TESTING
JAVA APPLICATIONS
CHEAT SHEET

Testing Java Applications Cheat Sheet

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Introduction

This cheat sheet follows a question & answer style to provide quickstart solutions for testing Java applications:

- beginner-friendly introduction to the Java testing ecosystem
- conventions, terminology, and best practices
- JUnit 5 & Mockito

Both JUnit 5 and Mockito are your main building blocks when it comes to testing Java applications. Therefore, mastering them is essential for your testing success.

The following code examples can be copied and pasted to your project as-is. In addition, you'll find instructions for both Maven & Gradle.

While this document might not cover all your questions around JUnit 5 and Mockito, it follows the Pareto principle and targets 20% of the features you use 80% of the time.

One important note before we jump into the Q&A style, always remember

> Theory without practices is just as incomplete as practice without theory.

Take a look at the following complementary resources to kickstart and revamp your testing knowledge with hands-on material.

Testing Toolbox (eBook)

There's more to testing Java applications than JUnit & Mockito:

The **Java testing ecosystem is huge**. Over the years, a lot of libraries have emerged, especially for niche areas. This book aims to cover all testing tools & libraries that should be part of your testing toolbox as a Java Developer. Each tool/library is present with a standardized cookbook-style approach.

The central goal of this book is to **enrich your testing toolbox with new tools & libraries** that you might not have even heard about (yet). Furthermore, you'll also learn about new features of testing tools that you are already using.

The book will be your go-to resources for an overview of Java's excellent testing ecosystem with a right-sized introduction for tools & libraries of the following categories:

- Test Frameworks
- Assertion Libraries
- Mocking Frameworks
- Infrastructure Libraries
- Utility Libraries
- Performance Testing

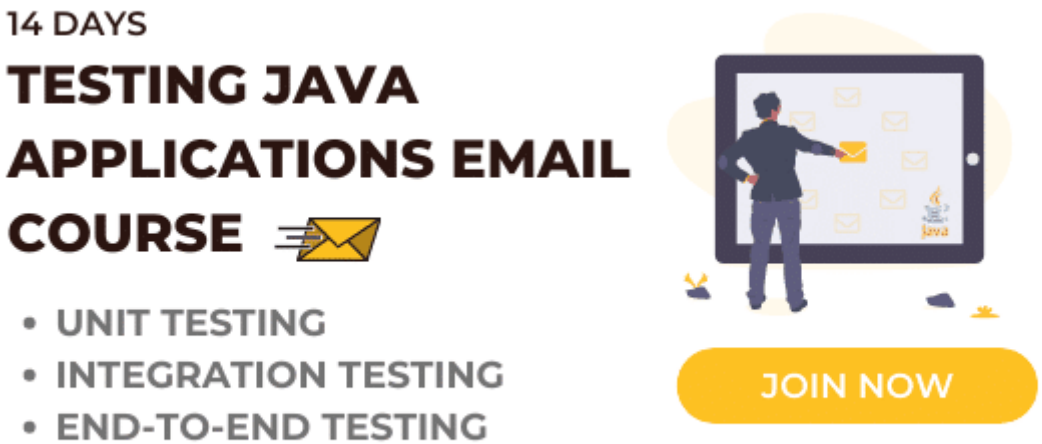
» Get your PDF copy of this eBook **here**.

Testing Mini Course (E-Mail Course)

You are new to testing Java applications or want to revamp your Testing Knowledge for Java Applications?

This **free 14 days email course** introduces you to the Java Testing landscape with **tips, tricks, and recipes**.

Regardless of whether you use Spring Boot, Jakarta EE, Quarkus, etc. for your application, the underlying testing libraries & strategies remain the same:



The different course lessons cover:

- Testing strategies & best practices
- Testing recipes (database access, HTTP clients, web layer, etc.)
- Tips, tricks and resources for your testing success

All course lessons are **sent right to your inbox** for your convenience.

» Join the 14 days free email course **here**.

Hands-On Mocking With Mockito (Online Course)

Learn the **ins and outs of the most popular mocking framework** for Java applications with this comprehensive hands-on online course about Mockito.

As Mockito is so omnipresent in the JVM testing landscape, a solid understanding of it is essential as a Java developer.

If you are coming from a different programming language, you'll love the **user-friendly API of Mockito**.

Having worked with JavaScript for almost three years, I still have to go to the Jest documentation every time I want to mock stuff.

With Mockito that's different.

Compared to other programming languages and their mocking frameworks, Mockito has the most intuitive API and the steepest learning curve.

The knowledge you gain with this course **applies to testing all your Java applications**, independent of the framework (Spring Boot, Jakarta EE, Micronaut, Helidon, Quarkus, etc.).

The course is beginner-friendly and no prior knowledge is required. We're starting off with answering the question of why we need mocks for our tests and then follow the classic Mockito workflow:

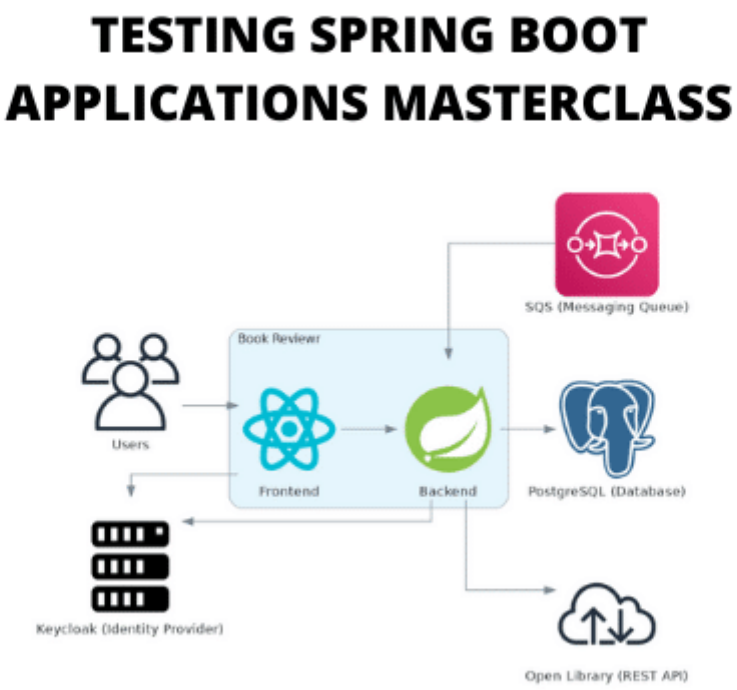
- Creating mocks
- Stubbing methods calls
- Verify the interaction of our mocks

» Enroll for the Hands-On Mocking With Mockito **here**.

Testing Spring Boot Applications Masterclass

You Don't Know How Easy Testing a Spring Boot Application Is (yet)!

Master testing Spring Boot applications with this comprehensive hands-on course:



The Testing Spring Boot Applications Masterclass is a **deep-dive course** on testing your Spring Boot applications. You'll learn how to effectively write **unit, integration, and end-to-end tests** while utilizing Spring Boot's excellent test support.

TL;DR for what you'll learn as part of the Masterclass:

- how to test a **real-world Spring Boot application** (Java 14, AWS, PostgreSQL, Keycloak)
- master unit/integration/end-to-end testing with **excellent Java testing libraries** like Testcontainers, WireMock, Selenide, etc.
- apply industry **testing best practices** and have recipes at hand on how to test several parts of your application (e.g. HTTP clients, database access, etc.)

Not only will your technical testing skills improve but also you'll **deploy to production with more confidence** and **sleep better at night** thanks to a sophisticated test suite.

» Enroll for the Testing Spring Boot Applications Masterclass **here**.

Let's get started!

