# Test Driven Development (TDD)

## Unit Testing with JUnit 4 and JUnit 5

# Unit Testing with JUnit 4 and JUnit 5

The solution to the problem of costly tests, however, is not to stop testing but instead to get better at it. Getting good value from tests requires clarity of intention and knowing what, when, and how to test.

— Sandi Metz, Practical Object Oriented Design in Ruby, page 192

Источник : http://c2.com/cgi/wiki?CodeUnitTestFirst

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# Writing High Quality Code

According to Sandi Metz these three skills required to build high quality, maintainable code:

- Understanding Object-Oriented Design
- Refactoring
- Writing high-value, efficient tests

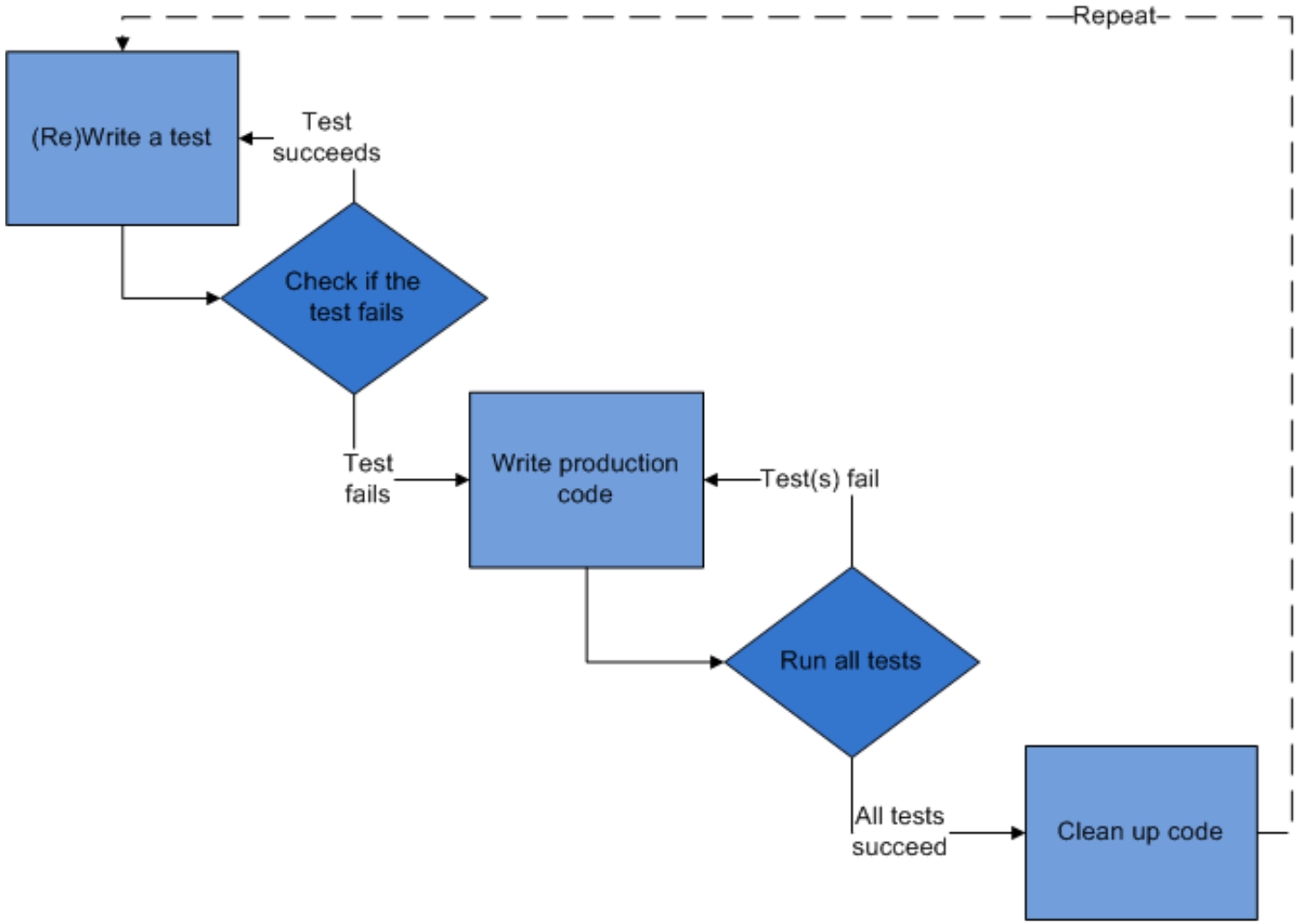
- Test is executable documentation for the code.

