# Unit Test

2023-1 KNU SCSE Software Testing Theory

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- Unit test using JUnit
- Test Driven Development (TDD)

# Unit Test

## Using JUnit

(Contents of this slides are borrowed from the lecture slides of Introduction to Software Testing by Ammann && Offutt )


- Open source Java testing framework used to write and run repeatable automated tests
- JUnit is open source (junit.org)
- A structure for writing test drivers
- JUnit features include:
  - Assertions for testing expected results
  - Test features for sharing common test data
  - Test suites for easily organizing and running tests
  - Graphical and textual test runners
- JUnit is widely used in industry
- JUnit can be used as stand alone Java programs (from the command line) or within an IDE such as Eclipse

# JUnit Test

- JUnit can be used to test ...
  - ... an entire object
  - ... part of an object – a method or some interacting methods
  - ... interaction between several objects
- It is primarily intended for unit and integration testing, not system testing
- Each test is embedded into one test method
- A test class contains one or more test methods
- Test classes include :
  - A collection of test methods
  - Methods to set up the state before and update the state after each test and before and after all tests
- Get started at junit.org

# Writing Tests for JUnit

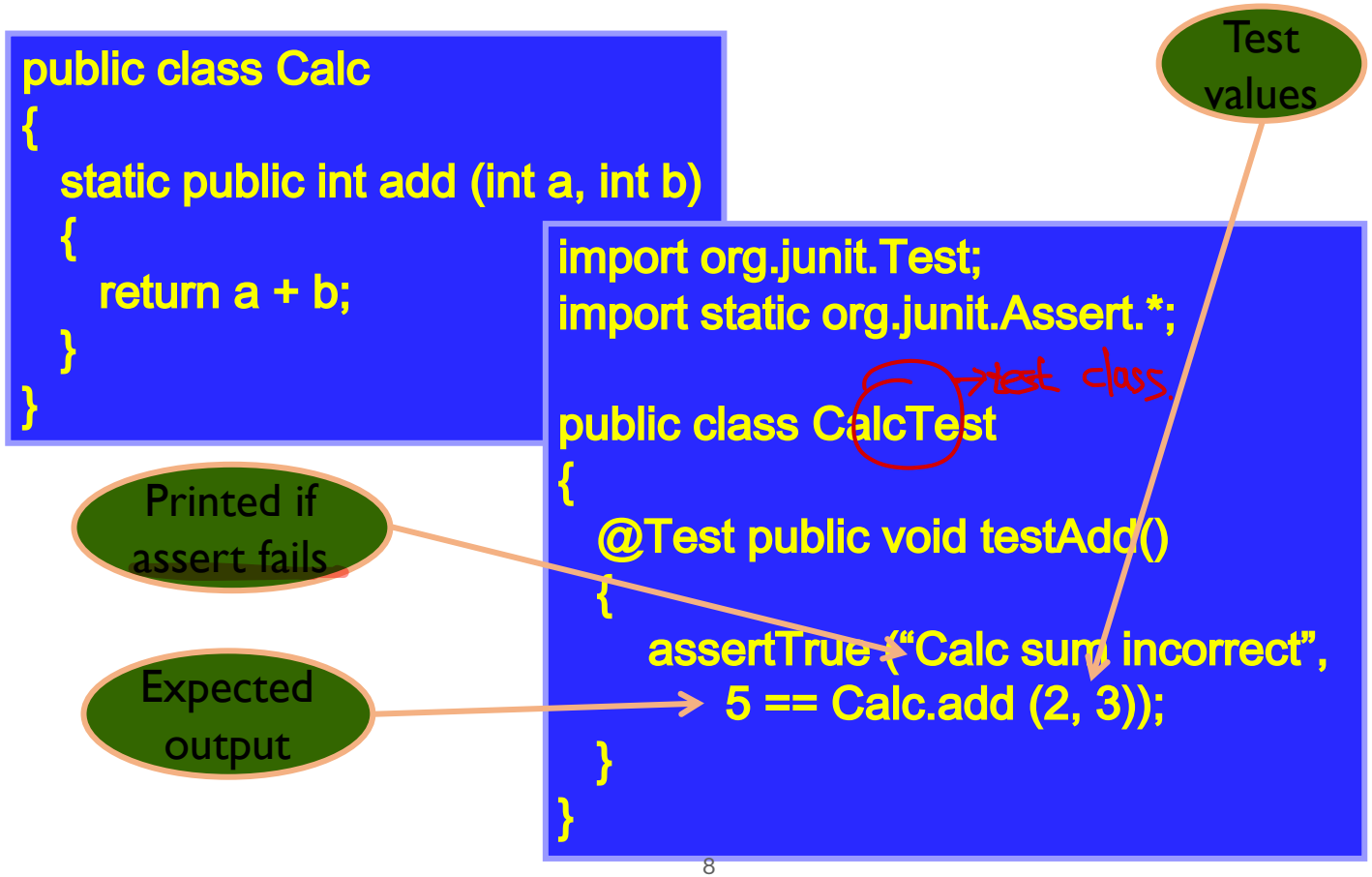

- Need to use the methods of the junit.framework.assert class
  - javadoc gives a complete description of its capabilities
- Each test method checks a condition (assertion) and reports to the test runner whether the test failed or succeeded
- The test runner uses the result to report to the user (in command line mode) or update the display (in an IDE)
- All of the methods return void
- A few representative methods of junit.framework.assert
  - assertTrue (boolean)
  - assertTrue (String, boolean)
  - fail (String)

# JUnit Test Fixtures

- A test fixture is the state of the test
  - Objects and variables that are used by more than one test
  - Initializations (prefix values)
  - Reset values (postfix values)
- Different tests can use the objects without sharing the state
- Objects used in test fixtures should be declared as instance variables
- They should be initialized in a @Before method
- Can be deallocated or reset in an @After method

# Example

## JUnit4



# Testing Min Class

```
import java.util.*;

public class Min
{
  /**