Build Tool Configuration

Maven

When writing applications with Java, we can't just pass our .java files to the JVM (Java Virtual Machine) to run our program. We first have to compile our Java source code to bytecode (`.class` files) using the Java Compiler (`javac`). Next, we pass this bytecode to the JVM (java binary on our machines) which then interprets our program and/or compiles parts of it even further to native machine code.

Given this two-step process, someone has to compile our Java classes and package our application accordingly. Manually calling `javac` and passing the correct classpath is a cumbersome task. A build tool automates this process. As developers, we then only have to execute one command, and everything get's build automatically.

The two most adopted build tools for the Java ecosystem are **Maven** and **Gradle**. *Ancient devs* might still prefer **Ant**, while *latest-greatest devs* might advocate for **Bazel** as a build tool for their Java applications.

To build and test our Java applications, we need a **JDK** (Java Development Kit) installed on our machine and **Maven**. We can either install Maven as a command-line tool (i.e., place the Maven binary on our system's PATH) or use the portable Maven Wrapper.

The Maven Wrapper is a convenient way to work with Maven without having to install it locally. It allows us to conveniently build Java projects with Maven without having to install and configure Maven as a CLI tool on our machine

When creating a new Spring Boot project, for example, you might have already wondered what the `mvnw` and `mvnw.cmd` files inside the root of the project are used for. That's the Maven Wrapper (the idea is borrowed from Gradle).

Creating a New Maven Project

There are several ways to bootstrap a new Maven project. Most of the popular Java application frameworks offer a project bootstrapping wizard-like interface. Good examples are the **Spring Initializr** for new Spring Boot applications, **Quarkus**, **MicroProfile**.

If we want to create a new Maven project without any framework support, we can use a **Maven Archetype** to create new projects. These archetypes are a project templating toolkit to generate a new Maven project conveniently.

Maven provides a set of **default Archetypes artifacts** for several purposes like a new web app, a new Maven plugin project, or a simple quickstart project.

We bootstrap a new Java project from one of these Archetypes using the mvn command-line tool:

```
mvn archetype:generate \
  -DarchetypeGroupId=org.apache.maven.archetypes  \
  -DarchetypeArtifactId=maven-archetype-quickstart \
  -DarchetypeVersion=1.4 \
  -DgroupId=com.mycompany \
  -DartifactId=order-service
```

The skeleton projects we create with the official Maven Archetypes are a good place to start.

However, some of these archetypes generate projects with outdated dependency versions like JUnit 4.11. While it's not a big effort to manually bump the dependency version after the project initialization, having an up-to-date Maven Archetype in the first place is even better.

Minimal Maven Project For Testing Java Applications

As part of my **Custom Maven Archetype** open-source project on GitHub, I've published a collection of useful Maven Archetypes. One of them is the `java-testing-toolkit` to create a Java Maven project with basic testing capabilities. **Creating our own Maven Archetype** is almost no effort.

We can create a new testing playground project using this custom Maven Archetype with the following Maven command (for Linux & Mac):

```
mvn archetype:generate \
  -DarchetypeGroupId=de.rieckpil.archetypes  \
  -DarchetypeArtifactId=java-testing-toolkit \
  -DarchetypeVersion=1.0.0 \
  -DgroupId=com.mycompany \
  -DartifactId=order-service
```

For Windows (both PowerShell and CMD), we can use the following command to bootstrap a new project from this template:

```
mvn archetype:generate "-DarchetypeGroupId=de.rieckpil.archetypes" "-DarchetypeArtifactId=testing-toolkit"
"-DarchetypeVersion=1.0.0" "-DgroupId=com.mycompany" "-DartifactId=order-service" "-DinteractiveMode=false"
```

We can adjust both `-DgroupId` and `-DartifactId` to our project's or company's preference.

The generated project comes with a basic set of the most central Java testing libraries. We can use it as a blueprint for our next project or explore testing Java applications with this playground.

In summary, the following default configuration and libraries are part of this project shell:

- Java 11
- JUnit Jupiter, Mockito, and Testcontainers dependencies
- A basic unit test

- Maven Surefire and Failsafe Plugin configuration
- A basic `.gitignore`
- Maven Wrapper

Next, we have to ensure a JDK 11 (or higher) is on our `PATH` and also `JAVA_HOME` points to the installation folder:

```
$ java -version
openjdk version "11.0.10" 2021-01-19
OpenJDK Runtime Environment AdoptOpenJDK (build 11.0.10+9)
OpenJDK 64-Bit Server VM AdoptOpenJDK (build 11.0.10+9, mixed mode)

# Windows
$ echo %JAVA_HOME%
C:\Program Files\AdoptOpenJDK\jdk-11.0.10.9-hotspot

# Mac and Linux
$ echo $JAVA_HOME
/usr/lib/jvm/adoptopenjdk-11.0.10.9-hotspot
```

As a final verification step, we can now build and test this project with Maven:

```
$ mvn archetype:generate ... // generate the project
$ cd order-service // navigate into the folder
$ ./mvnw package // mvnw.cmd package for Windows

....

[INFO] BUILD SUCCESS
[INFO] ------------------------------------------------------------------------
[INFO] Total time:  3.326 s
[INFO] Finished at: 2021-06-03T08:31:11+02:00
[INFO] ------------------------------------------------------------------------
```

We can now open and import the project to our editor or IDE (**IntelliJ IDEA**, **Eclipse**, **NetBeans**, **Visual Code**, etc.) to inspect the generated project in more detail.

Important Testing Folders and Files

First, let's take a look at the folders and files that are relevant for testing Java applications with Maven:

- `src/test/java`

This folder is the main place to add our Java test classes (`.java` files). As a general recommendation, we should try to mirror the package structure of our production code (`src/main/java`). Especially if there's a direct relationship between the test and the source class.

The corresponding `CustomerServiceTest` for a `CustomerService` class inside the package `com.company.customer` should be placed in the same package within `src/test/java`. This improves the likelihood that our colleagues (and our future us) locate the corresponding test for a particular Java class without too many facepalms.

Most of the IDEs and editors provide further support to jump to a test class. IntelliJ IDEA, for example, provides a shortcut (Ctrl + Shift + T) to navigate from a source file to its test classes(s) and vice-versa.

- `src/test/resources`

As part of this folder, we store static files that are only relevant for our test. This might be a CSV file to import test customers for an integration test, a dummy JSON response for **testing our HTTP clients**, or a configuration file.

- `target/test-classes`

At this location, Maven places our compiled test classes (`.class` files) and test resources whenever the Maven compiler compiles our test sources. We can explicitly trigger this with `mvn test-compile` and add a `clean` if we want to remove the existing content of the entire `target` folder first.

Usually, there's no need to perform any manual operations inside this folder as it contains build artifacts. Nevertheless, it's helpful to investigate the content for this folder whenever we face test failures because we, e.g., can't read a file from the classpath. Taking a look at this folder (after the Maven compiler did its work), can help to understand where a resources file ended up on the classpath.

- `pom.xml`

This is the heart of our Maven project. The abbreviation stands for **P**roject **O**bject **M**odel. Within this file, we define metadata about our project (e.g., description, artifactId, developers, etc.), which dependencies we require, and the configuration of our plugins.

Maven and Java Testing Naming Conventions

Next, let's take a look at the naming conventions for our test classes. We can separate our tests into two (or even more) basic categories: unit and integration test. To distinguish the tests for both of these two categories, we use different naming conventions with Maven.

The Maven Surefire Plugin, more about this plugin later, is designed to run our unit tests. The following patterns are the defaults so that the plugin will detect a class as a test:

- `**/Test*.java`
- `**/*Test.java`
- `**/*Tests.java`
- `**/*TestCase.java`

So what's actually a unit test?

