

Spring Boot Unit Testing



Course Development Team

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Coding with Roby

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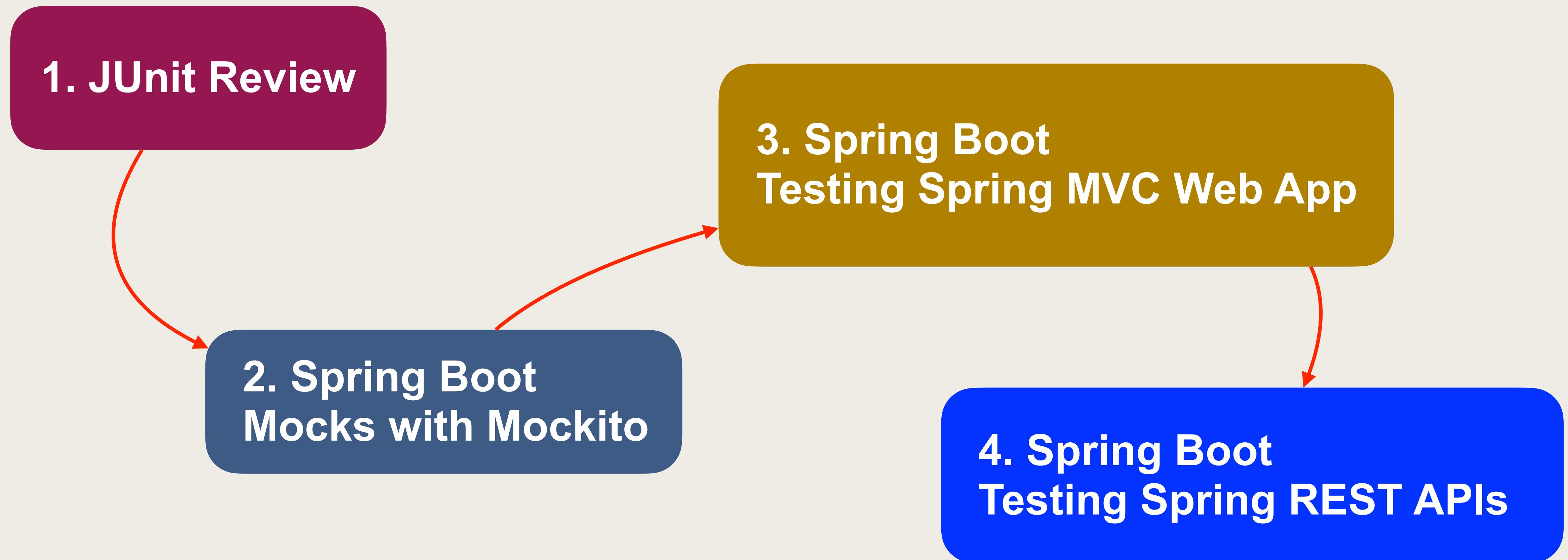


**Chád
Darby**

Spring Boot Unit Testing

- Spring Boot supports developing unit tests and integration tests using JUnit and Mockito.
- By developing tests, you can create applications with better code design, fewer bugs, and higher reliability.
- This course shows you how to take advantage of Spring Boot's testing support.

Course Road Map



Prerequisites

- You should have prior experience with
 - Java
 - Spring Boot
 - Maven

Spring & Hibernate for Beginners

Development Environment

- You should have these dev tools installed:
 - IntelliJ or Eclipse ... or your favorite IDE :-)
 - MySQL Database Server
 - MySQL Workbench

We will use IntelliJ (free version)
in the videos

But everything will work with
other IDEs such as
Eclipse, NetBeans etc

All you need is basic Maven support

Source Code and PDFs

All source code is available for download

All PDFs of slides are available for download

Questions / Help

If you have questions or need help...

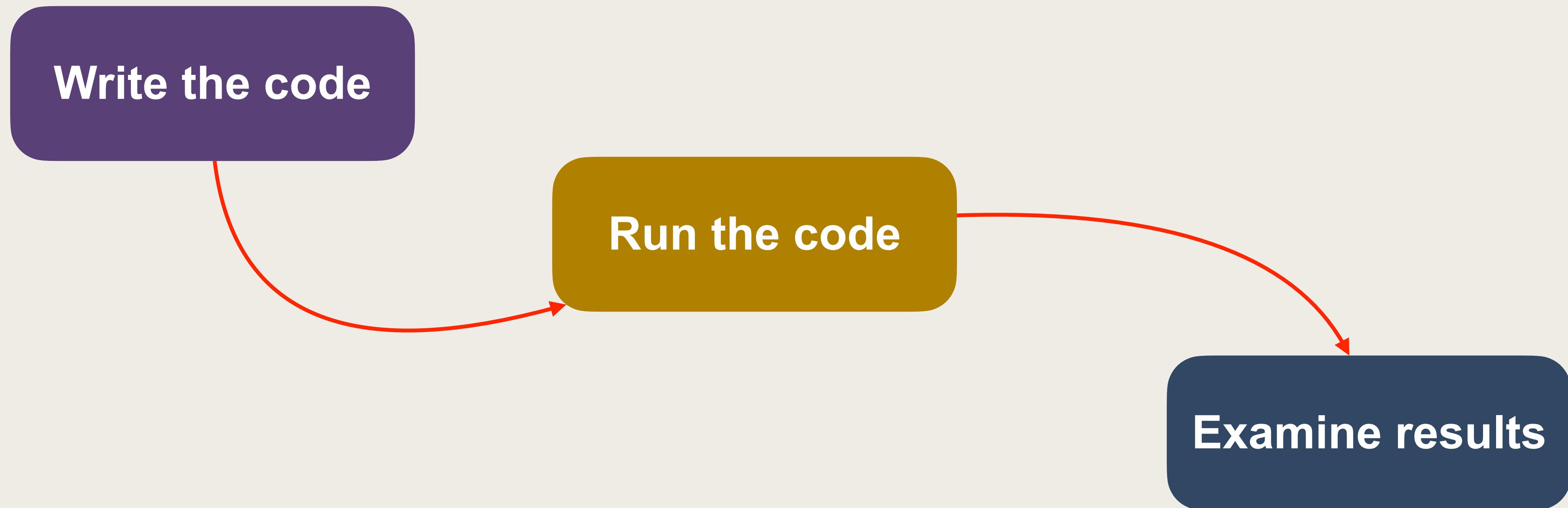
Post the question in the classroom discussion forum

Unit Testing Overview



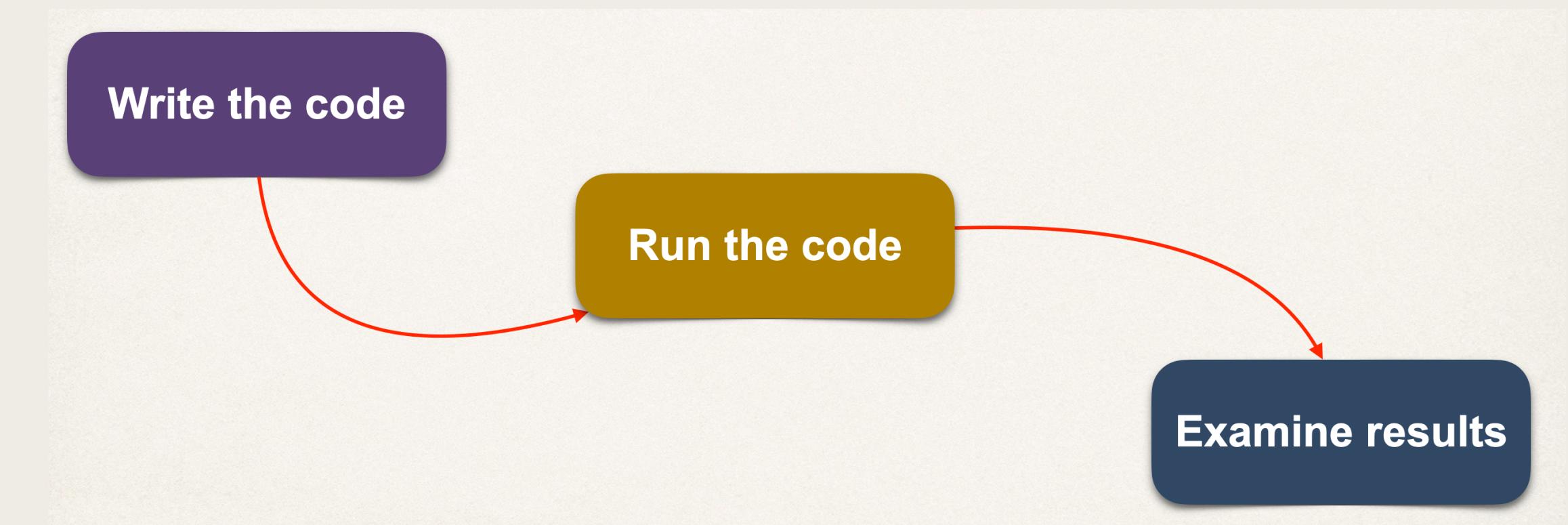
How Do We Test Code?

- Manual testing ... maybe this???



What's Wrong?

- Requires human interaction and analysis
- Test case is not reproducible
- No way to automate the test
- What if I wanted to
 - Run a battery of tests for each code commit
 - Produce a report of test results



What is Unit Testing?

- Testing an individual unit of code for correctness
- Provide fixed inputs
- Expect known output

Calculator

`add(int x, int y) : int`

Test Cases

`add(5, 2)`

7

`add(-3, -8)`

-11

`add(-3, 1)`

-2

`add(0, 0)`

0

Test Cases

capitalize("Luv2code")



LUV2CODE

capitalize("LUV2CODE")



LUV2CODE

capitalize("luv2code")



LUV2CODE

capitalize(null)



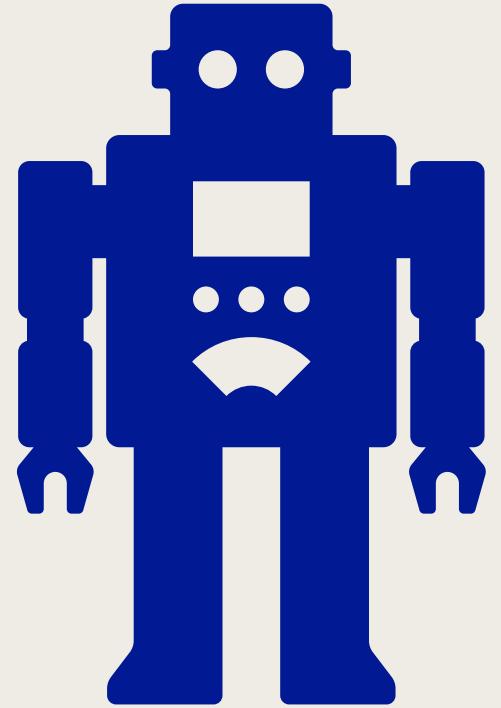
???

StringUtils

capitalize(String data) : String

Benefits of Unit Testing

- Automated tests
- Better code design
- Fewer bugs and higher reliability
- Increases confidence for code refactoring ... did I break anything??
- Basic requirement for
 - DevOps and Build Pipelines
 - Continuous Integration / Continuous Deployment (CI / CD)



Integration Testing

- Test multiple components together as part of a test plan
- Determine if software units work together as expected
- Identify any negative side effects due to integration
- Can test using mocks / stubs
- Can also test using live integrations (database, file system)

Unit Testing Frameworks

- JUnit
 - Supports creating test cases
 - Automation of the test cases with pass / fail
 - Utilities for test setup, teardown and assertions
- Mockito
 - Create mocks and stubs
 - Minimize dependencies on external components

Unit Testing Tooling Support

- IntelliJ

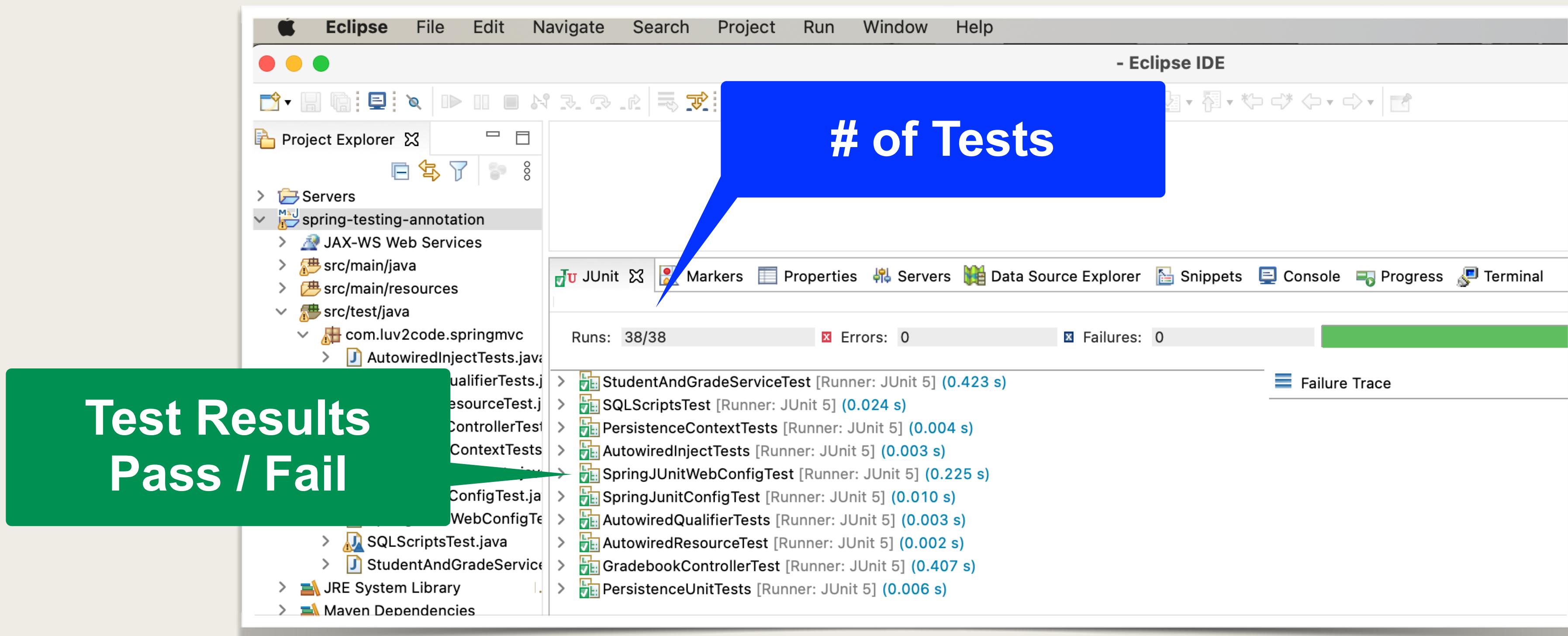
Test Results
Pass / Fail

The screenshot shows the IntelliJ IDEA interface with a project named "4.1-spring-junit-rest". The code editor displays a Java test class, "StudentAndGradeServiceTest.java", which includes annotations like @SpringBootTest and @Autowired. A blue callout bubble points to the code editor with the text "# of Tests". The bottom right corner of the screen displays the text "Tests passed: 38 of 38 tests - 1 sec 243 ms".

Test	Time	Log
> ✓ StudentAndGradeServiceTest	465 ms	20:58:02.189 [main] DEBUG org.springframework.test.context.SpringBootTest@1234567890
> ✓ SQLScriptsTest	24 ms	20:58:02.205 [main] DEBUG org.springframework.test.context.SpringBootTest@1234567890
> ✓ PersistenceContextTests	7 ms	20:58:02.228 [main] DEBUG org.springframework.test.context.SpringBootTest@1234567890
> ✓ AutowiredInjectTests	3 ms	20:58:02.239 [main] INFO org.springframework.boot.test.context.SpringBootTest@1234567890
> ✓ SpringJUnitWebConfigTest	207 ms	20:58:02.243 [main] DEBUG org.springframework.test.context.SpringBootTest@1234567890
> ✓ SpringJUnitConfigTest	12 ms	20:58:02.243 [main] DEBUG org.springframework.test.context.SpringBootTest@1234567890
> ✓ AutowiredQualifierTests	3 ms	20:58:02.243 [main] DEBUG org.springframework.test.context.SpringBootTest@1234567890
> ✓ AutowiredResourceTest	3 ms	20:58:02.243 [main] INFO org.springframework.test.context.SpringBootTest@1234567890
> ✓ GradebookControllerTest	511 ms	20:58:02.244 [main] INFO org.springframework.test.context.SpringBootTest@1234567890
> ✓ PersistenceUnitTests	8 ms	20:58:02.302 [main] DEBUG org.springframework.test.context.SpringBootTest@1234567890

Unit Testing Tooling Support

- Eclipse



Getting Started with JUnit



Getting Started

- Let's start with some simple examples for unit testing
- At the moment, we will focus on the JUnit fundamentals for testing
 - How to define a test
 - JUnit Assertions
 - Running tests
- Later we'll discuss other techniques such as Test-Driven-Development (TDD)

Test Cases

add(2, 4)



6

add(1, 9)



10

DemoUtils

add(int x, int y) : int

Code to Test

DemoUtils.java

```
package com.luv2code.junitdemo;

public class DemoUtils {

    public int add(int a, int b) {
        return a + b;
    }

}
```

Development Process

Step-By-Step

1. Add Maven dependencies for JUnit
2. Create test package
3. Create unit test
4. Run unit test

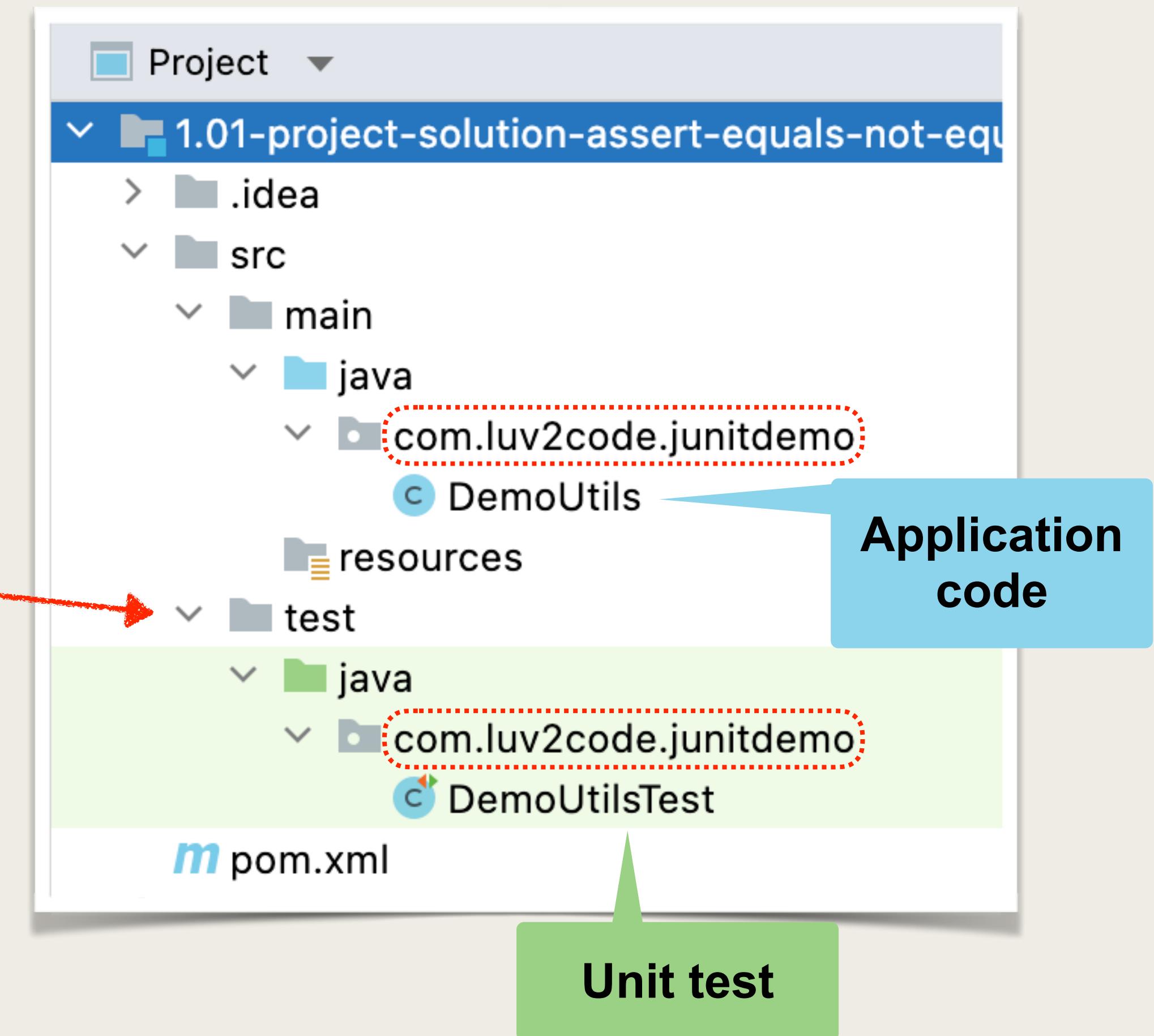
Step 1: Add Maven dependencies for JUnit

pom.xml

```
...
<dependency>
    <groupId>org.junit.jupiter</groupId>
    <artifactId>junit-jupiter</artifactId>
    <version>5.8.2</version>
    <scope>test</scope>
</dependency>
...
```

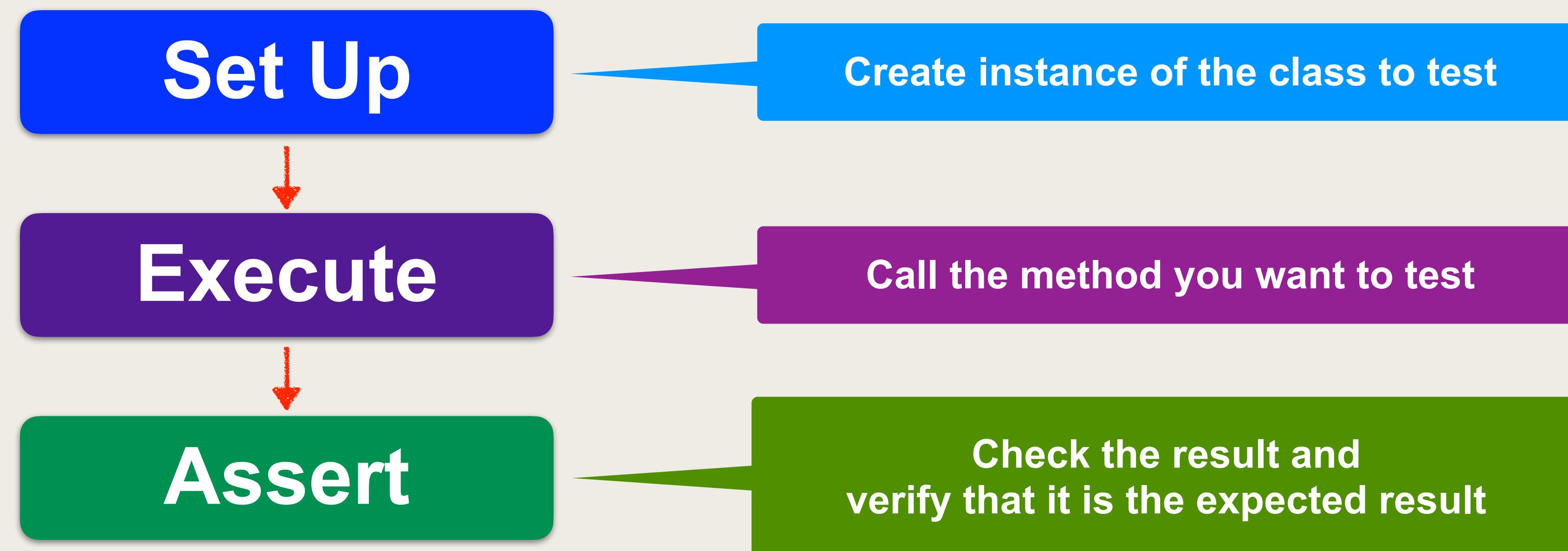
Step 2: Create test package

- The code we are testing is located in package:
 - `com.luv2code.junitdemo`
- A convention is to create test classes in similar package structure under `/test`
 - Not a hard requirement, merely a convention
 - Helps with organization of test classes
 - Easy to find test classes when joining new projects
 - Special edge cases for accessing protected class members



Step 3: Create unit test

- Unit tests have the following structure



Step 3: Create unit test

DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.
import org.junit.jupiter.

