Unit Testing with JUnit: A Very Brief Introduction

Originals of slides and source code for examples: http://courses.coreservlets.com/Course-Materials/java.html
Also see Java 8 tutorial: http://www.coreservlets.com/java-8-tutorial/ and many other Java EE tutorials: http://www.coreservlets.com/
Customized Java training courses (onsite or at public venues): http://courses.coreservlets.com/java-training.html

For additional materials, please see http://www.coreservlets.com/. The Java tutorial section contains complete source code for all examples in this tutorial series, plus exercises and exercise solutions for each topic.

coreservlets.com – custom onsite training

For customized training related to Java or JavaScript, please email hall@coreservlets.com

Marty is also available for consulting and development support

The instructor is author of several popular Java EE books, two of the most popular Safari videos on Java and JavaScript, and this tutorial.

Courses available at public venues, or
custom versions can be held on-site at your organization.

- **Courses developed and taught by Marty Hall**
  - JSF 2.3, PrimeFaces, Java programming (using Java 8, for those new to Java), Java 8 (for Java 7 programmers), JavaScript, jQuery, Angular 2, Ext JS, Spring Framework, Spring MVC, Android, GWT, custom mix of topics.
  - Java 9 training coming soon.
  - Courses available in any state or country.
  - Maryland/DC companies can also choose afternoon/evening courses.
- **Courses developed and taught by coreservlets.com experts (edited by Marty)**
  - Hadoop, Spark, Hibernate/JPA, HTML5, RESTful Web Services

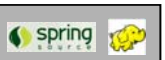
Contact hall@coreservlets.com for details

Topics in This Section

- **JUnit overview**
- **Static imports**
- **Modern style**
  - assertThat(value, matcher(...))
  - is, equalTo, nullValue, hasItem, not, anyOf, allOf, etc.
- **Traditional style**
  - assertEquals, assertTrue, assertFalse





JUnit Overview

Motivation

- **Unit testing in general**
  - Testing individual methods or small pieces of functionality. Testing overall behavior often not sufficient because not all code cases are used in integrated tests.
  - Whenever you modify code, you can rerun the test cases to verify you are still getting same answer
- **JUnit in particular**
  - Most popular and widely used unit testing framework in Java world. Easy to learn basics.
    - Not the only unit testing framework, or even necessarily the best for all situations. Even so, due to its popularity, almost all Java newcomers should start with JUnit first.
  - Not part of official Java SE
  - Integrated with Eclipse and other IDEs

Using JUnit in Eclipse: Simple Usage (Modern Style)

- **Put @Test above any zero-arg method**
  - Eclipse will prompt you to include the JUnit library and will automatically import org.junit.*;
    - Note: because @Test refers to a class, avoid classes in your package named Test!
- **Use import static org.junit.Assert.*; and import static org.hamcrest.CoreMatchers.*;**
  - Lets you use assertThat, etc. without class name
- **Test with assertThat**
  - Make tests with assertThat(someValue, someMatcher)
- **R-click in code, Run As → JUnit Test**
  - Check results printed by Eclipse

Quick Example (Imagine *You* Wrote Math.min)

```
import org.junit.*;
import static org.junit.Assert.*;
import static org.hamcrest.CoreMatchers.*;

public class MinTester {
  @Test
  public void testMin() {
    double d1 = Math.random();
    double d2 = Math.random();
    assertThat(Math.min(d1, d2),
               is(equalTo(Math.min(d2, d1))));
  }
}
```

Your goal is to write enough tests so that if all the tests pass, the method must be correct.

But, these tests could pass every time, yet Math.min could be written incorrectly. How so?
What test or tests would you need to add to account for this possibility?