Several smart people came up with a definition for this term. One of such smart people is **Michael Feathers**. He's turning the definition around and defines

what a unit test is not:

> A test is not a unit test if it ..
>
> - talks to the database
> - communicates across the network
> - touches the file system
> - can't run at the same time as any of your other unit tests
> - or you have to do special things to your environment (such as editing config files) to run it.

Kevlin Henney is also a great source of inspiration for a **definition of the term unit test**.

Nevertheless, our own definition or the definition of our coworkers might be entirely different. In the end, the actual definition is secondary as long as we're sharing the same definition within our team and talk about the same thing when referring to the term unit test.

The Maven Failsafe Plugin, designed to run our integration tests, detects our integration tests by the following default patterns:

- `**/IT*.java`
- `**/*IT.java`
- `**/*ITCase.java`

We can also override the default patterns for both plugins and come up with a different naming convention. However, sticking to the defaults is recommended.

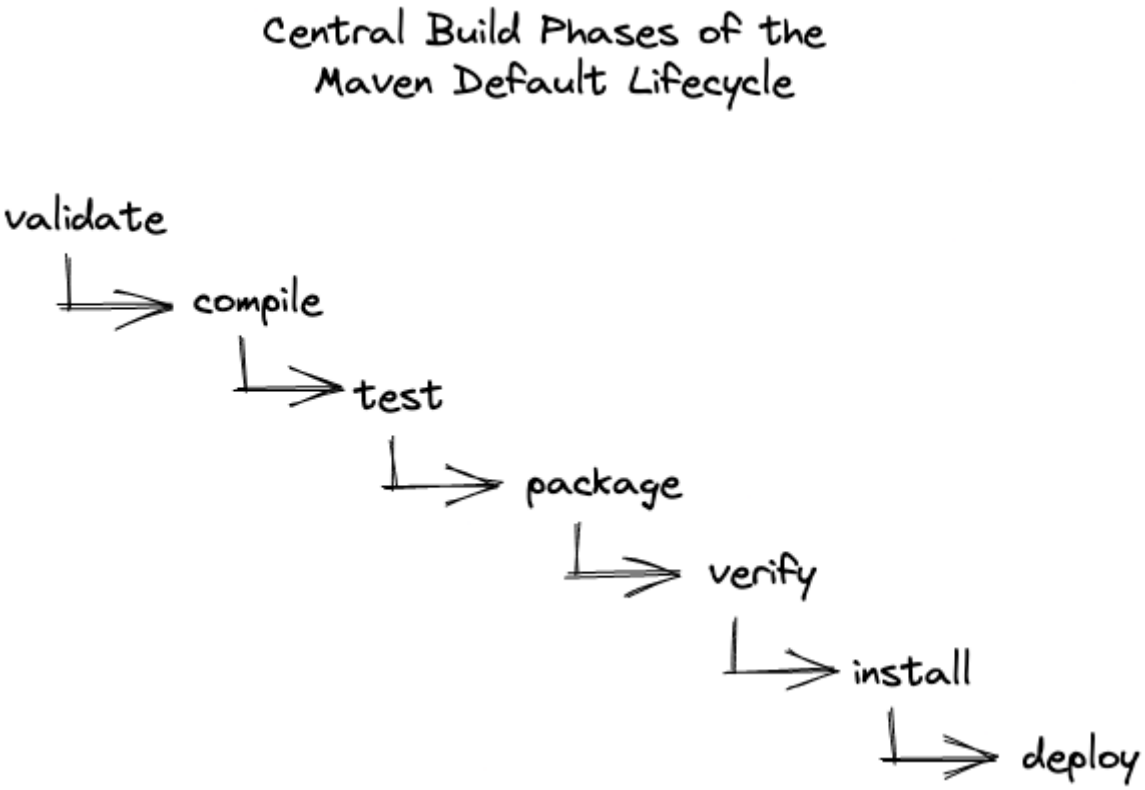
When Are Our Java Tests Executed?

Maven is built around the concept of build lifecycles. There are three built-in lifecycles:

- `default`: handling project building and deployment
- `clean`: project cleaning
- `site`: the creation of our project's (documentation) site

Each of the three built-in lifecycles has a list of build phases. For our testing example, the `default` lifecycle is important.

The `default` lifecycle compromises a set of build phases to handle building, testing and deploying our Java project. Each phase represents a stage in the build lifecycle with a central responsibility:



In short, the several phases have the following responsibilities:

- `validate`: validate that our project setup is correct (e.g., we have the correct Maven folder structure)
- `compile`: compile our source code with `javac`
- `test`: run our unit tests
- `package`: build our project in its distributable format (e.g., JAR or WAR)
- `verify`: run our integration tests and further checks (e.g., **the OWASP dependency check**)
- `install`: install the distributable format into our local repository (`~/.m2` folder)
- `deploy`: deploy the project to a remote repository (e.g., Maven Central or a company hosted Artifactory

These build phases represent the central phases of the `default` lifecycle. There are actually more phases. For a complete list, please refer to the **Lifecycle Reference** of the official Maven documentation.

Whenever we execute a build phase, our project will go through all build phases and sequentially until the build phase we specified. To phrase it differently, when we run mvn package, for example, Maven will execute the default lifecycle phases up to package in order:

```
validate -> compile -> test -> package
```

If one of the build phases in the chain fails, the entire build process will terminate. Imagine our Java source code has a missing semicolon, the `compile` phase would detect this and terminate the process. As with a corrupt source file, there'll be no compiled `.class` file to test.

When it comes to testing our Java project, both the `test` and `verify` build phases are of importance. As part of the test phase, we're running our unit tests with the **Maven Surefire Plugin**, and with verify our integration tests are executed by the **Maven Failsafe Plugin**.

Let's take a look at these two plugins.

Running Unit Tests With the Maven Surefire Plugin

The Maven Surefire is responsible for running our unit tests. We must either follow the default naming convention of our test classes, as discussed above, or **configure a different pattern** that matches our custom naming convention. In both cases, we have to place our tests inside `src/test/java` folder for the plugin to pick them up.

For the upcoming examples, we're using a basic format method

```
public class Main {

  public String format(String input) {
    return input.toUpperCase();
  }
}
```

... and its corresponding test as a unit test blueprint:

```
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Test;

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

class MainTest {

  private Main cut;

  @BeforeEach
  void setUp() {
    this.cut = new Main();
  }

  @Test
  void shouldReturnFormattedUppercase() {
    String input = "duke";

    String result = cut.format(input);

    assertEquals("DUKE", result);
  }
}
```

Depending on the Maven version and distribution format of our application (e.g., JAR or WAR), Maven **defines default versions for the core plugins**. Besides the

Maven Compiler Plugin, the Maven Resource Plugin, and other plugins, the Maven Surefire Plugin is such a core plugin.

When packaging our application as a JAR file and using Maven 3.8.1, for example, Maven picks the Maven Surefire Plugin with version 2.12.4 by default unless we override it. As the default versions are sometimes a little behind the latest plugin versions, it's worth updating the plugin versions and manually specifying the plugin version inside `our pom.xml`:

```
<project>
<!-- dependencies -->

  <build>
    <plugins>
      <plugin>
        <artifactId>maven-surefire-plugin</artifactId>
        <version>3.0.0-M5</version>
      </plugin>
    </plugins>
  </build>
</project>
```

As part of the test phase of the `default` lifecycle, we'll now see the Maven Surefire Plugin executing our tests:

```
$ mvn test

[INFO] --- maven-surefire-plugin:3.0.0-M5:test (default-test) @ testing-example ---
[INFO]
[INFO] -------------------------------------------------------
[INFO]  T E S T S
[INFO] -------------------------------------------------------
[INFO] Running de.rieckpil.blog.MainTest
[INFO] Tests run: 1, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.04 s - in de.rieckpil.blog.MainTest
[INFO]
[INFO] Results:
[INFO]
[INFO] Tests run: 1, Failures: 0, Errors: 0, Skipped: 0
[INFO]
[INFO] ------------------------------------------------------------------------
```

For the example above, we're running one unit test with JUnit 5 (testing provider). There's no need to configure the testing provider anywhere, as with recent Surefire versions, the plugin will pick up the correct test provider by itself. The Maven Surefire Plugin **integrates both JUnit and TestNG as testing providers** out-of-the-box.