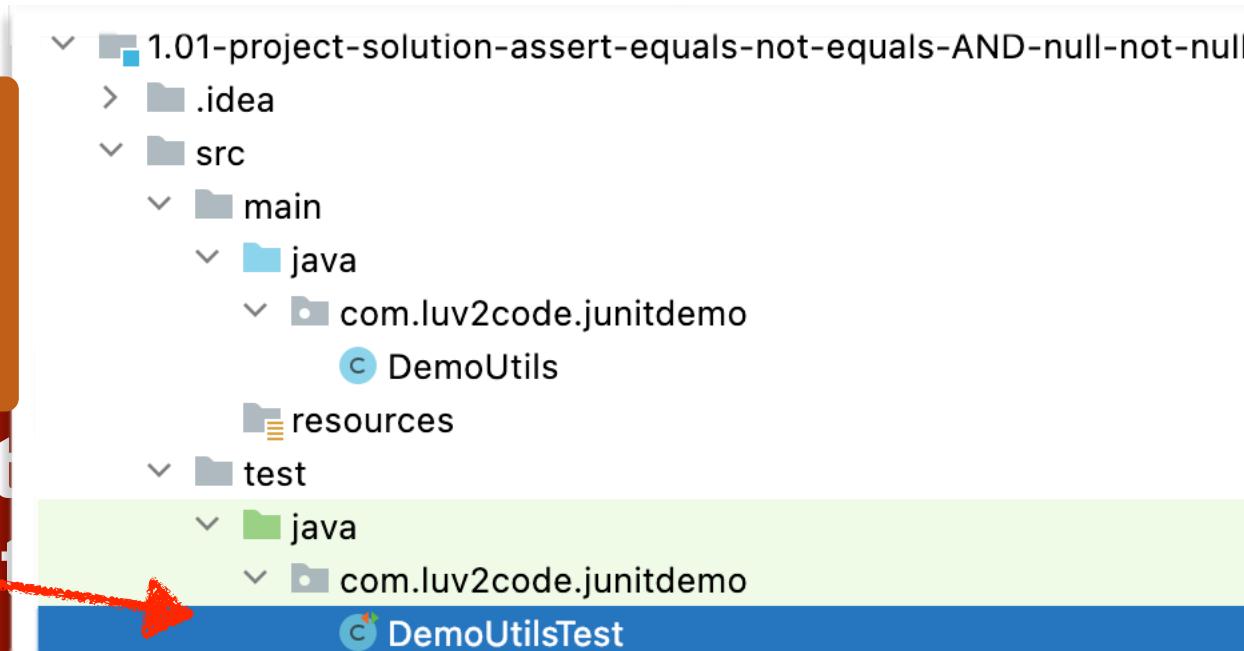
class DemoUtilsTest {
    @Test
    void testEqualsAndHashCode() {
        // Set Up
        DemoUtils demoUtils = new DemoUtils();

        // Execute
        int result = demoUtils.add(2, 4);

        // Assert
        assertEquals(6, result, "2+4 must be 6");
    }
}
```

Test can have
any method name

Annotate the
method with
@Test



of the class to test

Set Up

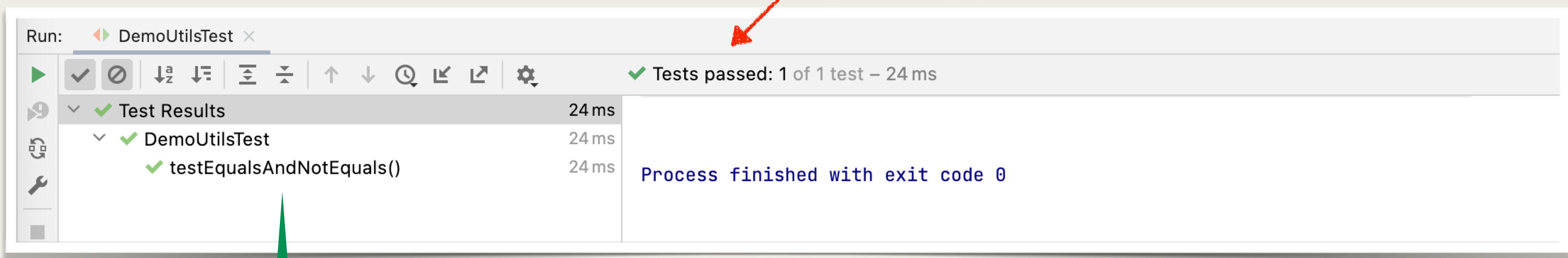
Execute

Assert

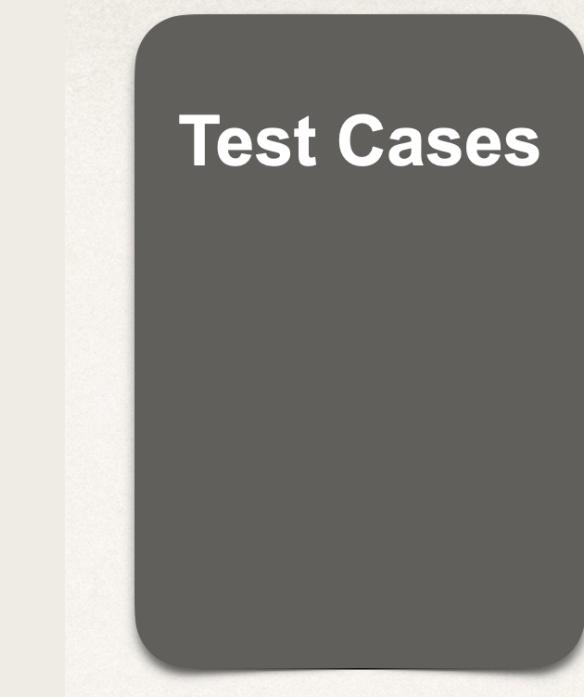
Call the method you want to test

Check the *actual* result and
verify that it is the *expected* result

Step 4: Run unit test



Test passed



DemoUtils
add(int x, int y) : int

IntelliJ Unit Testing Support

- IntelliJ provides additional unit testing support
 - Build dependency management: Maven and Gradle
 - Auto creation of test classes and test method stubs
 - ...

<https://www.jetbrains.com/help/idea/junit.html>

JUnit Assertions



JUnit Assertions

- JUnit has a collection of assertions
- Defined in class: `org.junit.jupiter.api.Assertions`

Method name	Description
<code>assertEquals</code>	Assert that the values are equal
<code>assertNotEquals</code>	Assert that the values are not equal
<code>assertNull</code>	Assert that the value is null
<code>assertNotNull</code>	Assert that the value is not null
...	...

assertEquals

```
Assertions.assertEquals(expected, actual, "2+4 must be 6");
```

Expected value

Optional message
if test fails

Actual value
after executing method
under test

assertNotEquals

```
Assertions.assertEquals(unexpected, actual, "2+4 must not be 8");
```

Unexpected value

Optional message
if test fails

Actual value
after executing method
under test

DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.Assertions;

class DemoUtilsTest {

    @Test
    void testEqualsAndHashCode() {

        // set up
        DemoUtils demoUtils = new DemoUtils();

        int expected = 6;
        int unexpected = 8;

        // execute
        int actual = demoUtils.add(2, 4);

        // assert
        Assertions.assertEquals(expected, actual, "2+4 must be 6");
        Assertions.assertNotEquals(unexpected, actual, "2+4 must not be 8");

    }
}
```

Create instance of the class to test

Call the method you want to test

Check the *actual* result and
verify that it is NOT the *unexpected* result

Static Import

- Static import: a short-cut for referencing static methods & fields in a class

BEFORE

```
import org.junit.jupiter.api.Assertions;  
  
...  
  
Assertions.assertEquals(expected, actual, "2+4 must be 6");  
Assertions.assertNotEquals(unexpected, actual, "2+4 must not be 8");
```

Class name

Static import

Method name

Short-cut for
static methods & fields

Just give
method name

```
import static org.junit.jupiter.api.Assertions.assertEquals;  
import static org.junit.jupiter.api.Assertions.assertNotEquals;  
  
...  
  
assertEquals(expected, actual, "2+4 must be 6");  
assertNotEquals(unexpected, actual, "2+4 must not be 8");
```

Static Import

- Can also use wildcard for static import

BEFORE

```
import static org.junit.jupiter.api.Assertions.assertEquals;
import static org.junit.jupiter.api.Assertions.assertNotEquals;

...
assertEquals(expected, actual, "2+4 must be 6");
assertNotEquals(unexpected, actual, "2+4 must not be 8");
```

Wildcard

AFTER

Just give
method name

```
import static org.junit.jupiter.api.Assertions.*;

...
assertEquals(expected, actual, "2+4 must be 6");
assertNotEquals(unexpected, actual, "2+4 must not be 8");
```

Short-cut for
static methods & fields

Static import

DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import static org.junit.jupiter.api.Assertions.*;

class DemoUtilsTest {

    @Test
    void testEqualsAndHashCode() {

        // set up
        DemoUtils demoUtils = new DemoUtils();

        int expected = 6;
        int unexpected = 8;

        // execute
        int actual = demoUtils.add(2, 4);

        // assert
        assertEquals(expected, actual, "2+4 must be 6");
        assertNotEquals(unexpected, actual, "2+4 must not be 8");
    }
}
```

Just give
method name

Restructuring code

DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import static org.junit.jupiter.api.Assertions.*;

class DemoUtilsTest {

    @Test
    void demoUtilsAdd() {
        DemoUtils demoUtils = new DemoUtils();

        // execute and assert
        assertEquals(6, demoUtils.add(2, 4), "2+4 must be 6");
        assertNotEquals(8, demoUtils.add(1, 9), "1+9 must not be 8");
    }
}
```

Unexpected value

Optional message
if test fails

Actual value
after executing method
under test

Code to Test

DemoUtils.java

```
package com.luv2code.junitdemo;

public class DemoUtils {

    public Object checkNull(Object obj) {

        if (obj != null) {
            return obj;
        }
        return null;

    }
}
```

Assertions: Null and NotNull

Method name	Description
<code>assertNull</code>	Assert that the value is null
<code>assertNotNull</code>	Assert that the value is not null
...	...

DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import static org.junit.jupiter.api.Assertions.*;

class DemoUtilsTest {

    @Test
    void testNullAndNotNull() {

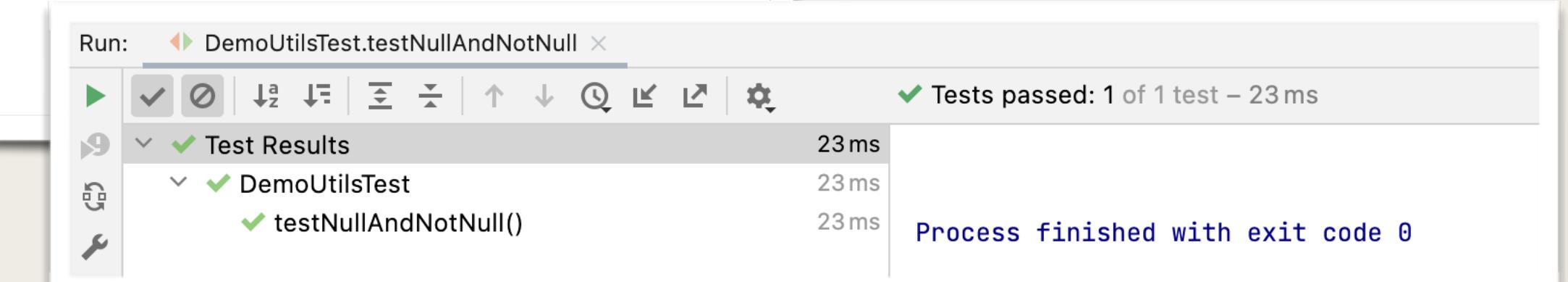
        DemoUtils demoUtils = new DemoUtils();

        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNull(str2), "Object should not be null");
    }
}
```

Actual value
after executing method
under test

Optional message
if test fails



Multiple Tests in One Class

DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import static org.junit.jupiter.api.Assertions.*;

class DemoUtilsTest {

    @Test
    void testEqualsAndNotEquals() {

        // set up
        DemoUtils demoUtils = new DemoUtils();

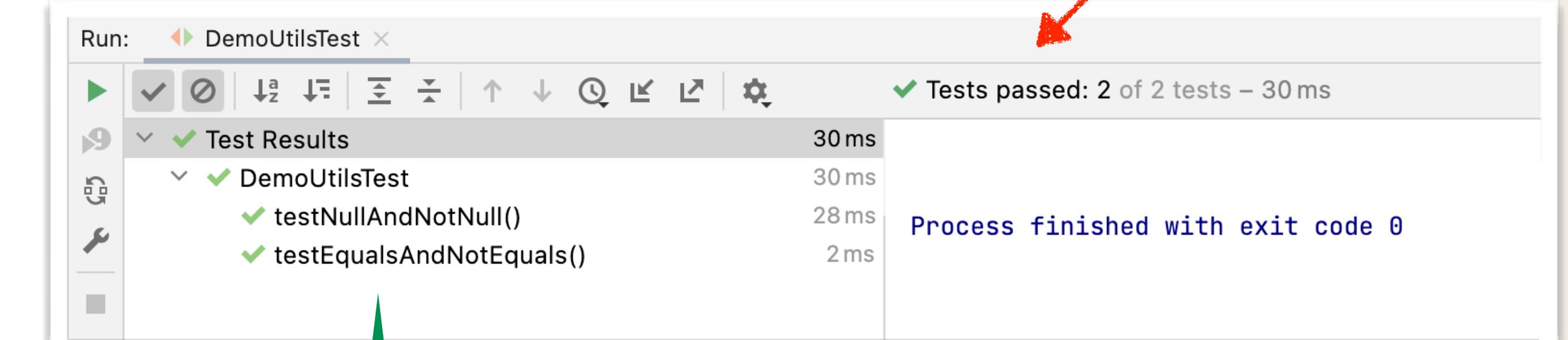
        // execute and assert
        assertEquals(6, demoUtils.add(2, 4), "2+4 must be 6");
        assertNotEquals(8, demoUtils.add(1, 9), "1+9 must not be 8");
    }

    @Test
    void testNullAndNotNull() {

        DemoUtils demoUtils = new DemoUtils();

        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNull(str2), "Object should not be null");
    }
}
```



Both tests passed

More Details

- JUnit User Guide

<https://junit.org/junit5/docs/current/user-guide/#writing-tests>

JUnit Lifecycle Methods



Lifecycle Methods

- When developing tests, we may need to perform common operations
- Before each test
 - Create objects, set up test data
- After each test
 - Release resources, clean up test data

DemoUtilsTest.java

BEFORE

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import static org.junit.jupiter.api.Assertions.*;

class DemoUtilsTest {

    @Test
    void testEqualsAndNotEquals() {
        // set up
        DemoUtils demoUtils = new DemoUtils();

        // execute and assert
        assertEquals(6, demoUtils.add(2, 4), "2+4 must be 6");
        assertNotEquals(8, demoUtils.add(1, 9), "1+9 must not be 8");
    }

    @Test
    void testNullAndNotNull() {
        // set up
        DemoUtils demoUtils = new DemoUtils();

        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNotNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNotNull(str2), "Object should not be null");
    }
}
```

DemoUtilsTest.java

AFTER

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.BeforeEach;
import static org.junit.jupiter.api.Assertions.*;

class DemoUtilsTest {

    DemoUtils demoUtils;

    @BeforeEach
    void setupBeforeEach() {
        // set up
        demoUtils = new DemoUtils();
        System.out.println("@BeforeEach executes before the execution of each test method");
    }

    @Test
    void testEqualsAndNotEquals() {
        // execute and assert
        assertEquals(6, demoUtils.add(2, 4), "2+4 must be 6");
        assertNotEquals(8, demoUtils.add(1, 9), "1+9 must not be 8");
    }

    @Test
    void testNullAndNotNull() {
        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNotNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNotNull(str2), "Object should not be null");
    }
}
```

Create object before each test

No need to create object ... handled by @BeforeEach

No need to create object ... handled by @BeforeEach

DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.AfterEach;
import static org.junit.jupiter.api.Assertions.*;

class DemoUtilsTest {

    DemoUtils demoUtils;

    @BeforeEach
    void setupBeforeEach() {
        // set up
        demoUtils = new DemoUtils();
        System.out.println("@BeforeEach executes before the execution of each test method");
    }

    @AfterEach
    void tearDownAfterEach() {
        System.out.println("Running @AfterEach\n");
    }

    @Test
    void testEqualsAndNotEquals() {

        // execute and assert
        assertEquals(6, demoUtils.add(2, 4), "2+4 must be 6");
        assertNotEquals(8, demoUtils.add(1, 9), "1+9 must not be 8");
    }

    @Test
    void testNullAndNotNull() {
        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNull(str2), "Object should not be null");
    }
}
```

Run after each test

DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.AfterEach;
import static org.junit.jupiter.api.Assertions.*;

class DemoUtilsTest {

    DemoUtils demoUtils;

    @BeforeEach
    void setupBeforeEach() {
        // set up
        demoUtils = new DemoUtils();
        System.out.println("@BeforeEach executes before the execution of each test method");
    }

    @AfterEach
    void tearDownAfterEach() {
        System.out.println("Running @AfterEach\n");
    }

    @Test
    void testEqualsAndNotEquals() {

        System.out.println("Running test: testEqualsAndNotEquals");

        // execute and assert
        assertEquals(6, demoUtils.add(2, 4), "2+4 must be 6");
        assertNotEquals(8, demoUtils.add(1, 9), "1+9 must not be 8");
    }

    @Test
    void testNullAndNotNull() {

        System.out.println("Running test: testNullAndNotNull");

        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNotNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNotNull(str2), "Object should not be null");
    }
}
```

Adding println(...) for diagnostics

Adding println(...) for diagnostics

Execution Sequence

Don't worry about order of test methods.
We'll cover that later.