    * Returns the mininum element in a list
    * @param list Comparable list of elements to search
    * @return the minimum element in the list
    * @throws NullPointerException if list is null or
    *         if any list elements are null
    * @throws ClassCastException if list elements are
not mutually comparable
    * @throws IllegalArgumentException if list is empty
    */
     …
}
```

```
public static <T extends Comparable<? super T>> T min
(List<? extends T> list)
   {
      if (list.size() == 0)
      {
        throw new IllegalArgumentException ("Min.min");
      }
      Iterator<? extends T> itr = list.iterator();
      T result = itr.next();

      if (result == null) throw new NullPointerException
("Min.min");

      while (itr.hasNext())
      {   // throws NPE, CCE as needed
         T comp = itr.next();
         if (comp.compareTo (result) < 0)
         {
            result = comp;
      } }
      return result;
}
```

# MinTest Class

Standard imports for all JUnit classes

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

Test fixture and pre-test setup method (prefix) :

```
private List<String> list;   // Test fixture

// Set up - Called before every test method.
@Before
 public void setUp()
 {
    list = new ArrayList<String>();
 }
```

nPost test teardown method (postfix) :

```
// Tear down - Called after every test method.
@After
public void tearDown()
{
   list = null;   // redundant in this example
}
```

# Min Test Cases: NullPointerException

```
@Test public void testForNullList()
{
  list = null;
  try {
     Min.min (list);
  } catch (NullPointerException e) {
     return;
  }
  fail ("NullPointerException expected");
}
```

Using fail assertion

NullPointerException test

```
@Test (expected = NullPointerException.class)
public void testForNullElement()
{
    list.add (null);
    list.add ("cat");
    Min.min (list);
}
```

```
@Test (expected = NullPointerException.class)
public void testForSoloNullElement()
{
    list.add (null);
    Min.min (list);
}
```

Catching an easily overlooked special case

# More Exception Test Cases for Min

```
@Test (expected = ClassCastException.class)
@SuppressWarnings ("unchecked")
public void testMutuallyIncomparable()
{
   List list = new ArrayList();
   list.add ("cat");
   list.add ("dog");
   list.add (1);
   Min.min (list);
}
```

Java generics do not prevent clients from using raw types

```
@Test (expected = IllegalArgumentException.class)
public void testEmptyList()
{
     Min.min (list);
}
```