If we don't want to execute all build phases before running our tests, we can also explicitly execute the test goal of the Surefire plugin:

```
mvn surefire:test
```

But keep in mind that we have to ensure that the test classes have been compiled first (e.g., by a previous build).

We can further tweak and configure the Maven Surefire Plugin to, e.g., parallelize

the execution of our unit tests. This is only relevant for JUnit 4, as JUnit 5 (JUnit Jupiter to be precise) **supports parallelization on the test framework level**.

Whenever we want to skip our unit tests when building our project, we can use an additional parameter:

```
mvn package -DskipTests
```

We can also explicitly **run only one or multiple tests**:

```
mvn test -Dtest=MainTest

mvn surefire:test -Dtest=MainTest
```

Running Integration Tests With the Maven Failsafe Plugin

Unlike the Maven Surefire Plugin, the Maven Failsafe Plugin is not a core plugin and hence won't be part of our project unless we manually include it. As already outlined, the Maven Failsafe plugin is used to run our integration test.

In contrast to our unit tests, the integration tests usually take more time, more setup effort (e.g., **start Docker containers for external infrastructure with Testcontainers**), and test multiple components of our application together.

We integrate the Maven Failsafe Plugin by adding it to the `build` section of our `pom.xml`:

```
<project>

  <!-- other dependencies -->

  <build>
      <!-- further plugins -->
      <plugin>
        <artifactId>maven-failsafe-plugin</artifactId>
        <version>3.0.0-M5</version>
        <executions>
          <execution>
            <goals>
              <goal>integration-test</goal>
              <goal>verify</goal>
            </goals>
          </execution>
        </executions>
      </plugin>
    </plugins>
  </build>
</project>
```

As part of the `executions` configuration, we specify **the goals of the Maven Failsafe plugin** we want to execute as part of our build process. A common pitfall is to only execute the `integration-test` goal. Without the `verify` goal, the plugin will run our integration tests but won't fail the build if there are test failures.

The Maven Failsafe Plugin is invoked as part of the `verify` build phase of the default lifecycle. That's right after the package build phase where we build our distributable artifact (e.g., JAR):

```
[INFO] --- maven-jar-plugin:2.4:jar (default-jar) @ testing-example ---
[INFO] Building jar: C:\Users\phili\Desktop\junk\testing-example\target\testing-example.jar
[INFO]
[INFO] --- maven-failsafe-plugin:3.0.0-M5:integration-test (default) @ testing-example ---
[INFO]
[INFO] -------------------------------------------------------
[INFO]  T E S T S
[INFO] -------------------------------------------------------
[INFO] Running de.rieckpil.blog.MainIT
[INFO] Tests run: 1, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.039 s - in de.rieckpil.blog.MainIT
[INFO]
[INFO] Results:
[INFO]
[INFO] Tests run: 1, Failures: 0, Errors: 0, Skipped: 0
[INFO]
[INFO]
[INFO] --- maven-failsafe-plugin:3.0.0-M5:verify (default) @ testing-example ---
[INFO] ------------------------------------------------------------------------
[INFO] BUILD SUCCESS
[INFO] ------------------------------------------------------------------------
```

If we want to run our integration tests manually, we can do so with the following command:

```
mvn failsafe:integration-test failsafe:verify
```

For scenarios where we don't want to run our integration test (but still our unit tests), we can add `-DskipITs` to our Maven execution:

```
mvn verify -DskipITs
```

Similar to the Maven Surefire Plugin, we can also run a subset of our integration tests:

```
mvn -Dit.test=MainIT failsafe:integration-test failsafe:verify
```

When using the command above, make sure the test classes have been compiled previously, as otherwise, there won't be any test execution.

There's also a property available to entirely skip the compilation of test classes and avoid running any tests when building our project (not recommended):

```
mvn verify -Dmaven.test.skip=true
```

Summary of Testing Java Applications With Maven

Maven is a powerful, mature, and well-adopted build tool for Java projects. As a newcomer or when coming from a different programming language, the basics

of the Maven build lifecycle and how and when different Maven Plugins interact is something to understand first.

With the help of Maven Archetypes or using a framework initializer, we can easily bootstrap new Maven projects. There's no need to install Maven as a CLI tool for our machine as we can instead use the portable Maven Wrapper.

Furthermore, keep this in mind when testing your Java applications and use Maven as the build tool:

- With Maven, we can separate the unit and integration test execution
- The Maven Surefire Plugin runs our unit tests
- The Maven Failsafe Plugin runs our integration tests
- By following the default naming conventions for both plugins, we can easily separate our tests
- The Maven default lifecycle consists of several build phases that are executed in order and sequentially
- Use the Java Testing Toolkit Maven archetype for your next testing adventure

Quickstart Solutions for JUnit 5

What is the difference between JUnit 4 and JUnit 5?

Before we start with the basics, let's have a brief look at the history of JUnit.

For a long time, JUnit 4.12 was the primary framework version. In 2017 JUnit 5 was launched and is now composed of several modules:

> JUnit 5 = JUnit Platform + JUnit Jupiter + JUnit Vintage

- JUnit Platform: Foundation to launch testing frameworks & it defines the `TestEngine` API for developing testing frameworks
- JUnit Jupiter: New programming model and extension model and provides the `JupiterTestEngine` that implements the `TestEngine` interface to run tests on the JUnit Platform
- JUnit Vintage: Provides a `TestEngine` to run both JUnit 3 and JUnit 4 tests

The JUnit team invested a lot in this refactoring to have a more **platform-based** approach with a **comprehensive extension model**.

Nevertheless, migrating from JUnit 4.X to 5.X requires effort. Like `@Test`, all annotations now reside in the package `org.junit.jupiter.api` and some annotations were renamed or dropped and have to be replaced.

More information about the migration process from JUnit 4 to JUnit 5 in one of the next sections.

How can I include JUnit 5 to my project?

Throughout this cheat sheet, I'll use the term JUnit 5 to refer to JUnit Jupiter (which is formally incorrect).

As a short recap, JUnit 5 is composed of several modules: JUnit Platform + JUnit Jupiter + JUnit Vintage.

If you only use JUnit Jupiter for your tests and have no JUnit 3 or JUnit 4 *left-overs*, your Maven project requires the following dependency:

```
<dependency>
  <groupId>org.junit.jupiter</groupId>
  <artifactId>junit-jupiter</artifactId>
  <version>5.7.1</version>
  <scope>test</scope>
</dependency>
```

As current Maven versions (3.8.1 at the time of writing) don't pick the latest Surefire Plugin version by default, you have to adjust it. You can **override the plugin version** using Maven's `pluginManagement` section. For projects that use Spring Boot, the Surefire Plugin version is managed and usually up-to-date.