Източник : http://c2.com/cgi/wiki?CodeUnitTestFirst

# Test Driven Development (TDD)

- **Test-Driven Development (TDD)** is a technique allowing to guide the software development by writing tests.
- Initially developed by Kent Beck (in the end 90s).
- The main idea is to repeat the following 5 steps:
  1. Write automatic test (Unit test) for the next **small** new functionality, imagining that the code implementing it already exists;
  2. Write empty methods (Stubs), to make the code compile;
  3. Run the test – it **should fail**, otherwise the test is not good;
  4. Write **minimal** functional code, so that the **test will pass** – it the test does not pass, then the code is not good;
  5. Change (Refactor) the old as well the new code in order to structure it better.

# Sequential Stages in TDD




Източник: Wikipedia (http://en.wikipedia.org/wiki/File:Test-driven_development.PNG), Автор: Excirial, Лиценз: Creative Commons Attribution, ShareAlike 3.0 License / GNU Free Documentation License, Version 1.2

# Agile Testing - TDD

A good way to develop new functionality is the following:

1. Consider what you have tot do.
2. Write a UnitTest for the desired functionality, and the least possible code increment to implement it.
3. Run the UnitTest. If the test passes you are ready; go to step 1 or if you have completed everything go home ☺
4. Solve the current problem: may be you have not written correctly the new method. May be the method is not working as expected. Do the necessary corrections. Go to step 3.

Източник : http://c2.com/cgi/wiki?CodeUnitTestFirst

# Should We Test Private Methods?

- I short: you shouldn't.
- Instead you can test indirectly their effects on the public methods calling them.
- Unit tests are clients for the object under test, which is not different from other clients of the object. Unit test is you first client in TDD.
- If it is hard to test the object via its public interface, it will be hard to use in the production code.
- It is a code smell and a good example how testing guides the good object-oriented design.

Източник : http://c2.com/cgi/wiki?CodeUnitTestFirst

# JUnit 4

- **UnitTest** – tests the specific class and in order to access all its methods is in the same package (if we want to access the private class members we can use рефлексия or we can implement the test as internal class, but most of the time it is better to refactor your code as explained in previous slides). In JUnit 3 it was necessary to extend the class junit.framework.TestCase and every method was named testXXX. In JUnit 4 all these requirements are removed and instead each test method should be annotated with **@Test**.
- **Test Suite** – allows to group test with similar purpose in a suite:

```
@RunWith(Suite.class) / @RunWith(Suite.class)

@SuiteClasses({ PriceComparatorTest.class, TransactionTest.class })

public class AllTests { }
```

# JUnit 4

- **UnitTest** – tests the specific class and in order to access all its methods is in the same package (if we want to access the private class members we can use рефлексия or we can implement the test as internal class, but most of the time it is better to refactor your code as explained in previous slides). In JUnit 3 it was necessary to extend the class junit.framework.TestCase and every method was named testXXX. In JUnit 4 all these requirements are removed and instead each test method should be annotated with **@Test**.
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# Основни анотации в JUnit 4

- **@Test** – identifies a test method in JUnit 4
- **@Test (expected = ExtendingException.class)**
- **@Test (timeout=200)** – maximal allowed time in milliseconds
- **@Before** – executed before each test
- **@After** – executed sfter each test
- **@BeforeClass** – executed once before all tests – the method should be static
- **@AfterClass** – executed once after finishing all tests – the method should be static
- **@Ignore** – ignores the test method
- **@RunWith** – specifies the Runner class which executes tests
- **@SuiteClasses** – annotates a test suit class grouping tests with similar purpose, used with **@RunWith(Suite.class)**

# Test Class Pattern for JUnit 4

```
import org.junit.Ignore;
import org.junit.Test;
import org.junit.runner.RunWith;
import org.junit.runners.JUnit4;

/** Tests for {@link Foo}. */
@RunWith(JUnit4.class)
public class FooTest {
    @Test
    public void thisAlwaysPasses() {}

    @Test
    @Ignore
    public void thisIsIgnored() {}
}
```

Источник : https://github.com/junit-team/junit/wiki/Getting-started

# JUnit 4 Unit Test Example (1)

```
public class GcdTest {
   @Test
   public void testIsPositiveInteger() {
      String[] testData = {"346", "-23", "29a34", "17.5"};
      boolean[] resultData = {true, false, false, false };
      for(int i = 0; i < testData.length; i++){
         assertEquals(resultData[i],
            Gcd.isPositiveInteger(testData[i]));
      }
   } ...
```

