Getting Started with TDD

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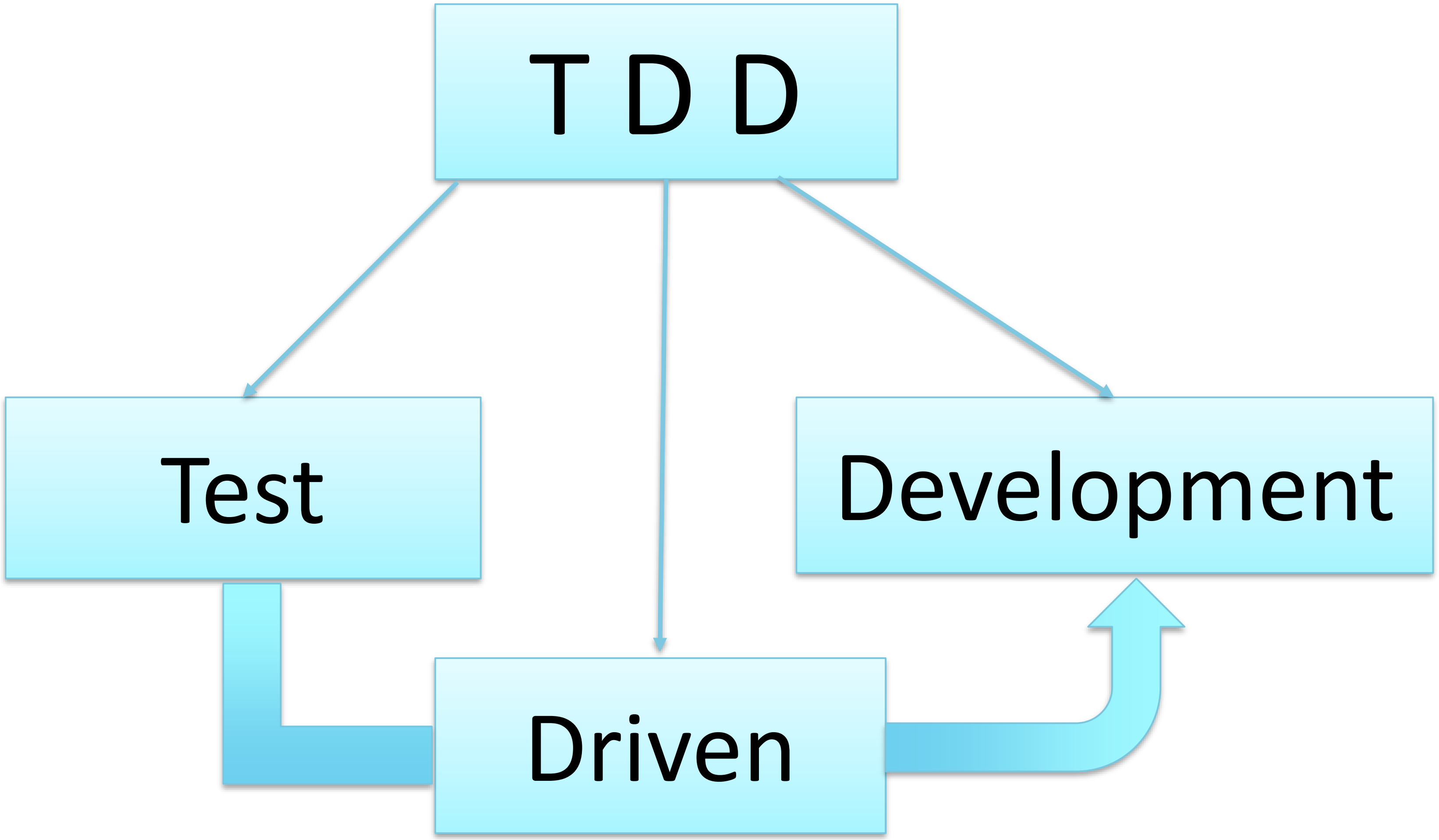
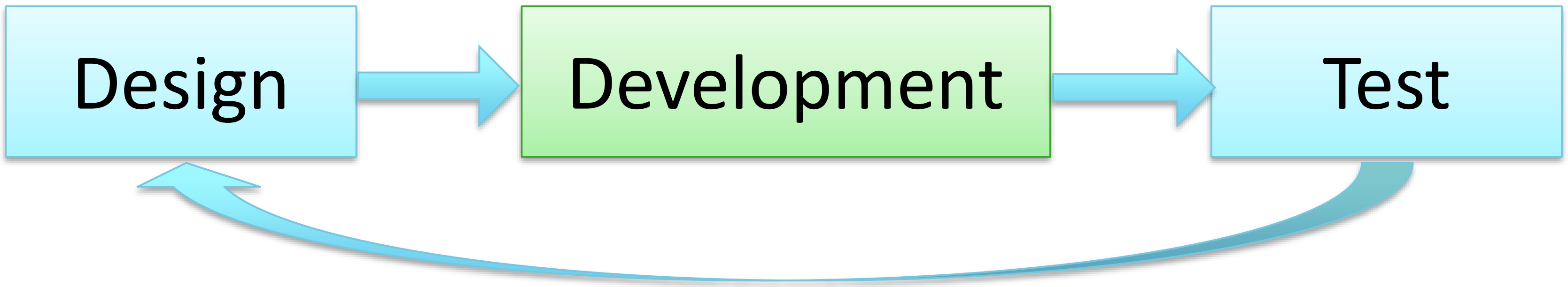
TDD stands for…



Old School Development Approach



New School Development Approach

$$\begin{tikzcd}
\text{Design} \arrow[r] & \text{Test} \arrow[r] & \text{Development} \arrow[ll, bend left]
\end{tikzcd}$$

Test Driven Development

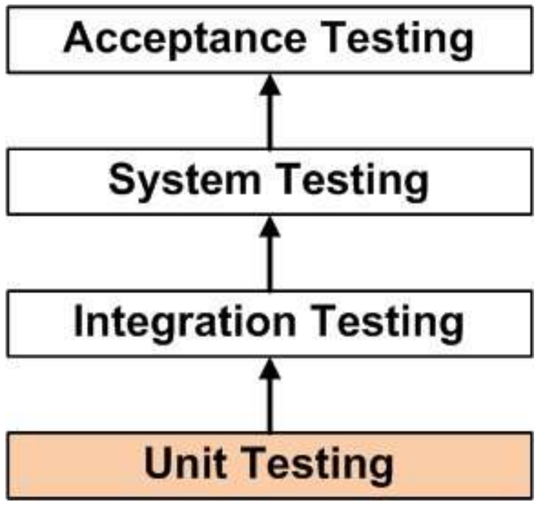
“**Test Driven Development (TDD)** is a technique for building software that guides **software development** by **writing tests**.”

- Martin Fowler (Chief Scientist, ThoughtWorks)

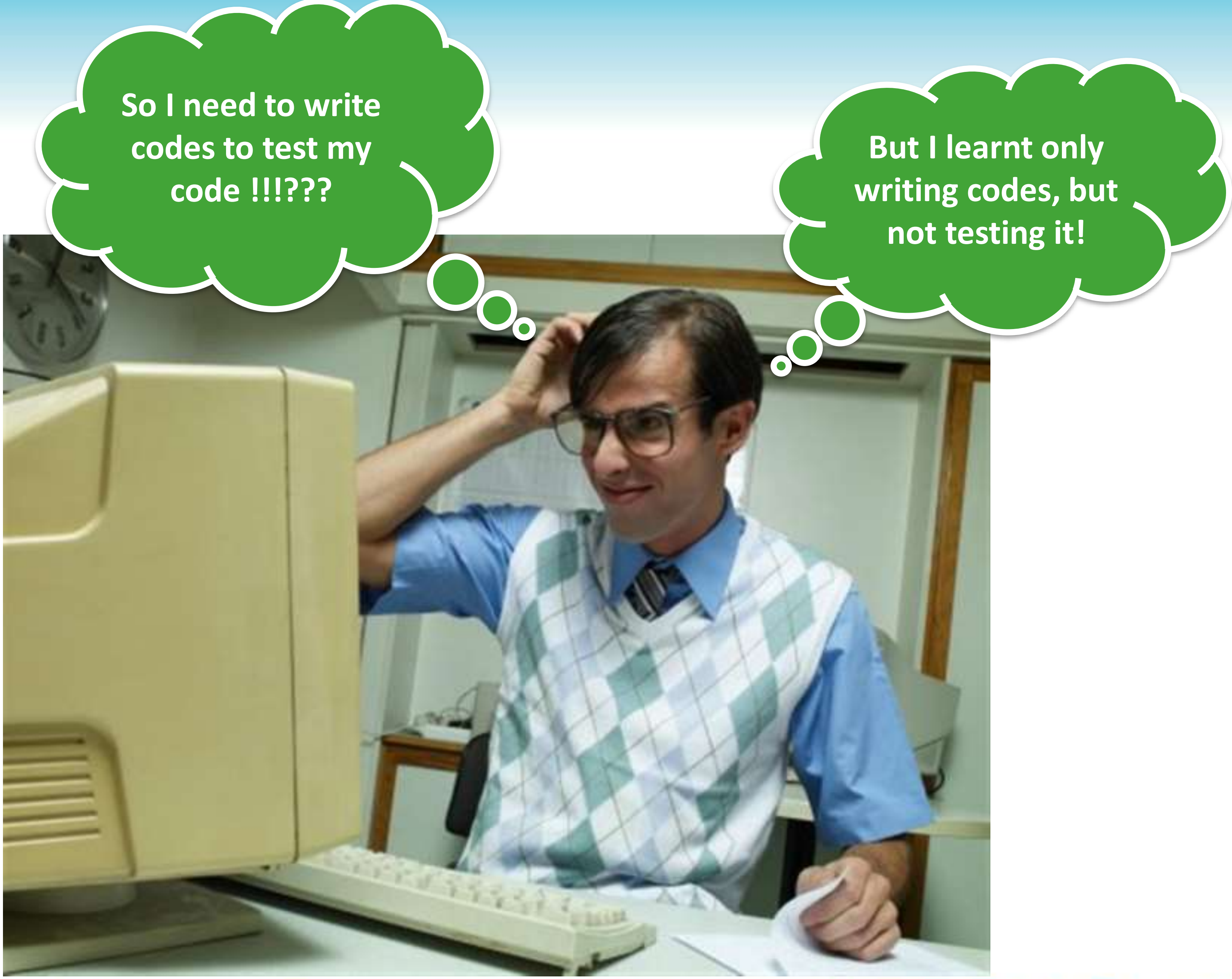
- TDD is NOT primarily about testing or development.
- It is rather about **software design**, where design is evolved through testing and refactoring.

TDD starts with Unit Testing

- In TDD, testing means **Unit Testing**
- Unit Testing is a testing technique by which individual units or components of a software are tested programmatically.



- Unit is the smallest testable part of any software.
- In OOP, smallest unit is a method of a class.
- Who is responsible for writing Unit Tests?
  - ~~Testers~~ Developers


So I need to write codes to test my code !!!???
But I learnt only writing codes, but not testing it!