Special case: Testing for the empty list

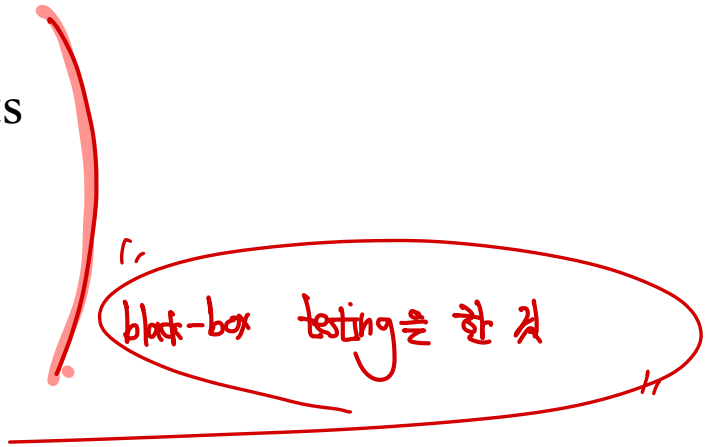
# Remaining Test Cases for Min

```
@Test
public void testSingleElement()
{
    list.add ("cat");
    Object obj = Min.min (list);
    assertTrue ("Single Element List", obj.equals ("cat"));
}

@Test
 public void testDoubleElement()
 {
    list.add ("dog");
    list.add ("cat");
    Object obj = Min.min (list);
    assertTrue ("Double Element List", obj.equals ("cat"));
 }
```

**Finally! A couple of "Happy Path" tests**

# Summary: Seven Tests for Min

- Five tests with exceptions
    1. null list
    2. null element with multiple elements
    3. null single element
    4. incomparable types
    5. empty elements
- Two without exceptions
    6. single element
    7. two elements



# Data-Driven Tests

- We want to avoid testing a function multiple times with similar values
  - e.g) Adding two numbers
- Data-driven unit tests call a constructor for each collection of test values
  - Same tests are then run on each set of data values
  - Collection of data values defined by method tagged with @Parameters annotation

# Date-Driven Unit Test

```
import org.junit.*;
import org.junit.runner.RunWith;
import org.junit.runners.Parameterized;
import org.junit.runners.Parameterized.Parameters;
import static org.junit.Assert.*;
import java.util.*;

@RunWith (Parameterized.class)
public class DataDrivenCalcTest
{  public int a, b, sum;

   public DataDrivenCalcTest (int v1, int v2, int expected)
   { this.a = v1; this.b = v2; this.sum = expected; }

  @Parameters public static Collection<Object[]> parameters()
  { return Arrays.asList (new Object [][] {{1, 1, 2}, {2, 3, 5}}); }

  @Test public void additionTest()
  { assertTrue ("Addition Test", sum == Calc.add (a, b)); }
}
```

