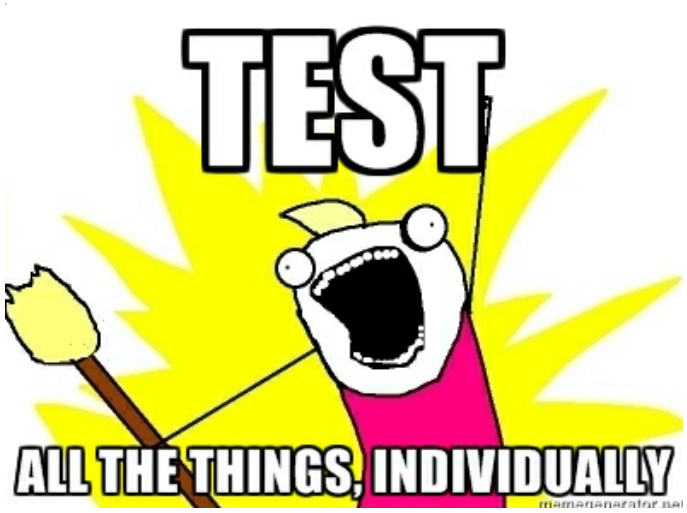
ECSE 321 - Tutorial 11

Testing Recap



Dominic Charley-Roy

https://github.com/dominiccharleyroy

dominic.charley-roy @ mail.mcgill

Test Types

- Functional
- Behavioral
- Performance
- Integration
- System

Functional Tests

- Treats a function as a black box.
- Given a set of inputs, you **expect** a set of outputs.

```
public void testFibonacci() {
        assertEquals(1, fib(2));
        assertEquals(2, fib(3));
        assertEquals(13, fib(7));
}
```

Behavioral Tests

- Tests that a function **behaves** correctly.
- Usually has to do with an object with state.
- Testing whether the state is modified correctly.

```
public int x;
public int y;

public void moveRight() {
        // ...
}

public void testMoveRight() {
        x = 2; y = 10;
        moveRight();
        assertEquals(2, x);
        assertEquals(11, y);
}
```

Performance Tests

- Tests how long a certain action takes.

```
public void testSendRequest() {
        long startTime = System.currentTimeMillis();
        sendRequests();
        long totalTime = System.currentTimeMillis() - startTime;

        // Do something with the time
}
```

Integration Tests

- Tests that a sequence of actions works correctly.
- Functional/behavioral tests focus on one method/class.
- These focus on more than one.

```
public void testExplosions() {
    placeEnemies();
    renderEnemies();
    Bomb b = Bomberman.addBomb(10, 10);
    explodeBomb(b);

    int totalKilled = 0;
    for (Enemy e : enemies) {
        if (e.isDead()) totalKilled++;
    }

    assertEquals(3, totalKilled);
}
```

System Testing

- These test a full end-to-end run through in your system.
- An example of this would be creating a game, saving it, loading it, and making sure it is in the same state.

It's been a while...

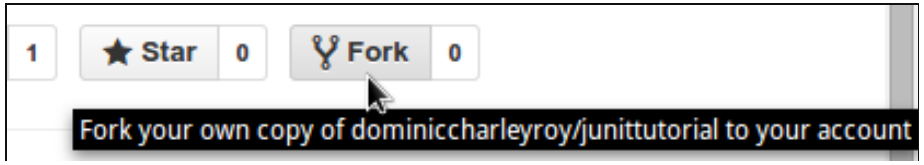
JUnit is a unit testing framework for Java.

What does that even mean?!

Unit tests are small tests which are responsible for testing a single rule of your program. JUnit provides **classes and methods** for writing these tests and runs them **automatically**.

Motivating Example

- A Grading System class which lets you add grade, get a list of student's grades, and compute the average.
- You will want to fork https://github.com/dominiccharleyroy/junittutorial in order to have your own copy of this tutorial.