Unit Testing Tools

JUnit	nunit
TestNG	xUnit.net
PyUnit	PHPUnit
RSpec	ScalaTest

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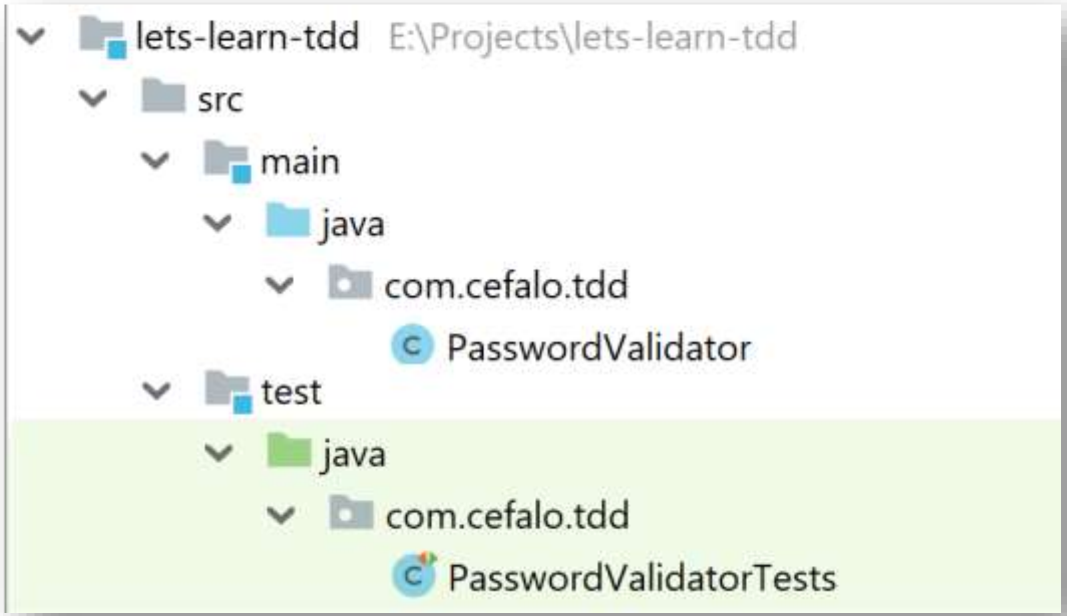
Unit Testing with JUnit

- JUnit is a popular unit testing framework for Java.
- Unit Tests are written like ordinary source codes.
- Source codes and corresponding unit tests are kept under **same package** name but in **different directories**.



```
lets-learn-tdd  E:\Projects\lets-learn-tdd
  src
    main
      java
        com.cefalo.tdd
          PasswordValidator
    test
      java
        com.cefalo.tdd
          PasswordValidatorTests
```

Installing JUnit 5

Gradle

```
dependencies {
  testImplementation("org.junit.jupiter:junit-jupiter-api:5.5.2")
  testRuntimeOnly("org.junit.jupiter:junit-jupiter-engine:5.5.2")
}
```

Maven

```
<dependencies>
  <dependency>
    <groupId>org.junit.jupiter</groupId>
    <artifactId>junit-jupiter-api</artifactId>
    <version>5.5.2</version>
    <scope>test</scope>
  </dependency>
  <dependency>
    <groupId>org.junit.jupiter</groupId>
    <artifactId>junit-jupiter-engine</artifactId>
    <version>5.5.2</version>
    <scope>test</scope>
  </dependency>
</dependencies>
```

JUnit Methods

- Annotations are used to mark a method as test method.
- Some helper methods might be needed to be executed before and/or after running a test method.
- All these methods must return “void” and take no parameters.
- A test method must have at least **one Assertion** in it.

JUnit5 Assert Methods

These methods are used in unit test methods for comparing expected and actual result. They are static methods in *org.junit.jupiter.api.Assertions* class.

Assert Method	Description

assertEquals()
assertNotEquals()
	Invokes the equals() methods on the arguments to check whether they are equal.

assertSame()
assertNotSame()
	Uses == on the arguments to check whether they are equal

assertTrue()
assertFalse()
	Checks if the given boolean argument evaluates to true or false

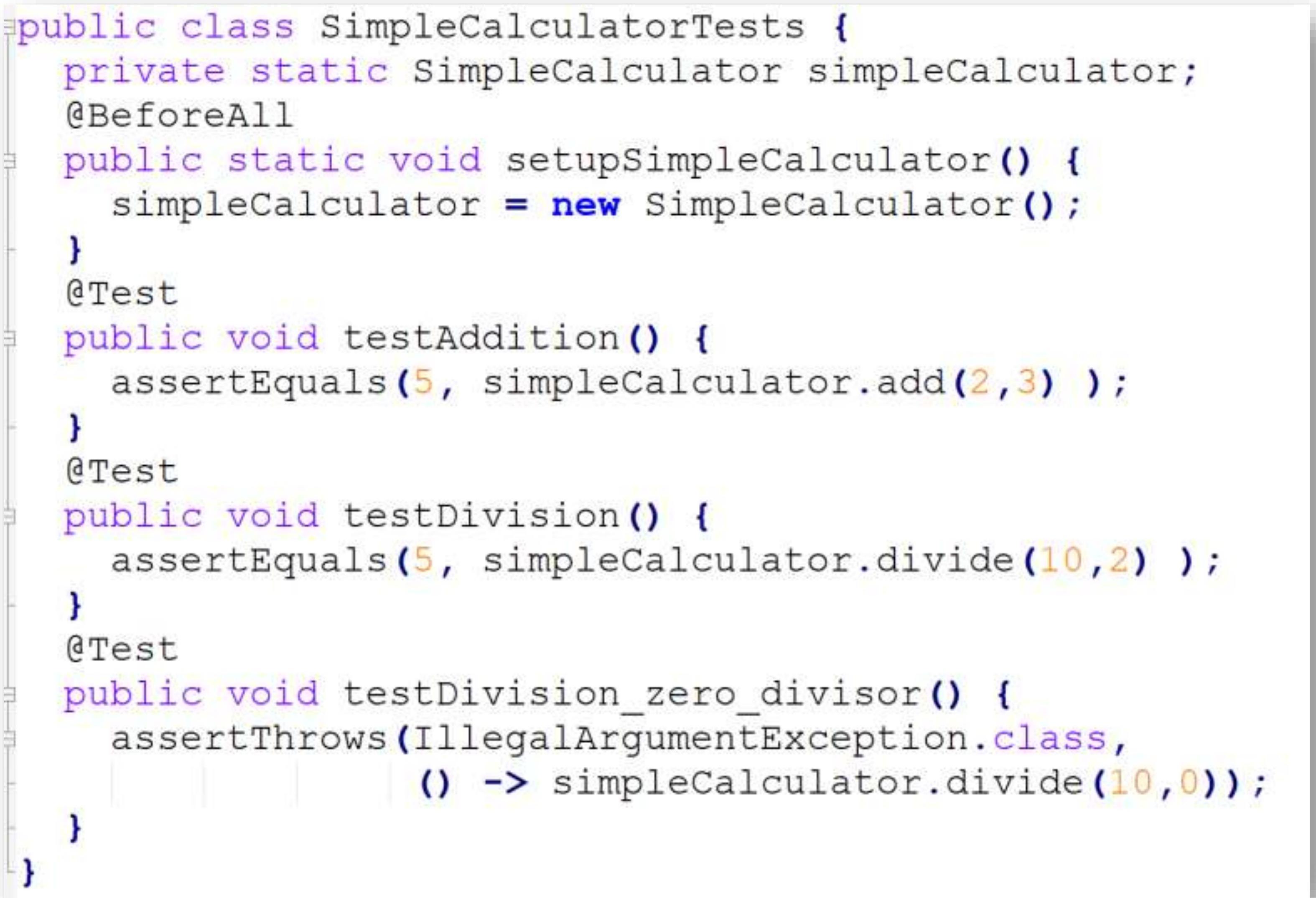
assertNull()
assertNotNull()
	Checks if the given argument is null or NOT null

assertArrayEquals()	Checks if the given array arguments passed have same elements in the same order
assertThrows()	Checks if the given code block throws an Exception and the type of the Exception matches with the given type.

JUnit5 Annotations

Annotation	Description
@Test	It is used to mark a method as a JUnit test. Referring to *org.junit.jupiter.api.Test*
@BeforeEach	The annotated method will be run before each test method in the test class. Referring to *org.junit.jupiter.api.BeforeEach*
@AfterEach	The annotated method will be run after each test method in the test class. Referring to *org.junit.jupiter.api.AfterEach*
@BeforeAll	The annotated method will be run before all test methods in the test class. This method must be static. Referring to *org.junit.jupiter.api.BeforeAll*
@AfterAll	The annotated method will be run after all test methods in the test class. This method must be static. Referring to *org.junit.jupiter.api.AfterAll*

Unit Test Example with JUnit5



```java
public class SimpleCalculatorTests {
  private static SimpleCalculator simpleCalculator;
  @BeforeAll
  public static void setupSimpleCalculator() {
    simpleCalculator = new SimpleCalculator();
  }
  @Test
  public void testAddition() {
    assertEquals(5, simpleCalculator.add(2,3) );
  }
  @Test
  public void testDivision() {
    assertEquals(5, simpleCalculator.divide(10,2) );
  }
  @Test
  public void testDivision_zero_divisor() {
    assertThrows(IllegalArgumentException.class,
                 () -> simpleCalculator.divide(10,0));
  }
}
```

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Unit Tests Best Practices

- Unit test cases should be independent. In case of any enhancements or change in requirements, unit test cases should not be affected.
- Follow clear and consistent naming conventions for your unit tests. Test name should reflect the intent/purpose of the test.
- In case of a change in code in any module, ensure there is a corresponding unit test case for the module, and the module passes the tests before changing the implementation.
- Bugs identified during unit testing must be fixed before proceeding to the next phase in SDLC
- Adopt a "test as your code" approach. The more code you write without testing, the more paths you have to check for errors.