Constructor is called for each triple of values

Test 1
Test values: 1, 1
Expected: 2

Test 2
Test values: 2, 3
Expected: 5

Test method

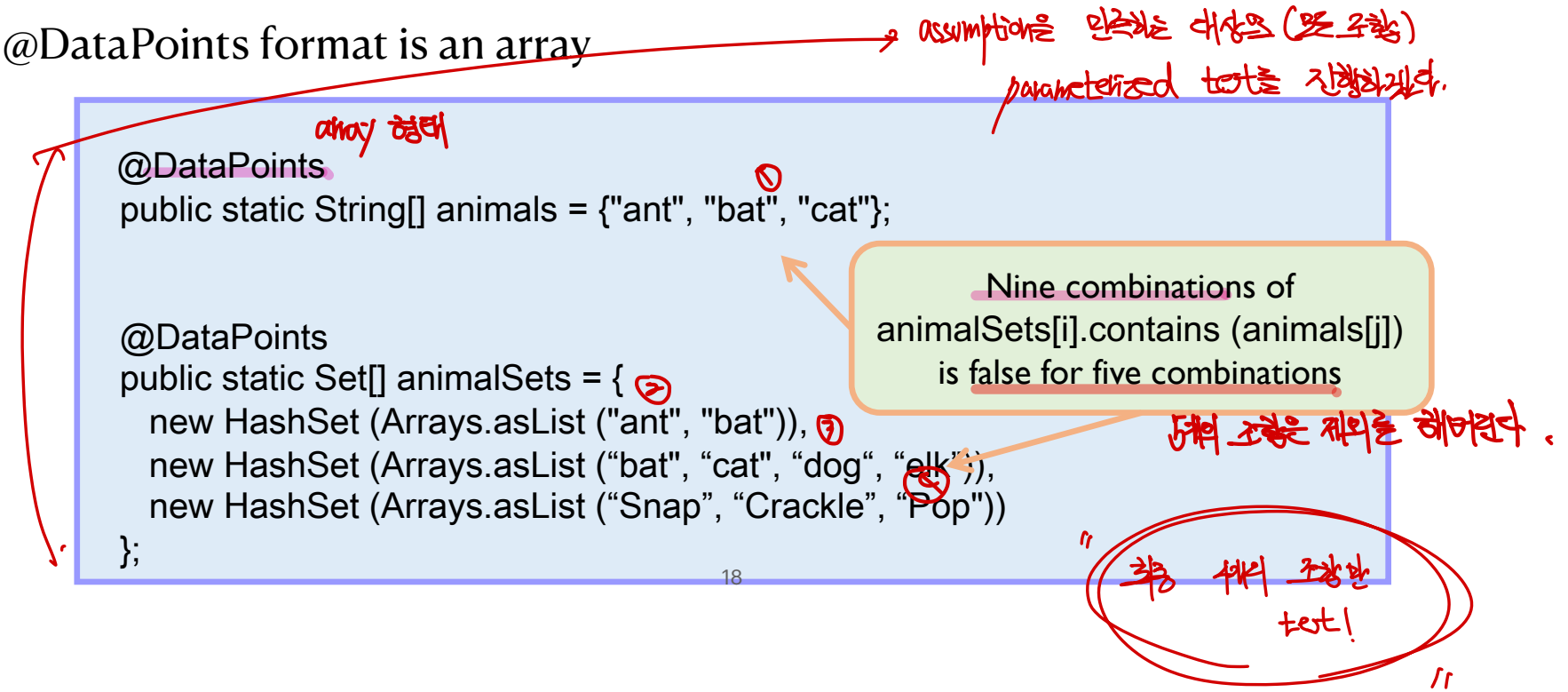
# Test with Parameters: JUnit Theories

- Unit tests can have actual parameters
  - So far, we've only seen parameterless test methods
- Contract model: Assume, Act, Assert
  - Assumptions (preconditions) limit values appropriately
  - Action performs activity under scrutiny
  - Assertions (postconditions) check result

```
@Theory public void removeThenAddDoesNotChangeSet (
        Set<String> someSet, String str) {                  // Parameters!
    assumeTrue (someSet != null)                            // Assume
    assumeTrue (someSet.contains (str)) ;                   // Assume
    Set<String> copy = new HashSet<String>(someSet);  // Act
    copy.remove (str);
    copy.add (str);
    assertTrue (someSet.equals (copy));                     // Assert
}
```

# Where Do the Data Values Come From?

- All combinations of values from @DataPoints annotations where assume clause is true
- Four (of nine) combinations in this particular case
- Note: @DataPoints format is an array