@BeforeEach

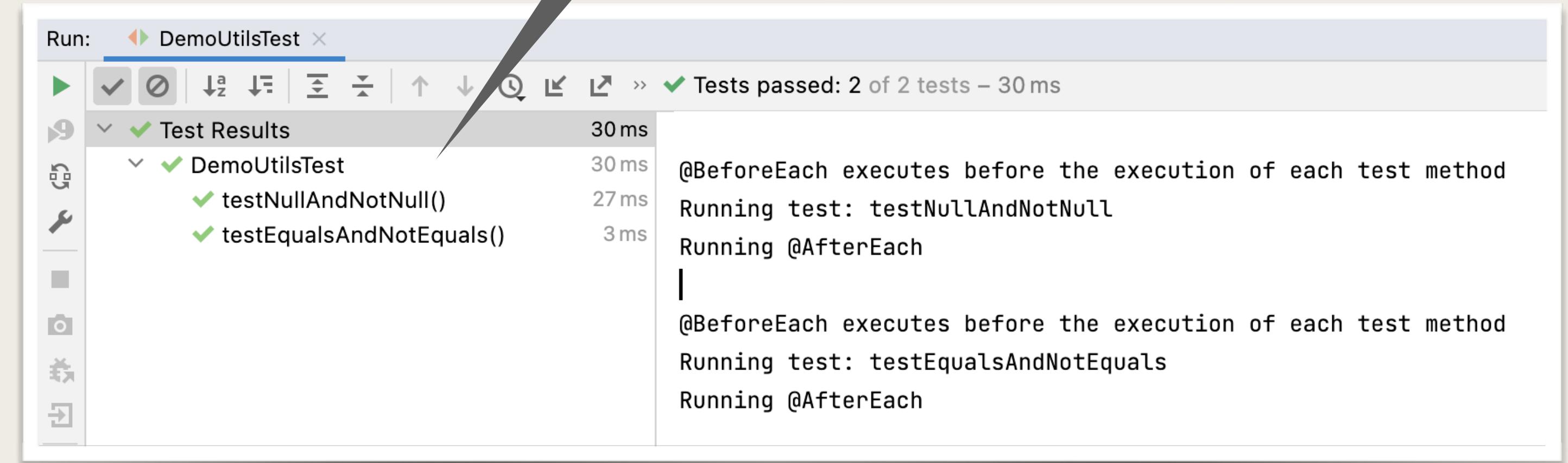
@Test Method One

@AfterEach

@BeforeEach

@Test Method Two

@AfterEach



```
@BeforeEach
void setupBeforeEach() {
    // set up
    demoUtils = new DemoUtils();
    System.out.println("@BeforeEach executes before the execution of each test method");
}

@AfterEach
void tearDownAfterEach() {
    System.out.println("Running @AfterEach\n");
}

@Test
void testNullAndNotNull() {

    System.out.println("Running test: testNullAndNotNull");

    String str1 = null;
    String str2 = "luv2code";

    assertNull(demoUtils.checkNull(str1), "Object should be null");
    assertNotNull(demoUtils.checkNull(str2), "Object should not be null");
}

...
```

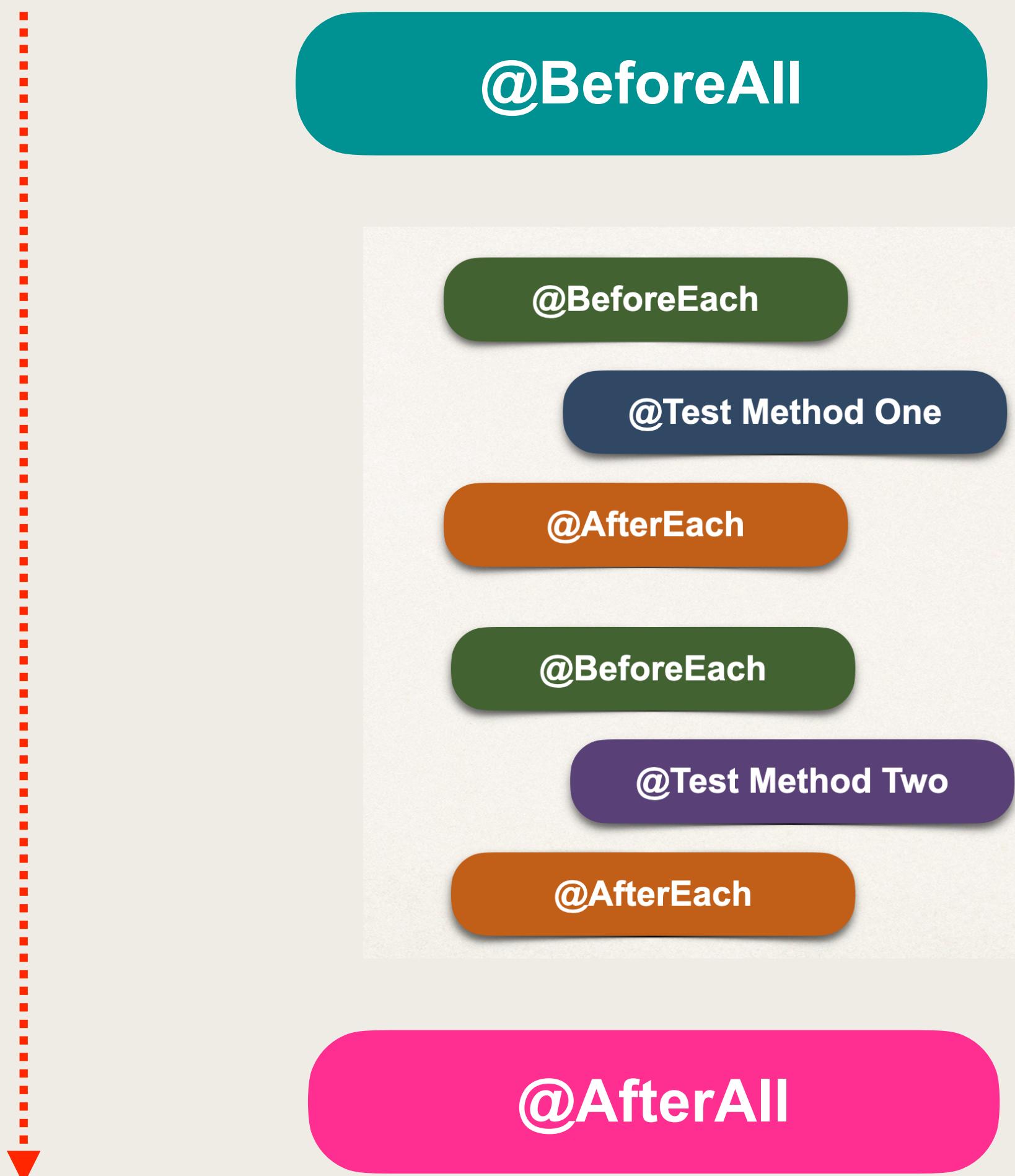
Lifecycle Methods

- When developing tests, we may need to perform one-time operations
- One-time set up before all tests
 - Get database connections, connect to remote servers ...
- One-time clean up after all tests
 - Release database connections, disconnect from remote servers ...

Lifecycle Method Annotations

Annotation	Description
@BeforeAll	<p>Method is executed only once, before all test methods. <i>Useful for getting database connections, connecting to servers ...</i></p>
@AfterAll	<p>Method is executed only once, after all test methods. <i>Useful for releasing database connections, disconnecting from servers ...</i></p>
...	...

Execution Sequence



DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.AfterEach;
import org.junit.jupiter.api.BeforeAll;
import org.junit.jupiter.api.AfterAll;
import static org.junit.jupiter.api.Assertions.*;

class DemoUtilsTest {

    DemoUtils demoUtils;

    @BeforeEach
    void setupBeforeEach() {
        // set up
        demoUtils = new DemoUtils();
        System.out.println("@BeforeEach executes before the execution of each test method");
    }

    @AfterEach
    void tearDownAfterEach() {
        System.out.println("Running @AfterEach\n");
    }

    @BeforeAll
    static void setupBeforeEachClass() {
        System.out.println("@BeforeAll executes only once before all test methods execution in the class\n");
    }

    @AfterAll
    static void tearDownAfterAll() {
        System.out.println("@AfterAll executes only once after all test methods execution in the class");
    }

    @Test
    void testEqualsAndNotEquals() {
        System.out.println("Running test: testEqualsAndNotEquals");
        ...
    }

    @Test
    void testNullAndNotNull() {
        System.out.println("Running test: testNullAndNotNull");
        ...
    }
}
```

Executed only once,
before all test methods

Executed only once,
after all test methods

By default, methods
must be static

Execution Sequence

@BeforeAll

@BeforeEach

@Test Method One

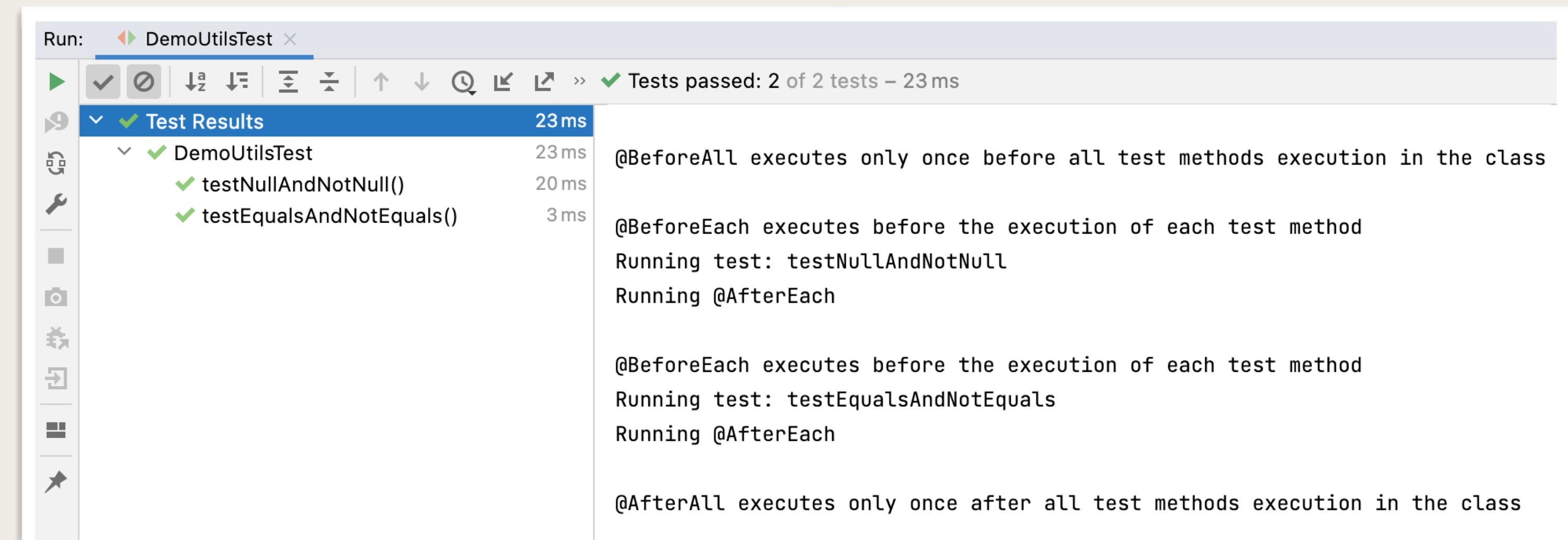
@AfterEach

@BeforeEach

@Test Method Two

@AfterEach

@AfterAll



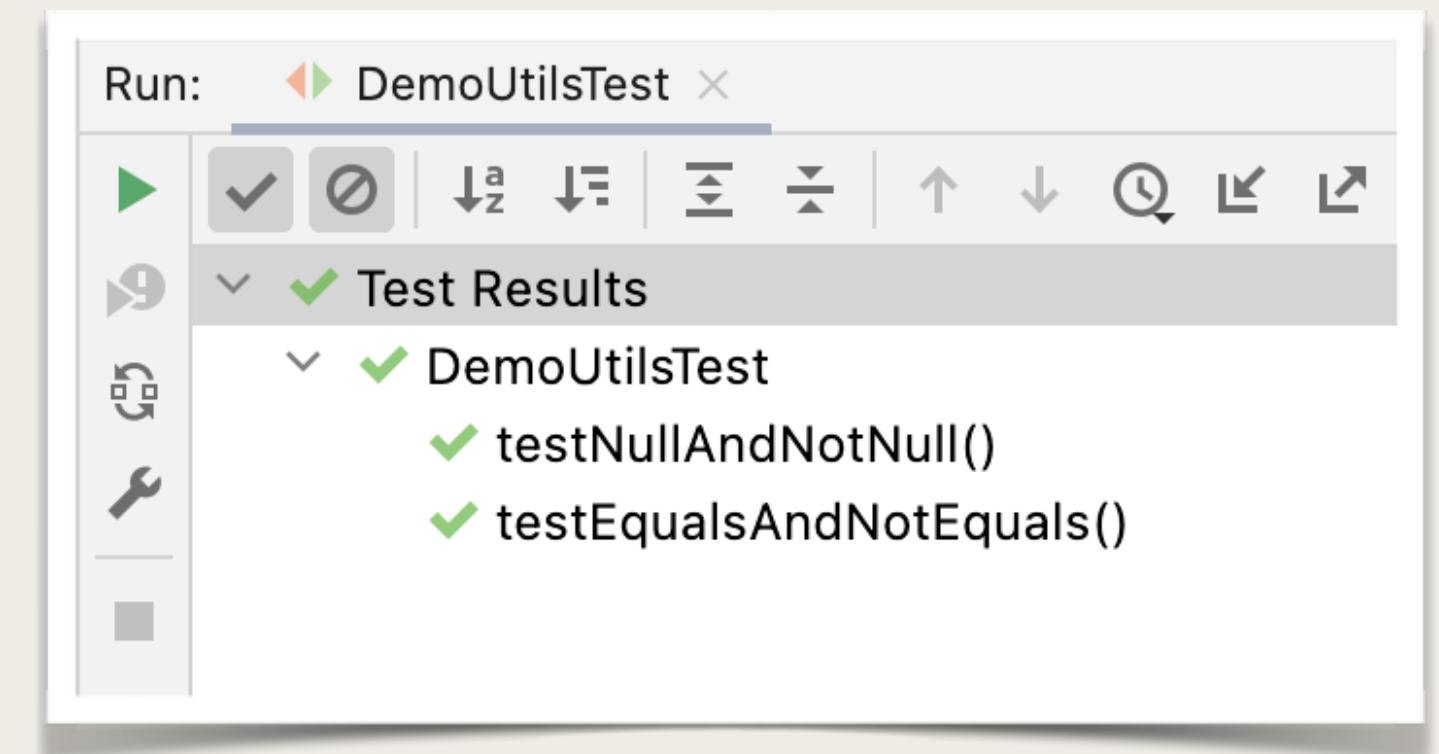
```
@BeforeAll  
static void setupBeforeEachClass() {  
    System.out.println("@BeforeAll executes only once before all test methods execution in the class\n");  
}  
  
@AfterAll  
static void tearDownAfterAll() {  
    System.out.println("@AfterAll executes only once after all test methods execution in the class");  
}
```

JUnit Custom Display Names



Custom Display Names

- Currently the method names are listed in test results
- We'd like to give custom display names
 - Provide a more descriptive name for the test
 - Include spaces, special characters: *Test for Equality to support JIRA #123*
 - Useful for sharing test reports with project management and non-techies



@DisplayName Annotation

Annotation	Description
@DisplayName	<p>Custom display name with spaces, special characters and emojis. <i>Useful for test reports in IDE or external test runner</i></p>

DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.DisplayName;
import static org.junit.jupiter.api.Assertions.*;

class DemoUtilsTest {

    DemoUtils demoUtils;

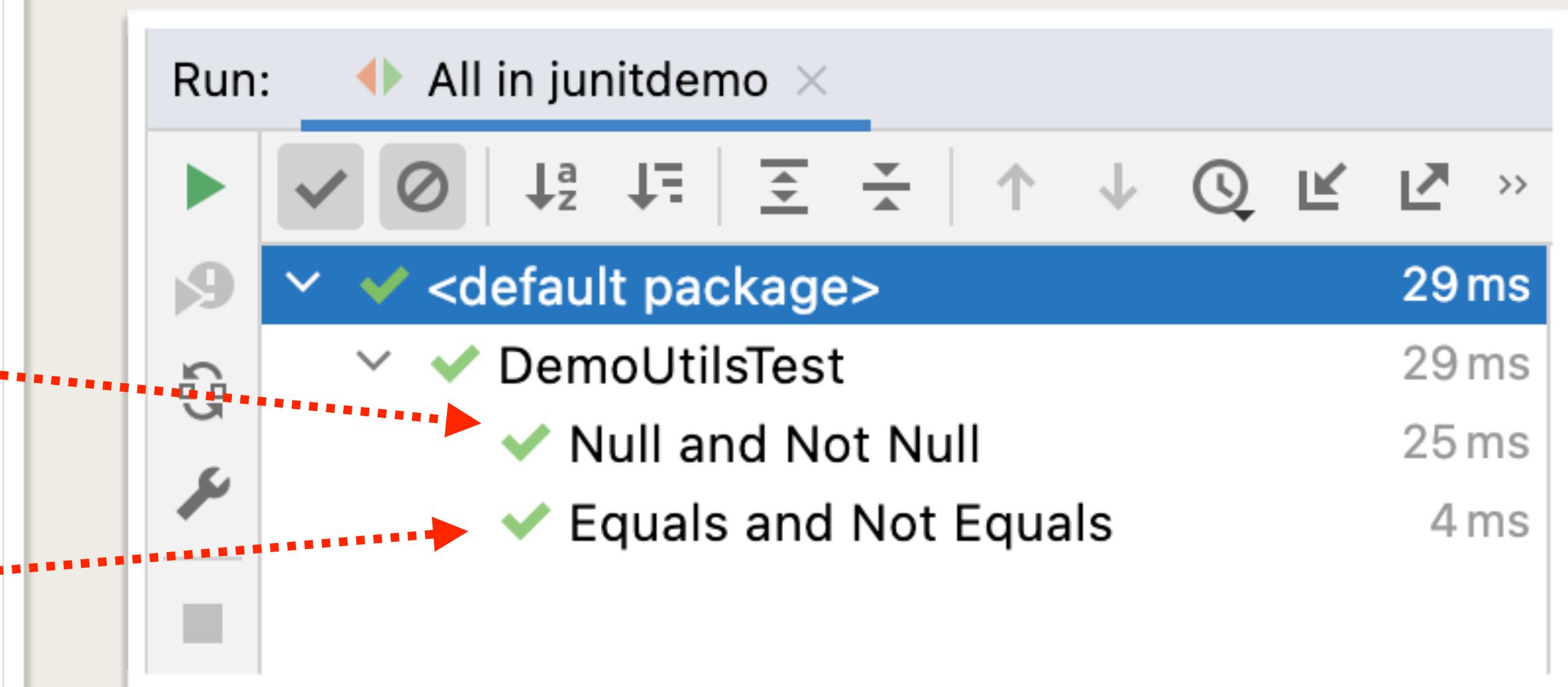
    @BeforeEach
    void setupBeforeEach() {
        // set up
        demoUtils = new DemoUtils();
    }

    @Test
    @DisplayName("Null and Not Null")
    void testNullAndNotNull() {
        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNotNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNotNull(str2), "Object should not be null");
    }

    @Test
    @DisplayName("Equals and Not Equals")
    void testEqualsAndNotEquals() {

        // execute and assert
        assertEquals(6, demoUtils.add(2, 4), "2+4 must be 6");
        assertNotEquals(8, demoUtils.add(1, 9), "1+9 must not be 8");
    }
}
```



Display Name Generators

- JUnit can generate display names for you

Name	Description
Simple	Removes trailing parentheses from test method name
ReplaceUnderscores	Replaces underscores in test method name with spaces
IndicativeSentences	Generate sentence based on test class name and test method name

Simple Generator

DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.DisplayNameGeneration;
import org.junit.jupiter.api.DisplayNameGenerator;
import static org.junit.jupiter.api.Assertions.*;

@DisplayNameGeneration(DisplayNameGenerator.Simple.class)
class DemoUtilsTest {

    DemoUtils demoUtils;

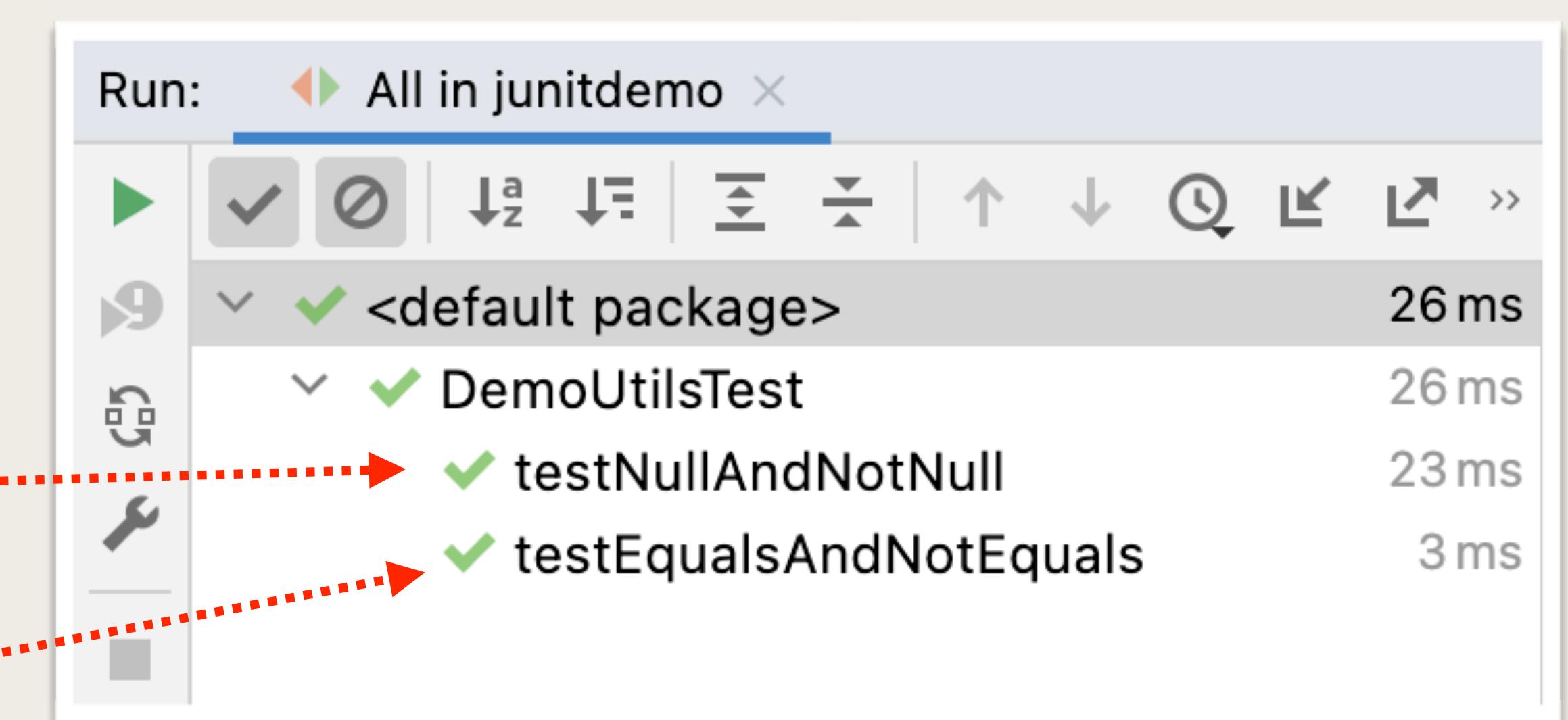
    @BeforeEach
    void setupBeforeEach() {
        // set up
        demoUtils = new DemoUtils();
    }

    @Test
    void testNullAndNotNull() {
        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNull(str2), "Object should not be null");
    }