Using JUnit in Eclipse: Simple Usage (Traditional Style)

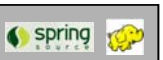
- **Put @Test above any zero-arg method**
  - Eclipse will prompt you to include the JUnit library
- **Use import static org.junit.Assert.*;**
  - Lets you use assertTrue, etc. without class name
- **Test with assertTrue, assertEquals, etc.**
  - Make tests with assertTrue(value), assertFalse(value), assertEquals(val1, val2)
- **R-click in code, Run As → JUnit Test**
  - Check results printed by Eclipse

Documentation

- **Home page**
  - http://junit.org/
    - Many more options than the simple ones shown here
- **Assertions**
  - Modern style
    - https://github.com/junit-team/junit/wiki/Matchers-and-assertthat
  - Traditional style
    - https://github.com/junit-team/junit/wiki/Assertions
- **JavaDoc**
  - http://junit.org/javadoc/latest/
    - For the new style, see especially CoreMatchers
  - http://hamcrest.org/JavaHamcrest/javadoc/1.3/





Quick Aside: Static Imports

Big Idea

- **Motivation**
  - Shortens code by letting you refer to static methods without the class name
- **Syntax**
  - import static package.Class.method;
  - import static package.Class.*;
- **Example**

```
import static java.lang.Math.*;
...
double d1 = cos(...);   // Instead of Math.cos(...)
double d2 = sin(...);   // Instead of Math.sin(...)
double d3 = random();   // Instead of Math.random()
```


Modern Approach

Overview

- **Setup**
  - Make public void zero-arg method marked with @Test
    - Eclipse will offer to add JUnit 4 to the project when you do so
  - Use imports

```
import org.junit.*;
import static org.junit.Assert.*;
import static org.hamcrest.CoreMatchers.*;
```

- **Create tests with assertThat(val, matcher)**

```
int n = someCalculation();
assertThat(n, is(equalTo(17));
String s = someOtherCalculation();
assertThat(s, containsString("blah"));
```

- **Run in Eclipse**
  - R-click in code, Run As → JUnit Test
  - Eclipse will show pass (green) or fail (red) results

Core Builtin Matcher: is

- **With simple value, synonymous to equalTo**
  - `assertThat(num, is(12));`
  - `assertThat(num, is(equalTo(12));`
- **With matcher, just syntactic sugar**
  - So omitting "is" has no effect except for readability

```
assertThat(someString, is(equalTo("blah"));
assertThat(someString, equalTo("blah");

assertThat(someObject, is(nullValue()));
assertThat(someObject, nullValue());
```

Other Core Matcher Types

- **Testing numbers**
  - equalTo, closeTo
    - To use closeTo, you must load the full hamcrest library and import static org.hamcrest.number.IsCloseTo.*;
- **Testing object values**
  - equalTo, instanceOf, nullValue, notNullValue, sameInstance
- **Strings and lists**
  - containsString, startsWith, endsWith, hasItem, hasItems
- **Combining tests**
  - not, anyOf, allOf
    - not takes one matcher
    - anyOf and allOf take multiple matchers

Mini Examples

- **Equality**
  - `assertThat(foo, is(equalTo(bar)))`
- **Boolean true**
  - `assertThat(foo, is(true))`
- **Boolean false**
  - `assertThat(foo, is(not(true)))`
- **Contains subtstring**
  - `assertThat(string1, containsString(string2))`
- **Contains elements**
  - `assertThat(list1, hasItem(blah))`
- **Combined tests**
  - `assertThat(string1, anyOf(nullValue(), startsWith("q")))`
  - `assertThat(list1, allOf(hasItem("foo"), hasItem("bar")))`
    - Equivalent to: assertThat(list1, hasItems("foo", "bar"))

Testing Example

- **reverseString**
  - Should reverse a string, preserving case
- **isPalindrome**
  - Should return true if and only if the string reads the same backward and forward, ignoring case differences
- **Examples taken from**
  - File IO section