# JUnit Theories Need BoilerPlate

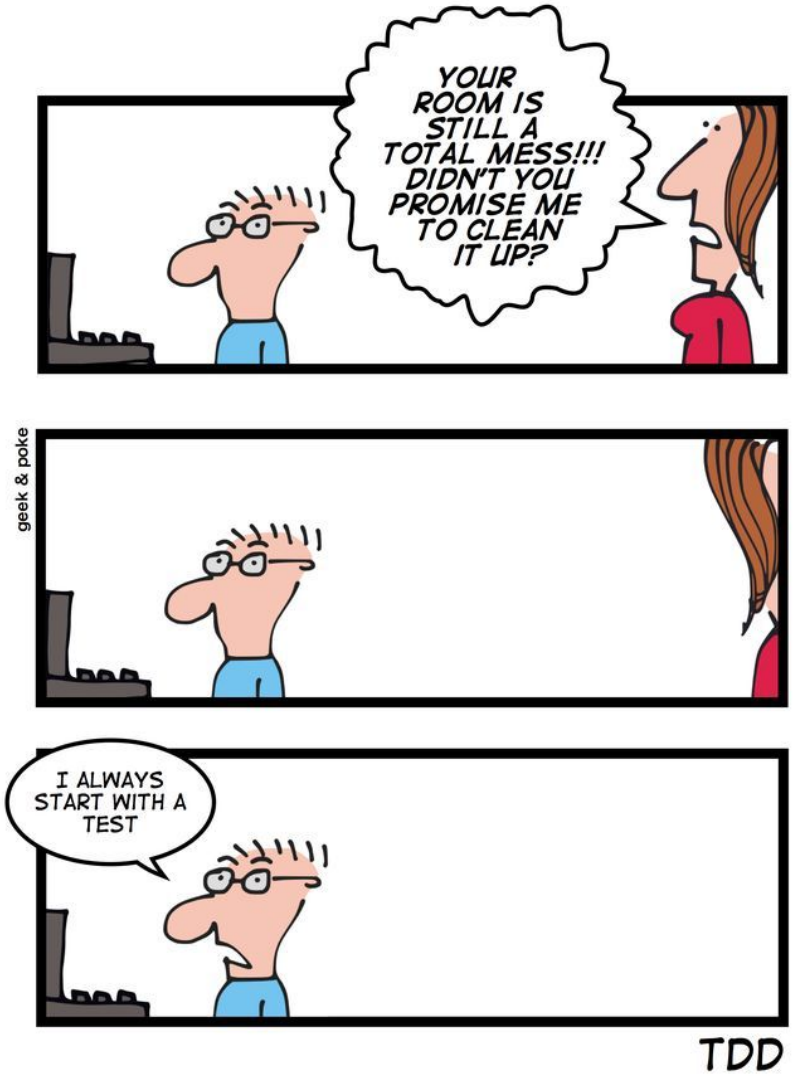
```
import org.junit.*;
import org.junit.runner.RunWith;
import static org.junit.Assert.*;
import static org.junit.Assume.*;

import org.junit.experimental.theories.DataPoint;
import org.junit.experimental.theories.DataPoints;
import org.junit.experimental.theories.Theories;
import org.junit.experimental.theories.Theory;

import java.util.*;

@RunWith (Theories.class)
public class SetTheoryTest
{
   …  // See Earlier Slides
}
```

# JUnit Resources

- Some JUnit tutorials
  - http://open.ncsu.edu/se/tutorials/junit/ (Laurie Williams, Dright Ho, and Sarah Smith )
  - http://www.laliluna.de/eclipse-junit-testing-tutorial.html (Sascha Wolski and Sebastian Hennebrueder)
  - http://www.diasparsoftware.com/template.php?content=jUnitStarterGuide (Diaspar software)
  - http://www.clarkware.com/articles/JUnitPrimer.html (Clarkware consulting)
- JUnit: Download, Documentation
  - http://www.junit.org/