    @Test
    void testEqualsAndNotEquals() {
        // execute and assert
        assertEquals(6, demoUtils.add(2, 4), "2+4 must be 6");
        assertNotEquals(8, demoUtils.add(1, 9), "1+9 must not be 8");
    }
}
```

Removes trailing parentheses from test method name



Simple Generator

DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.DisplayNameGeneration;
import org.junit.jupiter.api.DisplayNameGenerator;
import static org.junit.jupiter.api.Assertions.*;

@DisplayNameGeneration(DisplayNameGenerator.Simple.class)
class DemoUtilsTest {

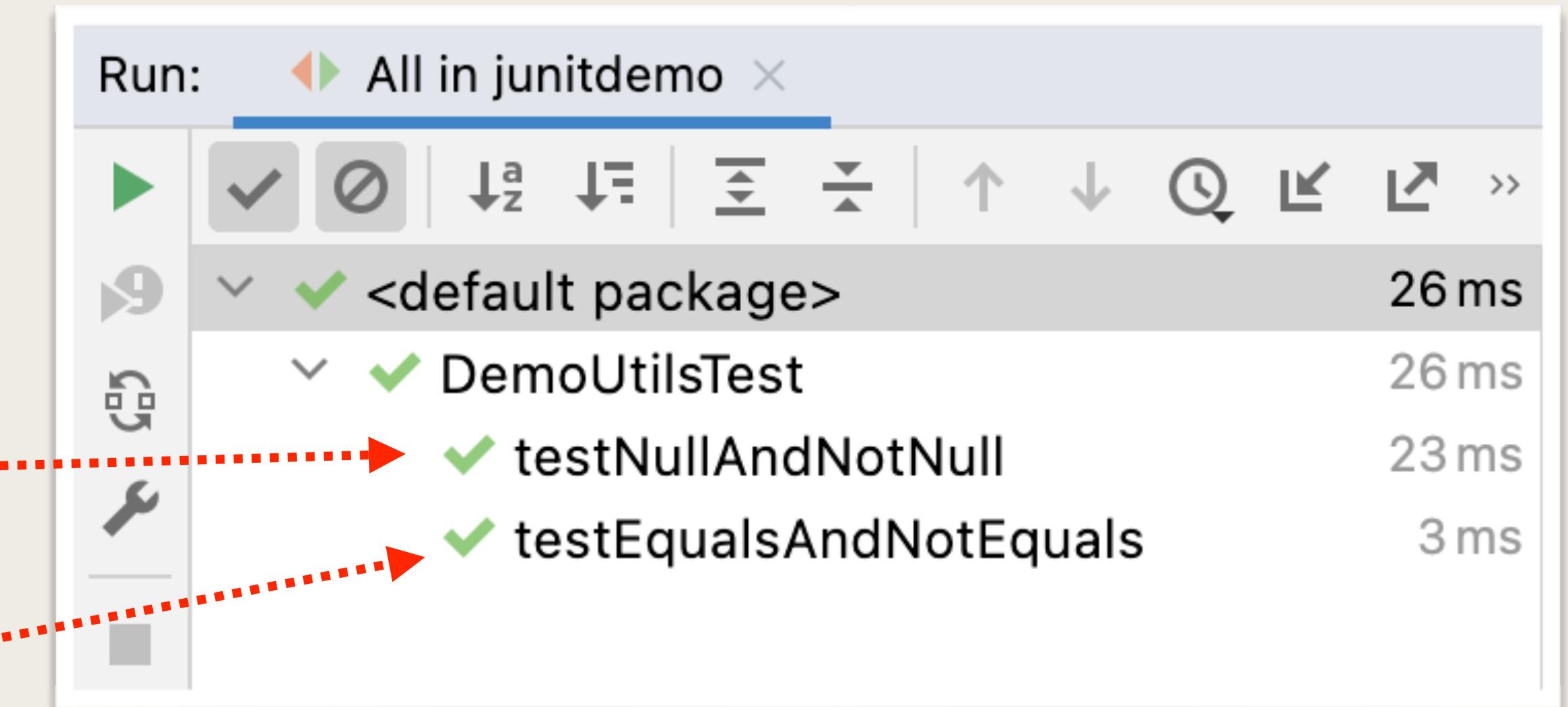
    DemoUtils demoUtils;

    @BeforeEach
    void setupBeforeEach() {
        // set up
        demoUtils = new DemoUtils();
    }

    @Test
    void testNullAndNotNull() {
        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNull(str2), "Object should not be null");
    }

    @Test
    void testEqualsAndHashCode() {
        // execute and assert
        assertEquals(6, demoUtils.add(2, 4), "2+4 must be 6");
        assertNotEquals(8, demoUtils.add(1, 9), "1+9 must not be 8");
    }
}
```



Replace Underscores Generator

DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.DisplayNameGeneration;
import org.junit.jupiter.api.DisplayNameGenerator;
import static org.junit.jupiter.api.Assertions.*;

@DisplayNameGeneration(DisplayNameGenerator.ReplaceUnderscores.class)
class DemoUtilsTest {

    DemoUtils demoUtils;

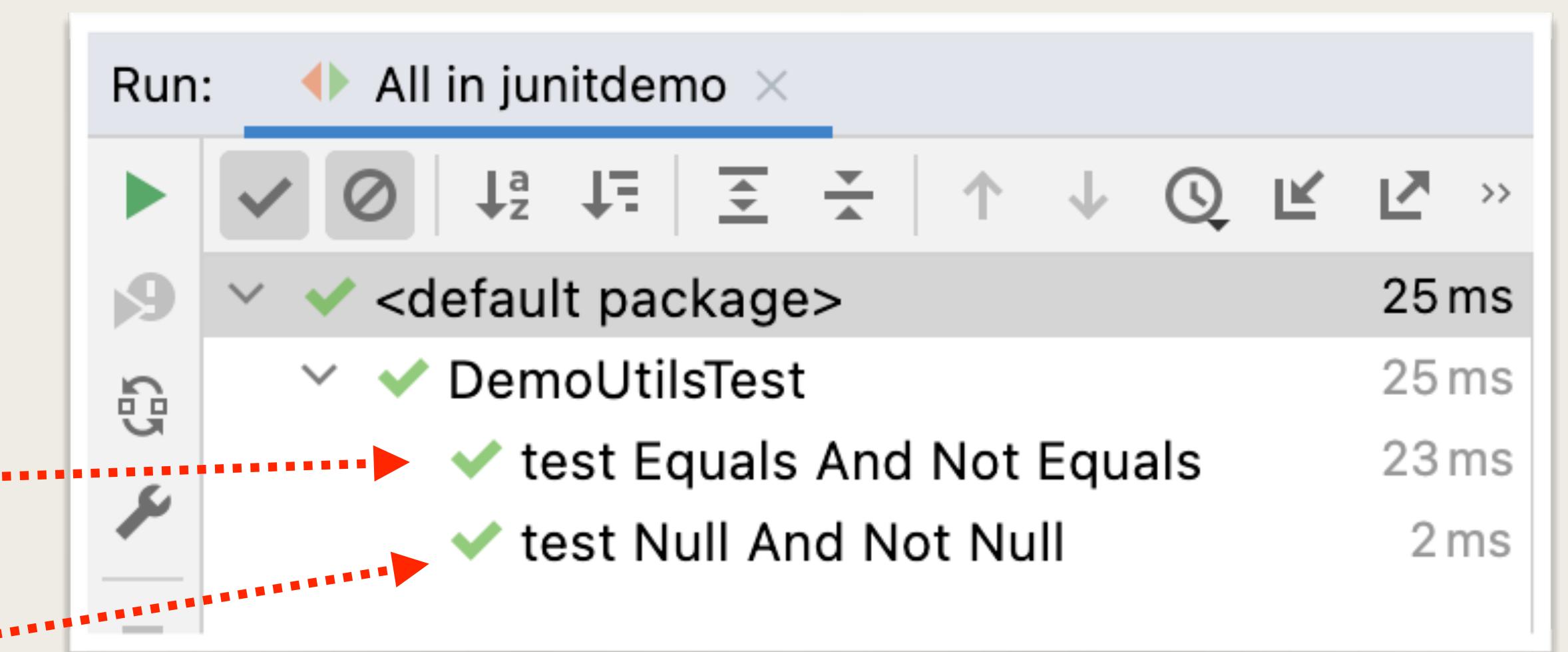
    @BeforeEach
    void setupBeforeEach() {
        // set up
        demoUtils = new DemoUtils();
    }

    @Test
    void test_Equals_And_Not_Equals() {
        // execute and assert
        assertEquals(6, demoUtils.add(2, 4), "2+4 must be 6");
        assertNotEquals(8, demoUtils.add(1, 9), "1+9 must not be 8");
    }

    @Test
    void test_Null_And_Not_Null() {
        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNull(str2), "Object should not be null");
    }
}
```

Replaces underscores with spaces



Indicative Sentences Generator

DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.DisplayNameGeneration;
import org.junit.jupiter.api.DisplayNameGenerator;
import static org.junit.jupiter.api.Assertions.*;

@DisplayNameGeneration(DisplayNameGenerator.IndicativeSentences.class)
class DemoUtilsTest {

    DemoUtils demoUtils;

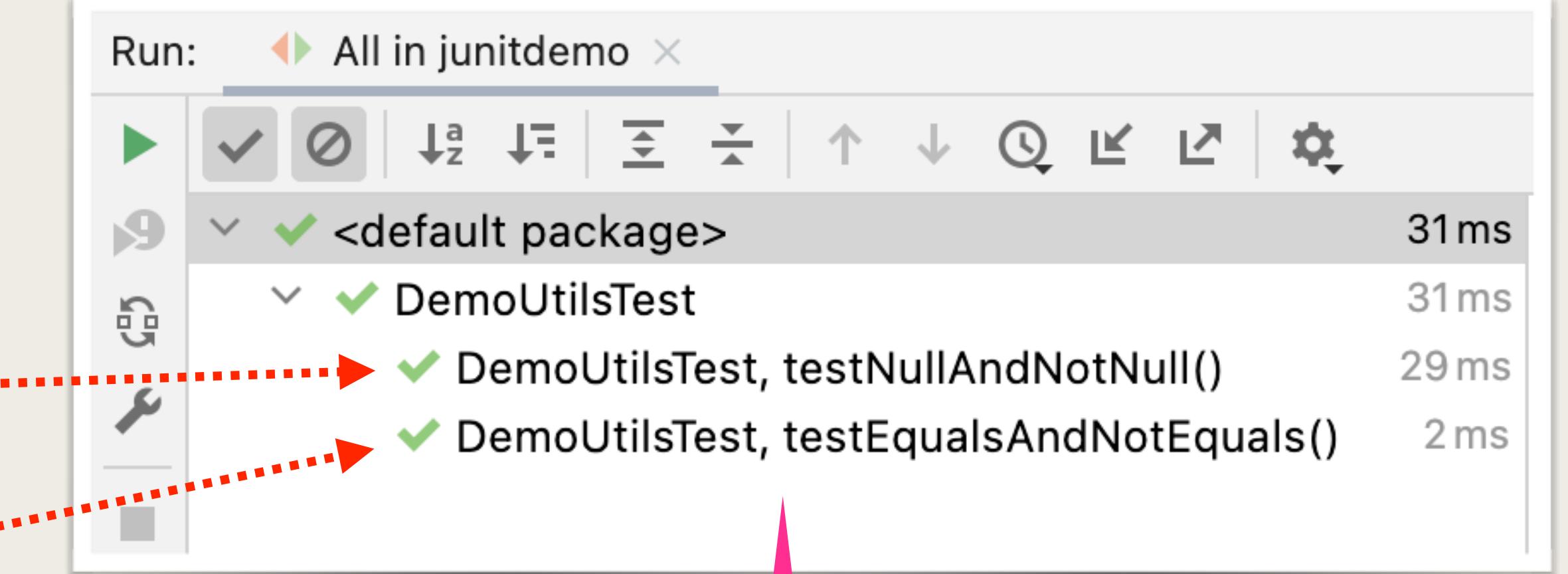
    @BeforeEach
    void setupBeforeEach() {
        // set up
        demoUtils = new DemoUtils();
    }

    @Test
    void testNullAndNotNull() {
        String str1 = null;
        String str2 = "luv2code";

        assertNull(demoUtils.checkNull(str1), "Object should be null");
        assertNotNull(demoUtils.checkNull(str2), "Object should not be null");
    }

    @Test
    void testEqualsAndNotEquals() {
        // execute and assert
        assertEquals(6, demoUtils.add(2, 4), "2+4 must be 6");
        assertNotEquals(8, demoUtils.add(1, 9), "1+9 must not be 8");
    }
}
```

Generate sentence based on
test class name and test method name



<testClassName>, <methodName>

Assertions: Same and True



Assertions

- Test for Same and NotSame

Method name	Description
assertSame	Assert that items refer to same object
assertNotSame	Assert that items do not refer to same object

Code to Test

DemoUtils.java

```
package com.luv2code.junitdemo;

public class DemoUtils {

    private String academy = "Luv2Code Academy";
    private String academyDuplicate = academy;

    public String getAcademy() {
        return academy;
    }

    public String getAcademyDuplicate() {
        return academyDuplicate;
    }
}
```

Check if these refer to the same object

DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.*;
import static org.junit.jupiter.api.Assertions.*;

class DemoUtilsTest {

    DemoUtils demoUtils;

    ...

    @DisplayName("Same and Not Same")
    @Test
    void testSameAndNotSame() {

        String str = "luv2code";

        assertEquals(demoUtils.getAcademy(), demoUtils.getAcademyDuplicate(), "Objects should refer to same object");
        assertNotSame(str, demoUtils.getAcademy(), "Objects should not refer to same object");
    }
}
```

Object1

Object2

```
DemoUtils.java

package com.luv2code.junitdemo;

public class DemoUtils {

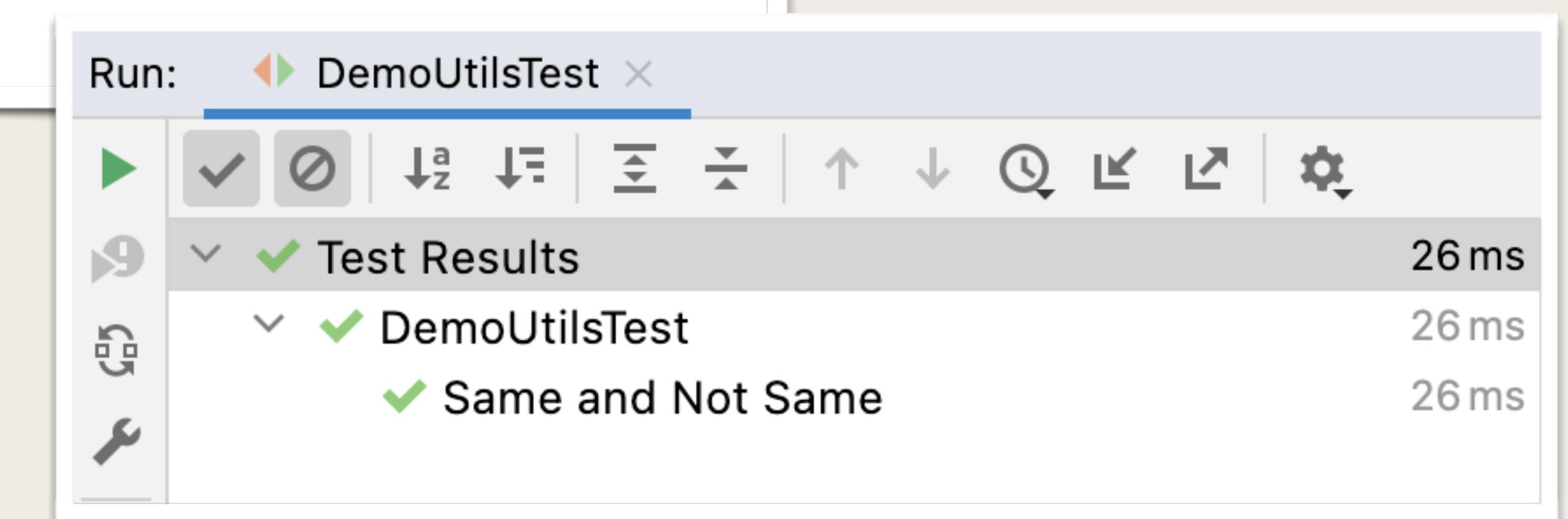
    private String academy = "Luv2Code Academy";
    private String academyDuplicate = academy;

    public String getAcademy() {
        return academy;
    }

    public String getAcademyDuplicate() {
        return academyDuplicate;
    }
}
```

Object1

Object2



Assertions

- Test for True and False

Method name	Description
<code>assertTrue</code>	Assert that condition is true
<code>assertFalse</code>	Assert that condition is false

Code to Test

DemoUtils.java

```
package com.luv2code.junitdemo;

public class DemoUtils {

    public Boolean isGreater(int n1, int n2) {
        return n1 > n2;
    }
}
```

Refactored version

(For learning purposes only :-)
We can refactor accordingly

DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.*;
import static org.junit.jupiter.api.Assertions.*;

class DemoUtilsTest {

    DemoUtils demoUtils;

    ...

    @DisplayName("True and False")
    @Test
    void testTrueFalse() {
        int gradeOne = 10;
        int gradeTwo = 5;

        assertTrue(demoUtils.isGreater(gradeOne, gradeTwo), "This should return true");
        assertFalse(demoUtils.isGreater(gradeTwo, gradeOne), "This should return false");
    }
}
```

Boolean condition

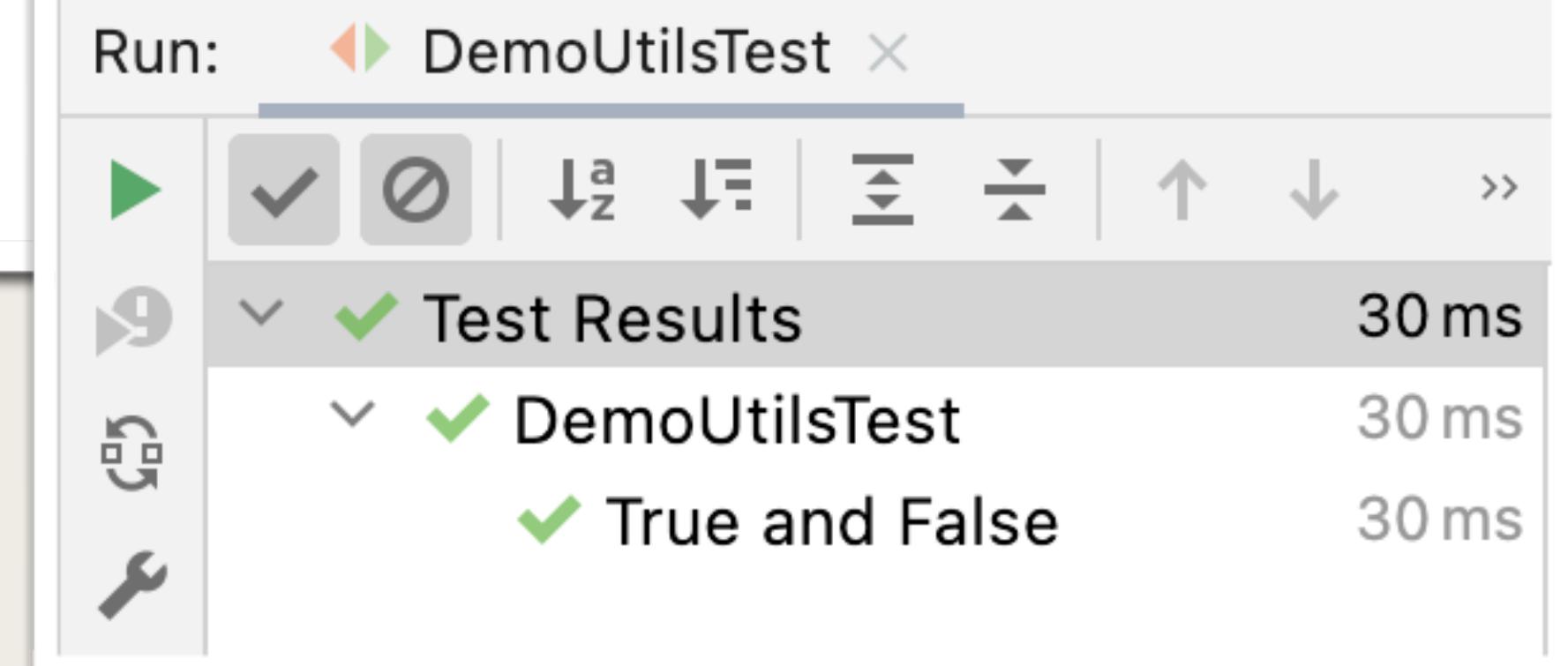
Boolean condition

DemoUtils.java

```
package com.luv2code.junitdemo;

public class DemoUtils {

    public Boolean isGreater(int n1, int n2) {
        return n1 > n2;
    }
}
```



Assertions: Arrays, Iterables and Lines



Assertions

Method name	Description
assertArrayEquals	Assert that both object arrays are deeply equal

Code to Test

DemoUtils.java

```
package com.luv2code.junitdemo;

public class DemoUtils {

    private String[] firstThreeLettersOfAlphabet = {"A", "B", "C"};

    public String[] getFirstThreeLettersOfAlphabet() {
        return firstThreeLettersOfAlphabet;
    }
}
```

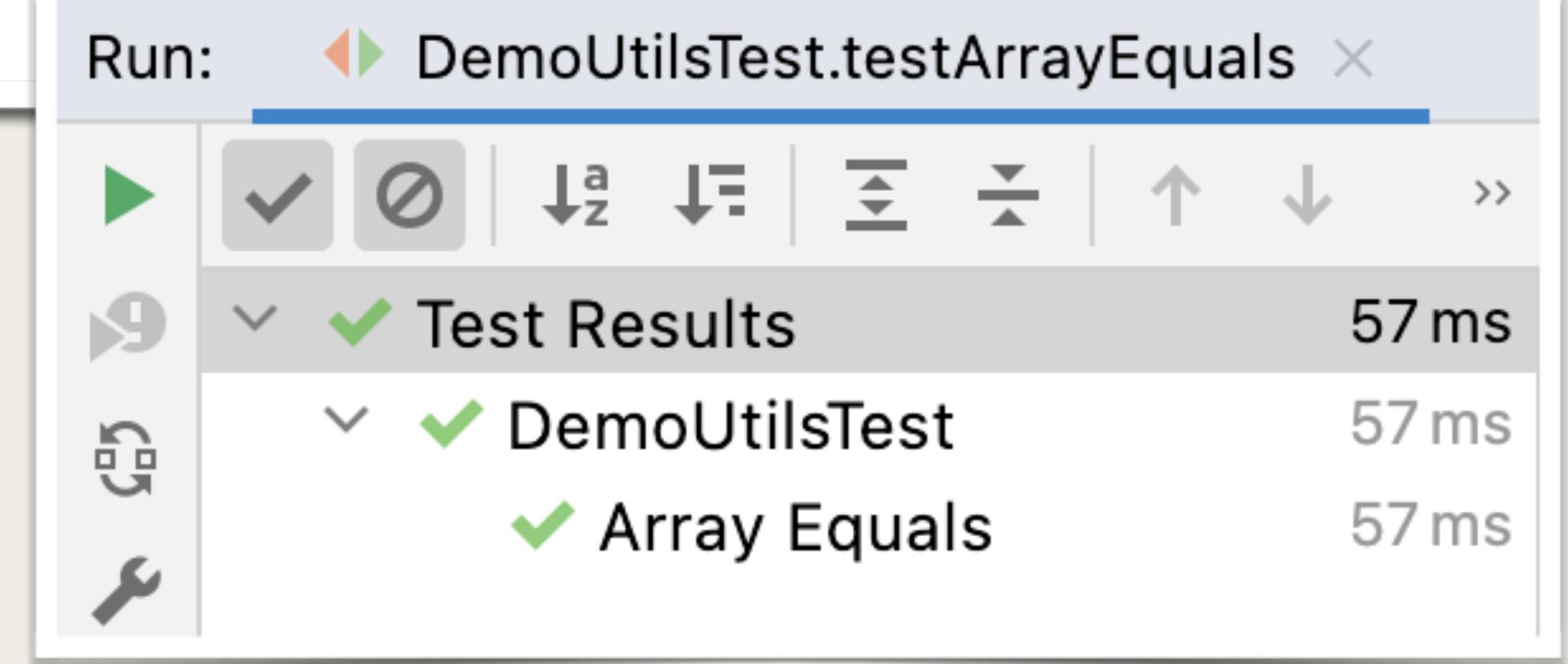
Make comparisons against this array

DemoUtilsTest.java

```
package com.luv2code.junitdemo;  
  
import org.junit.jupiter.api.*;  
import static org.junit.jupiter.api.Assertions.*;  
  
class DemoUtilsTest {  
  
    DemoUtils demoUtils;  
  
    ...  
  
    @DisplayName("Array Equals")  
    @Test  
    void testArrayEquals() {  
        String[] stringArray = {"A", "B", "C"};  
  
        assertArrayEquals(stringArray, demoUtils.getFirstThreeLettersOfAlphabet(), "Arrays should be the same");  
    }  
}
```

DemoUtils.java

```
package com.luv2code.junitdemo;  
  
public class DemoUtils {  
  
    private String[] firstThreeLettersOfAlphabet = {"A", "B", "C"};  
  
    public String[] getFirstThreeLettersOfAlphabet() {  
        return firstThreeLettersOfAlphabet;  
    }  
}
```



Assertions

Method name	Description
assertIterableEquals	Assert that both object iterables are deeply equal

An "iterable" is an instance of a class
that implements the `java.lang.Iterable` interface

Examples: `ArrayList`, `LinkedList`, `HashSet`, `TreeSet` ...

