert.assertEquals method when two RingTorus objects are checked for equality.

  Below is a version you are free to use.

```
public boolean equals(Object obj) {

   if (!(obj instanceof RingTorus )) {
      return false;
   }
   else {
      RingTorus rt = (RingTorus ) obj;
      return (label.equalsIgnoreCase(rt.getLabel())
             && (Math.abs(largeRadius - rt.getLargeRadius()) < .000001)
             && (Math.abs(smallRadius - rt.getSmallRadius()) < .000001));
   }
}
```

- `hashCode()`: Accepts no parameters and returns zero of type int. This method is required by Checkstyle if the `equals` method above is implemented.
- `compareTo`: Accepts a parameter of type RingTorus and returns an int as follows: a negative value if `this.volume()` is less than the parameter's volume; a positive value if `this.volume()` is greater than the parameter's volume; zero if the two volumes are essentially equal. *For a hint, see the activity for this module*.

Code and Test: As you implement the methods in your RingTorus class, you should compile it and then create test methods as described below for the RingTorusTest class.

When using the **setSmallRadius** and **setLargeRadius**, the values of the current smallRadius and largeRadius must be considered to decide the order in which you invoke the associated set methods. For setSmallRadius, the "new" small radius must be positive and smaller the current large radius, and for setLargeRadius, the "new" large radius must be positive and larger the current small radius. For example, a new RingTorus object has its smallRadius and largeRadius fields initialized to zero in the field declaration, which is default initial value for doubles. However, this means in the constructor, you must invoke the setLargeRadius before the setSmallRadius. If you wanted a small radius of 2.5 and attempt to set it first, it would not be set since it will not be less than largeRadius, which is initially zero. Thus, you invoke setLargeRadius first since any positive value will be greater than the smallRadius which is initially zero. Therefore, in general you need to consider the current value the smallRadius and largeRadius to decide the order you invoke the associated set methods.

- **RingTorusTest.java**

  Requirements: Create a RingTorusTest class that contains a set of *test* methods to test each of the methods in RingTorus. The goal for Part 2 is method, statement, and condition coverage.

  Design: Typically, in each test method, you will need to create an instance of RingTorus, call the method you are testing, and then make an assertion about the expected result and the actual result (note that the actual result is commonly the result of invoking the method unless it has a void return type). You can think of a test method as simply formalizing or codifying what you could be doing in jGRASP interactions to make sure a method is working correctly. That is, the sequence of statements that you would enter in interactions to test a method should be entered into a single test method. You should have at least one test method for each method in RingTorus, except for associated getters and setters which can be tested in the same method. In addition, you should have sufficient test methods so that each method, statement, and condition in RingTorus are covered. Collectively, these test methods are a set of test cases that can be invoked with a single click to test all the methods in your RingTorus class.

  Code and Test: A good strategy would be to begin by writing test methods for those methods in RingTorus that you "know" are correct. By doing this, you will be able to concentrate on the getting the test methods correct. That is, if the test method *fails*, it is most likely due to a defect in the test method itself rather the RingTorus method being testing. As you become more familiar with the process of writing test methods, you will be better prepared to write the test methods as new methods are developed. Be sure to call the RingTorus `toString` method in one of your test methods and assert something about the return value. If you do not want to use assertEquals, which would require the return value match the expected value exactly, you could use assertTrue and check that the return value contains the expected value. For example, for RingTorus ex3:

  ```
  Assert.assertTrue(ex3.toString().contains("\"Large Example\""));
  ```

  Also, remember that you can set a breakpoint in a JUnit test method and run the test file in Debug mode. Then, when you have an instance in the Debug tab, you can unfold it to see its values or you can open a canvas window and drag items from the Debug tab onto the canvas. You can also

step-in to the method being called by the test method and then single-step through it, looking for the error.

The Grading System

When you submit RingTorus.java and RingTorusTest.java, the grading system will use the results of your test methods and their level of coverage of your source files as well as the results of our reference correctness tests to determine your grade. In this project, your test file should provide method, statement, and condition coverage. Each condition in your source file must be exercised both true and false. See the note below for hints on testing the `equals`. To see your code coverage in Web-CAT, on "Your Assignment Submission Results" page, in "File Details", click on your source file and look for any highlighted lines of code. Hover your mouse on the highlighted source code, to see the hint about what was not covered. Example of hints you might see include: (1) This line was never executed by your tests. (2) Not all possibilities of this decision were tested. Remember that when you have N simple conditions combined, you must test all N+1 possibilities.

Note For Testing the `equals` Method

Perhaps the most complicated method to test is the `equals` method in RingTorus. This method has three conditions in the boolean expression that are &&'d. Since Java (and most other languages) uses short-cut logic, if the first condition in an && is false, the &&'d expression is false. This means that to test the second condition, the first conditions must be true. Furthermore, to test the third conditions both the first and second conditions must be true. To have condition coverage for the equals method, you need the four test cases where the three conditions evaluate to the following, where T is true, F is false, and X is don't care (could be true or false):

FXX - returns false
TFX - returns false
TTF - returns false
TTT - returns true