# JUnit 4 Unit Test Example (2)

```
@Test
public void testGreatestCommonDenominator() {
 int [][] testData= {{48, 72, 24}, {17, 351, 1},
     {81, 63, 9}};
 for(int[] data: testData){
   int result = Gcd.greatestCommonDenominator(data[0],
      data[1]);
   assertEquals(data[2], result);
   result = Gcd.greatestCommonDenominator(data[1],data[0]);
   assertEquals(data[2], result);
 }
}
```

# Validity constraints (Assertions)

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

assertArrayEquals("values not same", expected, actual)

assertFalse("failure - should be false", expected)

assertTrue("failure - should be true", expected)

assertNotNull("should not be null", myObject)

assertNotSame("should not be same Object", myObject, other)

assertNull("should be null", null)

assertSame("should be same", aNumber, aNumber)

assertThat("good", not(allOf(equalTo("bad"), equalTo("good"))))  ...
```

# JUnit 4 Test Lifecycle – Order of Execution

1.@BeforeClass setupClass()

2.@Before setup()

3.@Test test1()

4.@After cleanup()

5.@Before setup()

6.@Test test2()

7.@After cleanup()

8.@AfterClass cleanupClass()

# Example - JUnit 4 (1)

```
public class TransactionTest {

private static InputStream in;

@BeforeClass

public static void setUpBeforeClass() throws Exception {

  String data="Goole Inc.\nJohn Smith\nGOGL\n42.78\n120\n";

  in = new ByteArrayInputStream(data.getBytes()));

}

@AfterClass

public static void tearDownAfterClass() throws Exception {

  in.close();

}
```

# Example - JUnit 4 (2)

```
@Test
public void testTransactionFullConstructor() {
  Transaction t = new Transaction("Google Inc.", "John Smith", "GOGL", 27, 19.439834456455544);
  assertNotNull(t);
  assertTrue("Transaction ID not correct", t.getId() > 0);
  assertTrue("'timestamp' not correct",
     t.getTimestamp().getTime() <= new Date().getTime());
  assertEquals("Google Inc.", t.getSeller());
  assertEquals("John Smith", t.getBuyer());
  assertEquals("GOGL", t.getSymbol());
  assertEquals(27, t.getQuantity());
  assertEquals(19.4398, t.getPrice(),1E-4);
}
```

# Example - JUnit 4 (3)

```
  @Test
  public void testInput() {
    Transaction t = new Transaction();
    assertNotNull(t);
    t.input(in);
    assertTrue("Transaction ID not correct", t.getId()>0);
    assertEquals("Google Inc.", t.getSeller());
    assertEquals("John Smith", t.getBuyer());
    assertEquals("GOGL", t.getSymbol());
    assertEquals(120, t.getQuantity());
    assertEquals(42.78, t.getPrice(),1E-4);
  }
  ...
}
```

# Test Suite Example – JUnit 4

```
import org.junit.runner.RunWith;

import org.junit.runners.Suite;

import org.junit.runners.Suite.SuiteClasses;


@RunWith(Suite.class)

@SuiteClasses({ PriceComparatorTest.class,
  TransactionTest.class })

public class AllTests {

}
```

# Parameterized Tests with JUnit 4 (1)

