Unit Testing

Lecture Objective

- Add testing to lecture objectives 1, 2, and 3 -

Testing: In the tests package, complete the test suite named LectureObjective1 to test the functionality of Lecture Objective 1.

Testing: In the tests package, complete the test suite named LectureObjective2 to test the functionality of Lecture Objective 2.

Testing: In the tests package, complete the test suite named LectureObjective3 to test the functionality of Lecture Objective 3.

Testing

- How do you know if your code is correct?

- Submit to AutoLab?
  - Does not exist outside of class
  - Does not exist for your project

Recall

```
package example

object Conditional {

  def computeSize(input: Double): String = {
    val large: Double = 60.0
    val medium: Double = 30.0
    if (input >= large) {
      "large"
    } else if (input >= medium) {
      "medium"
    } else {
      "small"
    }
  }

}
```

- **How do we test this function to verify that it's correct?**

Recall

```
package example

object Conditional {

  def computeSize(input: Double): String = {
    val large: Double = 60.0
    val medium: Double = 30.0
    if (input >= large) {
      "large"
    } else if (input >= medium) {
      "medium"
    } else {
      "small"
    }
  }

  def main(args: Array[String]): Unit = {
    println(computeSize(70.0))
    println(computeSize(50.0))
    println(computeSize(10.0))
  }

}
```

- **Call the method from main**
- **Print the results**
- **Manually verify**

What About Large Projects?

- There may be 100's of files and 1000's of methods
- Any change in a function might break any code that calls that function
- Will you manually verify all that code for each change?

- Unit Testing
  - Automate testing
  - Provide structure to testing

Unit Testing

- Run a serious of tests on your code
- If the code is correct, all tests should pass
- If the code is incorrect, at least one test should fail
- A set of tests should test every possible error that could occur

Scala Unit Testing

```scala
package tests

import org.scalatest._
import example.Conditional

class TestComputeSize extends FunSuite {

  test("Doubles are checked for size in each category") {
    val largeDouble: Double = 70.0
    val mediumDouble: Double = 50.0
    val smallDouble: Double = 10.0

    assert(Conditional.computeSize(largeDouble) == "large", largeDouble)
    assert(Conditional.computeSize(mediumDouble) == "medium", mediumDouble)
    assert(Conditional.computeSize(smallDouble) == "small", smallDouble)
  }

}
```

Use Maven to download scalatest (see pom.xml on the course website)

Click Maven in the IntelliJ sidebar to interact with pom.xml

Scala Unit Testing

```
package tests

import org.scalatest._
import example.Conditional

class TestComputeSize extends FunSuite {

  test("Doubles are checked for size in each category") {
    val largeDouble: Double = 70.0
    val mediumDouble: Double = 50.0
    val smallDouble: Double = 10.0

    assert(Conditional.computeSize(largeDouble) == "large", largeDouble)
    assert(Conditional.computeSize(mediumDouble) == "medium", mediumDouble)
    assert(Conditional.computeSize(smallDouble) == "small", smallDouble)
  }

}
```

Import everything from the org.scalatest package

_ is a Scala wildcard

Scala Unit Testing

```scala
package tests

import org.scalatest._
import example.Conditional

class TestComputeSize extends FunSuite {

  test("Doubles are checked for size in each category") {
    val largeDouble: Double = 70.0
    val mediumDouble: Double = 50.0
    val smallDouble: Double = 10.0

    assert(Conditional.computeSize(largeDouble) == "large", largeDouble)
    assert(Conditional.computeSize(mediumDouble) == "medium", mediumDouble)
    assert(Conditional.computeSize(smallDouble) == "small", smallDouble)
  }

}
```

Create a new class of type FunSuite (Function Suite)

*More details on this syntax next week. This is inheritance

Scala Unit Testing

```
package tests

import org.scalatest._
import example.Conditional

class TestComputeSize extends FunSuite {

  test("Doubles are checked for size in each category") {
    val largeDouble: Double = 70.0
    val mediumDouble: Double = 50.0
    val smallDouble: Double = 10.0

    assert(Conditional.computeSize(largeDouble) == "large", largeDouble)
    assert(Conditional.computeSize(mediumDouble) == "medium", mediumDouble)
    assert(Conditional.computeSize(smallDouble) == "small", smallDouble)
  }

}
```

Create a new test that will be executed when this file is ran

No main method

FunSuite controls execution instead of main

Scala Unit Testing

```scala
package tests

import org.scalatest._
import example.Conditional

class TestComputeSize extends FunSuite {

  test("Doubles are checked for size in each category") {
    val largeDouble: Double = 70.0
    val mediumDouble: Double = 50.0
    val smallDouble: Double = 10.0

    assert(Conditional.computeSize(largeDouble) == "large", largeDouble)
    assert(Conditional.computeSize(mediumDouble) == "medium", mediumDouble)
    assert(Conditional.computeSize(smallDouble) == "small", smallDouble)
  }

}
```