For Gradle:

```
dependencies {
  testImplementation('org.junit.jupiter:junit-jupiter:5.7.1')
}
```

Gradle supports native support for the JUnit Platform since version 4.6. To enable it, we have to adjust the `test` task declaration as to the following:

```
test {
  useJUnitPlatform()
}
```

For those of you that still have tests written in JUnit 4, make sure to include the following dependencies:

```
<dependency>
  <groupId>org.junit.jupiter</groupId>
  <artifactId>junit-jupiter</artifactId>
  <version>5.7.1</version>
  <scope>test</scope>
</dependency>
<dependency>
  <groupId>org.junit.vintage</groupId>
  <artifactId>junit-vintage-engine</artifactId>
  <version>5.7.1</version>
  <scope>test</scope>
</dependency>
```

For Gradle:

```
dependencies {
  testImplementation('org.junit.jupiter:junit-jupiter:5.7.1')
  testImplementation('org.junit.vintage:junit-vintage-engine:5.7.1')
}
```

If your project uses Spring Boot, the **Spring Boot Starter Test** dependency includes everything you need. You only have to decide whether or not you want to include the Vintage Engine.

Including the Vintage Engine:

```
<dependency>
  <groupId>org.springframework.boot</groupId>
  <artifactId>spring-boot-starter-test</artifactId>
  <scope>test</scope>
</dependency>
```

Excluding the Vintage Engine:

```
<dependency>
  <groupId>org.springframework.boot</groupId>
  <artifactId>spring-boot-starter-test</artifactId>
  <scope>test</scope>
  <exclusions>
    <exclusion>
      <groupId>org.junit.vintage</groupId>
      <artifactId>junit-vintage-engine</artifactId>
    </exclusion>
  </exclusions>
</dependency>
```

UPDATE: As of Spring Boot 2.4.0, the Spring Boot Starter Test no longer includes the JUnit Vintage Engine.

For further application setup support, take a look at the different **JUnit 5 project setup examples** on GitHub.

How to migrate from JUnit 4 to JUnit 5?

Migration from JUnit 4 to JUnit 5 is not *just* a dependency version bump. The lifecycle annotations have been renamed, the extension model now supersedes JUnit 4's rules, etc.

The following list is a short overview of the differences between both framework versions:

- Assertions reside in `org.junit.jupiter.api.Assertions`
- Assumptions reside in `org.junit.jupiter.api.Assumptions`
- `@Before` and `@After` no longer exist; use `@BeforeEach` and `@AfterEach` instead.
- `@BeforeClass` and `@AfterClass` no longer exist; use `@BeforeAll` and `@AfterAll` instead.
- `@Ignore` no longer exists: use `@Disabled` or one of the other built-in execution conditions instead
- `@Category` no longer exists; use `@Tag` instead
- `@RunWith` no longer exists; superseded by `@ExtendWith`
- `@Rule` and `@ClassRule` no longer exist; superseded by `@ExtendWith` and `@RegisterExtension`

If your codebase is using JUnit 4, changing the annotations to the JUnit 5 ones is the first step. The most effort is required for migrating custom JUnit 4 rules to JUnit 5 extensions.

You can automate the trivial parts of the migration, with e.g., **Sam Brannen's script**. The JUnit documentation also includes an own section with **hints & pitfalls** for the migration

How to write your first test?

Writing your first test with JUnit 5 is as simple as the following:

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

class FirstTest {

  @Test // ①
  void firstTest() {
    System.out.println("Running my first test with JUnit 5");
  }

}
```

① Here starts your testing journey

All you need is to annotate a non-private method (the Java class can be package-private) with `@Test`.

Your tests must reside inside the `src/test/java` folder to follow default Maven/Java conventions.

Running `mvn test` or `gradle test` will then execute your test:

```
[INFO] --- maven-surefire-plugin:2.22.2:test (default-test) @ junit-5-and-mockito-cheat-sheet ---
[INFO]
[INFO] -------------------------------------------------------
[INFO]  T E S T S
[INFO] -------------------------------------------------------
[INFO] Running de.rieckpil.products.junit5.FirstTest
Running my first test with JUnit 5
[INFO] Tests run: 1, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.02 s - in
de.rieckpil.products.junit5.FirstTest
[INFO]
[INFO] Results:
[INFO]
[INFO] Tests run: 1, Failures: 0, Errors: 0, Skipped: 0
[INFO]
[INFO] ------------------------------------------------------------------------
[INFO] BUILD SUCCESS
[INFO] ------------------------------------------------------------------------
[INFO] Total time:  1.723 s
[INFO] Finished at: 2020-10-18T11:20:00+02:00
[INFO] ------------------------------------------------------------------------
```

How can I intercept the lifecycle of my test?

JUnit 5 offers several interception points to execute code within the test's lifecycle.

```
class LifecycleTest {

  public LifecycleTest() {
    System.out.println("-- Constructor called");
  }

  @BeforeAll
  static void beforeAllTests() {
    System.out.println("- Before all tests");
  }

  @BeforeEach
  void beforeEachTest() {
    System.out.println("--- Before each test");
  }

  @AfterAll
  static void afterAllTests() {
    System.out.println("- After all tests");
  }

  @AfterEach
  void afterEachTest() {
    System.out.println("--- After each test");
  }

  @Test
  void shouldAddIntegers() {
    System.out.println("Test: Adding integers with Java");
    assertEquals(4, 2 + 2);
  }

  @Test
  void shouldSubtractIntegers() {
    System.out.println("Test: Subtracting integers with Java");
    assertEquals(4, 6 - 2);
  }
}
```

Running the test above results in the following console output:

```
- Before all tests
-- Constructor called

--- Before each test
Test: Subtracting integers with Java
--- After each test

-- Constructor called

--- Before each test
Test: Adding integers with Java
--- After each test

- After all tests
```

How can I change the name and structure of my test?

As the name of your test should be explicit and reflect the tested scenario, the Java method name might grow. To make it more readable, you can use the camel case notation `shouldThrowExceptionWhenDividingByZero` or underscores `_`.

However, if you want to write a more readable sentence, you can use `@DisplayName` for your test:

```
class DisplayNameTest {

  @Test
  @DisplayName("This test verifies that Java can add integers")
  void shouldAddIntegers() {
    System.out.println("Test: Adding integers with Java");
    assertEquals(4, 2 + 2);
  }

  @Test
  @DisplayName("This test verifies that Java can subtract integers")
  void shouldSubtractIntegers() {
    System.out.println("Test: Subtracting integers with Java");
    assertEquals(4, 6 - 2);
  }
}
```

If you project uses Kotlin, you can achieve the same with:

```
@Test
fun `should throw an exception when dividing by zero`() {
  //
}
```

Once your test suite grows, you might want to structure them. You can place tests that verify a similar outcome together.

If you want to structure tests within a test class, you can use the `@Nested` annotation:

```
class NestedTest {

  @Nested
  class Addition {

    @Test
    void shouldAddIntegers() {
      System.out.println("Test: Adding integers with Java");
      assertEquals(4, 2 + 2);
    }
  }

  @Nested
  class Subtraction {

    @Test
    void shouldSubtractIntegers() {
      System.out.println("Test: Subtracting integers with Java");
      assertEquals(4, 6 - 2);
    }
  }
}
```

Or you can tag them (either the whole test class or specific tests) with `@Tag`:

```
class TaggingTest {

  @Test
  @Tag("slow")
  void shouldAddIntegers() {
    System.out.println("Test: Adding integers with Java");
    assertEquals(4, 2 + 2);
  }

  @Test
  @Tag("fast")
  void shouldSubtractIntegers() {
    System.out.println("Test: Subtracting integers with Java");
    assertEquals(4, 6 - 2);
  }
}
```

How to provide parameterized inputs for a test?

Sometimes you want to execute the same test for different input parameters. To avoid duplicating the same test multiple times, you can make use of parameterized tests.

JUnit 5 allows the following sources to feed input for a parameterized test:

- inline values
- method sources
- enums
- CSV files