Guidelines for writing Unit Tests

A test is not a Unit Test if:

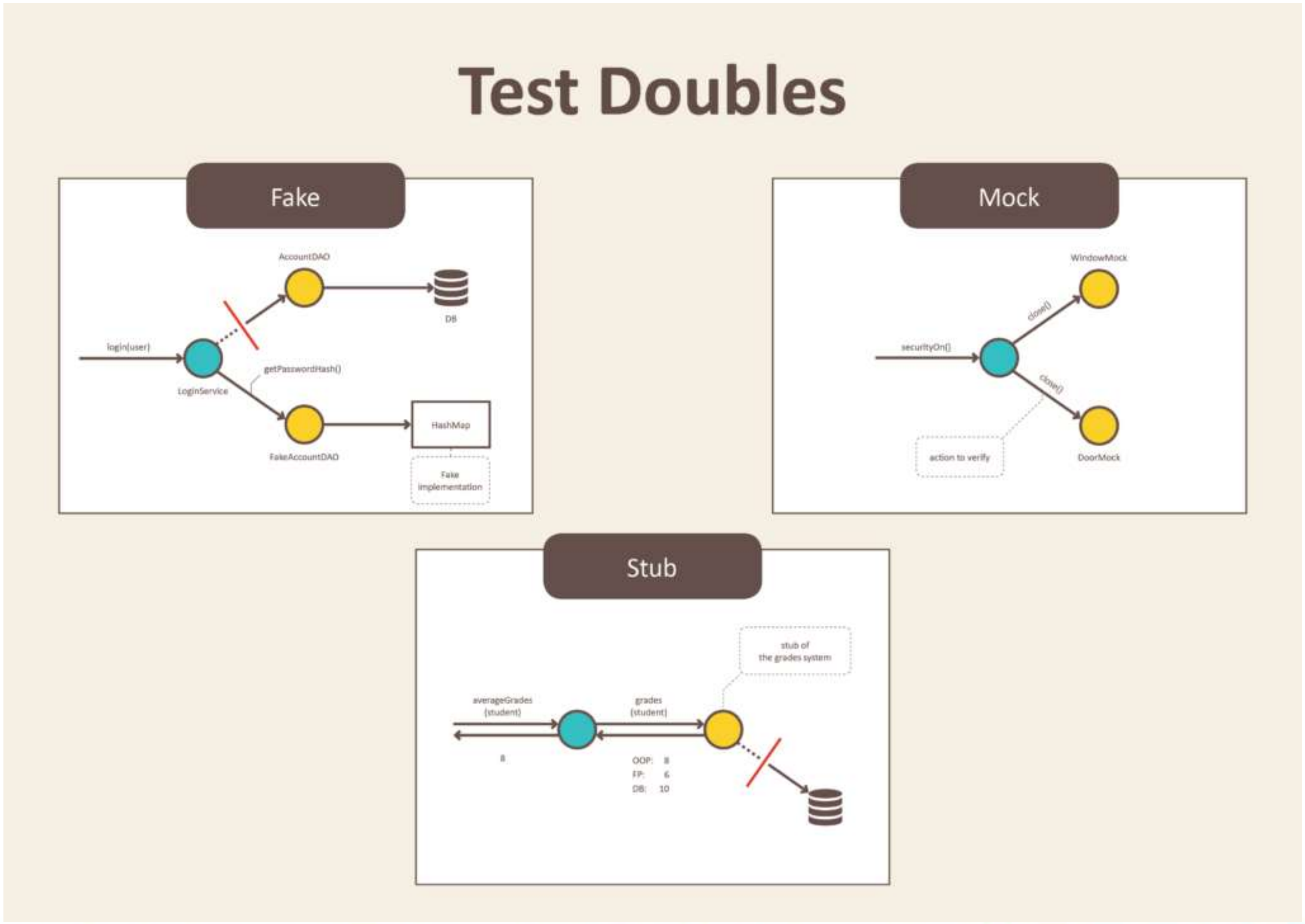
- It connects with the database
- It communicates across the network
- It touches the file system
- It can’t run at the same time as any of your other unit tests
- You have to do special things to your environment (such as editing config files) to run it.

— Michael Feathers,
A Set Of Unit Testing Rules (2005)

Test Doubles

- Unit test should test functionality in isolation.
- Side effects from other classes or the system should be eliminated for a unit test, if possible.
- This can be done via using test replacements (test doubles) for the real dependencies.
- Test double is an object that can stand in for a real object in a test, similar to how a stunt double stands in for an actor in a movie.

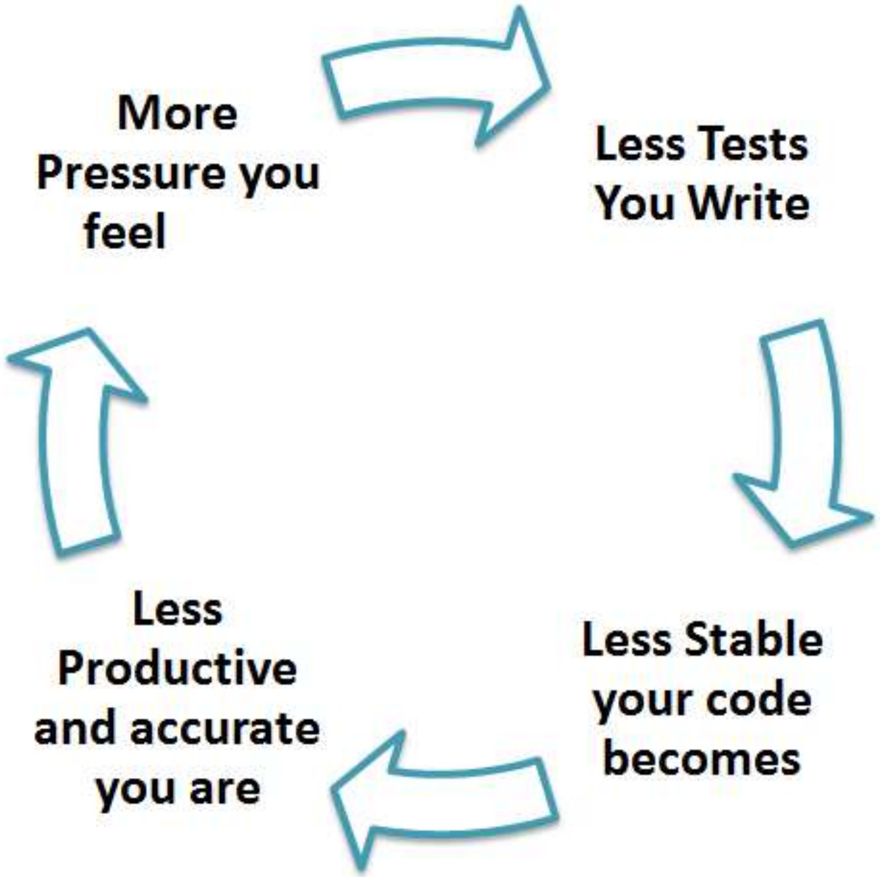
Test Doubles



Common Excuses against Unit Tests

- I am paid to write code, not tests!
- I am a developer, not tester - so I’m not responsible for writing tests!
- We already have testers - why do we need unit tests?
- We are working on a tight deadline - where do I have time for writing unit tests?
- I don’t know how to write unit tests
- Ours is legacy code - can’t write unit tests for them
- If I touch the code, it may break!

Myths lead to a Vicious Cycle


More Pressure you feel
Less Tests You Write
Less Stable your code becomes
Less Productive and accurate you are

"Never in the field of software engineering has so much been owed by so many to so few lines of code.”

– Martin Fowler on Unit Testing

But I already write unit tests!

- Just because, you write unit tests, doesn’t mean you follow TDD!
- Unit tests are often written after development (coding implementation)
  - That is called Plain Old Unit testing (POUting)
- However in TDD approach,
  Unit tests must be written first before development (coding implementation)

Unit testing after code: Disadvantages

- Testing does not give direct feedback to design and programming
  - But in TDD, the feedback is directly fed back into improving design and programs
- Most often, after implementing the functionality in code, unit testing is omitted.
  - TDD inverts this sequence and ensure all components have unit tests first before implementation
- Writing tests after developing code often results in “happy path” testing only!

Why Test First Approach?

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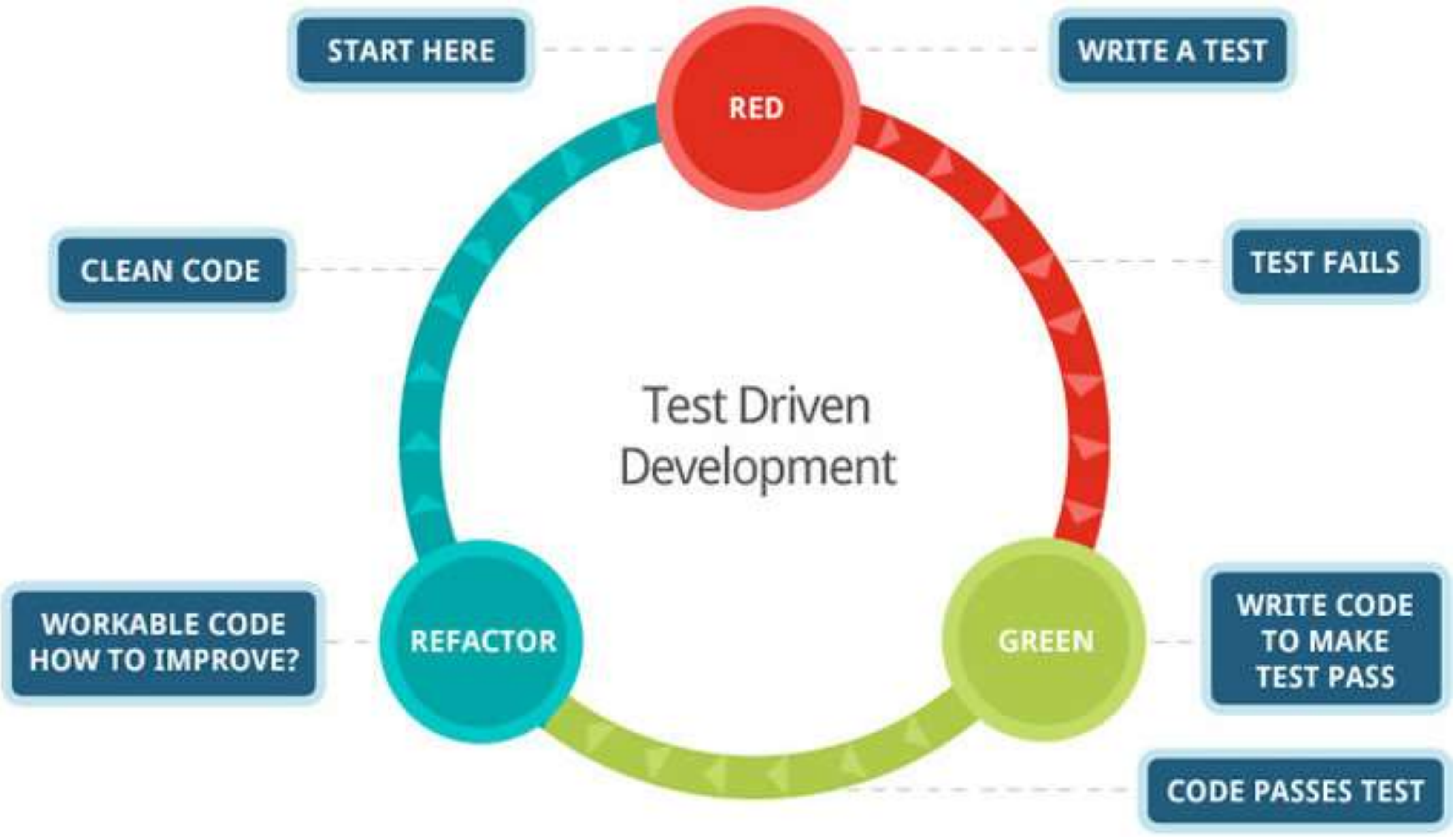
Why Test First Approach?

Test Driven Development Cycle



Step 1: Write test that fails

Red—write a little test that doesn't work, perhaps doesn't even compile at first!

Source: Test Driven Development: By Example, Kent Beck, 240 pages, Addison-Wesley Professional, 2002

Step 2: Get code working to pass test

Green — write minimal amount of code to make the test work, committing whatever sins necessary in the process.

Source: Test Driven Development: By Example, Kent Beck, 240 pages, Addison-Wesley Professional, 2002

Step 3: Cleanup and Refactor

- **Refactor** — eliminate all duplications and code smells, which may have been introduced while getting the test to pass in Step 2.