# Test Driven Development

TDD

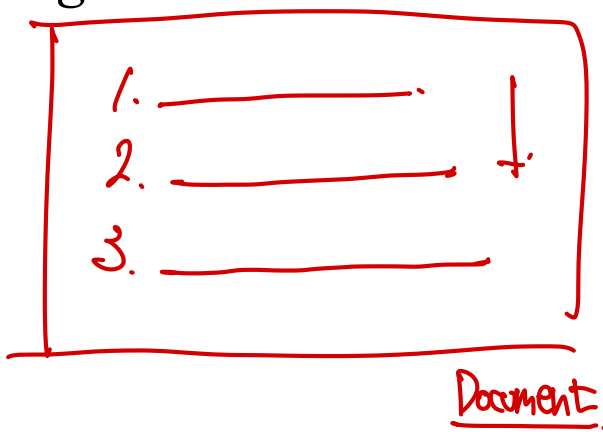


# Test-driven development

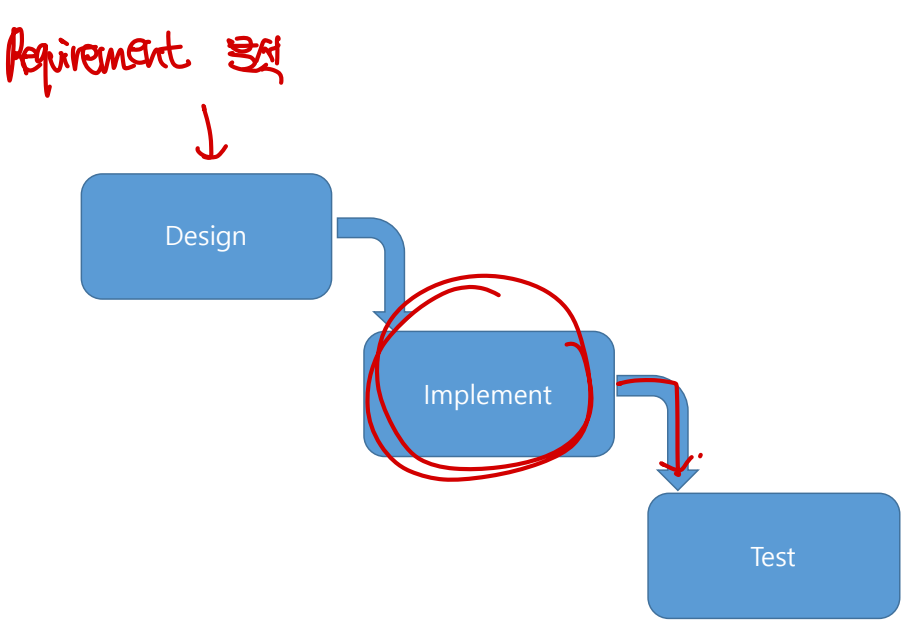
- TDD was introduced as part of agile methods such as Extreme Programming.
- Tests are written before code and ‘passing’ the tests is the critical driver of development.
- You develop code incrementally, along with a test for that increment.
  - You don’t move on to the next increment until the code that you have developed passes its test

# A perspective on TDD

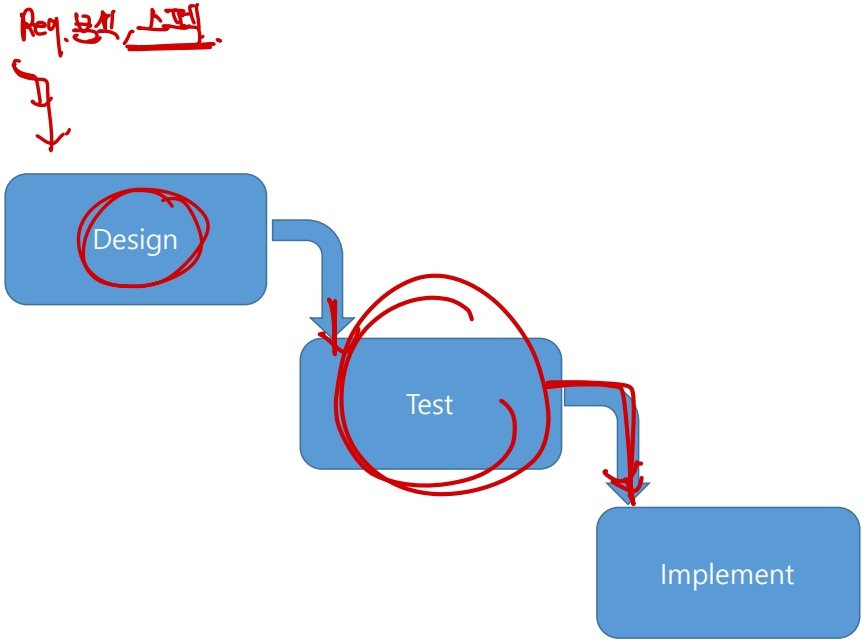
- TDD is mostly about design
- Gives confidence and enables change
- It is Documentation By Example
- Provides rapid feedback on
  - Quality of implementation
  - Quality of design
- It isn't the only testing you'll need to do
- Developers write tests