```
class ParameterizedExampleTest {

  @ParameterizedTest
  @ValueSource(ints = {2, 4, 6, 8, 10})
  void shouldAddIntegersValueSource(Integer input) {
    assertEquals(input * 2, input + input);
  }

  @ParameterizedTest
  @MethodSource("integerProvider")
  void shouldAddIntegersMethodSource(Integer input) {
    assertEquals(input * 2, input + input);
  }

  static Stream<Integer> integerProvider() {
    return Stream.of(2, 4, 6, 8, 10);
  }

  @ParameterizedTest
  @CsvFileSource(resources = "/integers.csv")
  void shouldAddIntegersCsvSource(Integer firstOperand,
                                  Integer secondOperand,
                                  Integer expectedResult) {
    assertEquals(expectedResult, firstOperand + secondOperand);
  }
}
```

How to write assertions with JUnit 5?

JUnit 5 also ships with assertions. There is no need to include AssertJ or Hamcrest, except you favor their assertion style over JUnit 5's.

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

import static org.junit.Assert.*;

class AssertionExampleTest {

  @Test
  void demoJUnit5Assertions() {

    assertEquals(4, 2 + 2);
    assertNotEquals(4, 2 + 1);

    assertFalse("Optional message", 2 == 3);
    assertTrue("Optional message", 2 == 1 + 1);

    assertArrayEquals(new int[]{1, 2, 3}, new int[]{1, 2, 3});

    String message = null;
    assertNull(message);
  }
}
```

How can I verify that my code throws an exception?

JUnit 5 ships with an assertion to verify that a particular code block throws an exception:

```
class AssertThrowsExampleTest {

  @Test
  void invocationShouldThrowException() {
    assertThrows(IllegalArgumentException.class, () -> {
      divide(5, 0);
    });
  }

  private Integer divide(int first, int second) {
    if (second == 0) {
      throw new IllegalArgumentException("Can't divide by zero");
    }

    return first / second;
  }
}
```

The `assertThrows` method also returns the exception. You can store it inside a variable to make further inspections and, e.g., check the message or the cause of the exception:

How can I parallelize my test?

While test parallelization was configured with the Maven or Gradle plugin in the past, you can now configure this directly with JUnit (since version 5.3).

This allows more fine-grain control on how to parallelize the tests.

A basic configuration can look like the following:

```
junit.jupiter.execution.parallel.enabled = true
junit.jupiter.execution.parallel.mode.default = concurrent
```

This enables parallel execution for all your tests and sets the execution mode to concurrent. Compared to `same_thread`, `concurrent` does not enforce to execute the test in the same thread of the parent. For a per test class or method mode configuration, you can use the @Execution annotation.

There are **multiple ways** to set these configuration values. One solution is to use the Maven Surefire plugin for the configuration:

```
<plugin>
  <artifactId>maven-surefire-plugin</artifactId>
  <version>3.0.0-M5</version>
  <configuration>
    <properties>
      <configurationParameters>
        junit.jupiter.execution.parallel.enabled = true
        junit.jupiter.execution.parallel.mode.default = concurrent
      </configurationParameters>
    </properties>
  </configuration>
</plugin>
```

Or place a `junit-platform.properties` file inside `src/test/resources` with the configuration values.

You should benefit the most when using this feature for unit tests. Enabling parallelization for integration tests might not be possible or easy to achieve, depending on your setup.

Therefore, I recommend executing your unit tests with the Maven Surefire Plugin and configure parallelization for them. All your integration tests can then be run with the Maven Failsafe Plugin where you don't specify these JUnit 5 configuration parameters.

For a more **fine-grain parallelism configuration**, take a look at the official JUnit 5 documentation.

How can I write my own extension?

The extension model of JUnit 5 allows you to create your own cross-cutting concerns and write callbacks, parameter resolvers etc.

If you have used Spring Boot or Mockito in the past, you probably already saw `@ExtendWith` on top of your test class, e.g. `@ExtendWith(SpringExtension.class)`.

This is the declarative approach to register an extension. You also use the programmatic approach using `@RegisterExtension` or use Java's `ServiceLoader` to automatically register them.

You can write extensions for the following use cases:

- BeforeAllCallback
- BeforeEachCallback
- BeforeTestExecutionCallback
- AfterTestExecutionCallback
- AfterEachCallback
- AfterAllCallback
- ParameterResolver
- TestExecutionExceptionHandler
- InvocationInterceptor
- etc.

For example, injecting Spring Beans (using `@Autowired`) during your test is achieved with a `ParameterResolver`.

Next, whenever you use the `@Testcontainers` annotation for your test, Testcontainers registers an extension in the background to start and stop your container definitions (using `@Container`) accordingly.

Let's write our first extension that resolves a random `UUID`.

```
public class RandomUUIDParameterResolver implements ParameterResolver {

  @Retention(RetentionPolicy.RUNTIME)
  @Target(ElementType.PARAMETER)
  public @interface RandomUUID {
  }

  @Override
  public boolean supportsParameter(ParameterContext parameterContext, ExtensionContext extensionContext) {
    return parameterContext.isAnnotated(RandomUUID.class);
  }

  @Override
  public Object resolveParameter(ParameterContext parameterContext, ExtensionContext extensionContext) {
    return UUID.randomUUID().toString();
  }
}
```

This extension class includes a custom annotation `@RandomUUID`. Whenever we now use this annotation next to a `UUID` and `RandomUUIDParameterResolver` extension is registered for this test, we'll get a random `UUID`.

Let's use this parameter resolver and register it for one of our tests:

```
import org.junit.jupiter.api.RepeatedTest;
import org.junit.jupiter.api.extension.ExtendWith;

@ExtendWith(RandomUUIDParameterResolver.class)
public class ParameterInjectionTest {

  @RepeatedTest(5)
  public void testUUIDInjection(@RandomUUIDParameterResolver.RandomUUID String uuid) {
    System.out.println("Random UUID: " + uuid);
  }
}
```

What other resources do you recommend for JUnit 5?

Find further resources on JUnit 5 and unit testing in general here:

- **JUnit 5's excellent User Guide**
- **Testing Spring Boot Applications Fundamentals**
- **Java Unit Testing with JUnit 5: Test Driven Development with JUnit 5**
- **Good Test, Bad Tests**
- **Modern Best Practices for Testing in Java**
- **Starting to Unit Test: Not as Hard as You Think**

Quickstart Solutions for Mockito

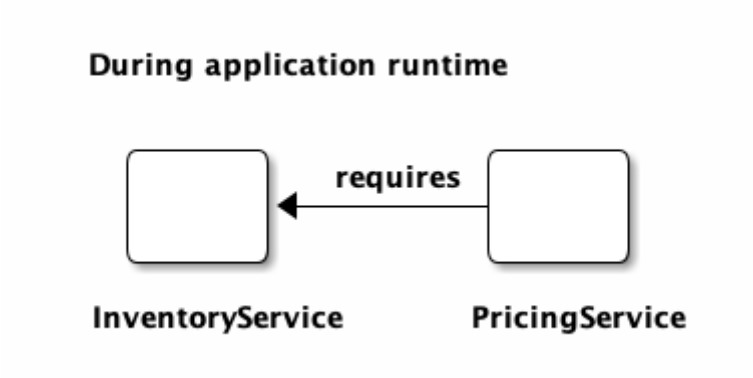
What do I need Mockito for?

Mockito is a ...