Call assert to test values

First argument is a boolean that must be true for the test to pass
-Should return false if the code is not correct
Second argument is optional. Is printed if the test fails

Scala Unit Testing

```scala
package tests

import org.scalatest._
import example.Conditional

class TestComputeSize extends FunSuite {

  test("Doubles are checked for size in each category") {
    val largeDouble: Double = 70.0
    val mediumDouble: Double = 50.0
    val smallDouble: Double = 10.0

    assert(Conditional.computeSize(largeDouble) == "large", largeDouble)
    assert(Conditional.computeSize(mediumDouble) == "medium", mediumDouble)
    assert(Conditional.computeSize(smallDouble) == "small", smallDouble)
  }

}
```

This class tests if the inputs 70.0, 50.0, and 10.0 return "large", "medium", and "small" respectively

Is this enough testing?

Correct Solution

```
package example

object Conditional {

  def computeSize(input: Double): String = {
    val large: Double = 60.0
    val medium: Double = 30.0
    if (input >= large) {
      "large"
    } else if (input >= medium) {
      "medium"
    } else {
      "small"
    }
  }

}
```

Incorrect Solution
-Passes the tests-

```scala
package example

object Conditional {

  def computeSize(input: Double): String = {
    val large: Double = 65.0
    val medium: Double = 20.0
    if (input >= large) {
      "large"
    } else if (input >= medium) {
      "medium"
    } else {
      "small"
    }
  }

}
```

Scala Unit Testing

```scala
package tests

import org.scalatest._
import example.Conditional

class TestComputeSize extends FunSuite {

  test("Size boundaries are checked"){
    val largeDouble: Double = 60.0
    val mediumDoubleUpperBound: Double = 59.99
    val mediumDoubleLowerBound: Double = 30.0
    val smallDouble: Double = 29.99

    assert(Conditional.computeSize(largeDouble) == "large", largeDouble)
    assert(Conditional.computeSize(mediumDoubleUpperBound) == "medium", mediumDoubleUpperBound)
    assert(Conditional.computeSize(mediumDoubleLowerBound) == "medium", mediumDoubleLowerBound)
    assert(Conditional.computeSize(smallDouble) == "small", smallDouble)
  }

}
```

Check the boundaries for more accurate testing

Is this enough testing?

Scala Unit Testing

```scala
package tests

import org.scalatest._
import example.Conditional

class TestComputeSize extends FunSuite {

  test("Size boundaries are checked"){
    val largeDouble: Double = 60.0
    val mediumDoubleUpperBound: Double = 59.99
    val mediumDoubleLowerBound: Double = 30.0
    val smallDouble: Double = 29.99

    assert(Conditional.computeSize(largeDouble) == "large", largeDouble)
    assert(Conditional.computeSize(mediumDoubleUpperBound) == "medium", mediumDoubleUpperBound)
    assert(Conditional.computeSize(mediumDoubleLowerBound) == "medium", mediumDoubleLowerBound)
    assert(Conditional.computeSize(smallDouble) == "small", smallDouble)
  }

}
```

Check the boundaries for more accurate testing

Is this enough testing?

We could reasonable stop here.. but we could do more thorough testing

Scala Unit Testing

```scala
package tests

import org.scalatest._
import example.Conditional

class TestComputeSize extends FunSuite {

  test("Use many test cases for each category"){
    // notice largeDoubles must be declared with var we change its value
    var largeDoubles: List[Double] = List(60.0, 60.01, 70.0, 90.0, 1000.0)
    val mediumDoubles: List[Double] = List(59.9, 30.0, 30.01, 40.0, 50.0)
    val smallDoubles: List[Double] = List(29.99, 20.0, 10.0, 0.0, -100.0, -10000.0)

    largeDoubles = largeDoubles :+ 10000.0 // Example of adding an element to a List

    for(largeDouble <- largeDoubles){
      assert(Conditional.computeSize(largeDouble) == "large", largeDouble)
    }
    for(mediumDouble <- mediumDoubles){
      assert(Conditional.computeSize(mediumDouble) == "medium", mediumDouble)
    }
    for(smallDouble <- smallDoubles){
      assert(Conditional.computeSize(smallDouble) == "small", smallDouble)
    }

  }

}
```