Testing Example: Current Implementation

```
public class StringUtils {

  /** Returns a reversed copy of a non-null String. */

  public static String reverseString(String s) {
    return(new StringBuilder(s).reverse().toString());
  }

  /** Checks if a String is a palindrome. Accepts
   *  zero-length or one-length strings, but not null.
   */
  public static boolean isPalindrome(String s) {
    return(s.equalsIgnoreCase(reverseString(s)));
  }

  private StringUtils() {}
}
```

JUnit Test (Part 1)

```
package coreservlets;

import org.junit.*;
import static org.junit.Assert.*;
import static org.hamcrest.CoreMatchers.*;


public class StringUtilsTester {
  @Test
  public void testReverse() {
  }

}
```

Lets you use assertThat without the class name. You must have JUnit 4 in the project before this will be recognized.

See JavaDocs for CoreMatchers for details on matchers like is, hasItem, anyOf, etc.

Do this before adding the import statements. Eclipse will first say it does not recognize @Test, but when you click on the lightbulb or hit Control-1, Eclipse will offer to add JUnit 4 to the project.

Note: because @Test refers to a class, avoid classes in your package named Test!

Of course, you can also add the JAR files manually, if you know how to do so in Eclipse.

JUnit Test (Part 2)

Because of the @Test annotation, Eclipse knows to run this when you R-click and choose Run As → JUnit Test

```
public class StringUtilsTester {
  @Test
  public void testReverse() {
    assertThat("oof",
               is(equalTo(StringUtils.reverseString("foo"))));
    assertThat("rab",
               is(equalTo(StringUtils.reverseString("bar"))));
    assertThat("!zaB",
               is(equalTo(StringUtils.reverseString("Baz!"))));
  }
```

If any of the tests fail, you get red error message in the Eclipse JUnit window.

Slightly longer than using assertEquals, the traditional approach shown later. But:

- More readable
- If you prefer, you can shorten is(equalTo(blah)) to is(blah)
- Type safe: won't compile if argument to equalTo is of wrong type

JUnit Test (Part 3)

```
  @Test
  public void testPalindromes() {
    String[] matches =
      { "a", "aba", "Aba", "abba", "AbBa",
        "abcdeffedcba", "abcdEffedcba" };
    String[] misMatches =
      { "ax", "axba", "Axba", "abbax", "xAbBa",
        "abcdeffedcdax", "axbcdEffedcda" };
    for(String s: matches) {
      assertThat(StringUtils.isPalindrome(s), is(true));
    }
    for(String s: misMatches) {
      assertThat(StringUtils.isPalindrome(s), is(false));
    }
  }
}
```

Slightly longer than assertTrue and assertFalse (traditional approach). But

- More readable
- There are often more specific tests such as startsWith
- When combining tests with not, anyOf, or allOf, the result is much more readable

Traditional Approach

Overview

- **Setup**
  - Use imports

```
import org.junit.*;
import static org.junit.Assert.*;
```

  - Make zero-arg method marked with @Test
- Test with assertTrue, assertFalse, assertEquals

```
int n = someCalculation();
assertEquals(n, 17);
String s = someOtherCalculation();
assertTrue(s.containsString("blah"));
```

- **Run in Eclipse**
  - R-click in code, Run As → JUnit Test
  - Eclipse will show pass (green) or fail (red) results

Traditional Approach: Summary

- **assertEquals**
  - `assertEquals("some string", someMethodCall(…))`
  - `assertEquals(var1, var2)`
- **assertTrue**
  - `assertTrue(someString.contains(someSubstring))`
  - `assertTrue(someList.contains(someItem))`
  - `assertTrue(someBoolean)`
- **assertFalse**
  - `assertFalse(someString.contains(someSubstring))`
  - `assertFalse(someList.contains(someItem))`
  - `assertFalse(someBoolean)`