Code to Test

DemoUtils.java

```
package com.luv2code.junitdemo;

import java.util.List;

public class DemoUtils {

    private List<String> academyInList = List.of("luv", "2", "code");

    public List<String> getAcademyInList() {
        return academyInList;
    }
}
```

Make comparisons against this List

DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.*;
import static org.junit.jupiter.api.Assertions.*;
import java.util.List;

class DemoUtilsTest {

    DemoUtils demoUtils;

    ...

    @DisplayName("Iterable equals")
    @Test
    void testIterableEquals() {
        List<String> theList = List.of("luv", "2", "code");

        assertEquals(theList, demoUtils.getAcademyInList(), "Expected list should be same as actual list");
    }
}
```

DemoUtils.java

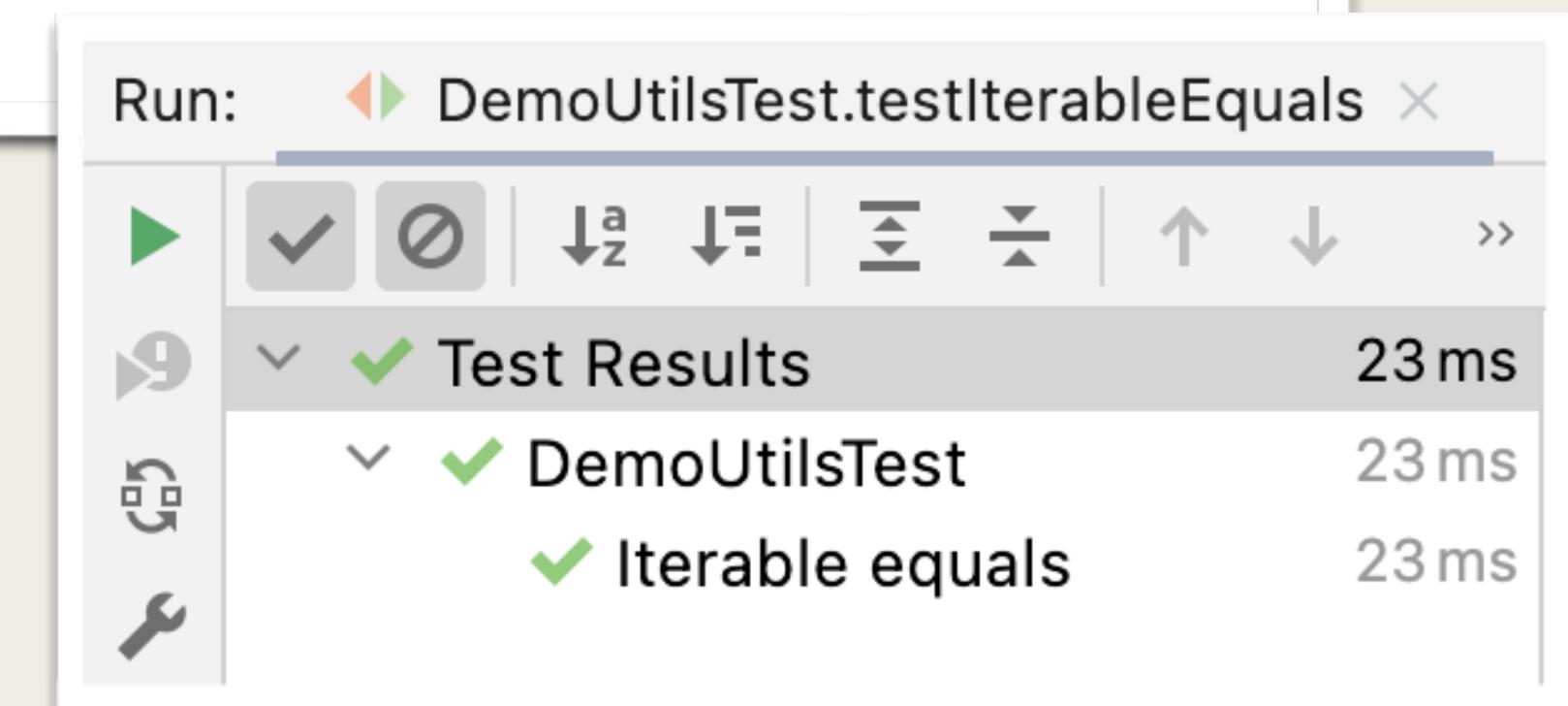
```
package com.luv2code.junitdemo;

import java.util.List;

public class DemoUtils {

    private List<String> academyInList = List.of("luv", "2", "code");

    public List<String> getAcademyInList() {
        return academyInList;
    }
}
```



Assertions

Method name	Description
<code>assertLinesMatch</code>	Assert that both lists of strings match

Code to Test

DemoUtils.java

```
package com.luv2code.junitdemo;

import java.util.List;

public class DemoUtils {

    private List<String> academyInList = List.of("luv", "2", "code");

    public List<String> getAcademyInList() {
        return academyInList;
    }
}
```

Make comparisons against this List

DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.*;
import static org.junit.jupiter.api.Assertions.*;
import java.util.List;

class DemoUtilsTest {

    DemoUtils demoUtils;

    ...

    @DisplayName("Lines match")
    @Test
    void testLinesMatch() {
        List<String> theList = List.of("luv", "2", "code");

        assertLinesMatch(theList, demoUtils.getAcademyInList(), "Lines should match");
    }
}
```

DemoUtils.java

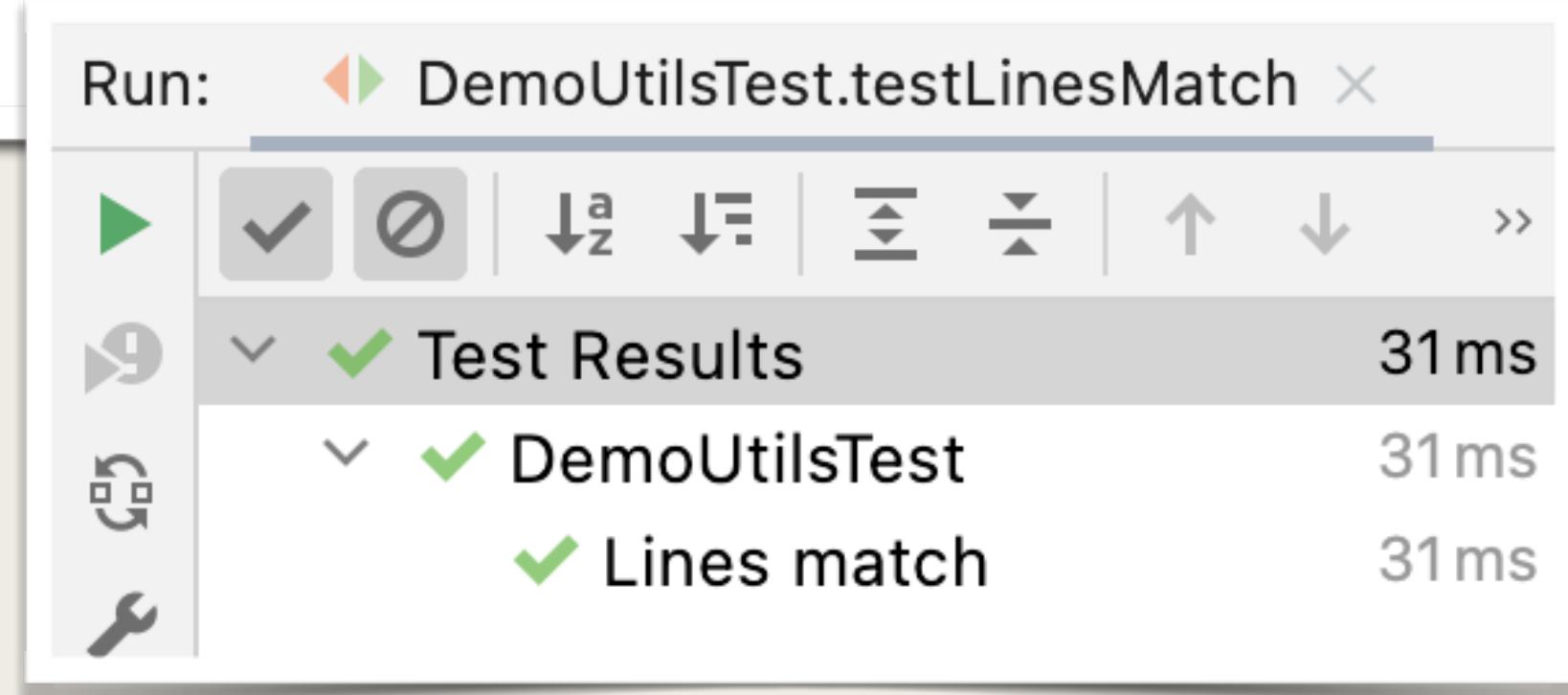
```
package com.luv2code.junitdemo;

import java.util.List;

public class DemoUtils {

    private List<String> academyInList = List.of("luv", "2", "code");

    public List<String> getAcademyInList() {
        return academyInList;
    }
}
```



Assertions: Throws and Timeout



Assertions

Method name	Description
assertThrows	Assert that an executable throws an exception of expected type

Code to Test

DemoUtils.java

```
package com.luv2code.junitdemo;

public class DemoUtils {

    public String throwException(int a) throws Exception {
        if (a < 0) {
            throw new Exception("Value should be greater than or equal to 0");
        }
        return "Value is greater than or equal to 0";
    }
}
```

Verify this method
throws an exception for values < 0

DemoUtilsTest.java

```
package com.luv2code.junitdemo;

import org.junit.jupiter.api.*;
import static org.junit.jupiter.api.Assertions.*;

class DemoUtilsTest {

    DemoUtils demoUtils;

    ...

    @DisplayName("Throws and Does Not Throw")
    @Test
    void testThrowsAndDoesNotThrow() {
        assertThrows(Exception.class, () -> { demoUtils.throwException(-1); }, "Should throw exception");

        assertDoesNotThrow(() -> { demoUtils.throwException(5); }, "Should not throw exception");
    }
}
```

Lambda expression

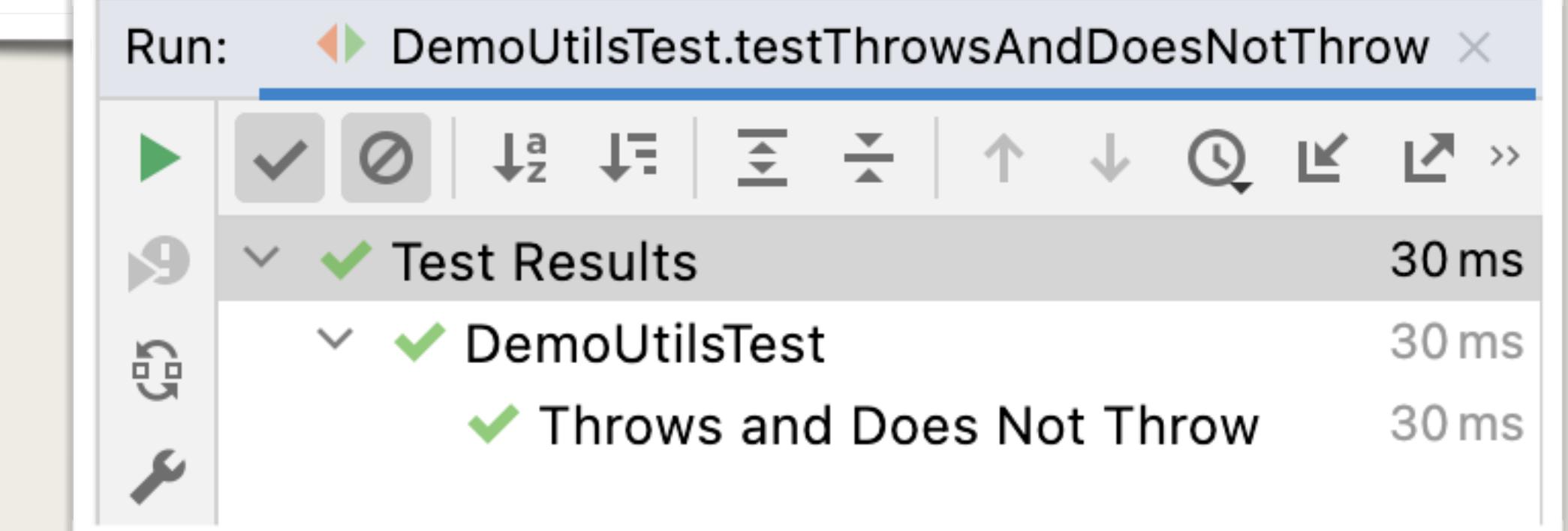
Lambda expression

DemoUtils.java

```
package com.luv2code.junitdemo;

public class DemoUtils {

    public String throwException(int a) throws Exception {
        if (a < 0) {
            throw new Exception("Value should be greater than or equal to 0");
        }
        return "Value is greater than or equal to 0";
    }
}
```



Assertions

Method name	Description
<code>assertTimeoutPreemptively</code>	Assert that an executable completes before given timeout is exceeded

**Execution is preemptively aborted
if timeout is exceeded**

Code to Test

DemoUtils.java

```
package com.luv2code.junitdemo;

public class DemoUtils {

    public void checkTimeout() throws InterruptedException {
        System.out.println("I am going to sleep");
        Thread.sleep(2000);
        System.out.println("Sleeping over");
    }
}
```

Make sure method doesn't oversleep. :-)

DemoUtilsTest.java

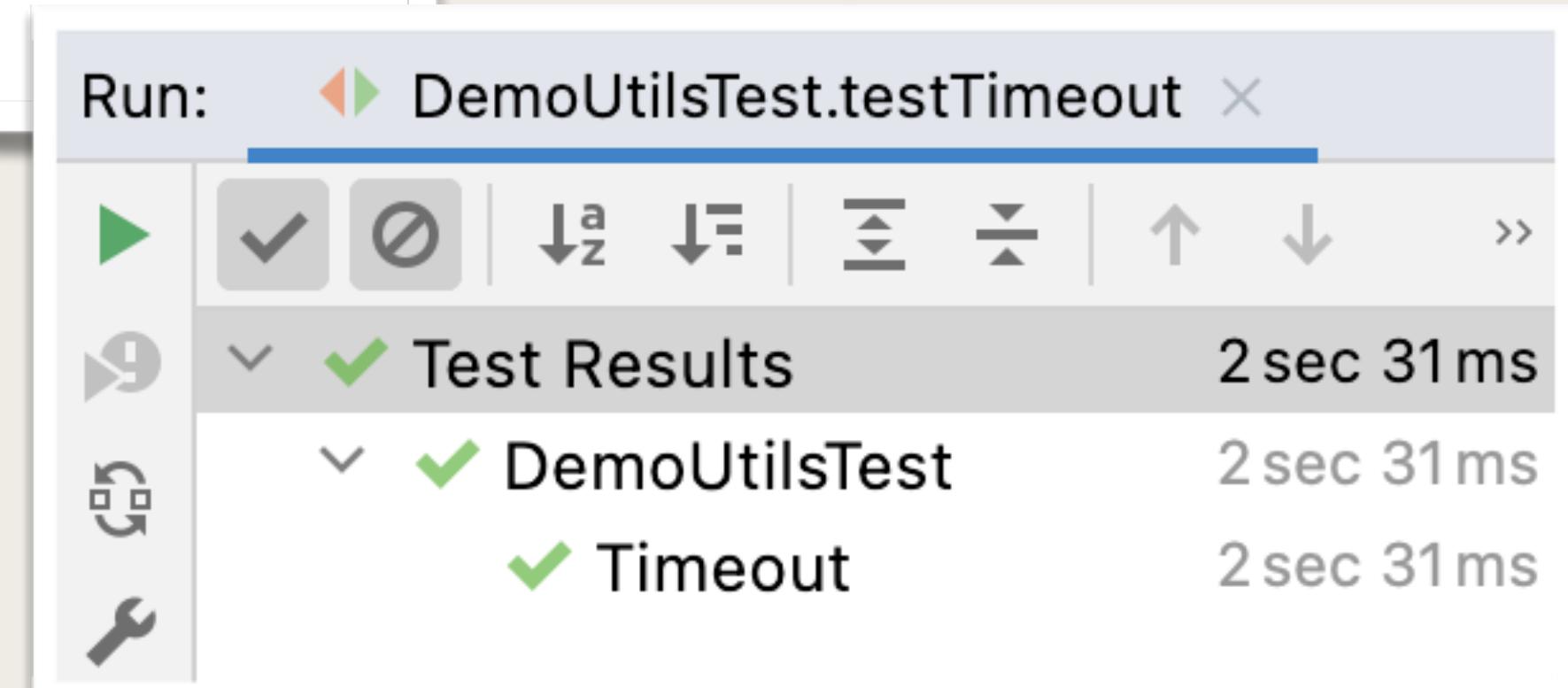
```
package com.luv2code.junitdemo;  
  
import org.junit.jupiter.api.*;  
import static org.junit.jupiter.api.Assertions.*;  
import java.time.Duration;  
  
class DemoUtilsTest {  
  
    DemoUtils demoUtils;  
  
    ...  
  
    @DisplayName("Timeout")  
    @Test  
    void testTimeout() {  
  
        assertTimeoutPreemptively(Duration.ofSeconds(3), () -> { demoUtils.checkTimeout(); },  
            "Method should execute in 3 seconds");  
    }  
}
```

Timeout duration

Lambda expression

DemoUtils.java

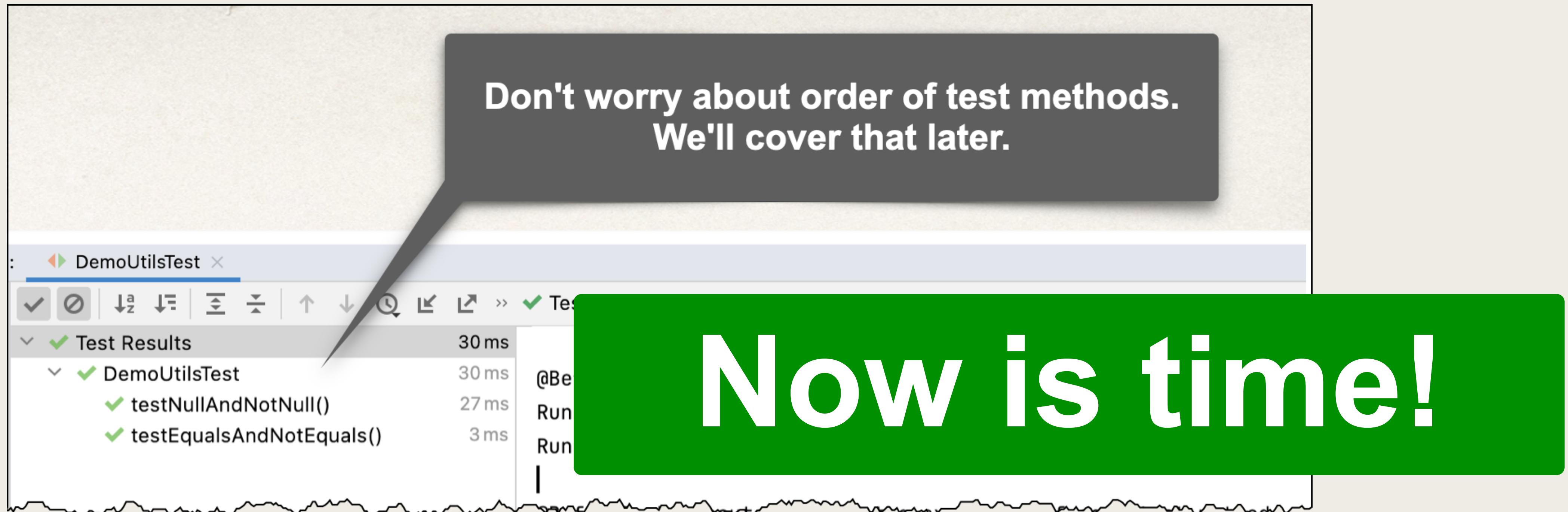
```
package com.luv2code.junitdemo;  
  
public class DemoUtils {  
  
    public void checkTimeout() throws InterruptedException {  
        System.out.println("I am going to sleep");  
        Thread.sleep(2000);  
        System.out.println("Sleeping over");  
    }  
}
```



Running Tests in Order



Remember this?



Order???