```
@RunWith(value = Parameterized.class)
public class GcdTestWithParameters {
    private int numberA;
    private int numberB;
    private int expected;
    //pass parameters using test constructor
    public GcdTestWithParameters(
                    int numberA, int numberB, int expected) {
        this.numberA = numberA;
        this.numberB = numberB;
        this.expected = expected;
    }
```

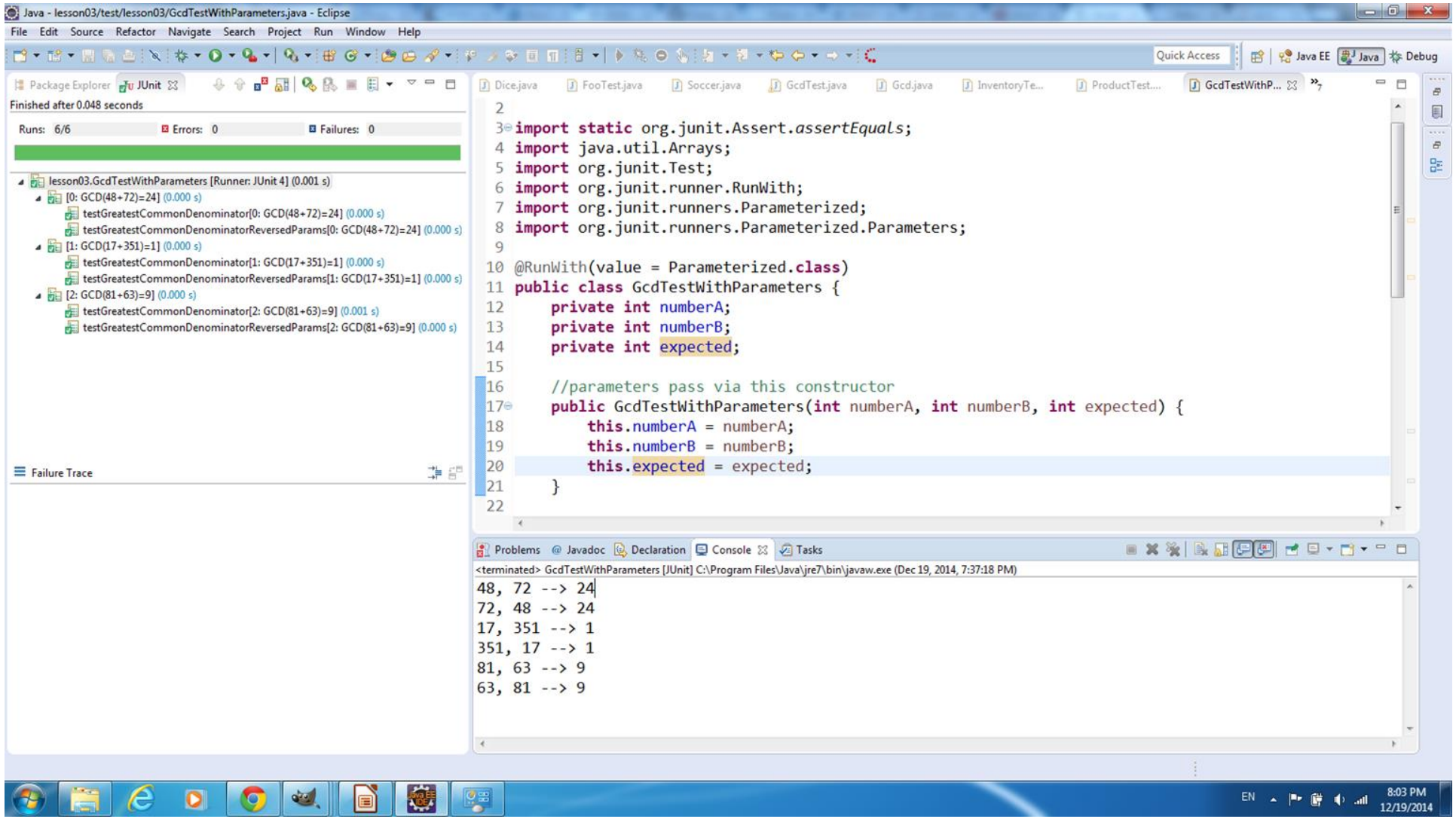
# Parameterized Tests with JUnit 4 (2)

```
//Declared test parameters
@Parameters(name = "{index}: GCD({0}+{1})={2}")
public static Iterable<Object[]> data1() {
    return Arrays.asList(new Object[][] {
        {48, 72, 24},
        {17, 351, 1},
        {81, 63, 9}
    });
}
```

# Parameterized Tests with JUnit 4 (3)