JUnit Test (Part 1)

```
package coreservlets.java8;

import static org.junit.Assert.*;
import org.junit.*;

public class StringUtilsTester {
  @Test
  public void testReverse() {
    assertEquals("oof", StringUtils.reverseString("foo"));
    assertEquals("rab", StringUtils.reverseString("bar"));
    assertEquals("!zaB", StringUtils.reverseString("Baz!"));
  }
```

Lets you use assertEquals instead of Assert.assertEquals

If any of the pairs are not equal, you will get error message in the Eclipse JUnit window

JUnit Test (Part 2)

```
  @Test
  public void testPalindromes() {
    String[] matches =
      { "a", "aba", "Aba", "abba", "AbBa",
        "abcdeffedcba", "abcdEffedcba" };
    String[] misMatches =
      { "ax", "axba", "Axba", "abbax", "xAbBa",
        "abcdeffedcdax", "axbcdEffedcda" };
    for(String s: matches) {
      assertTrue(StringUtils.isPalindrome(s));
    }
    for(String s: misMatches) {
      assertFalse(StringUtils.isPalindrome(s));
    }
  }
}
```

If any of the arguments fail to evaluate to true (assertTrue) or false (assertFalse), you will get error message in the Eclipse JUnit window

My Conventions

Overview

- **There are several possible approaches**
  - Modern vs. classic, use *is* or not, use equalsTo inside *is* or just *is*, use assertThat or assertTrue when comparing to Booleans, etc.
- **There is general consensus on some**
  - Prefer modern to classic
  - Use *is*; do not use assertEquals
- **No consensus on others**
  - So I will show my personal style, but no strong reason to follow it if you prefer something else
- **This is not very important!**
  - What matters is that you get in the habit of making JUnit tests early, and that you retest when you modify the code

Style 1: Using equalsTo

- When comparing calculations, use is(equalTo(...))

```
assertThat(calculation1(),
           is(equalTo(calculation2())));
SomeType val1 = doOneThing();
SomeType val2 = doAnotherThing();
assertThat(val1, is(equalTo(val2)));
```

- When comparing to literal value, use is(...) without equalTo

```
assertThat(calculation1(), is(17));
String val = doSomething();
assertThat(val, is("Hello"));
```


Style 2: Boolean Tests

- For testing a single value, use assertThat and is(true) or is(false)

```
assertThat(myPerson.isMarried(), is(true));
boolean isPrime = Primes.isPrime(50);
assertThat(isPrime, is(false));
```

- For multiple tests combined with && and ||, use assertTrue or assertFalse

```
assertTrue((x > 5) && (x < 50));
assertFalse((n > 100) || (Primes.isPrime(n)));
```

Wrap-Up

Summary

- **Write unit tests from beginning**
  - Rerun whenever you change the code
- **Example usage**

```
@Test
public void someMethod() {
  String blah = someFancyComputation();
  assertThat(blah, allOf(notNullValue(),
                         startsWith("q"),
                         not(contains("z"))));
  List<String> items = someMethod();
  assertThat(items, hasItem("foobar"));
  Blah b1 = doComputationOneWay();
  Blah b2 = doComputationAnotherWay();
  assertThat(b1, is(equalTo(b2)));
}
```

coreservlets.com – custom onsite training





Questions?

More info:
http://courses.coreservlets.com/Course-Materials/java.html – General Java programming tutorial
http://www.coreservlets.com/java-8-tutorial/ – Java 8 tutorial
http://courses.coreservlets.com/java-training.html – Customized Java training courses, at public venues or onsite at *your* organization
http://coreservlets.com/ – JSF 2, PrimeFaces, Java 7 or 8, Ajax, jQuery, Hadoop, RESTful Web Services, Android, HTML5, Spring, Hibernate, Servlets, JSP, GWT, and other Java EE training
Many additional free tutorials at coreservlets.com (JSF, Android, Ajax, Hadoop, and lots more)

For additional materials, please see http://www.coreservlets.com/. The Java tutorial section contains complete source code for all examples in this tutorial series, plus exercises and exercise solutions for each topic.