- In general
 - Order should not be a factor in unit tests
 - There should be no dependency between tests
 - All tests should pass regardless of the order in which they are run

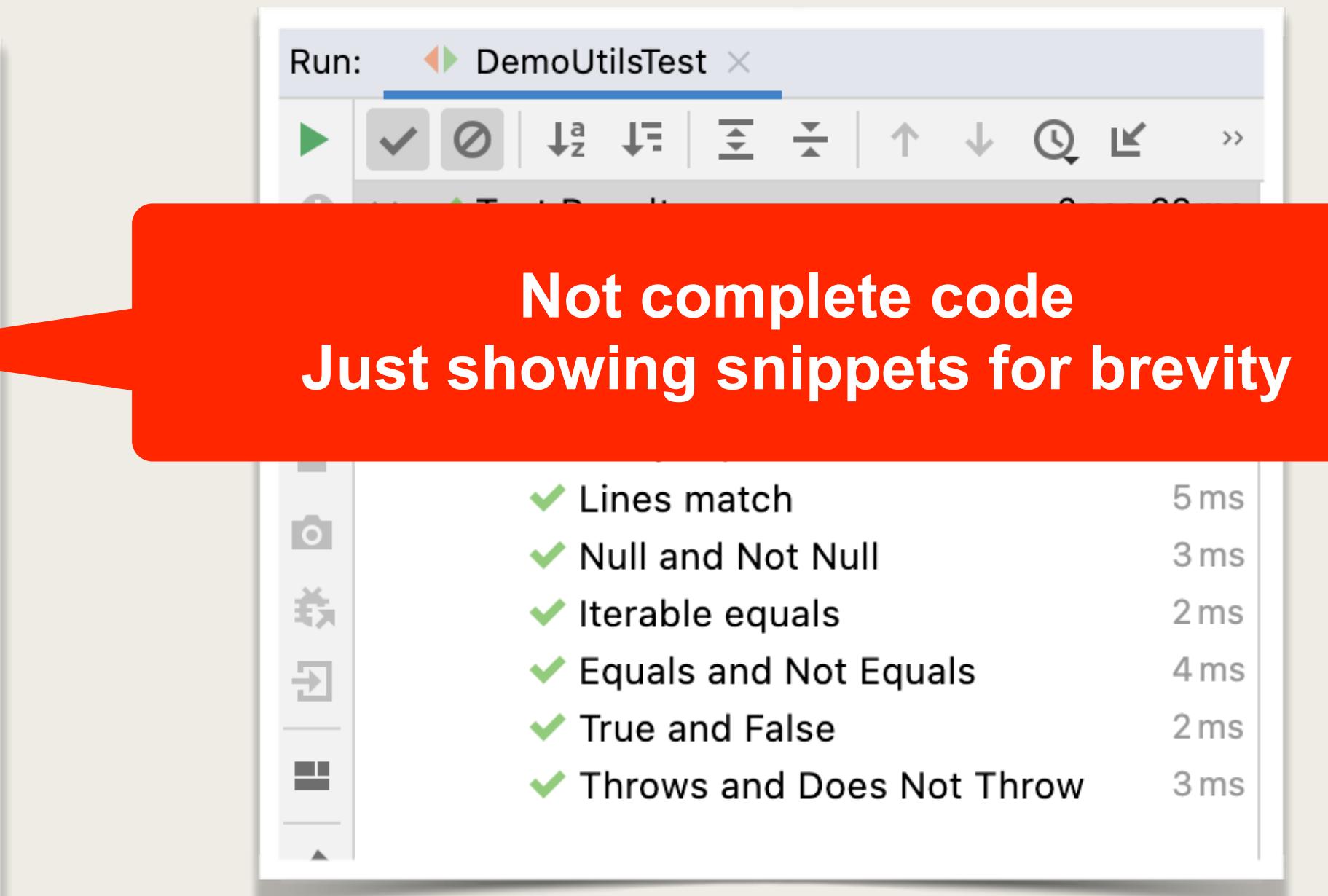
Use Cases

- However, there are some uses cases when you want to control the order
 - You want tests to appear in alphabetical order for reporting purposes
 - Sharing reports with project management, QA team etc...
 - Group tests based on functionality or requirements

Existing ... before any changes

DemoUtilsTest.java

```
class DemoUtilsTest {  
    ...  
  
    @DisplayName("Equals and Not Equals")  
    void testEqualsAndNotEquals()  
  
    @DisplayName("Null and Not Null")  
    void testNullAndNotNull()  
  
    @DisplayName("Same and Not Same")  
    void testSameAndNotSame()  
  
    @DisplayName("True and False")  
    void testTrueFalse()  
  
    @DisplayName("Array Equals")  
    void testArrayEquals()  
  
    @DisplayName("Iterable equals")  
    void testIterableEquals()  
  
    @DisplayName("Lines match")  
    void testLinesMatch()  
  
    @DisplayName("Throws and Does Not Throw")  
    void testThrowsAndDoesNotThrow()  
  
    @DisplayName("Timeout")  
    void testTimeout()  
}
```



Not complete code
Just showing snippets for brevity

JUnit Docs

By default, test classes and methods will be ordered using an algorithm that is deterministic

<https://junit.org/junit5/docs/current/user-guide/>

Annotation

Annotation	Description
@TestMethodOrder	Configures the order / sort algorithm for the test methods

Specify Method Order

Name	Description
MethodOrderer.DisplayName	Sorts test methods alphanumerically based on display names
MethodOrderer.MethodName	Sorts test methods alphanumerically based on method names
MethodOrderer.Random	Pseudo-random order based on method names
MethodOrderer.OrderAnnotation	Sorts test methods numerically based on @Order annotation

Order by Display Name

Sorted alphabetically

DemoUtilsTest.java

```
→ @TestMethodOrder(MethodOrderer.DisplayName.class)
class DemoUtilsTest {
    ...
    @DisplayName("Equals and Not Equals")
    void testEqualsAndNotEquals()

    @DisplayName("Null and Not Null")
    void testNullAndNotNull()

    @DisplayName("Same and Not Same")
    void testSameAndNotSame()

    @DisplayName("True and False")
    void testTrueFalse()

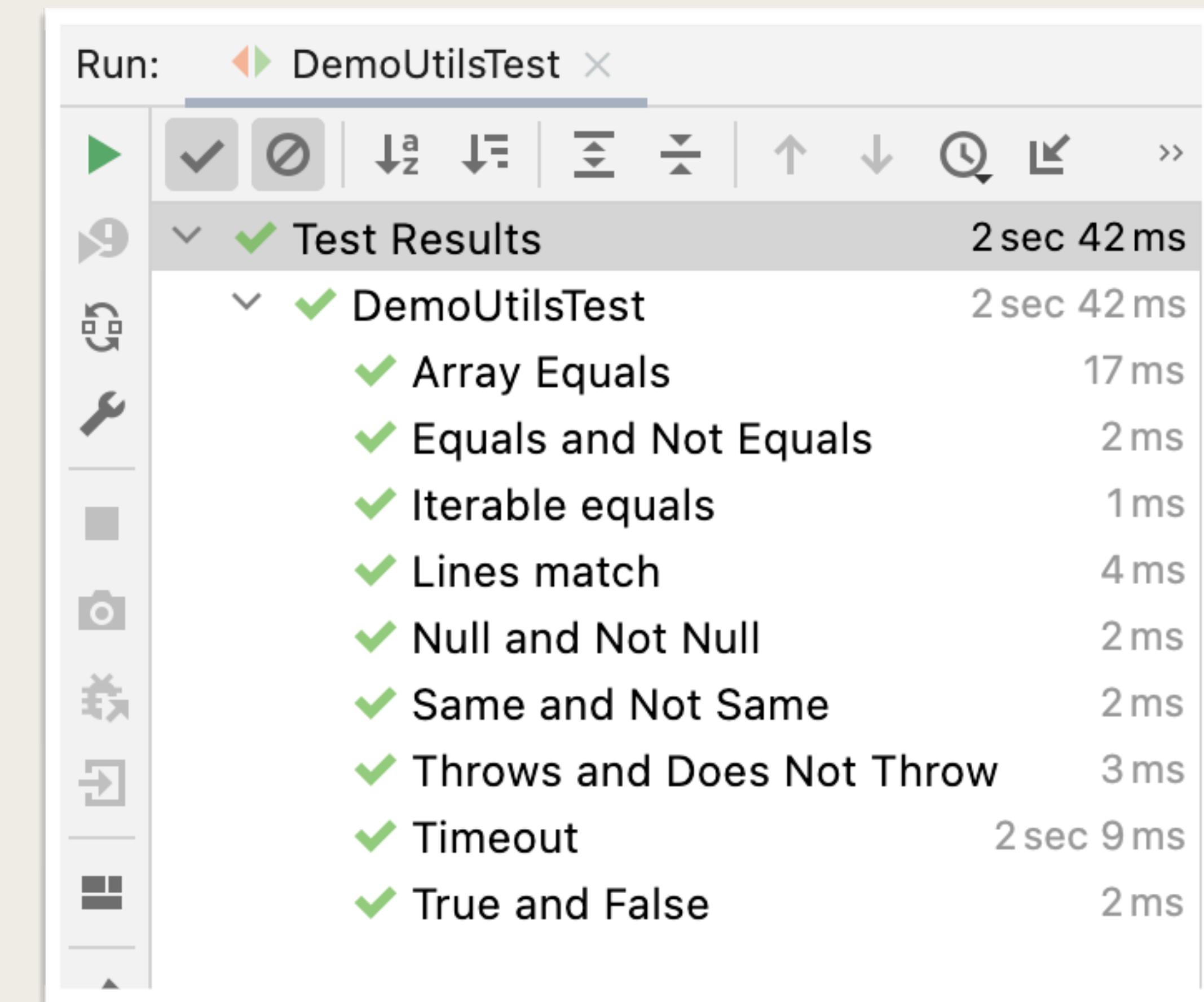
    @DisplayName("Array Equals")
    void testArrayEquals()

    @DisplayName("Iterable equals")
    void testIterableEquals()

    @DisplayName("Lines match")
    void testLinesMatch()

    @DisplayName("Throws and Does Not Throw")
    void testThrowsAndDoesNotThrow()

    @DisplayName("Timeout")
    void testTimeout()
}
```



Order by Method Name

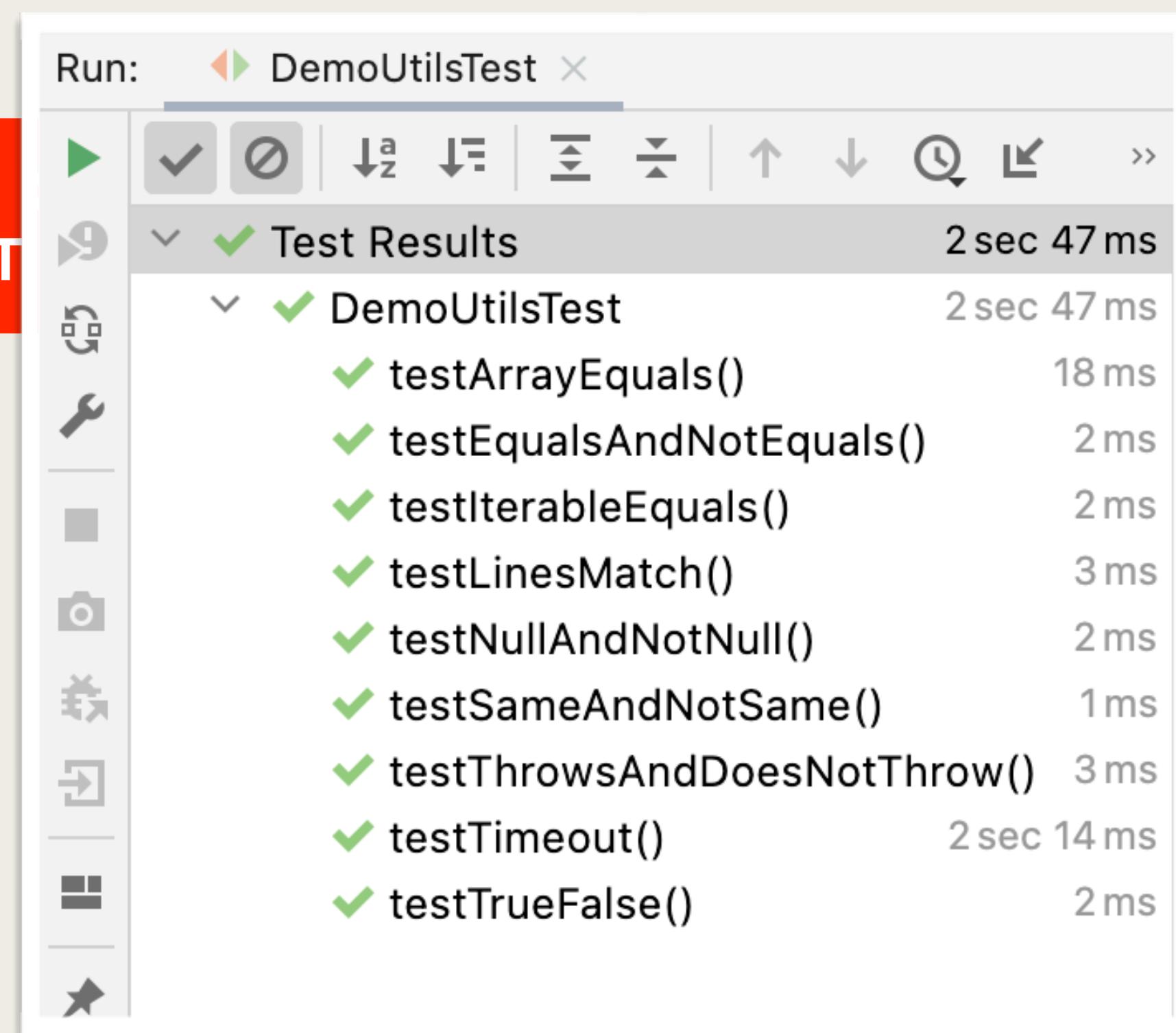
Sorted alphanumerically

DemoUtilsTest.java



```
@TestMethodOrder(MethodOrderer.MethodName.class)
class DemoUtilsTest {
    ...
    // @DisplayName("Equals and Not Equals")
    void testEqualsAndNotEquals()

    void testNullAndNotNull()
    void testSameAndNotSame()
    void testTrueFalse()
    void testArrayEquals()
    void testIterableEquals()
    void testLinesMatch()
    void testThrowsAndDoesNotThrow()
    void testTimeout()
}
```



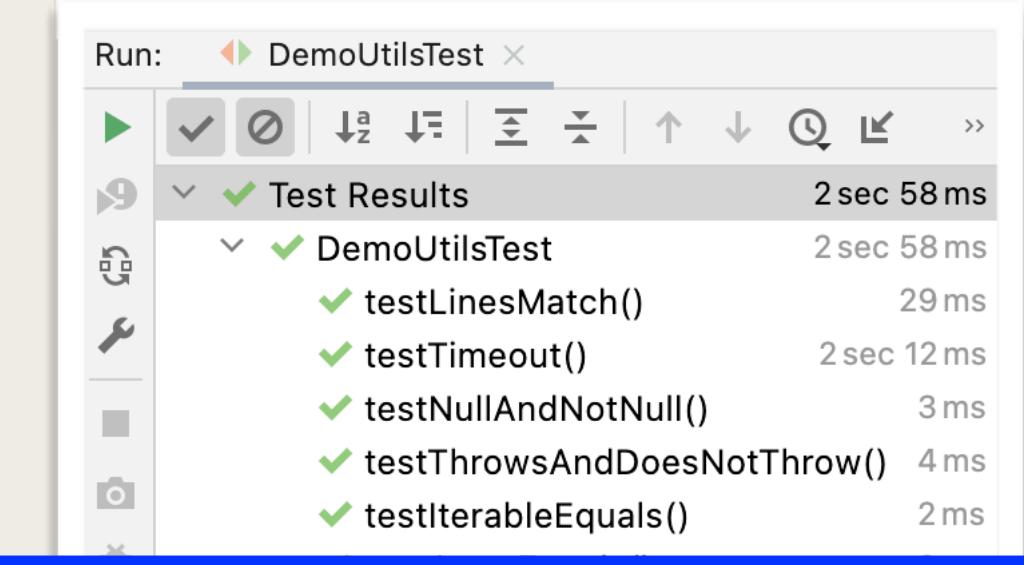
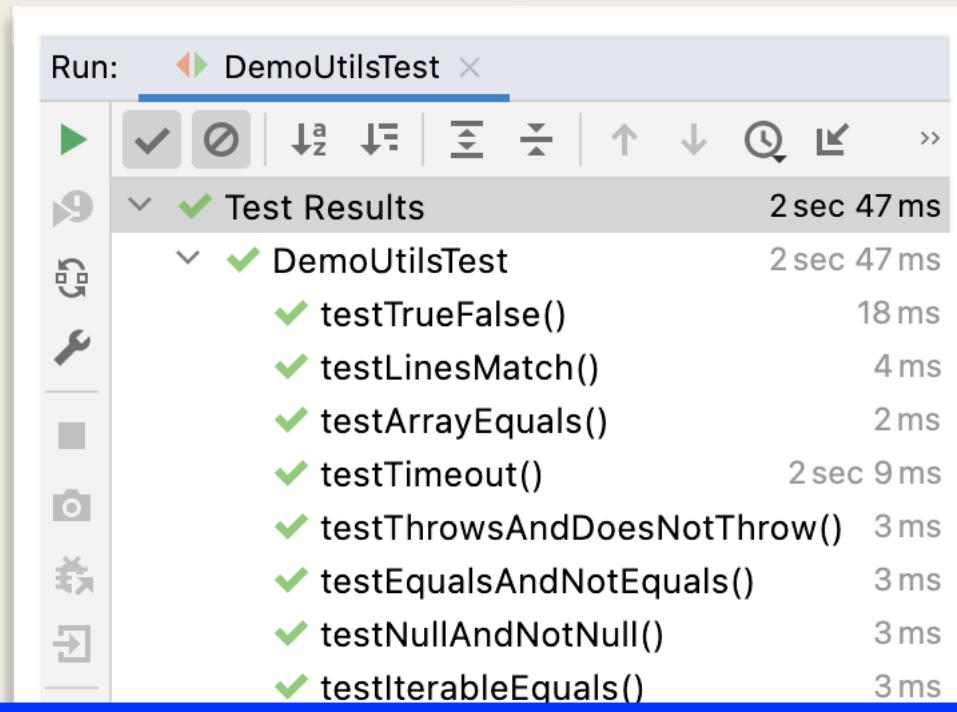
Method	Time
testArrayEquals()	18 ms
testEqualsAndNotEquals()	2 ms
testIterableEquals()	2 ms
testLinesMatch()	3 ms
testNullAndNotNull()	2 ms
testSameAndNotSame()	1 ms
testThrowsAndDoesNotThrow()	3 ms
testTimeout()	2 sec 14 ms
testTrueFalse()	2 ms

Random by Method Name

DemoUtilsTest.java

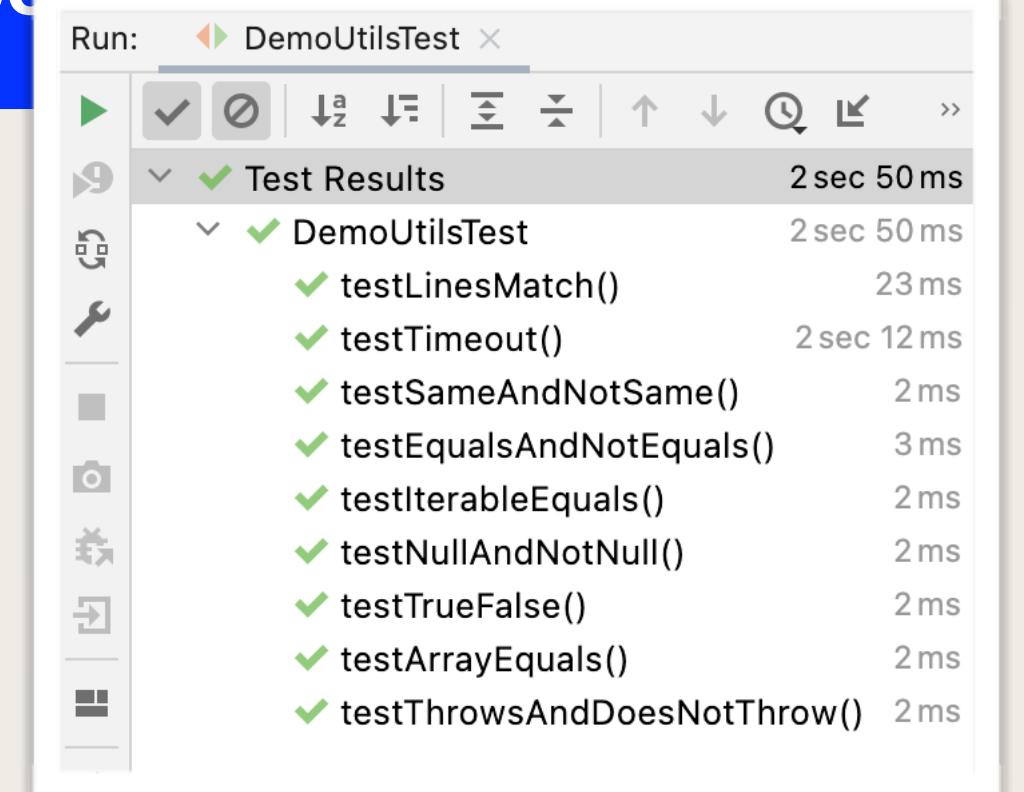
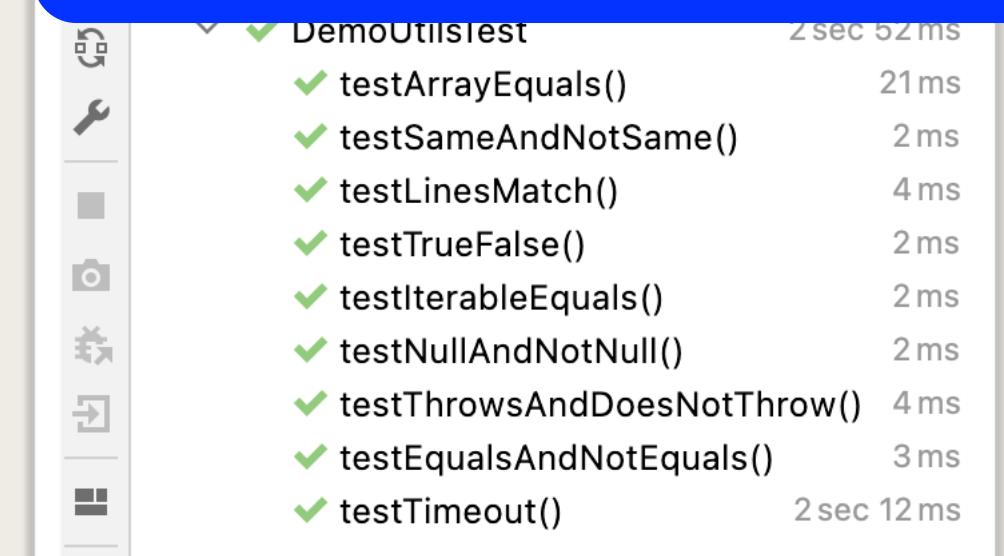
```
@TestMethodOrder(MethodOrderer.Random.class)
class DemoUtilsTest {
    ...
    void testEqualsAndHashCode()
    void testNullAndNotNull()
    void testSameAndNotSame()
    void testTrueFalse()
}
```

Can also use DisplayName
since everything is random
... order doesn't matter



Great scenario!!!!