```
    @Test
    public void testGreatestCommonDenominator() {
        int result = Gcd.greatestCommonDenominator(numberA, numberB);
        assertEquals(expected, result);
    }
    @Test
    public void testGreatestCommonDenominatorReversedParams() {
        int result = Gcd.greatestCommonDenominator(numberB, numberA);
        assertEquals(expected, result);
    }
}
```

# Parameterized Tests with JUnit 4 (4)



# Core Principles Guiding Evolution of JUnit

- **Prefer extension points over features** - it's better to enable new functionality by creating or augmenting an extension point rather than adding the functionality as a core feature
- **Complementarily, an extension point should be good at one thing** - let an extension point be good at what it's good at, and don't be afraid to introduce new extension points to handle weak points in existing ones.
- **It should be hard to write tests that behave differently based on how they are run**
- **Tests should be easy to understand** - It should be possible to understand how JUnit will treat a class based on reading the test class (and base class) and looking at the annotations.
- **Minimize dependencies (especially third-party)** – example Hamcrest assertThat

# JUnit 5

## JUnit 5 = *JUnit Platform + JUnit Jupiter + JUnit Vintage*

- **JUnit Platform** - IDEs, build tools or plugins need to extend platform APIs to launch JUnit tests,. Includes TestEngine API for developing testing frameworks that run on the platform. Provides a Console Launcher to launch the platform from the command line and build plugins for Gradle and Maven.
- **JUnit Jupiter** - new programming and extension models for writing tests. It has all new JUnit annotations and TestEngine implementation to run tests written with these annotations.
- **JUnit Vintage** - supports running JUnit 3 and JUnit 4 written tests on the JUnit 5 platform for backward compatibility.

# JUnit 5 New Annotations – II

**@Test** - method is a test method. Unlike JUnit 4's @Test annotation, this annotation does not declare any attributes, since test extensions in JUnit Jupiter operate based on their own dedicated annotations. Such methods are inherited unless they are overridden.

**@DisplayName** – defines custom display name for a test class or method

**@Nested** – denotes that the annotated class is a nested, non-static test class. @BeforeAll and @AfterAll methods cannot be used directly in a @Nested test class unless the "per-class" test instance lifecycle is used.

**@Tag** – declares tags for filtering tests

**@Disable** – it is used to disable a test class or method (previously @Ignore)

# JUnit 5 New Annotations – I

**@ExtendWith** – it is used to register custom extensions declaratively

**@BeforeEach** – denotes that the annotated method will be executed before each test method (previously @Before)

**@AfterEach** – denotes that the annotated method will be executed after each test method (previously @After)

**@BeforeAll** – denotes that the annotated method will be executed before all test methods in the current class (previously @BeforeClass)

**@AfterAll** – denotes that the annotated method will be executed after all test methods in the current class (previously @AfterClass)

# JUnit 5 New Annotations – III

**@ParameterizedTest** - denotes that a method is a parameterized test

**@RepeatedTest** - method is a test template for a repeated test

**@TestFactory** – denotes a method that is a test factory for dynamic tests

**@TestTemplate** - denotes that a method is a template for test cases designed to be invoked multiple times depending on the number of invocation contexts returned by the registered providers

**@TestMethodOrder** - used to configure the test method execution order for the annotated test class; similar to JUnit 4's @FixMethodOrder

**@TestInstance** - used to configure the test instance lifecycle for the annotated test class.

# JUnit 5 New Annotations – IV

**@DisplayNameGeneration** - declares a custom display name generator for the test class.

**@Timeout** - used to fail a test, test factory, test template, or lifecycle method if its execution exceeds a given duration

**@RegisterExtension** - used to register extensions programmatically via fields

**@TempDir** - used to supply a temporary directory via field injection or parameter injection in a lifecycle method or test method; located in the org.junit.jupiter.api.io package

# JUnit 5 Maven Dependencies

```
<dependency>
    <groupId>org.junit.jupiter</groupId>
    <artifactId>junit-jupiter-engine</artifactId>
    <version>5.7.0</version>
    <scope>test</scope>
</dependency>

<dependency>
    <groupId>org.assertj</groupId>
    <artifactId>assertj-core</artifactId>
    <version>3.15.0</version>
    <scope>test</scope>
</dependency>
```

# JUnit 5 Lifecycle Methods - I

```
@BeforeAll
static void setup() {
    log.info("@BeforeAll - executes once before all test methods in this class");
}

@AfterAll
static void cleanup() {
    log.info("@AfterAll - executes once before all test methods in this class");
}
```

# JUnit 5 Lifecycle Methods - II

```
@BeforeEach
void init() {
    log.info("@BeforeEach - executes before each test method in this class");
    repo = new ProductRepositoryMemoryImpl(new LongKeyGenerator());
    SAMPLE_PRODUCTS.forEach(p -> {
        try {
            repo.create(p);
        } catch (EntityAlreadyExistsException e) {
            e.printStackTrace();
        }
    });
}

@AfterEach
void tearDown() {
    log.info("@AfterEach - executes before each test method in this class");
}
```

# JUnit 5 Test Methods - I

```
@Test
void findById() throws EntityAlreadyExistsException {
    assertEquals(repo.create(NEW_PRODUCT).getCode(), "CB001");
}
```

```
@Test
@Disabled("Not implemented yet")
void create() {
}
```

# JUnit 5 Test Methods – Using AssertJ Soft Assertions