Importing into Eclipse

1. Clone your new repository:

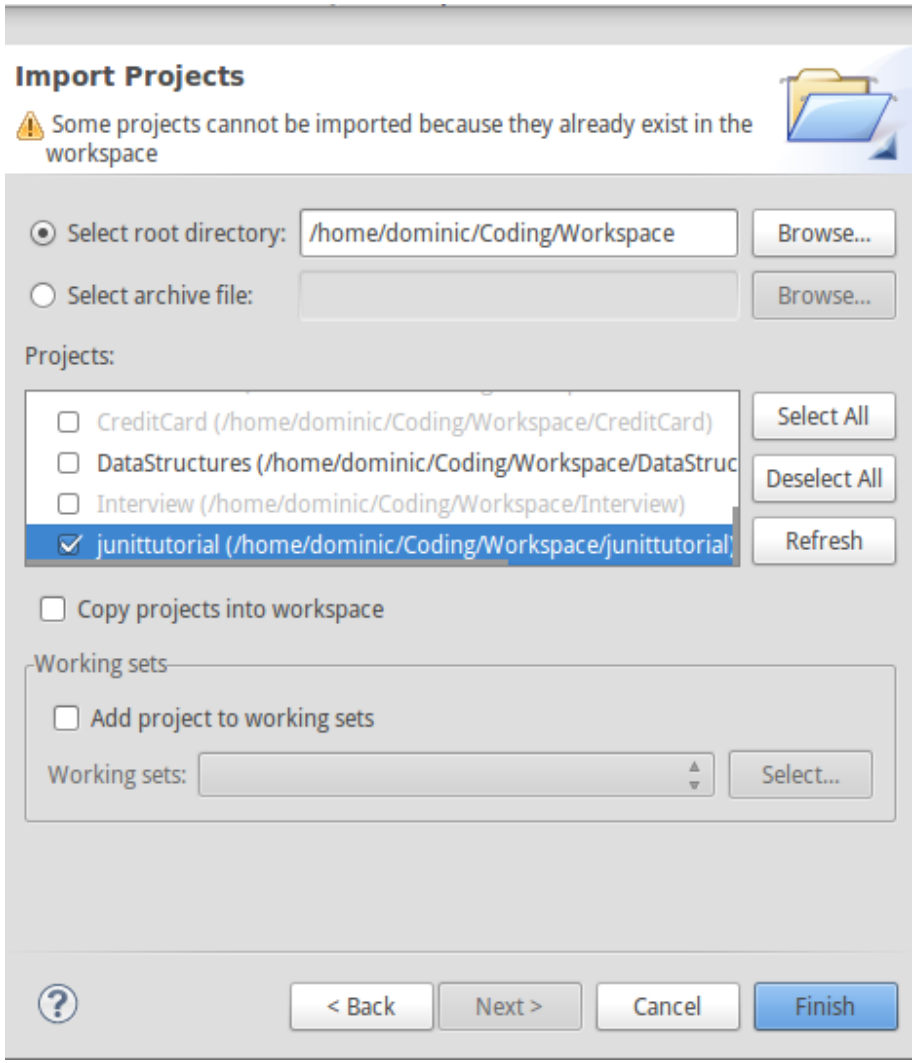
git clone url

2. Open Eclipse

3. File > Import > Existing Projects into Workspace

4. Set directory to the directory containing your cloned repository.

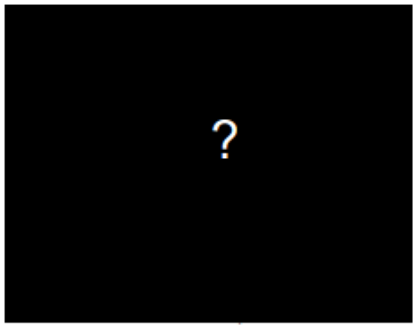
5. Select the project an import!



Example Overview

```java
public interface GradingSystem {

    /**
     * This method registers a grade for a student.
     * @param studentId The ID of the student.
     * @param grade The grade obtained by the student. Should be
     *      between 0 and 100.
     * @throws IllegalArgumentException if the grade is not
     *      in the valid range.
     */
    public void registerGrade(String studentId, int grade);

    /**
     * This method fetches the list of grades for a given student.
     * The grades are presented in the order they were registered.
     * @param studentId The ID of the student.
     * @return A list of grades for the student, or null if the
     *      student does not exist.
     */
    public List<Integer> getGrades(String studentId);

    /**
     * This method fetches the average grade for a student.
     * @param studentId The ID of the student.
     * @return The average grade of the student, or -1 if
     *      the student does not exist.
     */
    public int getAverage(String studentId);

}
```

```java
public class BrokenGradingSystem implements GradingSystem {
```




```java
}
```