Source: Test Driven Development: By Example, Kent Beck, 240 pages, Addison-Wesley Professional, 2002

TDD Mantra

NEVER FORGET
ALWAYS REMEMBER
TDD
MAKE IT GREEN THEN MAKE IT CLEAN

TDD in action

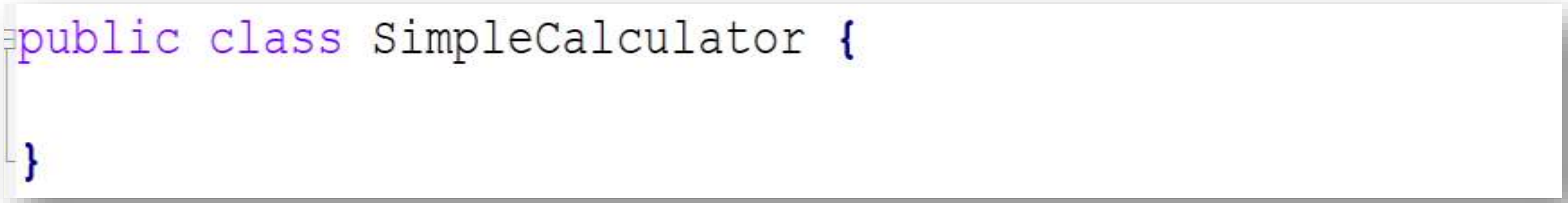
Let’s Build a Simple Calculator

- We will try to implement a simple calculator by applying TDD approach
- Let’s keep the requirements very simple.
- Our simple calculator will cover only 2 functions:
  - **Addition** of 2 given numbers
    - Input 2 numbers
    - Returns the sum of the 2 numbers
  - **Division** of one number by another number
    - Input 2 numbers – dividend and divisor
    - Returns the quotient of the 2 numbers
    - Note, divisor cannot be zero

TDD in action

SimpleCalculator Class

- Let’s start with an empty class
- We’ll gradually build up this through TDD



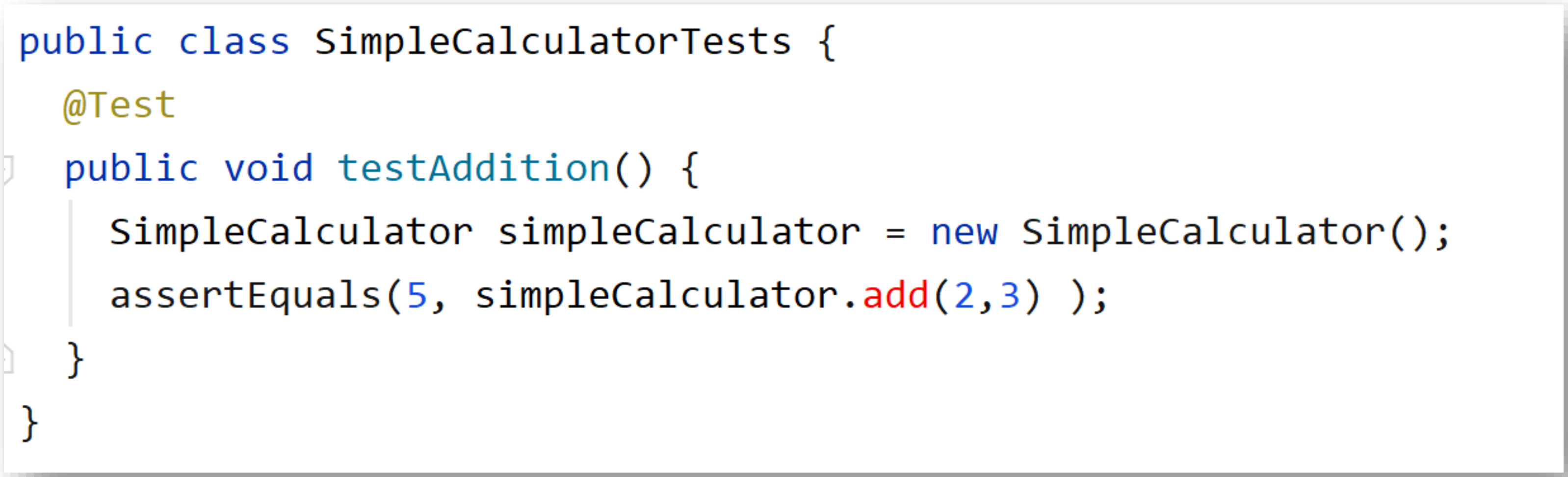
```
public class SimpleCalculator {

}
```

TDD in action

Test1: write a testcase for adding 2 numbers

– input any 2 numbers

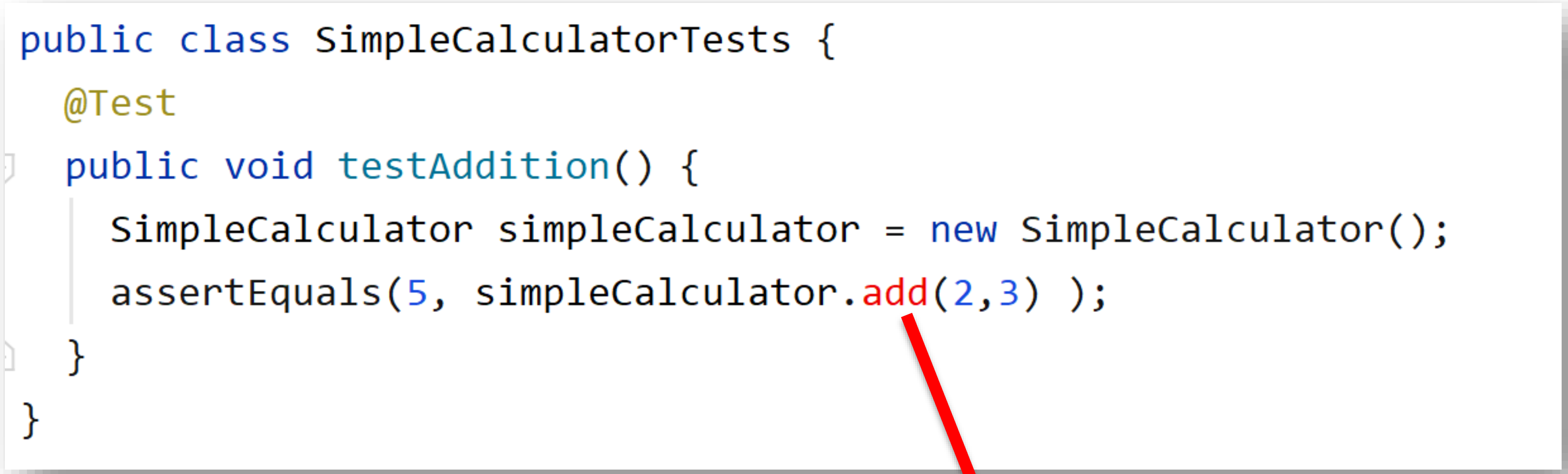
– expect to have the sum of them



```
public class SimpleCalculatorTests {
  @Test
  public void testAddition() {
    SimpleCalculator simpleCalculator = new SimpleCalculator();
    assertEquals(5, simpleCalculator.add(2,3) );
  }
}
```

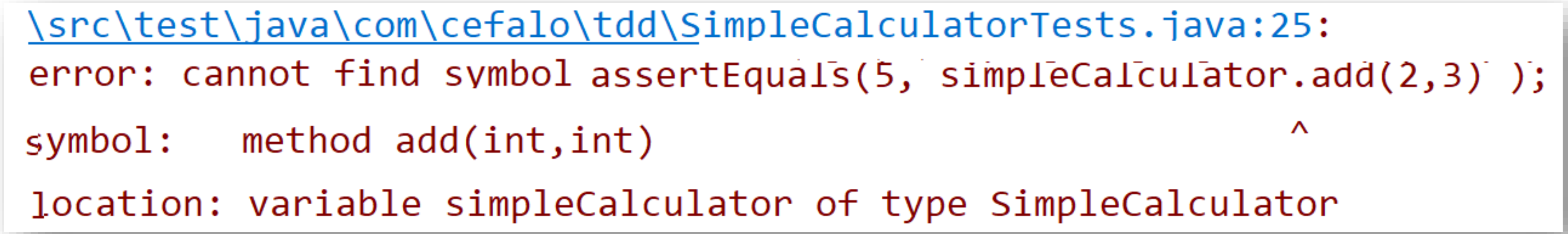
TDD in action

But our test for addition fails!



```
public class SimpleCalculatorTests {
  @Test
  public void testAddition() {
    SimpleCalculator simpleCalculator = new SimpleCalculator();
    assertEquals(5, simpleCalculator.add(2,3) );
  }
}
```

Error:

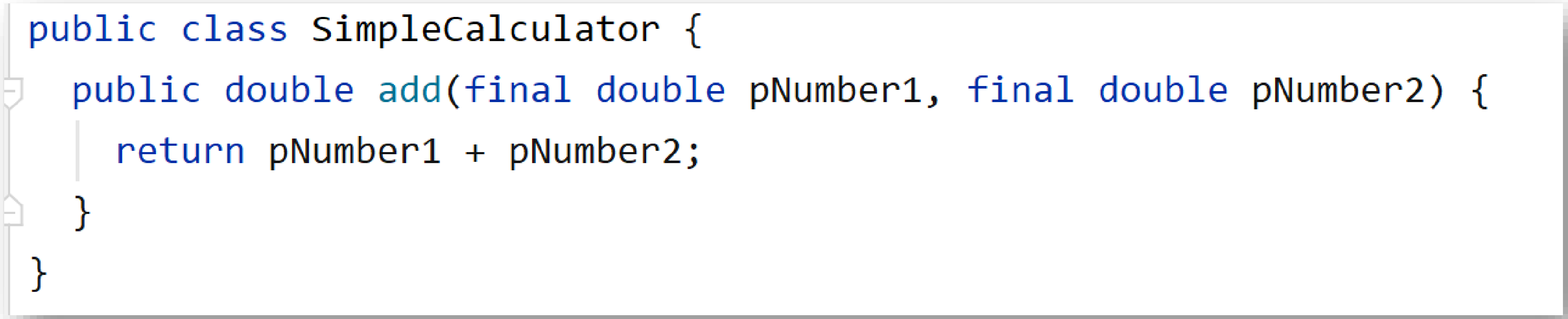


```
\src\test\java\com\cefalo\tdd\SimpleCalculatorTests.java:25:
error: cannot find symbol assertEquals(5, simpleCalculator.add(2,3) );
symbol:   method add(int,int)                                ^
location: variable simpleCalculator of type SimpleCalculator
```