# Testing vs. TDD



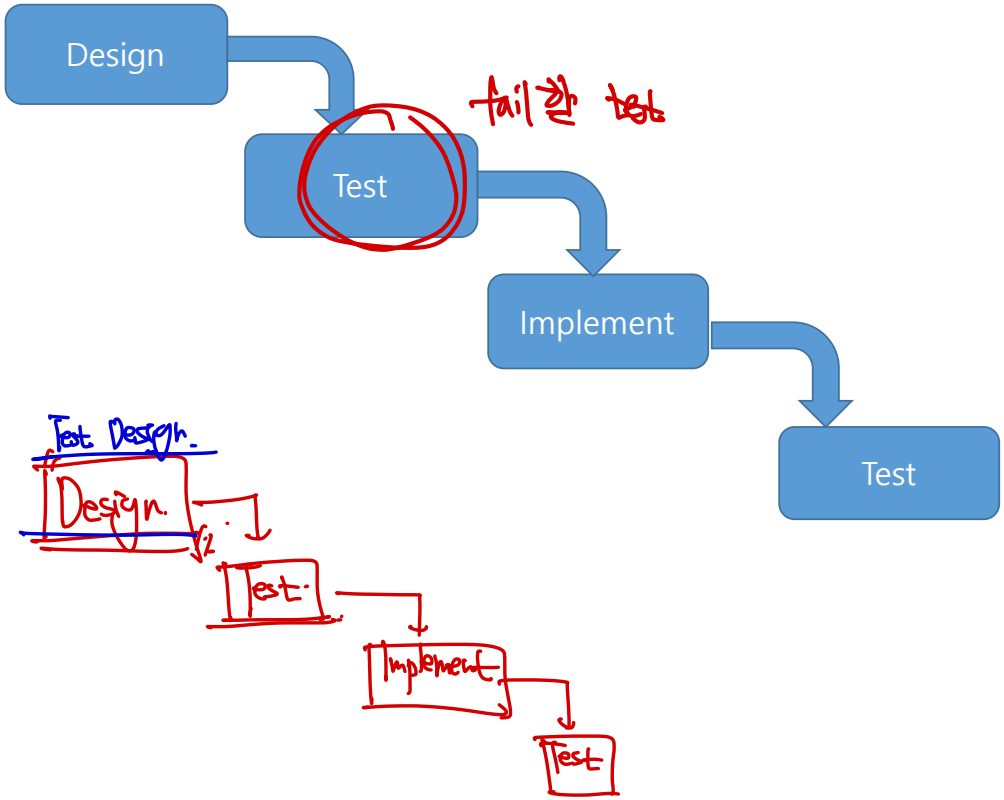

Testing



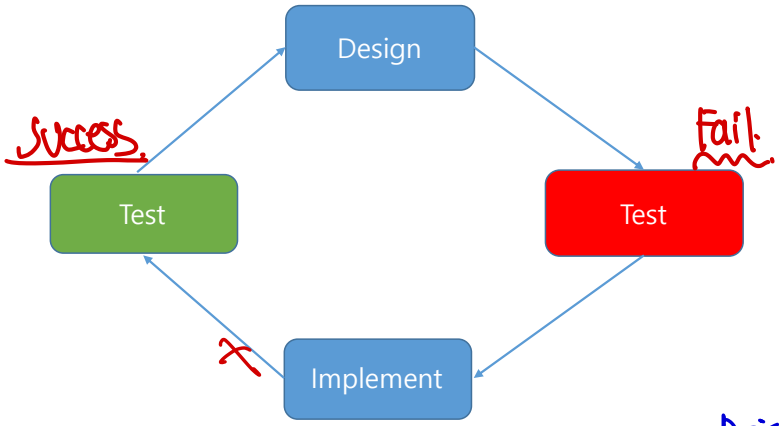

TDD

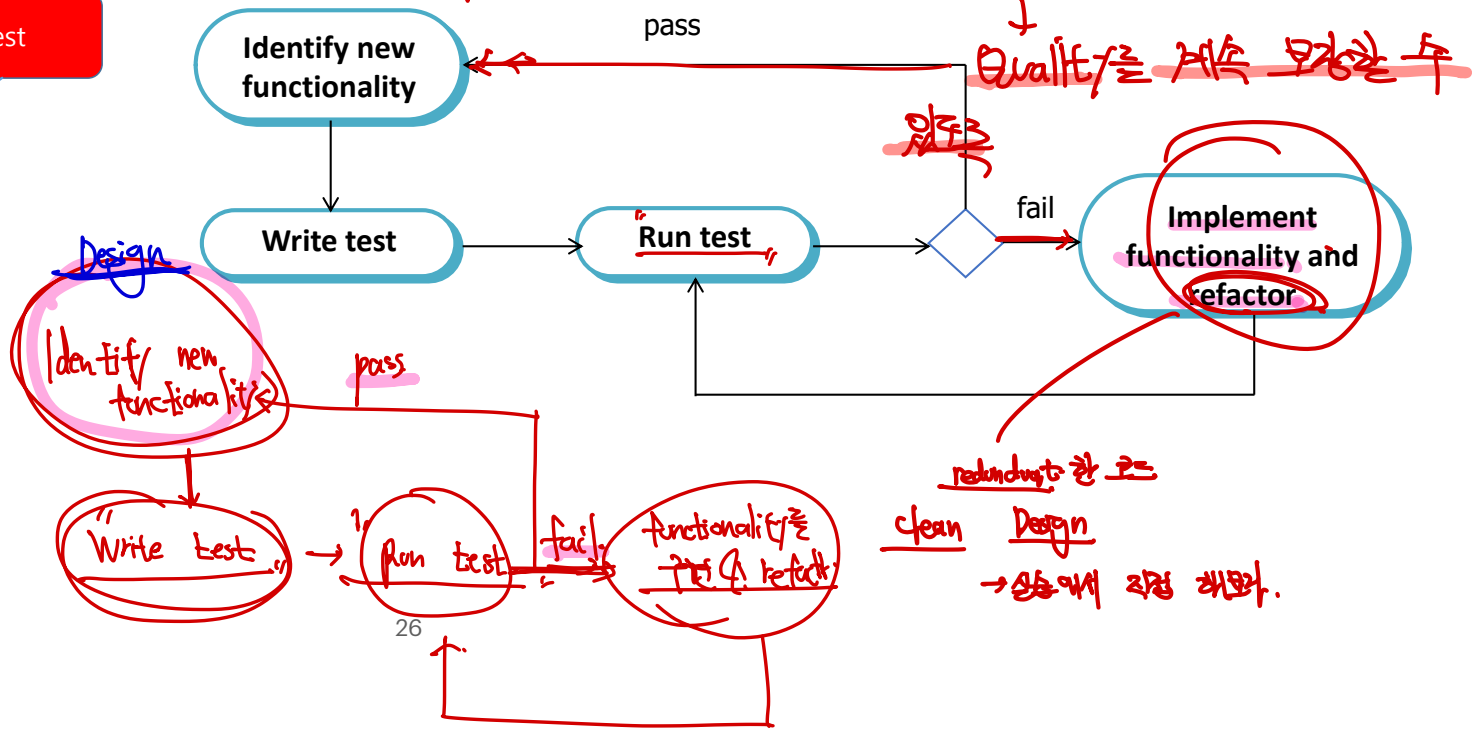
# TDD

- Design: figure out what you want to do
- Test: write a test to express the design
  - It should fail
- Implement: write the code
- Test again
  - It should pass



# TDD Process


Design
Test
Test
Implement


Identify new functionality
pass
Write test
Run test
fail
Implement functionality and refactor
Identify new functionality
pass
Write test
Run test
fail

# TDD example

- To do: We need to be able to add amounts in two different currencies and convert the result given a set of exchange rates
- Test-first

```
public void testMultiplication(){
    Dollar five = new Dollar(5);
    five.times(2);
    assertEquals(10, five.amount);
}
```

→ Dollar class는 amount 필드를 가져야 하고 times 메서드를 제공한다.

| Instrument | Shares | Price | Total |
|---|---|---|---|
| IBM | 1000 | 25 | 25000 |
| GE | 400 | 100 | 40000 |
| | | Total | 65000 |

| Instrument | Shares | Price | Total |
|---|---|---|---|
| IBM | 1000 | 25 USD | 25000 USD |
| Novartis | 400 | 150 CHF | 60000 CHF |
| | | Total | 65000 USD |

| From | To | Rate |
|---|---|---|
| CHF | USD | 1.5 |

# Exercise

# Benefits of TDD

- Code coverage
  - Every code segment that you write has at least one associated test so all code written has at least one test.
- Regression testing
  - A regression test suite is developed incrementally as a program is developed.
- Simplified debugging
  - When a test fails, it should be obvious where the problem lies. The newly written code needs to be checked and modified.
- System documentation
  - The tests themselves are a form of documentation that describe what the code should be doing

# Summary

- Unit test is a prerequisite of integration test and system test
  - It is no matter which development method is used (Waterfall, Agile, MDD, etc.)
- Unit test is usually performed by programmers themselves
- Automation is a must for efficient unit test
  - Partial support is already available through xUnit
- TDD and Agile are heavily dependent on unit test