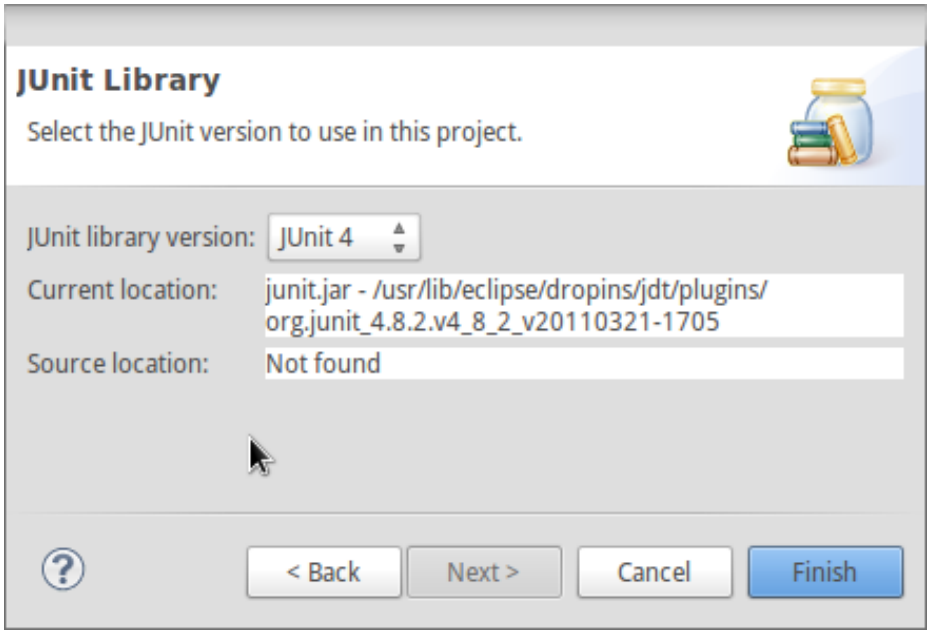
Adding JUnit

In order to test our implementation, we need to add the JUnit library to our project.

1. Right-click project > Build Path > Add Libraries...

2. Select JUnit and Next

3. Set JUnit version to 4



Non-Eclipse Users

If you aren't using Eclipse, you have to take some extra steps to install JUnit in your project.

1. Go to https://github.com/junit-team/junit/wiki/Download-and-Install
2. Download junit.jar
3. Add junit.jar to your project's class path

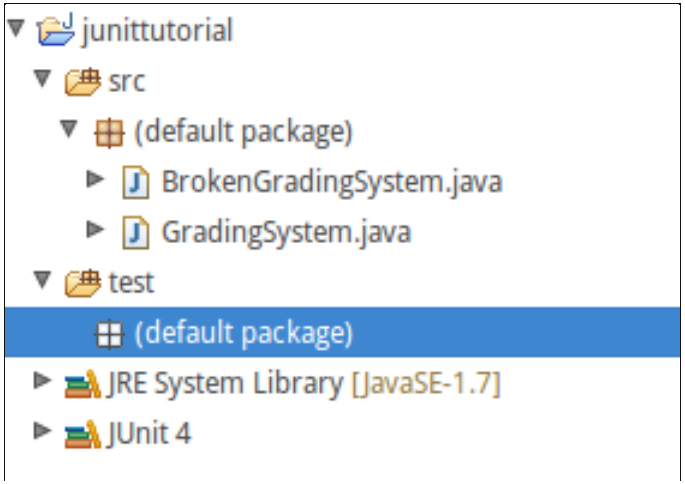
Anatomy of a JUnit Test

- A Java class usually has a corresponding **test case** class. If the class is called A, then the test case class is **ATest**.
- A test case has **tests** which are methods. Each test should correspond to one single functionality / logic rule. Usually prefixed with *test* and describe what is being tested, eg. *testGetName* or *testSetAgeWithNegativeValue*.
- Many test cases can be bundled together in a **test suite**.
- JUnit lets you run either a single test, all tests in a single test case, or all tests in a test suite.

Where are tests stored?

- Tests are usually kept separate from our src/ folder to keep things clean and allow tests to be easily included/excluded from a jar file.
- We store them in a test/ source folder. In Eclipse, we create this like:

    1. Right-click project and New > Source Folder
    2. Set Folder Name to test and click Finish.

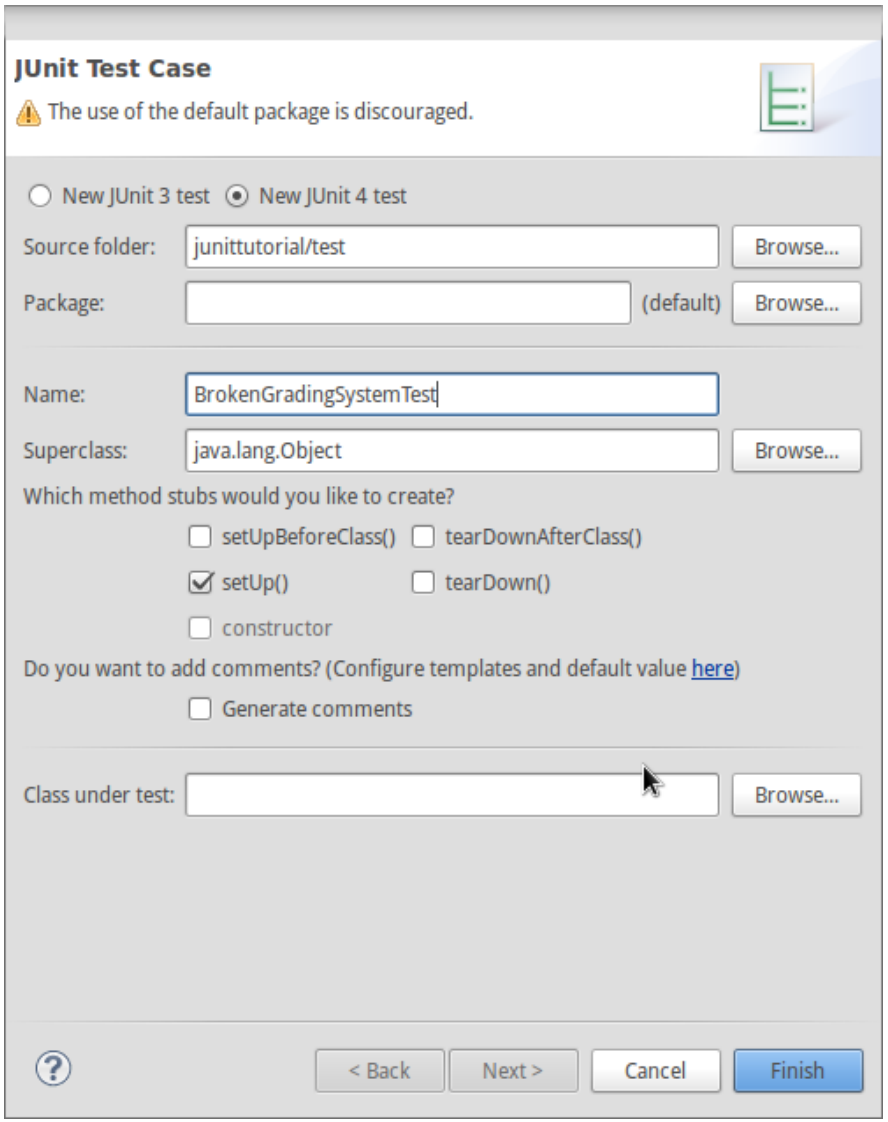


Creating a Test Case

Let's create a test case for BrokenGradingSystem!

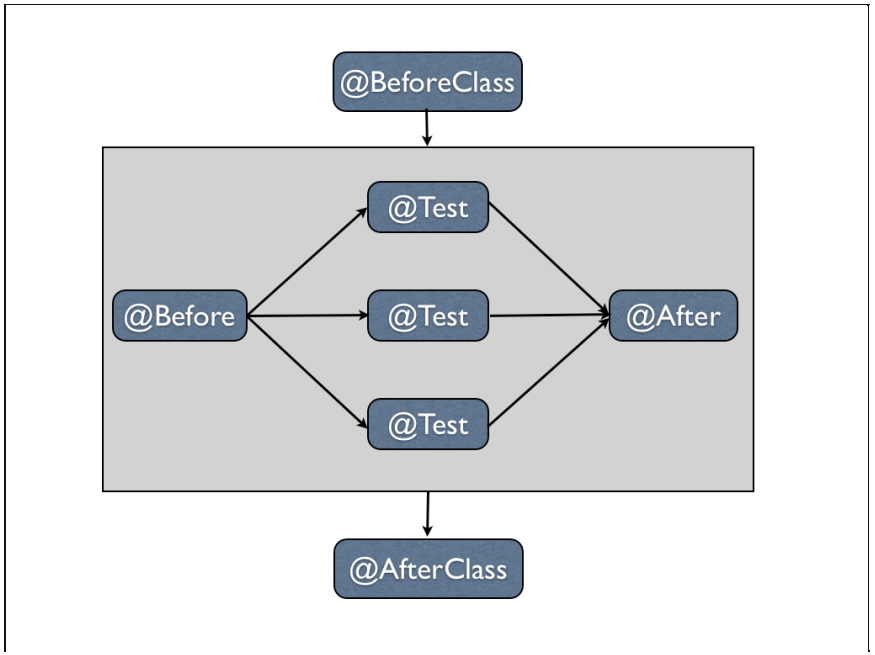
1. Right-click test/, New > JUnit Test Case