> Tasty mocking framework for unit tests in Java

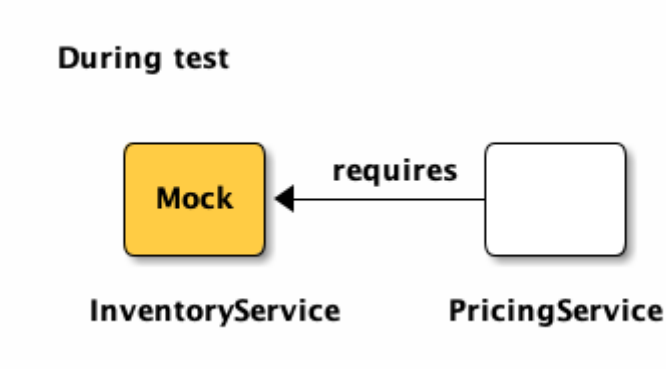
The main reason to use Mockito is to **stub methods calls** and **verify interaction** of objects. The first is essential if you write unit tests, and your test class requires other objects to work (so-called collaborators). As your unit test should focus on just testing your class under test, you mock the behavior of the dependent objects of this class.

A visual overview might explain this even better. Let's take the following example. Our application has a `PricingService` that makes use of public methods of the `InventoryService`.



When we now want to write a **unit test** for the `PricingService` we don't want to interact with the *real* `InventoryService`, but rather a mock of it.

This way, we can control the behavior of the collaborator and test different scenarios:



Code-wise this example looks like the following:

```
public class PricingService {

  private final InventoryService inventoryService;

  public PricingService(InventoryService inventoryService) {
    this.inventoryService = inventoryService;
  }

  public BigDecimal calculatePrice(String productName) {
    if (inventoryService.isCurrentlyInStockOfCompetitor(productName)) {
      return new BigDecimal("99.99");
    }

    return new BigDecimal("149.99");
  }
}
```

```
public class InventoryService {
  public boolean isCurrentlyInStockOfCompetitor(String productName) {
    // Determine if product is in stock of competitor, e.g. HTTP call
    return false;
  }

  public boolean isAvailable(String productName) {
    // Determine if product is available, e.g. database access
    return true;
  }
}
```

We'll use this example for most of the following sections.

How to include Mockito to my project?

If your project uses Spring Boot, the **Spring Boot Starter Test** dependency already includes Mockito.

Otherwise, you need to include the following dependencies (for Maven):

```
<dependency>
  <groupId>org.mockito</groupId>
  <artifactId>mockito-core</artifactId>
  <version>3.9.0</version>
  <scope>test</scope>
</dependency>
<dependency>
  <groupId>org.mockito</groupId>
  <artifactId>mockito-junit-jupiter</artifactId>
  <version>3.9.0</version>
  <scope>test</scope>
</dependency>
```

The corresponding Gradle import looks like the following:

```
dependencies {
  testImplementation('org.mockito:mockito-core:3.9.0')
  testImplementation('org.mockito:mockito-junit-jupiter:3.9.0')
}
```

How can I create mocks?

You can't create mocks from final classes and methods with Mockito. Everything else is *mockable*. Be aware of this if you are using Kotlin, as you have to declare your classes as open.

If we now want to create a mock for the `InventoryService` while unit testing the `PricingService`, we can do the following:

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

import static org.mockito.Mockito.mock;

class PricingServiceTest {

  private InventoryService inventoryService = mock(InventoryService.class); // ①
  private PricingService pricingService = new PricingService(inventorySerivce);

  @Test
  void shouldReturnHigherPriceIfProductIsInStockOfCompetitor() {
    // Test comes here
  }
}
```

① Using Mockito's static `mock()` method to create a mocked instance of the `inventoryService`

or

```
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Test;
import org.mockito.Mock;
import org.mockito.MockitoAnnotations;

class PricingServiceTest {

  @Mock
  private InventoryService inventoryService;

  private PricingService pricingService;

  @BeforeEach
  void setup() {
    MockitoAnnotations.openMocks(this); // ①
    this.pricingService = new PricingService(inventoryService);
  }

  @Test
  void shouldReturnHigherPriceIfProductIsInStockOfCompetitor() {
    // Test comes here
  }
}
```

① Initializing all `@Mock` annotated fields within this test class

There is a third way to create mocks that I prefer for my tests. More about this approach on the next page.

How can I create mocks with the JUnit 5 extension?

The `mockito-junit-jupiter` comes with a JUnit 5 extension (`MockitoExtension`) that we can use to initialize our mocks:

```
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.extension.ExtendWith;
import org.mockito.InjectMocks;
import org.mockito.Mock;
import org.mockito.junit.jupiter.MockitoExtension;

@ExtendWith(MockitoExtension.class) // ①
class PricingServiceTest {

  @Mock // ②
  private InventoryService inventoryService;

  @InjectMocks // ③
  private PricingService pricingService;

  @Test
  void shouldReturnHigherPriceIfProductIsInStockOfCompetitor() {
    // Test comes here
  }
}
```

① Register the `MockitoExtension` for this test

② Mark the `inventoryService` to be mocked

③ Instruct Mockito to inject all mocks while instantiating the `PricingService`

How can I mock the response of a mocked class?

You can stub the response of a mock using Mockito's stubbing setup `when().thenReturn()`:

```
@Test
void shouldReturnHigherPriceIfProductIsInStockOfCompetitor() {
  when(inventoryService.isCurrentlyInStockOfCompetitor("MacBook")).thenReturn(false);

  BigDecimal result = pricingService.calculatePrice("MacBook");

  assertEquals(new BigDecimal("149.99"), result);
}
```

For this stubbing to work **your setup has to match the exact method arguments** your stub is called with during test execution.

This might be sometimes hard to achieve, and you can use the following workaround:

```
@Test
void mockWithAnyInputParameter() {
  when(inventoryService.isCurrentlyInStockOfCompetitor(anyString())).thenReturn(true);

  BigDecimal result = pricingService.calculatePrice("MacBook");

  assertEquals(new BigDecimal("99.99"), result);
}
```

Or use `any(JavaClass.class)` to match all passed objects of a Java class.

```
@Test
void mockWithAnyClassInputParameter() {
  when(inventoryService.isCurrentlyInStockOfCompetitor(any(String.class))).thenReturn(true);

  BigDecimal result = pricingService.calculatePrice("MacBook");

  assertEquals(new BigDecimal("99.99"), result);
}
```

Apart from returning a value, you can also instruct your mock to throw an exception:

```
@Test
void shouldThrowExceptionWhenCheckingForAvailability() {
  when(inventoryService.isCurrentlyInStockOfCompetitor("MacBook"))
    .thenThrow(new RuntimeException("Network error"));

  assertThrows(RuntimeException.class, () -> pricingService.calculatePrice("MacBook"));
}
```

If you want to return a value based on the method argument of your mock, `thenAnswer` fits perfectly:

```
@Test
void mockWithThenAnswer() {
  when(inventoryService.isCurrentlyInStockOfCompetitor(any(String.class))).thenAnswer(invocation -> {
    String productName = invocation.getArgument(0);
    return productName.contains("Mac");
  });

  BigDecimal result = pricingService.calculatePrice("MacBook");

  assertEquals(new BigDecimal("99.99"), result);
}
```

I've a **recorded a video** that explains where `thenAnswer` can reduce your boilerplate setup.

What happens when I don't stub a method invocation?

Whenever you don't stub the method invocation, your mock will return the default values depending on the method's return type:

- for primitive types (e.g. `int`, `boolean`): the default value, e.g. `0` for `int` and `false` for `boolean`
- for reference types (e.g. `String` or `Customer`): `null`
- for collections: `[]`
- for Java's `Optional`: `Optional.empty()`

```
@ExtendWith(MockitoExtension.class)
class PricingServiceTest {

  @Mock
  private InventoryService inventoryService;

  @InjectMocks
  private PricingService pricingService;

  @Test
  void shouldReturnHigherPriceIfProductIsInStockOfCompetitor() {
    // the inventoryService will return false
   BigDecimal result = pricingService.calculatePrice("MacBook");
  }
}
```

How can I verify the mock was invoked during test execution?

Sometimes it's helpful to verify that a mock was called. This might be the case if you have a collaborator that returns `void` but you want to ensure the interaction with this mock.

On the other side, you might also want to test that no interaction happened with a mock.