TDD in action

In SimpleCalculator class, we'll write bear minimum amount of code to

- fix the error by introducing add() method
- Pass the test for adding 2 numbers



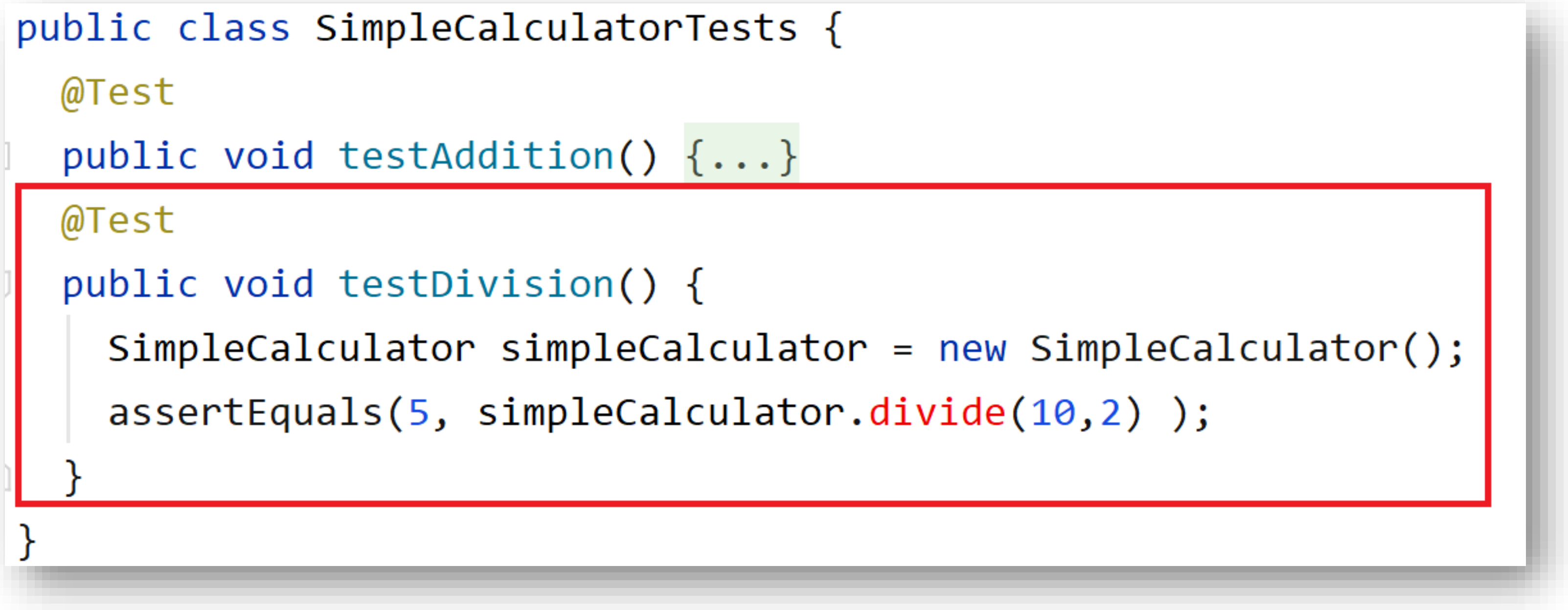
```
public class SimpleCalculator {
  public double add(final double pNumber1, final double pNumber2) {
    return pNumber1 + pNumber2;
  }
}
```

- Change it until we make it RED to GREEN!

TDD in action

Test2: write a testcase for division of 2 numbers

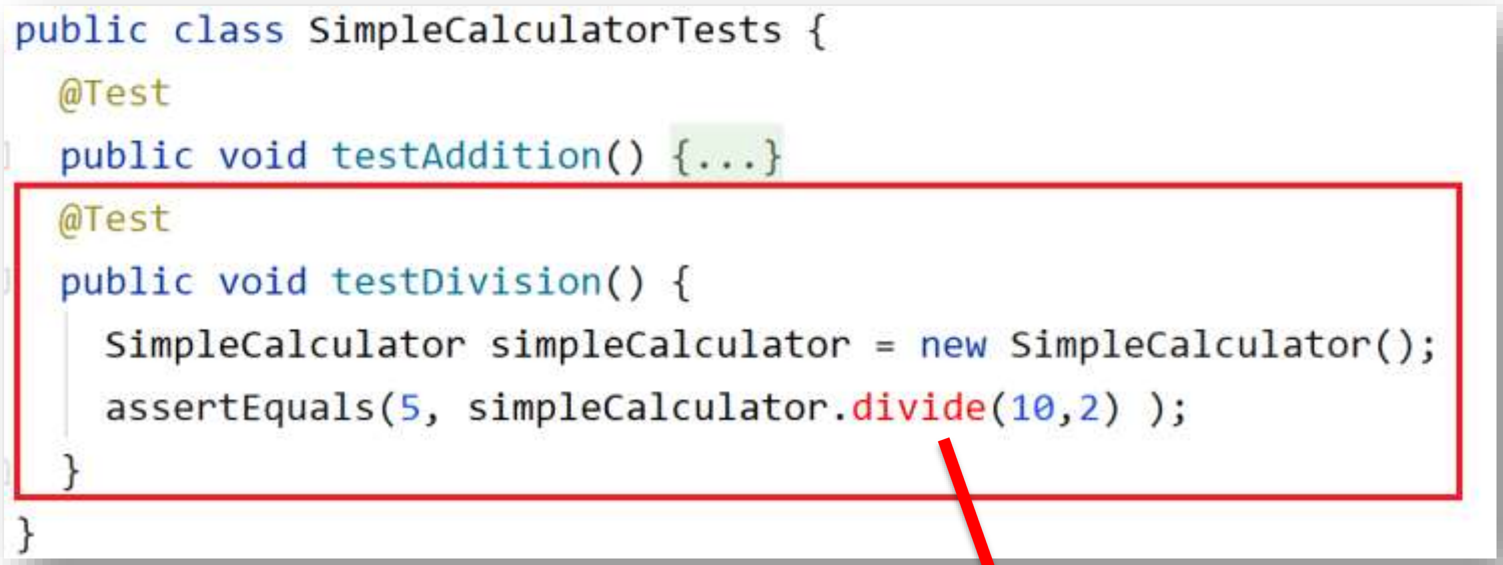
- input 2 numbers: dividend and divisor
- expect to have the quotient



```
public class SimpleCalculatorTests {
  @Test
  public void testAddition() {...}
  @Test
  public void testDivision() {
    SimpleCalculator simpleCalculator = new SimpleCalculator();
    assertEquals(5, simpleCalculator.divide(10,2) );
  }
}
```

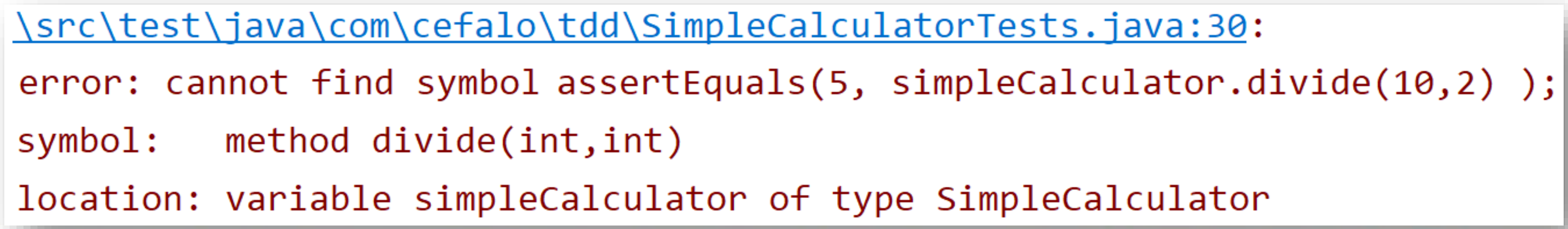
TDD in action

But our test for division also fails!



```
public class SimpleCalculatorTests {
  @Test
  public void testAddition() {...}
  @Test
  public void testDivision() {
    SimpleCalculator simpleCalculator = new SimpleCalculator();
    assertEquals(5, simpleCalculator.divide(10,2) );
  }
}
```

Error:



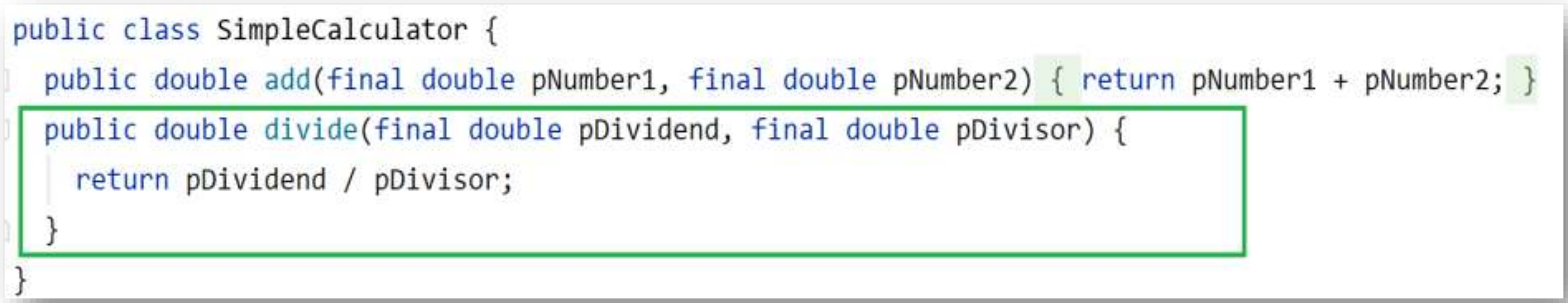
```
\src\test\java\com\cefalo\tdd\SimpleCalculatorTests.java:30:
error: cannot find symbol assertEquals(5, simpleCalculator.divide(10,2) );
symbol:   method divide(int,int)
location: variable simpleCalculator of type SimpleCalculator
```

TDD in action

In SimpleCalculator class, we'll write bear minimum amount of code to

– fix the error by introducing divide() method

– Pass the test for division of 2 numbers



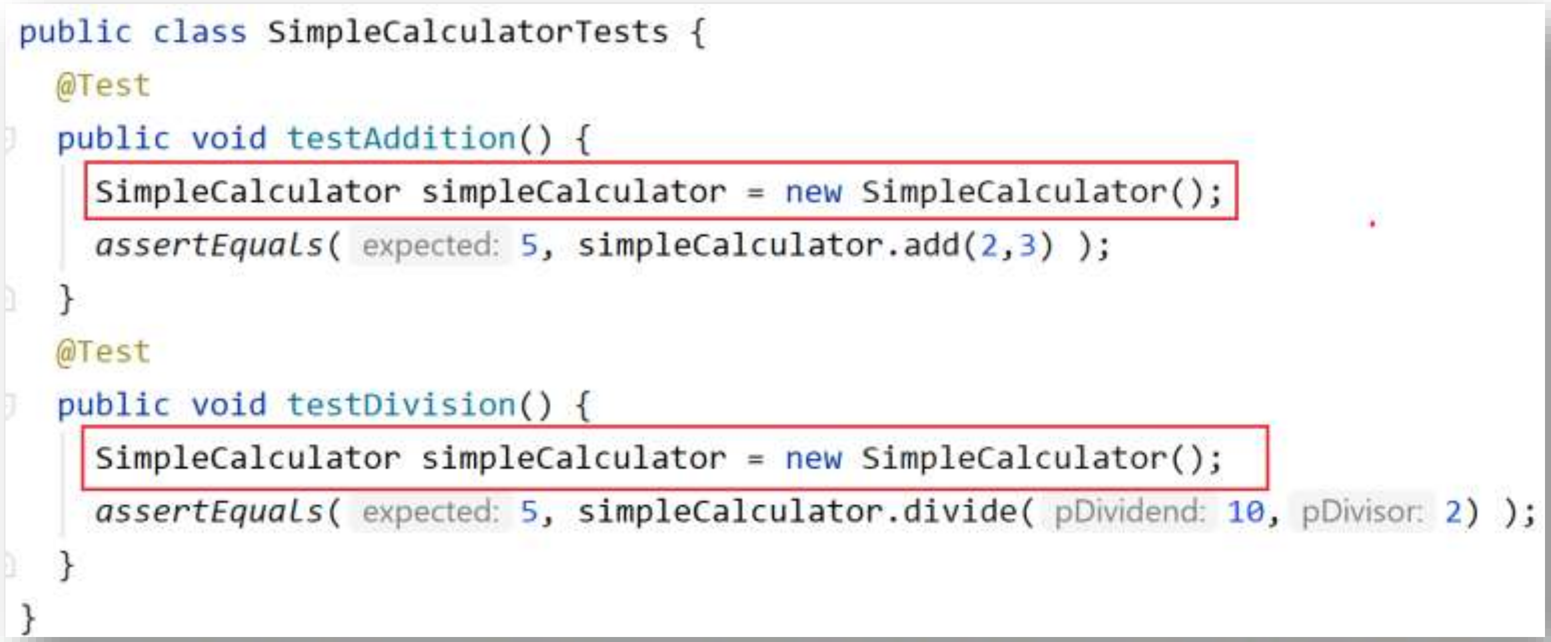
```
public class SimpleCalculator {
  public double add(final double pNumber1, final double pNumber2) { return pNumber1 + pNumber2; }
  public double divide(final double pDividend, final double pDivisor) {
    return pDividend / pDivisor;
  }
}
```

– The goal is to pass the failing test somehow.