Use data structures to run many test cases

Unit Testing Objectives

- Each homework, and other places in the course, will have objectives that require thorough testing
- When these objectives are graded, your test suite is ran:
  - Against your solution
  - Against a correct solution stored o the server
  - Against a variety of incorrect solution stored on the server
- Your test suite should pass on both your solution and the correct solution
- Your test suite should fail on all the incorrect solutions

Maven: Dependency Management

- To run this testing code, we used an external library named Scalatest
  - Scalatest does not come with Scala
  - We must download it before running tests
- To manage external libraries, we'll use Maven
  - List all dependancies (libraries) in a file named pom.xml
  - Save pom.xml in the root directory of your project
  - Use Maven to download all dependancies
- The pom.xml is similar to the requirements.txt file we used in Python

Maven Demo

Maven

- Find new libraries at https://mvnrepository.com
  - An enormous wealth of shared libraries
  - Search for the new libraries, paste the dependency into you pom.xml file

Lecture Question

Method: In a package named "lecture" create an object named "FirstObject" with a method named "computeShippingCost" that takes a Double representing the weight of a package as a parameter and returns a Double representing the shipping cost of the package

The shipping cost is ($)5 + 0.25 for each pound over 30

Unit Testing: In a package named "tests" create a class/file named "UnitTesting" as a test suite that tests the computeShippingCost method

rounding_weight

```
def computeShippingCost(weight: Double): Double = {
  if (weight < 3.0) {
    5.0
  } else {
    5.0 + (Math.round(weight) - 30.0) * 0.25
  }
}
```

always_over_thirty

```
def computeShippingCost(weight: Double): Double = {
  5.0 + (weight - 30.0) * 0.25
}
```

boundary_overweight

```
def computeShippingCost(weight: Double): Double = {
  if (weight < 33.0) {
    5.0
  } else {
    5.0 + (weight - 33.0) * 0.25
  }
}
```

light_employee_discount

```
def computeShippingCost(weight: Double): Double = {
  if (weight < 30.0) {
    4.0
  } else {
    5.0 + (weight - 30.0) * 0.25
  }
}
```

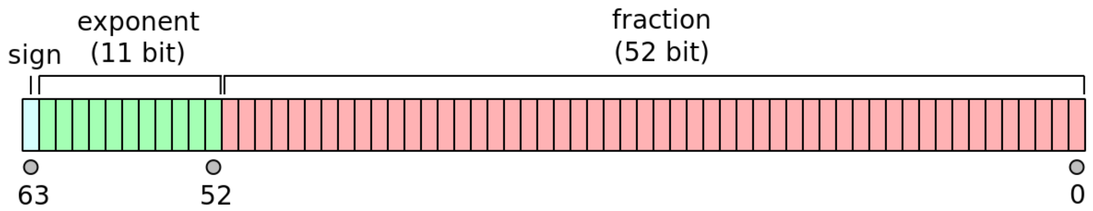
always_under_thirty

```
def computeShippingCost(weight: Double): Double = {
  5.0
}
```

Testing Doubles

Double

- Number with a whole number and a decimal portion
- 64 bit representation
- Values are truncated to fit in 64 bits
  - Loss of precision!



https://en.wikipedia.org/wiki/Double-precision_floating-point_format

Double

- Values are represented in binary
  - Ex. 0.11 == 1/2 + 1/4 == 3/4
- In decimal we have values that cannot be stored without truncation
  - Ex. 1/3 != 0.33333333333333333333
- Values such as 0.1 cannot be represented as a sum of powers of 2
  - 0.1 (base 10) != 0.00011001100110011001100110011001100110011001100110011001 (base 2)
  - But this the best we can do with Double representations

Double

- We need to be aware of this truncation in our programs
- In the code below, c == 0.3 is false!

```
val b: Double = 0.1
val c: Double = b * 3
println(c)
```

0.30000000000000004

Double

- Checking for equality with Doubles
- Allow a small amount of tolerance when comparing two doubles
- Math.abs(x - y) < small_value
  - As long as x and y are within a small value of each other this will be true

```
val b: Double = 0.1
val c: Double = b * 3
val expected: Double = 0.3
println(c == expected)
```

false

```
val epsilon: Double = 0.00000001
val b: Double = 0.1
val c: Double = b * 3
val expected: Double = 0.3
println(Math.abs(c - 0.3) < epsilon)
```

true

Lecture Objective

- Add testing to lecture objectives 1, 2, and 3 -

Testing: In the tests package, complete the test suite named LectureObjective1 to test the functionality of Lecture Objective 1.

Testing: In the tests package, complete the test suite named LectureObjective2 to test the functionality of Lecture Objective 2.

Testing: In the tests package, complete the test suite named LectureObjective3 to test the functionality of Lecture Objective 3.