2. Set the name to BrokenGradingSystemTest.



Running a Test Case

Once we've added tests, we'll want to run an entire test case. JUnit follows a special process for this based on **method annotations**. These must be imported (eg. import org.junit.Test).



BeforeClass/AfterClass methods should be *static* and are only run *once*. Before/After methods should be *non-static* and are run *before and after every test* (for setting up / cleaning up).

What's in a test?

- A test is any method annotated with **@Test**.
- A test runs code and makes **assertions** about it.
- If any assertions are false in the test, the test **fails**.
- JUnit provides many different assert statements, including: assertEquals, assertNull, assertTrue, assertFalse.
- JUnit also provides a method for automatically failing, fail.
- Generally put import static **org.junit.Assert.*;** to have access to all assert methods without qualifying.
- http://junit.sourceforge.net/javadoc/org/junit/Assert.html

Our First Test!!

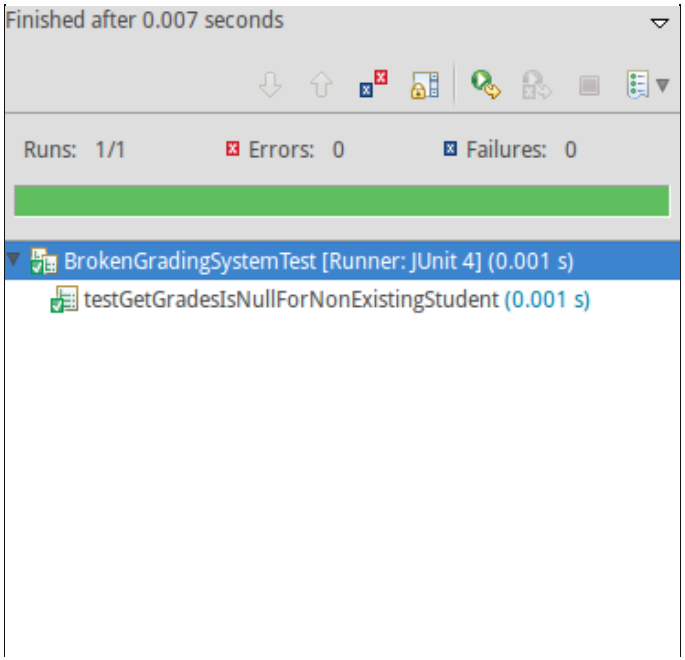
The first test is that **getGrades** returns null for a student that doesn't exist.

We use @Before to create a new Grading System for each test.

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

import org.junit.Before;
import org.junit.Test;


public class BrokenGradingSystemTest {

    private BrokenGradingSystem system;

    @Before
    public void setUp() throws Exception {
        system = new BrokenGradingSystem();
    }

    @Test
    public void testGetGradesIsNullForNonExistingStudent() {
        assertNull(system.getGrades("I DON'T EXIST"));
    }

}
```

Running our Test Case

We're now ready to run our test! We do this by either hitting the run button when our test file is open, or by right-clicking on the *Test file and Run As > JUnit Test



Testing getGrades Works!

```java
@Test
public void testGetGradesReturnsListOfGrades() {
    system.registerGrade("dominic", 80);
    system.registerGrade("dominic", 100);
    system.registerGrade("david", 90);

    List<Integer> grades = system.getGrades("dominic");