TDD in action

Refactor

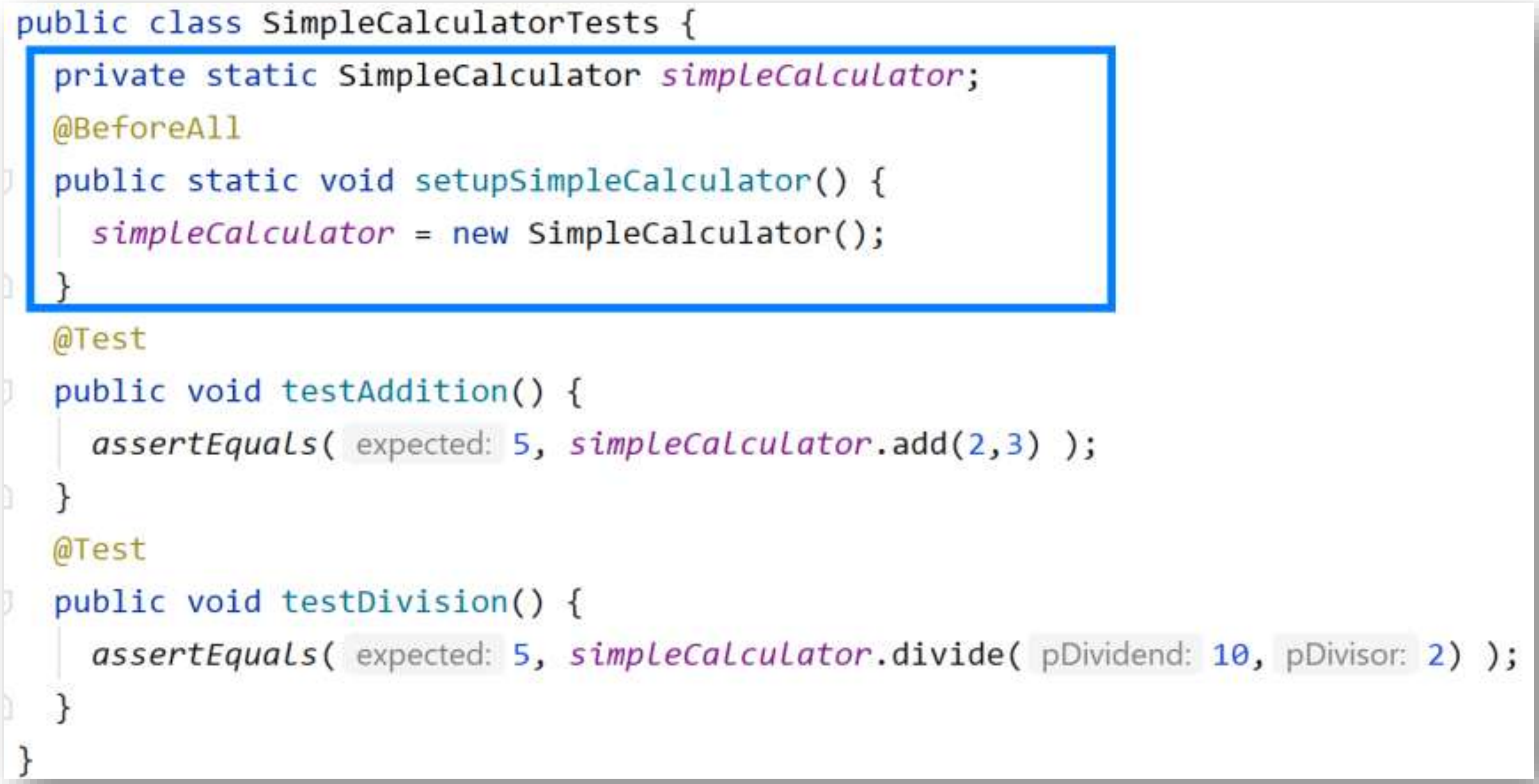
- Look for any code smells, duplicates in main and test class and refactor them.
- Make sure, the test result doesn't get affected!



```
public class SimpleCalculatorTests {
  @Test
  public void testAddition() {
    SimpleCalculator simpleCalculator = new SimpleCalculator();
    assertEquals( expected: 5, simpleCalculator.add(2,3) );
  }
  @Test
  public void testDivision() {
    SimpleCalculator simpleCalculator = new SimpleCalculator();
    assertEquals( expected: 5, simpleCalculator.divide( pDividend: 10, pDivisor: 2) );
  }
}
```

TDD in action

Refactor the Code Smells



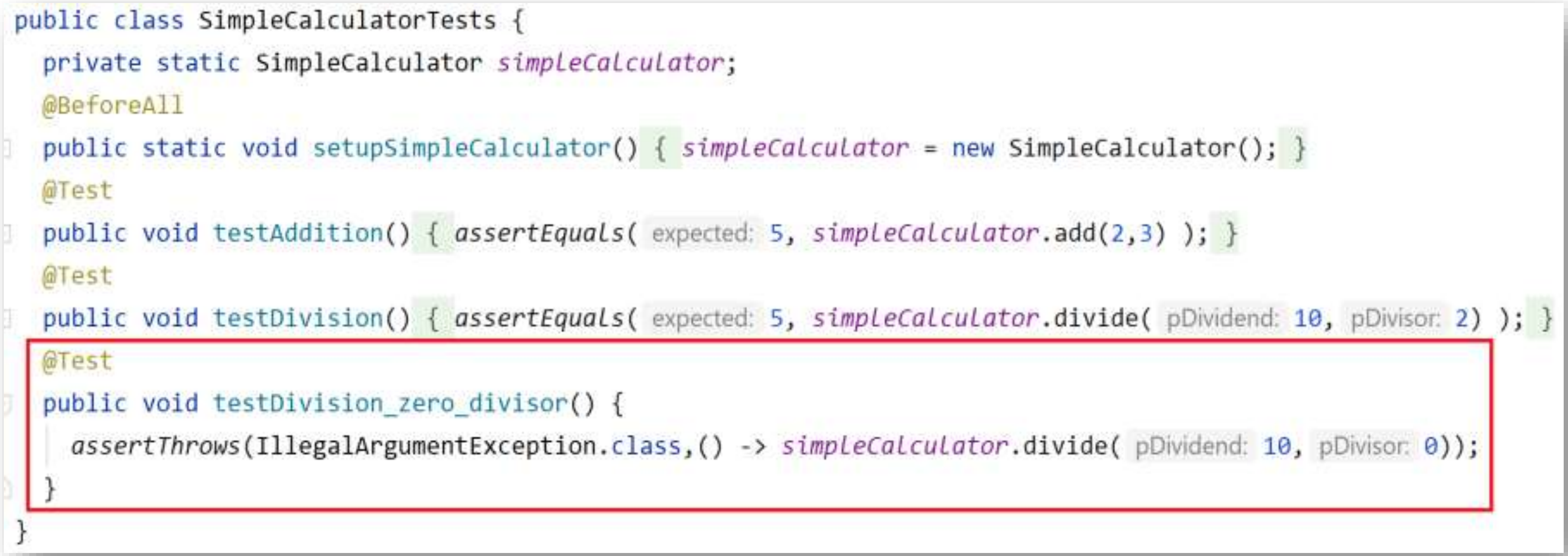
```
public class SimpleCalculatorTests {
    private static SimpleCalculator simpleCalculator;
    @BeforeAll
    public static void setupSimpleCalculator() {
        simpleCalculator = new SimpleCalculator();
    }
    @Test
    public void testAddition() {
        assertEquals( expected: 5, simpleCalculator.add(2,3) );
    }
    @Test
    public void testDivision() {
        assertEquals( expected: 5, simpleCalculator.divide( pDividend: 10, pDivisor: 2) );
    }
}
```

TDD in action

Test3: write a testcase for division with 0 as divisor

– input any number as dividend and 0 as divisor

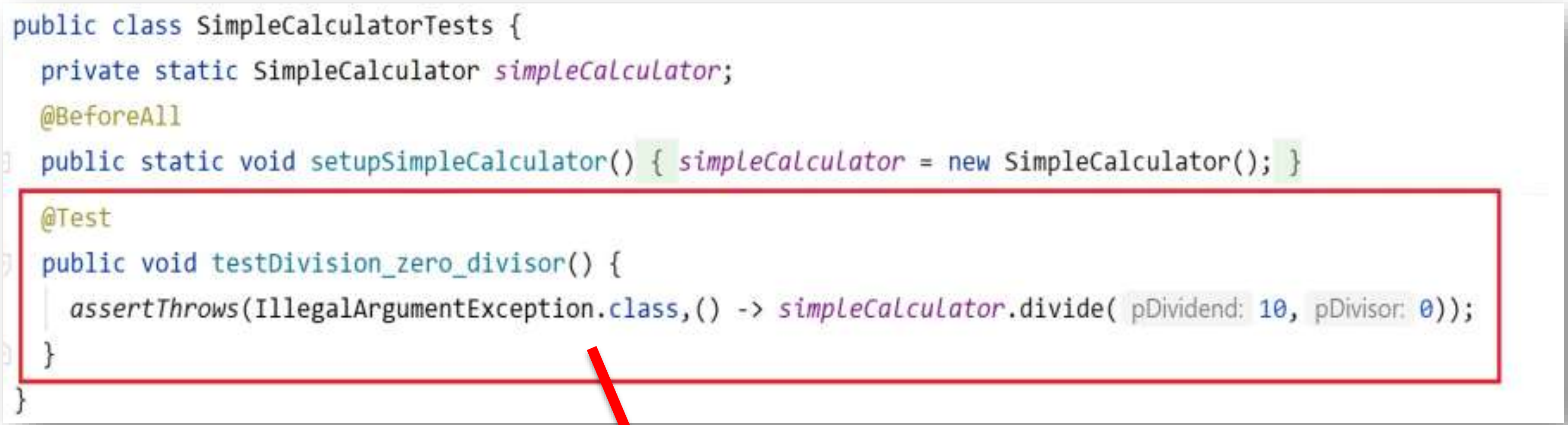
– Let’s expect to have IllegalArgumentException



```
public class SimpleCalculatorTests {
  private static SimpleCalculator simpleCalculator;
  @BeforeAll
  public static void setupSimpleCalculator() { simpleCalculator = new SimpleCalculator(); }
  @Test
  public void testAddition() { assertEquals( expected: 5, simpleCalculator.add(2,3) ); }
  @Test
  public void testDivision() { assertEquals( expected: 5, simpleCalculator.divide( pDividend: 10, pDivisor: 2) ); }
  @Test
  public void testDivision_zero_divisor() {
    assertThrows(IllegalArgumentException.class,() -> simpleCalculator.divide( pDividend: 10, pDivisor: 0));
  }
}
```