```
@Test
@DisplayName("Find all products")
void findAll() {
    List<Product> result = repo.findAll();
    SoftAssertions softly = new SoftAssertions();
    softly.assertThat(softly.assertThat(result)).isNotNull();
    softly.assertThat(result.size()).isEqualTo(5);
    softly.assertThat(result.get(0).getCode()).isEqualTo("BK001");
    softly.assertAll();
}
```

@TestFactory

# JUnit 5 Assumptions

```
@Test
void assumptionThat() {
    String someString = "Some string";
    assumingThat(
            someString.equals("Some string"),
            () -> assertEquals(11, someString.length())
    );
}
```

# JUnit 5 Testing for Exceptions

```
@Test
void shouldThrowException() {
    Throwable exception = assertThrows(UnsupportedOperationException.class, () -> {
        throw new UnsupportedOperationException("Not supported");
    });
    assertEquals(exception.getMessage(), "Not supported");
}
```

# JUnit 5 Parameterized Tests

```
<dependency>
    <groupId>org.junit.jupiter</groupId>
    <artifactId>junit-jupiter-params</artifactId>
    <version>${junit.jupiter.version}</version>
    <scope>test</scope>
</dependency>
```

```
@ParameterizedTest(name="#{index} - Test with Argument={0}")
@ValueSource(ints = {8,4,2,6,10})
void test_int_arrays(int arg) {
    System.out.println("arg => "+arg);
    assertTrue(arg % 2 == 0);
}
```

# JUnit 5 Parameterized Tests - II

```
@ParameterizedTest
@CsvSource({
        "Peter, admin, 1",
        "John, author, 2",
        "Martin, subscriber, 3"
})
void testWith_CsvSource(String name, String role, long id) {
    System.out.println("testWith_CsvSource: name => "+name+"; role =>
"+role+"; id => "+id);
    assertTrue(name.length() >= 0);
    assertTrue(id >=1 && id <=3);
    assertTrue(!role.isEmpty());
}
```

# JUnit 5 Parameterized Tests - III

```
@ParameterizedTest
@CsvFileSource(resources = "/users-data.csv", numLinesToSkip = 1)
void testWith_MethodSource(String name, String role, long id) {
    System.out.println("name => "+name+"; role => "+role+"; id => "+id);
    assertTrue(name.length() >= 0);
    assertTrue(id >=1 && id <=3);
    assertTrue(!role.isEmpty());
}
```

# JUnit 5 Dynamic Tests using @TestFactory

- **DynamicTest** is a test generated during runtime
- DynamicTests are generated by a factory method annotated with the ***@TestFactory*** annotation
- A ***@TestFactory*** method cannot be static or *private* and must return a *Stream*, *Collection*, *Iterable*, or *Iterator of DynamicTest* instances. Otherwise a *JUnitException* is thrown
- DynamicTests are executed id different way than the standard @Tests and do not support lifecycle callbacks
- DynamicTests differ from the parameterized tests because they support full test lifecycle, while parametrized tests do not
- JUnit 5 prefers extensions over features principle

# JUnit 5 Dynamic Tests Example

```
@TestFactory
Collection<DynamicTest> dynamicTestsCollection() {
    return Arrays.asList(
            DynamicTest.dynamicTest("Add test",
                    () -> assertEquals(5, Math.addExact(2, 3))),
            DynamicTest.dynamicTest("Multiply Test",
                    () -> assertEquals(15, Math.multiplyExact(5, 3))));
}

@TestFactory
Stream<DynamicTest> dynamicTestsStream() {
    return IntStream.iterate(0, n -> n + 5).limit(10)
            .mapToObj(n -> DynamicTest.dynamicTest("testMultipleOfFive_" + n,
                    () -> assertTrue(n % 5 == 0)));
}
```

# Resources

- Software testing в Wikipedia - http://en.wikipedia.org/wiki/Software_testing
- Test-driven development в Wikipedia - http://en.wikipedia.org/wiki/Test-driven_development
- Test Driven Development wiki - http://c2.com/cgi/wiki?TestDrivenDevelopment
- Junit 4 - https://github.com/junit-team/junit/wiki
- JUnit 4 Tutorial - http://www.vogella.com/articles/JUnit/article.html
- JUnit 5 User Guide - https://junit.org/junit5/docs/current/user-guide/
- JUnit 5 Dynamic Tests – https://www.baeldung.com/junit5-dynamic-tests
- JUnit 5 Tutorial - https://javabydeveloper.com/junit-5-tutorial/

# Thank's for Your Attention!

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