    assertEquals("There should be 2 registered grades for dominic.",
            2, grades.size());
    assertEquals(80, (int) grades.get(0));
    assertEquals(100, (int) grades.get(1));
}
```

Note that assertEquals, as do most other assertions, have two signatures.

1. assertEquals(expected value, obtained value)
2. assertEquals(message, expected value, obtained value)

Testing Exceptions

Some tests should only pass if an exception is thrown! There are two ways of testing this.

1. (Preferred way)

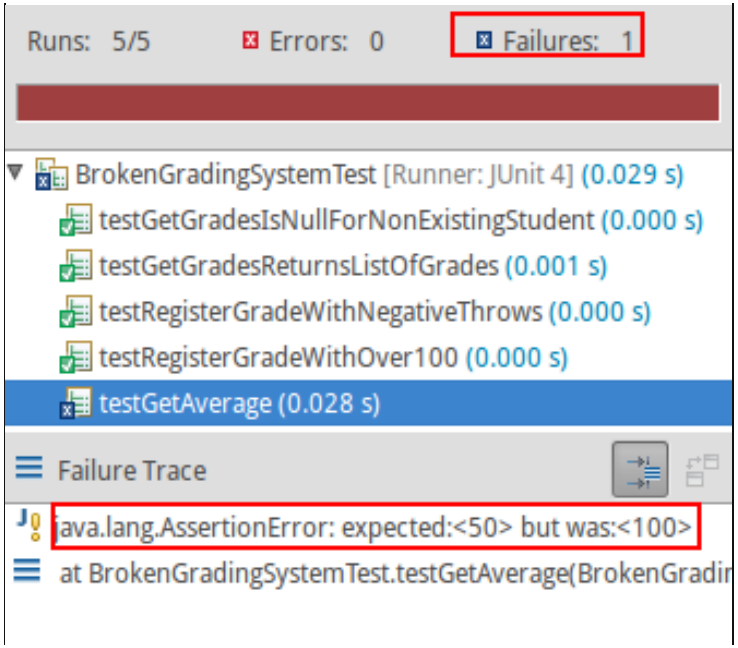
@Test(expected=ExceptionName.class)

2. Wrap the code in a try catch and put a fail() after the call which should throw an exception.

```
@Test(expected=IllegalArgumentException.class)
public void testRegisterGradeWithNegativeThrows() {
    system.registerGrade("dominic", -1);
}

@Test
public void testRegisterGradeWithOver100() {
    try {
        system.registerGrade("dominic", 101);
        fail();
    } catch (Exception e) {}
}
```

Finding a Bug!

```java
@Test
public void testGetAverage() {
    system.registerGrade("dominic", 25);
    system.registerGrade("dominic", 75);
    assertEquals(50, system.getAverage("dominic"));
}
```



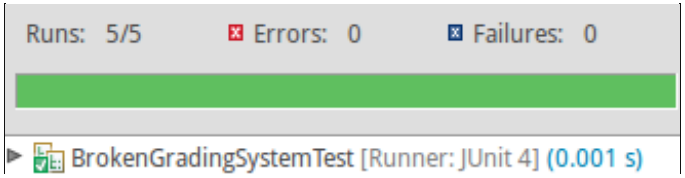
Time to fix our code!

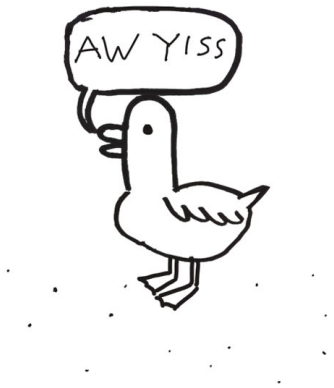
Our test helped us pinpoint a bug in getAverage, so let's take a look at our function.

```
public int getAverage(String studentId) {
    // Check for non-existing
    if (!grades.containsKey(studentId)) {
        return -1;
    }

    // Sum up the total number of grades
    int total = 0;
    for (int grade : grades.get(studentId)) {
        total += grade;
    }

    // Divide the total by the number of grades
    int average = total / grades.get(studentId).size();

    return total;
};
```

Once it's fixed...

After fixing our bug, we re-run the JUnit tests...





But wait...

How do we know our tests are **good enough**? Did we test everything?

EclEmma

http://www.eclemma.org/

What's that?!

- EclEmma is an eclipse plugin.
- Lets you do **code coverage** - see how much of your code is actually run when you run your tests!

Demo

Finding a Missing Test

After running our tests we see:

```
public int getAverage(String studentId) {
    // Check for non-existing
    if (!grades.containsKey(studentId)) {
        return -1;
    }
```

Adding the missing test:

```
@Test
public void testGetAverageForMissingStudent() {
    assertEquals(-1, system.getAverage("missing"));
}
```

TL;DR

- JUnit lets you write tests which can be run automatically to find bugs in your application.
- EclEmma is a tool that lets you see how much of your code is actually executed when you run your tests.
- These let you find new bugs as well as make sure new features aren't breaking old code (**regression bugs**).
- **Note:** Test-driven development works by writing tests *first* and then coding to make the tests pass.