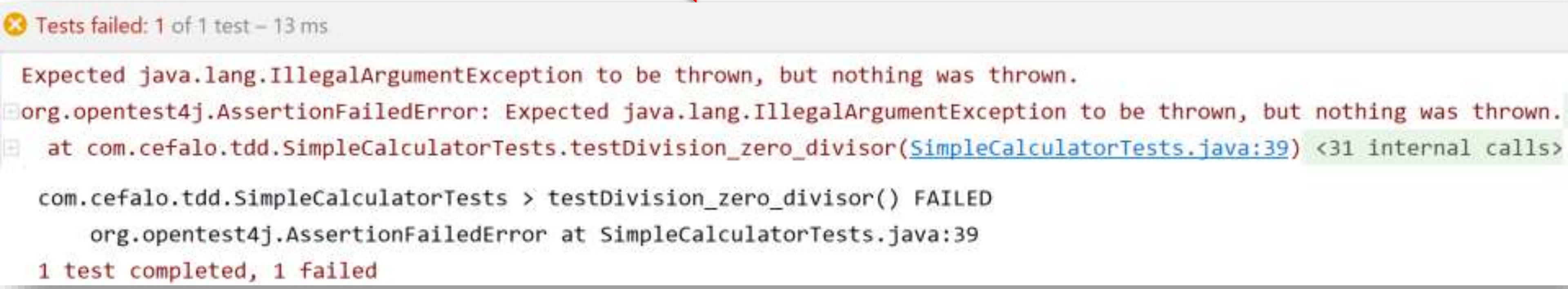
TDD in action

But our 0 divisor test fails!



```
public class SimpleCalculatorTests {
  private static SimpleCalculator simpleCalculator;
  @BeforeAll
  public static void setupSimpleCalculator() { simpleCalculator = new SimpleCalculator(); }
  @Test
  public void testDivision_zero_divisor() {
    assertThrows(IllegalArgumentException.class,() -> simpleCalculator.divide( pDividend: 10, pDivisor: 0));
  }
}
```

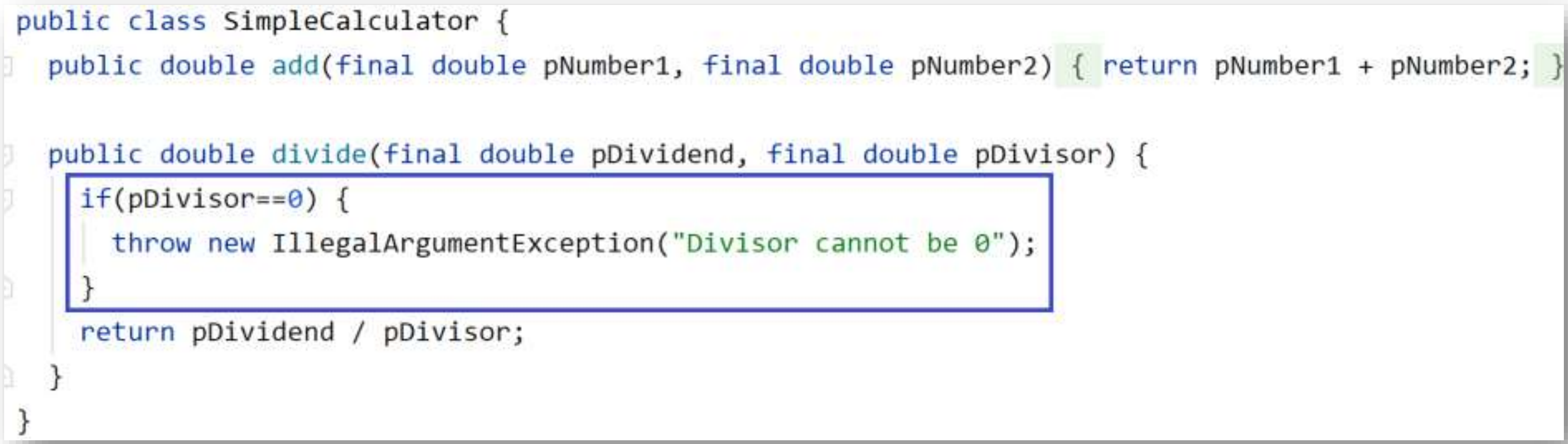
Error:



```
Tests failed: 1 of 1 test – 13 ms

Expected java.lang.IllegalArgumentException to be thrown, but nothing was thrown.
org.opentest4j.AssertionFailedError: Expected java.lang.IllegalArgumentException to be thrown, but nothing was thrown.
  at com.cefalo.tdd.SimpleCalculatorTests.testDivision_zero_divisor(SimpleCalculatorTests.java:39) <31 internal calls>

 com.cefalo.tdd.SimpleCalculatorTests > testDivision_zero_divisor() FAILED
     org.opentest4j.AssertionFailedError at SimpleCalculatorTests.java:39
 1 test completed, 1 failed
```

TDD in action

Now, we'll just need to throw IllegalArgumentException, if divisor is 0.



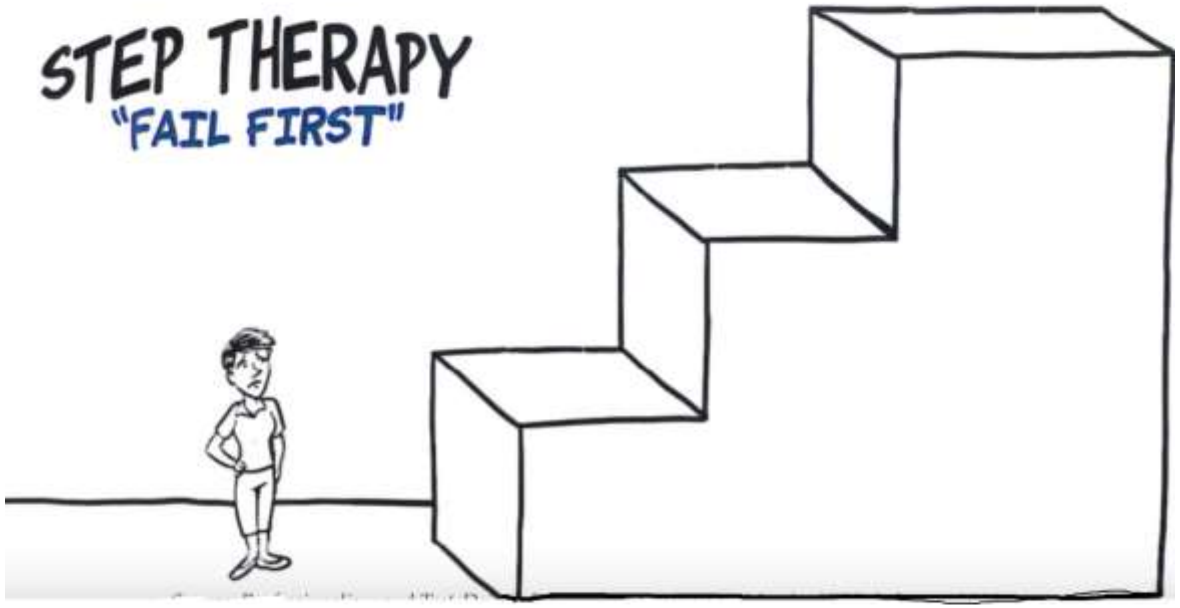
```
public class SimpleCalculator {
  public double add(final double pNumber1, final double pNumber2) { return pNumber1 + pNumber2; }

  public double divide(final double pDividend, final double pDivisor) {
    if(pDivisor==0) {
      throw new IllegalArgumentException("Divisor cannot be 0");
    }
    return pDividend / pDivisor;
  }
}
```

This small change is enough to pass the test.

3 Laws of TDD

Uncle Bob's **First law** of *Testto Dynamics*:

You may not write production code unless you've first written a failing unit test.



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3 Laws of TDD (cont.)

Uncle Bob's **Second law** of *Testto Dynamics*:

You may not write any more of a unit test than is sufficient to fail.

3 Laws of TDD (cont.)

Uncle Bob's **Third law** of *Testto Dynamics*:

You may not write more production code than is sufficient to make the failing unit test pass.

Summarize Uncle Bob’s rules for TDD

- Start with a small unit test, that fails
- Write bare minimum code to make the failing test pass
- Refactor the code smells without affecting functionality and test result
- Continue the above 3 steps until you have any failing unit tests

Benefits of TDD

Cleaner Code	Testable SOLID Code
Self-documenting Unit Tests	Increased Quality, Reduced Bugs
Maintainable and Extensible Code	Happy-path and Unhappy path Testing
Safer Refactoring	Faster Debugging

When not to use TDD?

- Developers must be experienced in writing tests before implementing TDD.
- More suited for implementing complex business logic, back-end systems etc.
- Can be overhead for very simple projects.
- Not suitable for UI development.
- Can backfire when the environment is not suitable or it is used incorrectly.

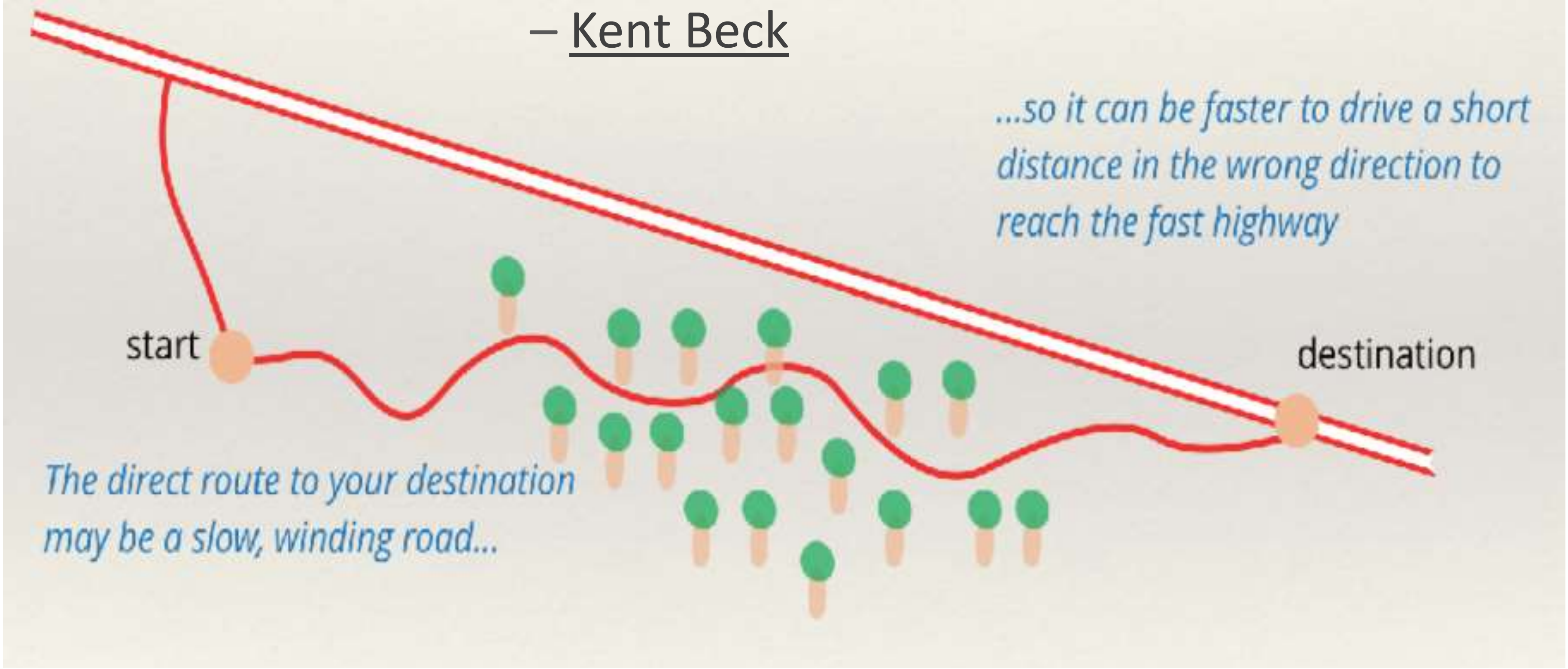
Does TDD guarantee Good Code?