Make sure all of your tests pass regardless of order
Confirms no dependencies between tests



Annotation

Annotation	Description
@Order	<p>Manually specify the order with an <code>int</code> number</p> <ul style="list-style-type: none">- Order with lowest number has highest priority- Negative numbers are allowed

@Order

Remember
Lowest number has highest priority

```
DemoUtilsTest.java
@TestMethodOrder(MethodOrderer.OrderAnnotation.class)
class DemoUtilsTest {
    ...
    @DisplayName("Equals and Not Equals")
    @Order(3)
    void testEqualsAndNotEquals()

    @DisplayName("Null and Not Null")
    @Order(1)
    void testNullAndNotNull()

    @DisplayName("Same and Not Same")
    void testSameAndNotSame()

    @DisplayName("True and False")
    void testTrueFalse()

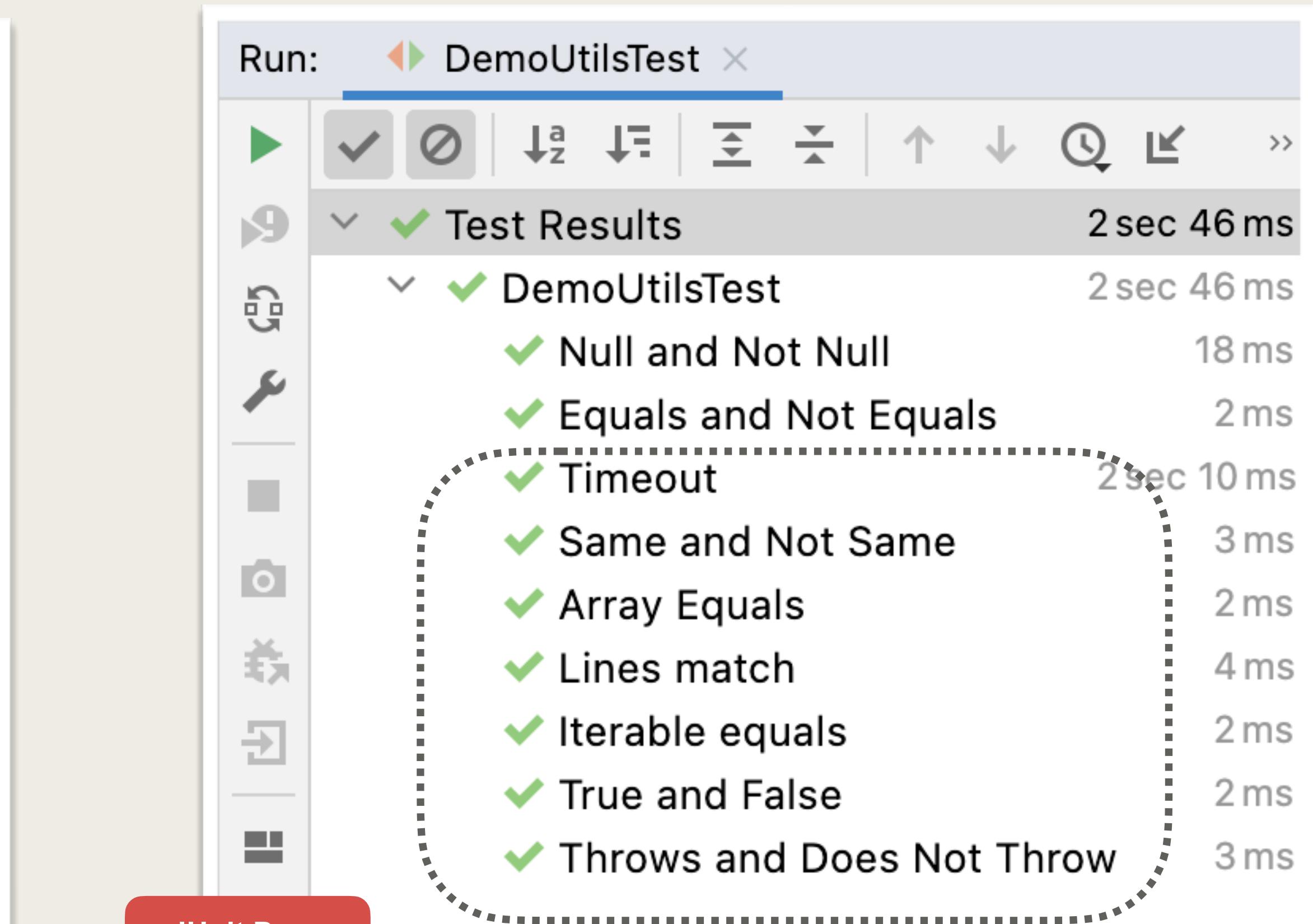
    @DisplayName("Array Equals")
    void testArrayEquals()

    @DisplayName("Iterable equals")
    void testIterableEquals()

    @DisplayName("Lines match")
    void testLinesMatch()

    @DisplayName("Throws and Does Not Throw")
    void testThrowsAndDoesNotThrow()

    @DisplayName("Timeout")
    void testTimeout()
}
```



JUnit Docs

By default, test classes and methods will be ordered using an algorithm that is deterministic but intentionally nonobvious.

@Order - Negative Numbers

Remember
Lowest number has highest priority

The screenshot shows the IntelliJ IDEA interface. On the left, the code editor displays `DemoUtilsTest.java` with several test methods annotated with `@Order`. A red arrow points from the code editor towards the run configuration. Three annotations are highlighted with red circles and numbers: `@Order(3)` for `testEqualsAndNotEquals()`, `@Order(1)` for `testNullAndNotNull()`, and `@Order(-7)` for `testArrayEquals()`.

```
class DemoUtilsTest {
    ...
    @DisplayName("Equals and Not Equals")
    @Order(3)
    void testEqualsAndNotEquals()

    @DisplayName("Null and Not Null")
    @Order(1)
    void testNullAndNotNull()

    @DisplayName("Same and Not Same")
    void testSameAndNotSame()

    @DisplayName("True and False")
    void testTrueFalse()

    @DisplayName("Array Equals")
    @Order(-7)
    void testArrayEquals() -7

    @DisplayName("Iterable equals")
    void testIterableEquals()

    @DisplayName("Lines match")
    void testLinesMatch()

    @DisplayName("Throws and Does Not Throw")
    void testThrowsAndDoesNotThrow()

    @DisplayName("Timeout")
    void testTimeout()
}
```

On the right, the "Run" interface shows the "Test Results" for the `DemoUtilsTest` class. The results are listed as follows:

Test Method	Execution Time
Array Equals	21ms
Null and Not Null	1ms
Equals and Not Equals	2ms
Timeout	2 sec 10 ms
Same and Not Same	2ms
Lines match	5ms
Iterable equals	2ms
True and False	2ms
Throws and Does Not Throw	3ms

@Order - Duplicate Order Values

If duplicate @Order values
then ...

JUnit Docs

By default, test classes and methods will be ordered using an algorithm that is deterministic but intentionally nonobvious.

Additional Features

- If you have multiple test classes, you can order the classes
- Define custom order implementation
- Configure default order in properties file

<https://junit.org/junit5/docs/current/user-guide/>

Code Coverage and Test Reports with IntelliJ



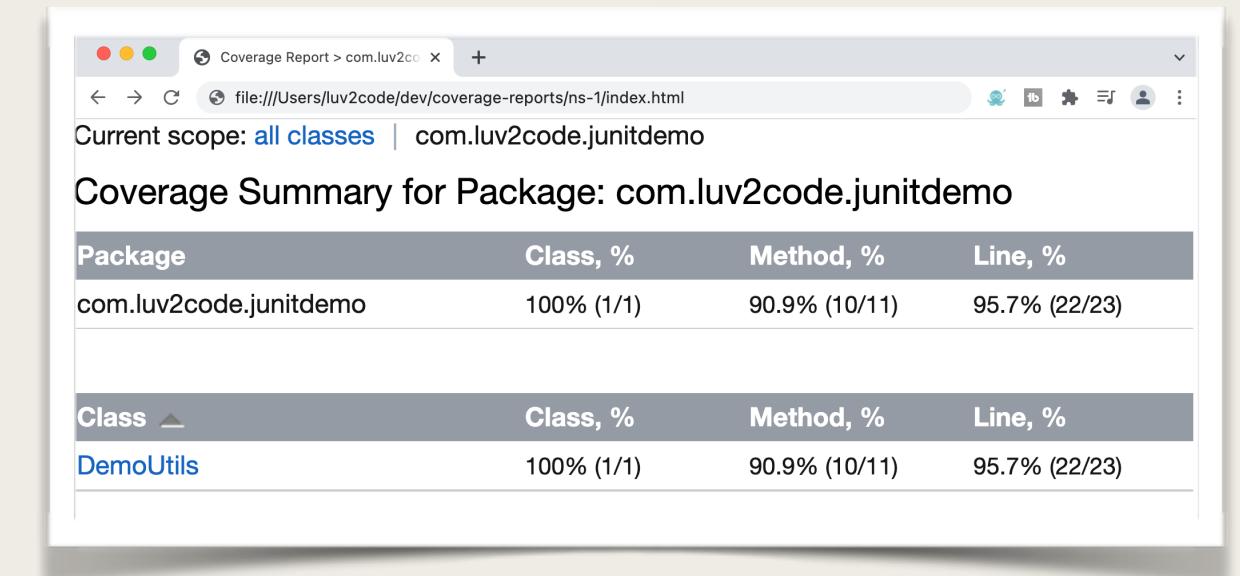
Code Coverage

- Code coverage measures how many methods/lines are called by your tests
- Coverage is represented as a percentage: 50% coverage etc ...
- In general, the higher the coverage the better
 - However, 100% is not always attainable
 - On most teams, 70%-80% is acceptable
- Code coverage is only a metric and can be easily tricked with bad tests
- Use the metric as simply one data point in your software process



IntelliJ Support for Code Coverage

- IntelliJ has built-in support for code coverage
- Can generate coverage reports in the IDE
- Also can generate HTML output for viewing in web browser
- If you are not using IntelliJ, don't worry
 - In later videos, I'll show you how to do the same using Maven commands
 - No IDE is required ... run Maven from command-line



IntelliJ Support for Code Coverage

The screenshot shows the IntelliJ IDEA interface with a context menu open over some code. The menu includes options like 'Show Context Actions', 'Paste', 'Copy / Paste Special', 'Column Selection Mode', 'Refactor', 'Folding', 'Analyze', 'Go To', 'Generate...', 'Run 'DemoUtilsTest'', 'Debug 'DemoUtilsTest'', 'Run 'DemoUtilsTest' with Coverage' (which is selected), 'Modify Run Configuration...', 'Open...', 'Locate...', 'Git...', 'Compare...', 'Create Gist...', and 'Check Current File'. A red callout box points from the 'Run 'DemoUtilsTest' with Coverage' option to the code editor, containing the text 'multiply(...) method not covered by our unit tests'. The code editor displays the following Java code:

```
public class DemoUtils {  
    private String academy = "Luv2Code Academy";  
    private String academyDuplicate = academy;  
    private String[] firstThreeLettersOfAlphabet = {"A", "B", "C"};  
    private List<String> academyInList = List.of("Luv", "2", "code");  
  
    public List<String> getAcademyInList() { return academyInList; }  
  
    public String getAcademy() { return academy; }  
  
    public String getAcademyDuplicate() { return academyDuplicate; }  
  
    public String[] getFirstThreeLettersOfAlphabet() { return firstThreeLettersOfAlphabet; }  
  
    public int add(int a, int b) { return a + b; }  
  
    public int multiply(int a, int b) { return a * b; }  
  
    public Object.checkNotNull(Object obj) {  
        if (obj == null) {  
            throw new NullPointerException("Object cannot be null");  
        }  
        return obj;  
    }  
}
```

The coverage report window shows the following statistics:

Element	Class, %	Method, %	Line, %
com.luv2code.junitdemo	100% (1/1)	90% (9/10)	95% (22/23)

The report also states: '100% classes, 95% lines covered in 'all classes in scope''.

IntelliJ - Generate Code Coverage Report

The screenshot shows an IntelliJ browser window with the title "Coverage Report > com.luv2code.junitdemo". The URL in the address bar is "file:///Users/luv2code/dev/coverage-reports/ns-1/index.html". The page displays coverage statistics for the package "com.luv2code.junitdemo".

Coverage Summary for Package: com.luv2code.junitdemo

Package	Class, %	Method, %	Line, %
com.luv2code.junitdemo	100% (1/1)	90.9% (10/11)	95.7% (22/23)

Coverage Summary for Class: DemoUtils (com.luv2code.junitdemo)

Class	Class, %	Method, %	Line, %
DemoUtils	100% (1/1)	90.9% (10/11)	95.7% (22/23)

multiply(...) method not covered
by our unit tests

Current scope: all classes | com.luv2code.junitdemo

Coverage Summary for Class: DemoUtils (com.luv2code.junitdemo)

Class

DemoUtils

```
1 package com.luv2code.junitdemo;
2
3 import java.util.List;
4
5 public class DemoUtils {
6
7     private String academy = "Luv2Code Academy";
8     private String academyDuplicate = academy;
9     private String[] firstThreeLettersOfAlphabet = {"A", "B", "C"};
10    private List<String> academyInList = List.of("luv", "2", "code");
11
12    public List<String> getAcademyInList() {
13        return academyInList;
14    }
15
16    public String getAcademy() {
17        return academy;
18    }
19
20    public String getAcademyDuplicate() {
21        return academyDuplicate;
22    }
23
24    public String[] getFirstThreeLettersOfAlphabet() {
25        return firstThreeLettersOfAlphabet;
26    }
27
28    public int add(int a, int b) {
29        return a + b;
30    }
31
32    public int multiply(int a, int b) {
33        return a * b;
34    }
35
36    public Object checkNull(Object obj) {
37
38        if (obj != null) {
39            return obj;
40        }
41    }
42}
```

IntelliJ - Generate Test Reports

The screenshot shows a web browser window titled "Test Results – DemoUtilsTest". The URL in the address bar is "file:///Users/luv2code/dev/test-reports/Test%20Results%20-%20DemoUtilsTest.html". The main content of the page is a test report for "DemoUtilsTest". The report summary states "DemoUtilsTest: 9 total, 9 passed" and "2.06 s". Below this, there is a "Collapse | Expand" link. The detailed test results table lists nine test cases, all of which have passed:

Test Case	Status	Time
Same and Not Same	passed	23 ms
Array Equals	passed	3 ms
True and False	passed	2 ms
Null and Not Null	passed	2 ms
Equals and Not Equals	passed	3 ms
Timeout	passed	2.02 s
Lines match	passed	4 ms
Iterable equals	passed	2 ms
Throws and Does Not Throw	passed	3 ms

IntelliJ Documentation

- Additional features and support for testing

<https://www.jetbrains.com/help/idea/tests-in-ide.html>

Code Coverage and Test Reports with Maven



Code Coverage Reports

- If you are not using IntelliJ, don't worry
 - In this video, I'll show you how to do the same using Maven commands
 - No IDE is required ... run Maven from command-line
 - Useful when running as part of DevOps build process
 - Continuous Integration / Continuous Deployment (CI/CD) environments

System Requirements

- To complete these steps, you must have Maven installed (not with IDE)
- If you don't have Maven installed, follow steps at: <https://maven.apache.org>
- Once installed, verify your Maven installation
- Open a terminal window and type: **mvn -version**



```
Apache Maven 3.8.4 (9b656c72d54e5bacbed989b64718c159fe39b537)
```

```
Maven home: ...
```

```
...
```

Development Process

Step-By-Step

1. Configure Maven to find unit tests
2. Run unit tests
3. Generate unit test reports
4. Generate code coverage reports

Step 1: Configure Maven to find unit tests

- By default, Maven will NOT find JUnit 5 test classes
- At command-line, type: **mvn clean test**



```
...
-----
T E S T S
-----
Results :
Tests run: 0, Failures: 0, Errors: 0, Skipped: 0
[INFO] -----
[INFO] BUILD SUCCESS
[INFO] -----
[INFO] Total time: 1.450 s
[INFO] Finished at: 2022-1-2T10:20:17-05:00
[INFO] -----
```

No tests were found??!!!

Step 1: Configure Maven to find unit tests

- Resolve this by using Maven **Surefire** Plugin version 2.22.0 or higher

pom.xml

```
...
<build>
  <plugins>
    <plugin>
      <groupId>org.apache.maven.plugins</groupId>
      <artifactId>maven-surefire-plugin</artifactId>
      <version>3.0.0-M5</version>
    </plugin>
  </plugins>
</build>
...
```

Step 2: Run unit tests

- At command-line, type: **mvn clean test**

```
...
[INFO] --- maven-surefire-plugin:3.0.0-M5:test (default-test) @ junitdemo ---
[INFO]
[INFO] -----
[INFO] T E S T S
[INFO] -----
[INFO] Running com.luv2code.junitdemo.DemoUtilsTest
I am going to sleep
Sleeping over
[INFO] Tests run: 9, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 2.077 s - in com.luv2code.junitdemo.DemoUtilsTest
[INFO]
[INFO] Results:
[INFO]
[INFO] Tests run: 9, Failures: 0, Errors: 0, Skipped: 0
[INFO]
[INFO] -----
[INFO] BUILD SUCCESS
[INFO] -----
[INFO] Total time: 4.673 s
[INFO] Finished at: 2022-1-2T02:32:07-05:00
[INFO] -----
```

Step 3: Generate unit test reports

- Maven **SureFire-Report** plugin can generate HTML unit test report

pom.xml

```
...
<build>
  <plugins>

    <plugin>
      <groupId>org.apache.maven.plugins</groupId>
      <artifactId>maven-surefire-report-plugin</artifactId>
      <version>3.0.0-M5</version>

      <!-- TO DO ... -->

    </plugin>

  </plugins>
</build>
...
```

Step 3: Generate unit test reports

pom.xml

```
...
<build>
  <plugins>
    <plugin>
      <groupId>org.apache.maven.plugins</groupId>
      <artifactId>maven-surefire-report-plugin</artifactId>
      <version>3.0.0-M5</version>
      <executions>
        <execution>
          <phase>test</phase>
          <goals>
            <goal>report</goal>
          </goals> _____
        </execution>
      </executions>
    </plugin>
  </plugins>
</build>
```

During Maven's test phase,

execute the plugin goal

maven-surefire-report-plugin:report

Step 3: Generate unit test reports

- At command-line, type:

```
mvn clean test
```

Run tests and
executes Surefire Report Plugin
to generate HTML reports

```
mvn site -DgenerateReports=false
```

Add website resources
images, css etc...

Don't overwrite existing HTML reports

View unit test reports

File: target/site/surefire-report.html

Surefire Report

Summary

[Summary] [Package List] [Test Cases]

Tests	Errors	Failures	Skipped	Success Rate	Time
9	0	0	0	100%	2.069

Note: failures are anticipated and checked for with assertions while errors are unanticipated.

Package List

[Summary] [Package List] [Test Cases]

Package	Tests	Errors	Failures	Skipped	Success Rate	Time
com.luv2code.junitdemo	9	0	0	0	100%	2.069

Note: package statistics are not computed recursively, they only sum up all of its testsuites numbers.

com.luv2code.junitdemo

	Class	Tests	Errors	Failures	Skipped	Success Rate	Time
⚠	DemoUtilsTest	9	0	0	0	100%	2.069

Test Cases

[Summary] [Package List] [Test Cases]

DemoUtilsTest

⚠	testSameAndNotSame	0.021
⚠	testArrayEquals	0.001
⚠	testTrueFalse	0.002
⚠	testNullAndNotNull	0.002
⚠	testEqualsAndNotEquals	0.001
⚠	testTimeout	2.01
⚠	testLinesMatch	0.004
⚠	testIterableEquals	0.002
⚠	testThrowsAndDoesNotThrow	0.003

Handling tests failure

- By default, Maven **Surefire** plugin will NOT generate reports if tests fail
- To generate reports if tests pass or fail

pom.xml

```
...
<build>
  <plugins>
    <plugin>
      <groupId>org.apache.maven.plugins</groupId>
      <artifactId>maven-surefire-plugin</artifactId>
      <version>3.0.0-M5</version>

      <configuration>
        <testFailureIgnore>true</testFailureIgnore>
      </configuration>
    </plugin>
  </plugins>
</build>
...
```

generate reports
if tests pass or fail

Show Failing Tests

File: target/site/surefire-report.html

Surefire Report

Summary

[Summary] [Package List] [Test Cases]

Tests	Errors	Failures	Skipped	Success Rate	Time
9	0	1	0	88.889%	2.073

Note: failures are anticipated and checked for with assertions while errors are unanticipated.

Package List

[Summary] [Package List] [Test Cases]

Package	Tests	Errors	Failures	Skipped	Success Rate	Time
com.luv2code.junitdemo	9	0	1	0	88.889%	2.073

Note: package statistics are not computed recursively, they only sum up all of its testsuites numbers.

com.luv2code.junitdemo

	Class	Tests	Errors	Failures	Skipped	Success Rate	Time
⚠	DemoUtilsTest	9	0	1	0	88.889%	2.073

Test Cases

[Summary] [Package List] [Test Cases]

DemoUtilsTest

⚠	testSameAndNotSame	0.021
⚠	testArrayEquals	0.001
✖	testTrueFalse + [Detail]	0.003
⚠	testNullAndNotNull	0.002
⚠	testEqualsAndHashCode	0.001
⚠	testTimeout	2.01
⚠	testLinesMatch	0.005
⚠	testIterableEquals	0.002
⚠	testThrowsAndDoesNotThrow	0.002

Failure Details

[Summary] [Package List] [Test Cases]

✖	testTrueFalse	
	org.opentest4j.AssertionFailedError	
	com.luv2code.junitdemo.DemoUtilsTest:60	

Showing @DisplayName in reports

- By default, Maven **Surefire** plugin will NOT show @DisplayName in reports
- To show @DisplayName in reports

pom.xml

```
...
<build>
  <plugins>
    <plugin>
      <groupId>org.apache.maven.plugins</groupId>
      <artifactId>maven-surefire-plugin</artifactId>
      <version>3.0.0-M5</version>

      <configuration>
        <testFailureIgnore>true</testFailureIgnore>
        <statelessTestsetReporter implementation="org.apache.maven.plugin.surefire.extensions.junit5.JUnit5Xml130StatelessReporter">
          <usePhrasedTestCaseMethodName>true</usePhrasedTestCaseMethodName>
        </statelessTestsetReporter>
      </configuration>
    </plugin>
  </plugins>
</build>
...
```

Show @DisplayName

Showing @DisplayName

File: target/site/surefire-report.html

Surefire Report

Summary

[Summary] [Package List] [Test Cases]

Tests	Errors	Failures	Skipped	Success Rate	Time
9	0	0	0	100%	2.069

Note: failures are anticipated and checked for with assertions while errors are unanticipated.