```
@ExtendWith(MockitoExtension.class)
class PricingServiceVerificationTest {

  @Mock
  private InventoryService inventoryService;

  @InjectMocks
  private PricingService pricingService;

  @Test
  void shouldReturnHigherPriceIfProductIsInStockOfCompetitor() {
    when(inventoryService.isCurrentlyInStockOfCompetitor(anyString())).thenReturn(false);

    BigDecimal result = pricingService.calculatePrice("MacBook");

    verify(inventoryService).isCurrentlyInStockOfCompetitor("MacBook");
    // verifyNoInteractions(otherMock);

    assertEquals(new BigDecimal("149.99"), result);
  }

}
```

How can I capture the argument my mock was called with?

With the help of an `ArgumentCaptor` you can capture the method arguments of your mocked instance.

```
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.extension.ExtendWith;
import org.mockito.ArgumentCaptor;
import org.mockito.Captor;
import org.mockito.InjectMocks;
import org.mockito.Mock;
import org.mockito.junit.jupiter.MockitoExtension;

import java.math.BigDecimal;

import static org.junit.Assert.assertEquals;
import static org.mockito.ArgumentMatchers.anyString;
import static org.mockito.Mockito.verify;
import static org.mockito.Mockito.when;

@ExtendWith(MockitoExtension.class)
class PricingServiceArgumentCaptureTest {

  @Mock
  private InventoryService inventoryService;

  @InjectMocks
  private PricingService pricingService;

  @Captor
  private ArgumentCaptor<String> stringArgumentCaptor;

  @Test
  void shouldReturnHigherPriceIfProductIsInStockOfCompetitor() {
    when(inventoryService.isCurrentlyInStockOfCompetitor(anyString())).thenReturn(false);

    BigDecimal result = pricingService.calculatePrice("MacBook");

    verify(inventoryService).isCurrentlyInStockOfCompetitor(stringArgumentCaptor.capture());

    assertEquals(new BigDecimal("149.99"), result);
    assertEquals("MacBook", stringArgumentCaptor.getValue());
  }

}
```

After capturing the arguments, you can then inspect them and write assertions for them.

How can I change the Mockito settings?

When using the `MockitoExtension`, your stubbing setup is strict.

If you stub a method during your test setup that is not used during your test execution, Mockito will fail the test:

```
org.mockito.exceptions.misusing.UnnecessaryStubbingException:
Unnecessary stubbings detected.
Clean & maintainable test code requires zero unnecessary code.
Following stubbings are unnecessary (click to navigate to relevant line of code):
1. -> at
de.rieckpil.products.mockito.PricingServiceMockitoSettingsTest.shouldReturnHigherPriceIfProductIsInStockOfCo
mpetitor(PricingServiceMockitoSettingsTest.java:27)
Please remove unnecessary stubbings or use 'lenient' strictness. More info: javadoc for
UnnecessaryStubbingException class.
```

In this example the stubbing setup `when(inventoryService.isAvailable("MacBook")).thenReturn(false);` is not used while calculating the price and hence unnecessary.

```
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.extension.ExtendWith;
import org.mockito.InjectMocks;
import org.mockito.Mock;
import org.mockito.junit.jupiter.MockitoExtension;
import org.mockito.junit.jupiter.MockitoSettings;
import org.mockito.quality.Strictness;

import static org.mockito.Mockito.when;

@ExtendWith(MockitoExtension.class)
@MockitoSettings(strictness = Strictness.WARN)
class PricingServiceMockitoSettingsTest {

  @Mock
  private InventoryService inventoryService;

  @InjectMocks
  private PricingService pricingService;

  @Test
  void shouldReturnHigherPriceIfProductIsInStockOfCompetitor() {
    when(inventoryService.isAvailable("MacBook")).thenReturn(false);
    when(inventoryService.isCurrentlyInStockOfCompetitor("MacBook")).thenReturn(false);

    pricingService.calculatePrice("MacBook");
  }
}
```

You can override this strictness setting to be either lenient, produce warn logs or fail on unnecessary stubs (default):

- `Strictness.LENIENT`
- `Strictness.WARN`
- `Strictness.STRICT_STUBS`

How can I mock static methods calls?

For this to work you have to replace/add `mockito-core` with `mockito-inline`. More information in one of my **blog post**.

Let's take a look at the following `OrderService` that makes use of two static methods `UUID.randomUUID()` and `LocalDateTime.now()`:

```
public class OrderService {

  public Order createOrder(String productName, Long amount, String parentOrderId) {
    Order order = new Order();

    order.setId(parentOrderId == null ? UUID.randomUUID().toString() : parentOrderId);
    order.setCreationDate(LocalDateTime.now());
    order.setAmount(amount);
    order.setProductName(productName);

    return order;
  }
}
```

Starting with version 3.4.0 can now mock these static calls with Mockito

```
import org.junit.jupiter.api.Test;
import org.mockito.MockedStatic;
import org.mockito.Mockito;

import java.time.LocalDateTime;
import java.util.UUID;

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

class OrderServiceTest {

  private OrderService cut = new OrderService();
  private UUID defaultUuid = UUID.fromString("8d8b30e3-de52-4f1c-a71c-9905a8043dac");
  private LocalDateTime defaultLocalDateTime = LocalDateTime.of(2020, 1, 1, 12, 0);

  @Test
  void shouldIncludeRandomOrderIdWhenNoParentOrderExists() {
    try (MockedStatic<UUID> mockedUuid = Mockito.mockStatic(UUID.class)) {
      mockedUuid.when(UUID::randomUUID).thenReturn(defaultUuid);

      Order result = cut.createOrder("MacBook Pro", 2L, null);

      assertEquals("8d8b30e3-de52-4f1c-a71c-9905a8043dac", result.getId());
    }
  }

  @Test
  void shouldIncludeCurrentTimeWhenCreatingANewOrder() {
    try (MockedStatic<LocalDateTime> mockedLocalDateTime = Mockito.mockStatic(LocalDateTime.class)) {
      mockedLocalDateTime.when(LocalDateTime::now).thenReturn(defaultLocalDateTime);

      Order result = cut.createOrder("MacBook Pro", 2L, "42");

      assertEquals(defaultLocalDateTime, result.getCreationDate());
    }
  }
}
```

What is the difference between @Mock and @MockBean?

While we use `@Mock` to define a mock for our unit tests, `@MockBean` is used to replace a bean with a mock inside the Spring Context.

Whenever you launch a **sliced Spring Context** (e.g. `@WebMvcTest` or `@DataJpaTest`) for your test, you might want to mock collaborators of your class under test.

A good is example is **testing your web layer**. Therefore, you can use `@WebMvcTest` and `MockMvc` to start a mocked Servlet environment to access your controller endpoints.

For such test, you usually don't want any interaction with your *service layer* and hence mock any collaborator of your controller with `@MockBean`.

What other resources do you recommend for Mockito?

Find further resources on Mockito and testing in general here:

- **Project Wiki** of Mockito
- **Hands-On Mocking With Mockito Online Course**
- **Practical Unit Testing with JUnit and Mockito**
- **Mockito Tips & Tricks on YouTube**
- **Testing Spring Boot Applications Fundamentals**