"TDD helps with, but does not guarantee, good design & good code. **Skill**, **talent**, and **expertise** remain necessary."

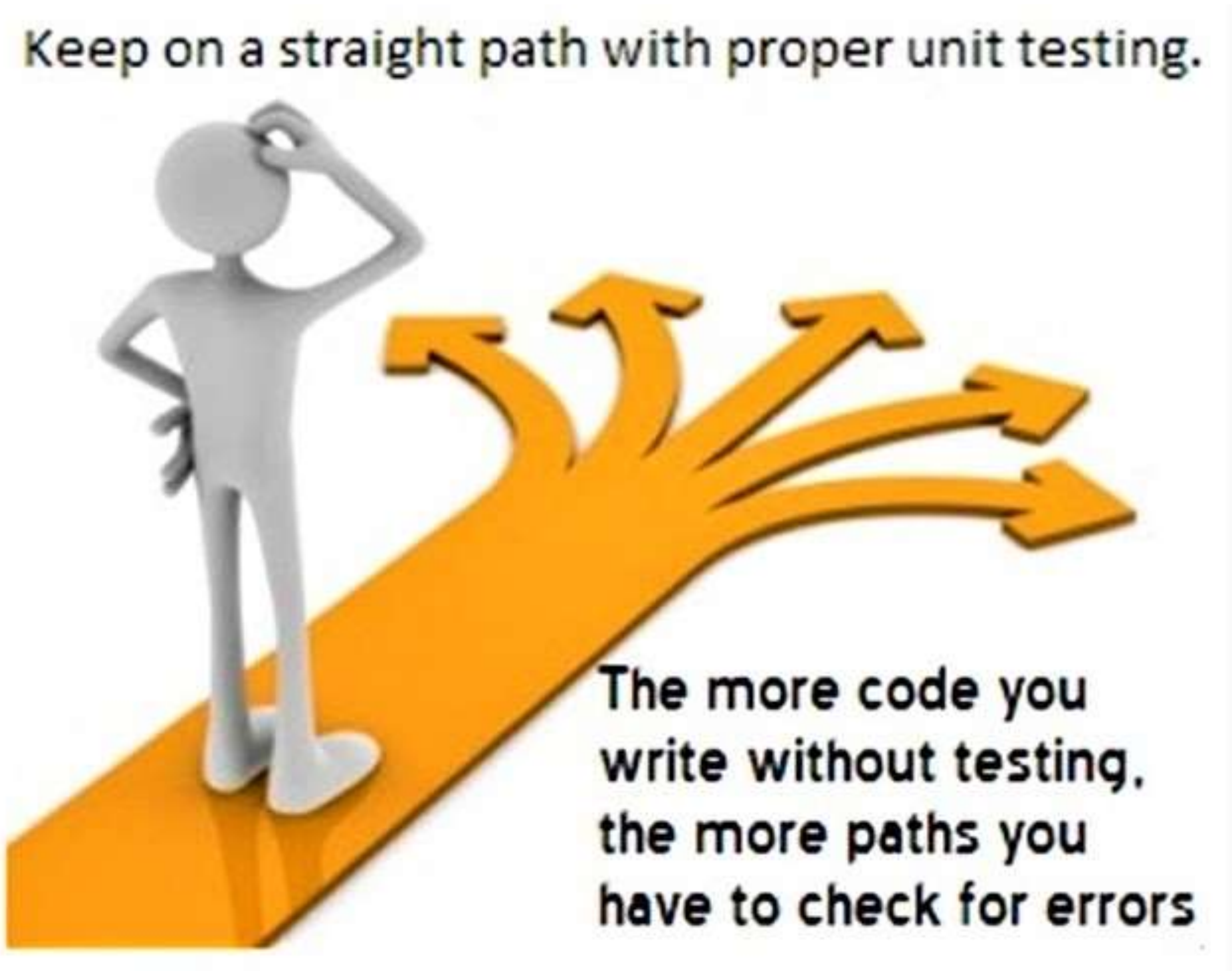
— Esko Luontola

TDD slows down Development?

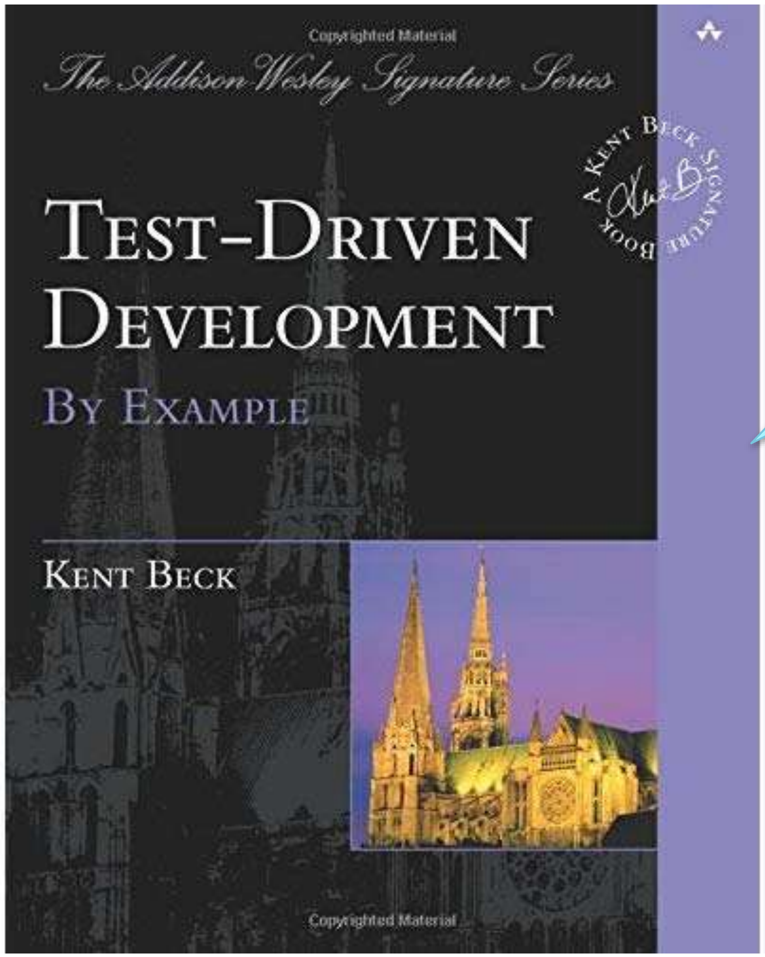
"I can write code a lot faster if it doesn't have to work!"
– Kent Beck


...so it can be faster to drive a short distance in the wrong direction to reach the fast highway
start
destination
The direct route to your destination may be a slow, winding road...

Follow the straight path!


Keep on a straight path with proper unit testing.
The more code you write without testing, the more paths you have to check for errors

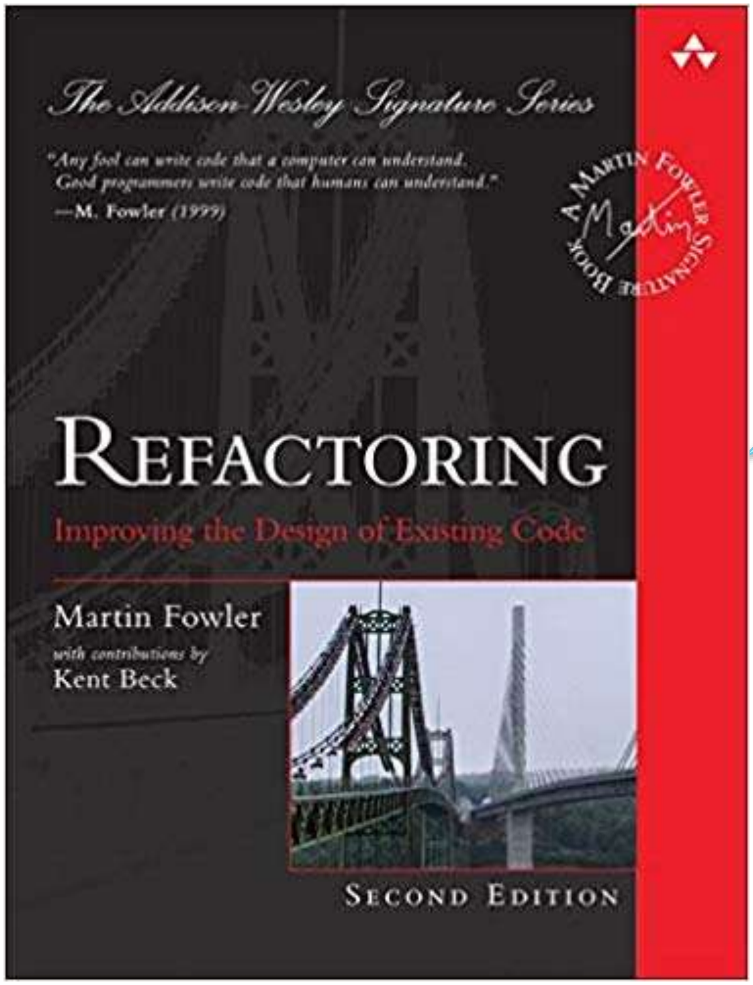
Recommended Reading



Must read on TDD by its originator Kent Beck

Test Driven Development: By Example, by Kent Beck

Recommended Reading


The Addison-Wesley Signature Series

"Any fool can write code that a computer can understand. Good programmers write code that humans can understand."
—M. Fowler (1999)

A Martin Fowler Signature Book

REFACTORING

Improving the Design of Existing Code

Martin Fowler

with contributions by

Kent Beck

SECOND EDITION

Covers refactoring of code smells by design principles & best practices!

Refactoring: Improving the Design of Existing Code, by Martin Fowler

Useful Links

- GitHub Repository
  https://github.com/Cefalo/lets-learn-tdd

- https://www.freecodecamp.org/news/test-driven-development-what-it-is-and-what-it-is-not-41fa6bca02a2/

- https://hackernoon.com/introduction-to-test-driven-development-tdd-61a13bc92d92

- https://www.guru99.com/test-driven-development.html

- http://agiledata.org/essays/tdd.html

Thank You!

Question & Answers

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