Package List

[Summary] [Package List] [Test Cases]

Package	Tests	Errors	Failures	Skipped	Success Rate	Time
com.luv2code.junitdemo	9	0	0	0	100%	2.069

Note: package statistics are not computed recursively, they only sum up all of its testsuites numbers.

com.luv2code.junitdemo

	Class	Tests	Errors	Failures	Skipped	Success Rate	Time
⚠	DemoUtilsTest	9	0	0	0	100%	2.069

Showing @DisplayName

Test Cases

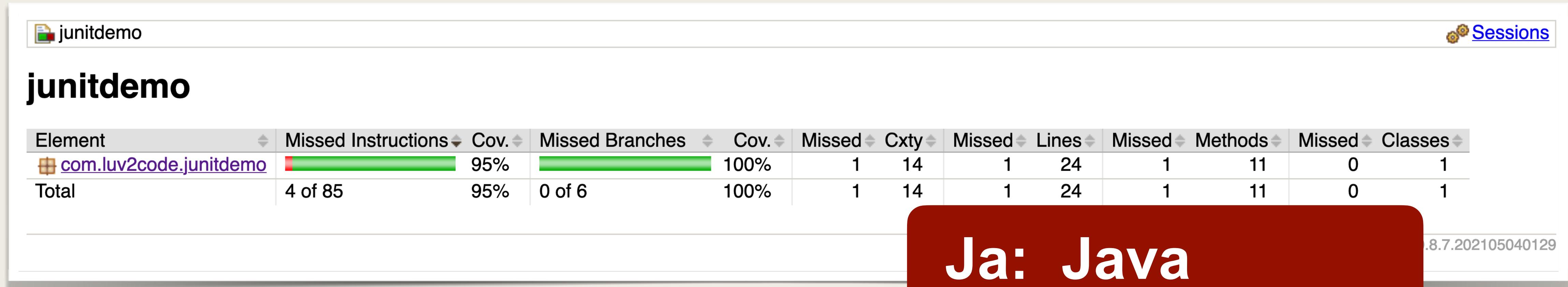
[Summary] [Package List] [Test Cases]

DemoUtilsTest

⚠	Same and Not Same	0.032
⚠	Array Equals	0.006
⚠	True and False	0.003
⚠	Null and Not Null	0.002
⚠	Equals and Not Equals	0.004
⚠	Timeout	2.009
⚠	Lines match	0.006
⚠	Iterable equals	0.003
⚠	Throws and Does Not Throw	0.004

Step 4: Generate code coverage reports

- JaCoCo is a free code coverage library
- JaCoCo provides a Maven plugin to generate code coverage reports



www.jacoco.org

Ja: Java
Co: Code
Co: Coverage

Step 4: Generate code coverage reports

pom.xml

```
...
<build>
  <plugin>
    <groupId>org.jacoco</groupId>
    <artifactId>jacoco-maven-plugin</artifactId>
    <version>0.8.7</version>
    <executions>
      <execution>
        <id>jacoco-prepare</id>
        <goals>
          <goal>prepare-agent</goal>
        </goals>
      </execution>
      <execution>
        <id>jacoco-report</id>
        <phase>test</phase>
        <goals>
          <goal>report</goal>
        </goals>
      </execution>
    </executions>
  </plugin>
</build>
...
```

Prepare JaCoCo agent

This goal is bound by default to
Maven's initialize phase

During Maven's test phase,

execute the plugin goal

jacoco-maven-plugin:report

Step 4: Generate code coverage reports

- At command-line, type: **mvn clean test**

```
...
[INFO] -----< com.luv2code:junitdemo >-----
[INFO] Building junitdemo 1.0
[INFO] ----- [ jar ] -----
[INFO]
[INFO] --- maven-clean-plugin:2.5:clean (default-clean) @ junitdemo ---
[INFO] ...
[INFO]
[INFO] --- jacoco-maven-plugin:0.8.7:prepare-agent (jacoco-prepare) @ junitdemo ---
[INFO] ...
[INFO]
[INFO] --- maven-surefire-plugin:3.0.0-M5:test (default-test) @ junitdemo ---
[INFO] ...
[INFO]
[INFO] --- jacoco-maven-plugin:0.8.7:report (jacoco-report) @ junitdemo ---
[INFO] ...
[INFO]
[INFO] BUILD SUCCESS
[INFO]
[INFO] Total time: 5.548 s
[INFO] Finished at: 2022-1-2T04:19:16-05:00
[INFO]
...
...
```

Code generation is
in the test phase.

Automatically generated
tests are executed

View code coverage reports

File: target/site/jacoco/index.html

junitdemo Sessions

junitdemo

Element	Missed Instructions	Cov.	Missed Branches	Cov.	Missed	Cqty	Missed	Lines	Missed	Methods	Missed	Classes
com.luv2code.junitdemo	95%	100%	1	14	1	24	1	11	0	1	0	1
Total	4 of 85	95%	0 of 6	100%	1	14	1	24	1	11	0	1

junitdemo > com.luv2code.junitdemo > DemoUtils Sessions

DemoUtils

Element	Missed Instructions	Cov.	Missed Branches	Cov.	Missed	Cqty	Missed	Lines	Missed	Methods	Missed	Methods
multiply(int, int)	0%	n/a	1	1	1	1	1	1	1	1	1	1
DemoUtils()	100%	n/a	0	1	0	5	0	1	0	1	0	1
isGreater(int, int)	100%	100%	0	2	0	3	0	3	0	1	0	1
throwException(int)	100%	100%	0	2	0	3	0	3	0	1	0	1
checkTimeout()	100%	n/a	0	1	0	4	0	4	0	1	0	1
checkNull(Object)	100%	100%	0	2	0	3	0	3	0	1	0	1
add(int, int)	100%	n/a	0	1	0	1	0	1	0	1	0	1
getAcademyInList()	100%	n/a	0	1	0	1	0	1	0	1	0	1
getAcademy()	100%	n/a	0	1	0	1	0	1	0	1	0	1
getAcademyDuplicate()	100%	n/a	0	1	0	1	0	1	0	1	0	1
getFirstThreeLettersOfAlphabet()	100%	n/a	0	1	0	1	0	1	0	1	0	1
Total	4 of 85	95%	0 of 6	100%	1	14	1	24	1	11	0	11

Created with JaCoCo 0.8.7.202105040129

Maven Plugin Documentation

<https://maven.apache.org/plugins>

<https://www.jacoco.org/jacoco/trunk/doc/>

Conditional Tests



Conditional Tests

We may not need to run all of the tests

Conditional Tests - Use Cases

- Don't run a test because the method to test is broken ... and we are waiting on dev team to fix it
- A test should only run for a specific version of Java (Java 18) or range of versions (13 - 18)
- A test should only run on a given operating system: MS Windows, Mac, Linux
- A test should only run if specific environment variables or system properties are set

Why not just comment the code???

- We could do that ... but then the tests will not be displayed in reports
- Easy to forget about broken tests
- Manual process to enable / disable tests for a given operating system etc ...
- Let's report the tests ... so that management and QA are aware of the issue

Annotations

Name	Description
@Disabled	Disable a test method
@EnabledOnOs	Enable test when running on a given operating system
...	...

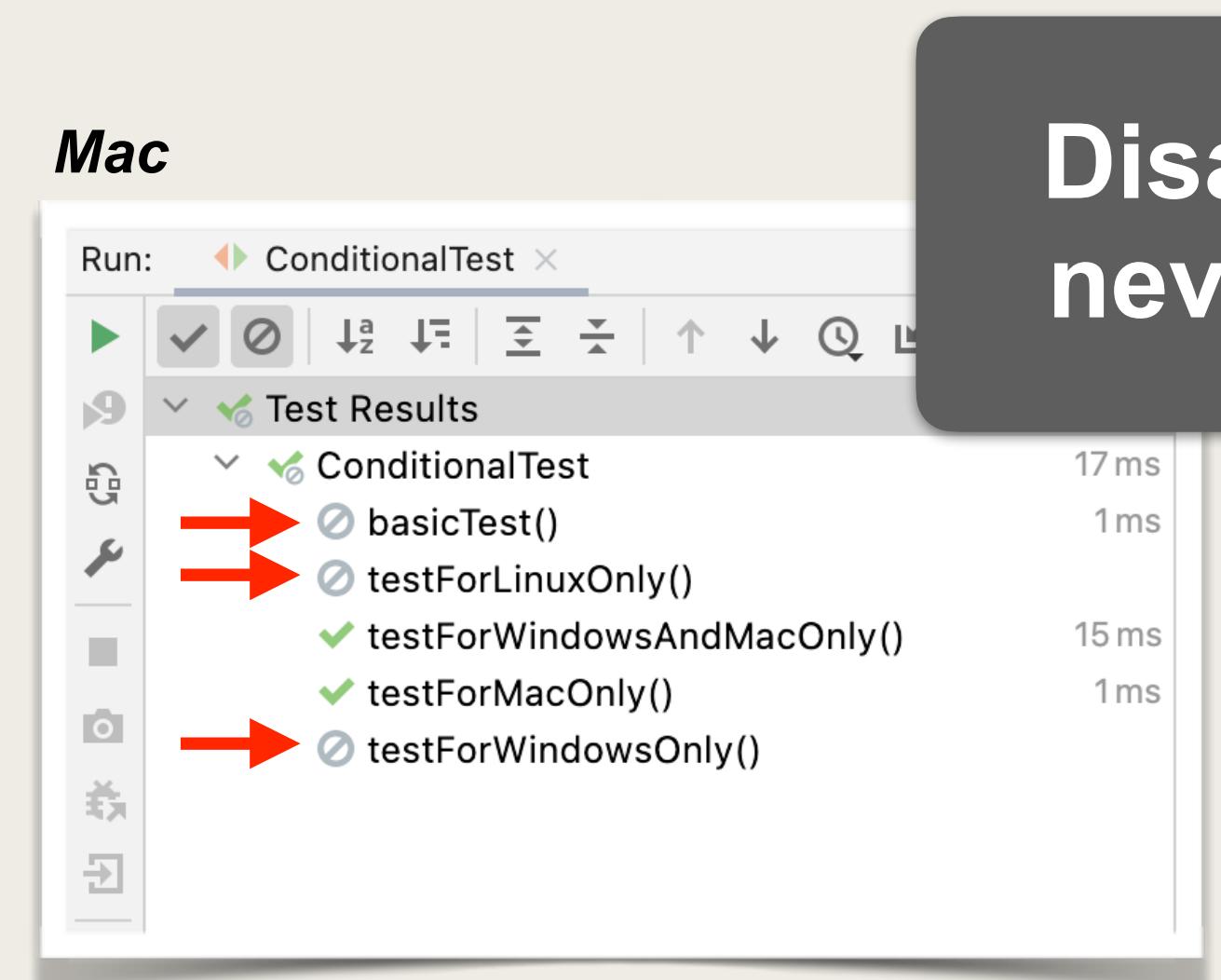
**Annotations can be applied at
the class level or method level**

@Disabled and @EnabledOnOs

ConditionalTest.java

```
class ConditionalTest {  
  
    @Test  
    @Disabled("Don't run until JIRA #123 is resolved")  
    void basicTest() {  
        // execute method and perform assertions  
    }  
  
    @Test  
    @EnabledOnOs(OS.WINDOWS)  
    void testForWindowsOnly() {  
        // execute method and perform assertions  
    }  
  
    @Test  
    @EnabledOnOs(OS.MAC)  
    void testForMacOnly() {  
        // execute method and perform assertions  
    }  
  
    @Test  
    @EnabledOnOs({OS.WINDOWS, OS.MAC})  
    void testForWindowsAndMacOnly() {  
        // execute method and perform assertions  
    }  
  
    @Test  
    @EnabledOnOs(OS.LINUX)  
    void testForLinuxOnly() {  
        // execute method and perform assertions  
    }  
}
```

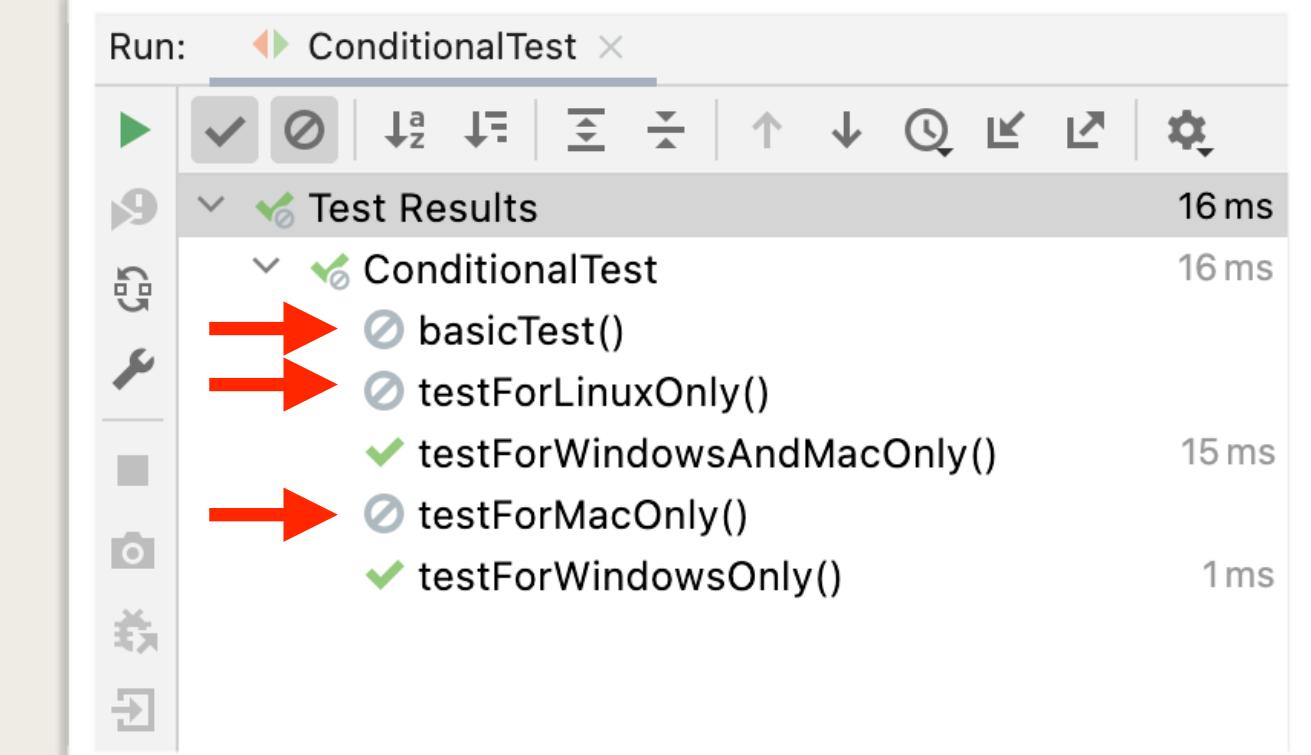
Mac



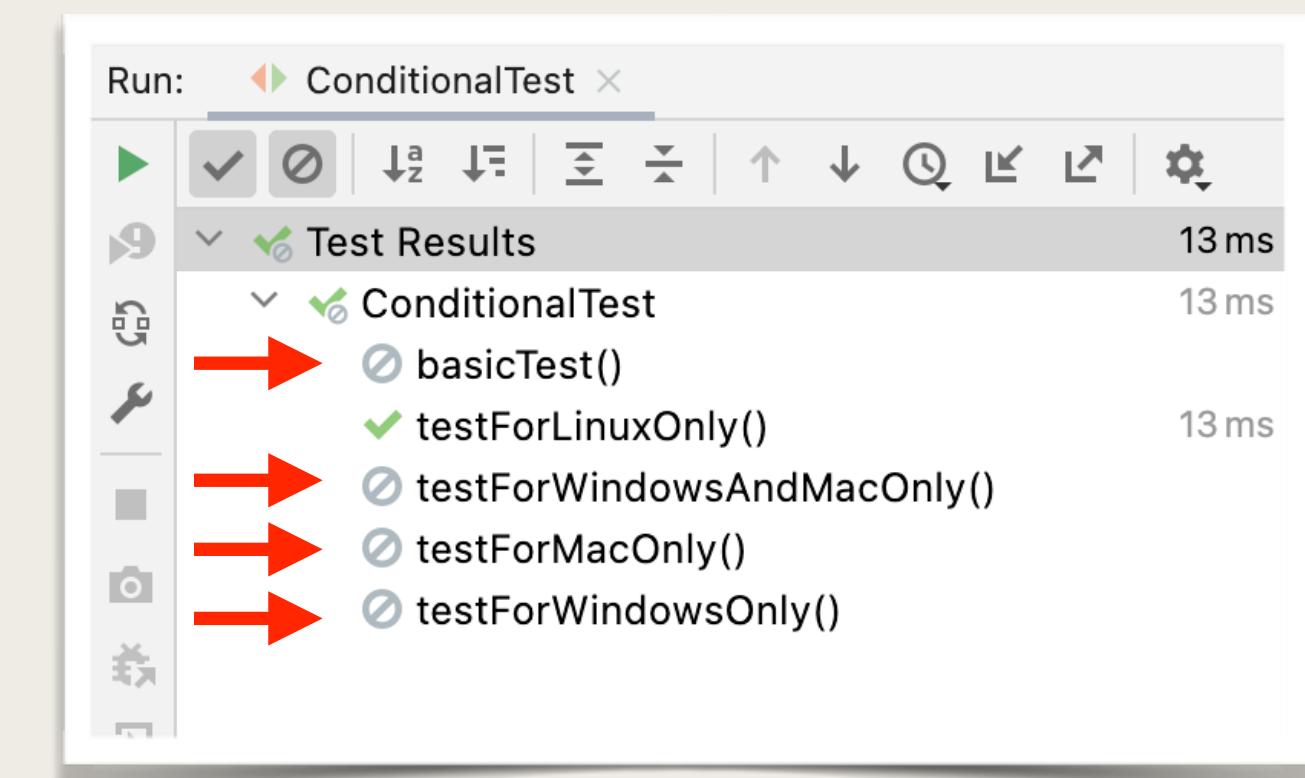
Disabled tests never execute

Disabled tests never execute

MS Windows



Linux



Disabled tests never execute

Annotations

Name	Description
@EnabledOnJre	Enable test for a given Java version
@EnabledForJreRange	Enable test for a given Java version range
...	...

@EnabledOnJre @EnabledForJreRange

ConditionalTest.java

```
class ConditionalTest {

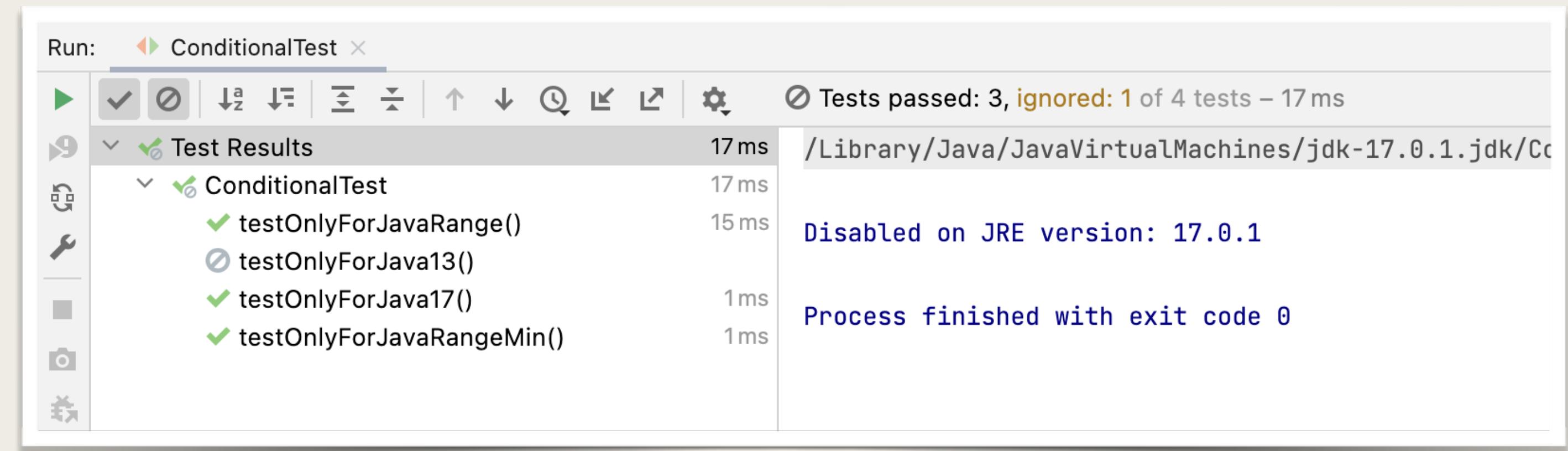
    @Test
    @EnabledOnJre(JRE.JAVA_17)
    void testOnlyForJava17() {
        // execute method and perform assertions
    }

    @Test
    @EnabledOnJre(JRE.JAVA_13)
    void testOnlyForJava13() {
        // execute method and perform assertions
    }

    @Test
    @EnabledForJreRange(min=JRE.JAVA_13, max=JRE.JAVA_18)
    void testOnlyForJavaRange() {
        // execute method and perform assertions
    }

    @Test
    @EnabledForJreRange(min=JRE.JAVA_11)
    void testOnlyForJavaRangeMin() {
        // execute method and perform assertions
    }
}
```

Running on Java 17



Annotations

Name	Description
@EnabledIfSystemProperty	Enable test based on system property
@EnabledIfEnvironmentVariable	Enable test based on environment variable
...	...

@EnabledIfSystemProperty @EnabledIfEnvironmentVariable

