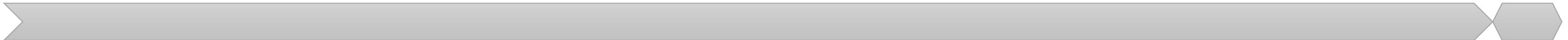


Software Testing Part 2

Junit Testing

AY24/25

Week 11



Outline

1. Unit Testing and JUnit
2. Assertion Methods
3. JUnit Test Cycle and Annotation

1. Unit Testing and JUnit

1.1 Review - Unit Testing

- Testing of an individual software unit
 - usually an object class
- Focus on the functions of the unit
 - functionality, correctness, accuracy
- Usually carried out by the developers of the unit

1.2 Review - Automated Framework

- A setup part, where you initialize the system with the test case (e.g., initialize the object under test)
- A call part, where you call the object or method to be tested.
- An assertion part where you compare the result of the call with the expected result. If the assertion evaluates to true, the test has been successful if false, then it has failed.



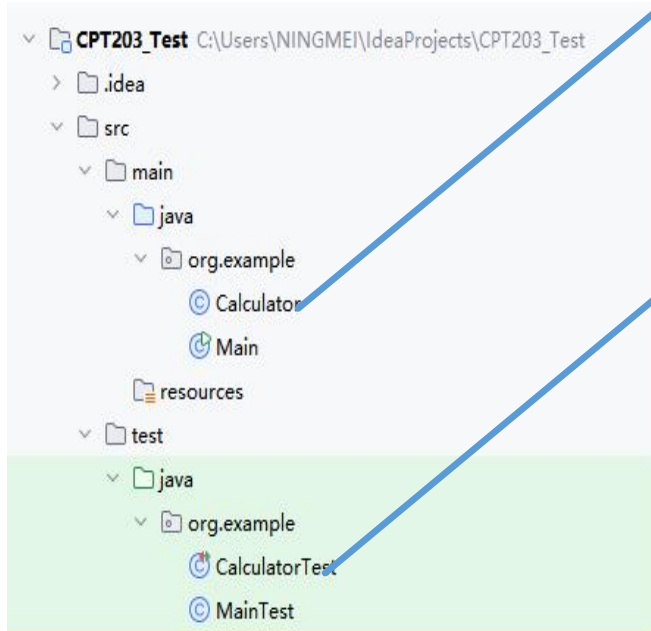
1.3 JUnit

- JUnit is a framework for writing unit tests
 - Designed for the purpose of writing and running tests on Java code
 - A unit test is a test of a single class, where a test case is a single test of a single method
 - Ensures individual test cases are executed in isolation, promoting more accurate results
- Why Junit
 - Enhanced Code Quality
 - Java-based
 - Integrates seamlessly with IDEs like Eclipse and build tools like Maven and Gradle
 - Free

1.3.1 A Junit Test Example

Formally...

Class that is being tested and its test class (where the test is implemented) are separated



```
public class Calculator { no usages
    public static int add(int x, int y) {
        return x + y;
    }
}
```

Class being tested

```
1 package org.example;
2
3 import org.junit.jupiter.api.Test;
4
5 import static org.junit.jupiter.api.Assertions.*;
6
7 class CalculatorTest { A separate test class
8
9     @Test // Marks the method as a test method. Annotation marking a test will be implemented
10    public void CalculatorTest() {
11        // Setup part - Creating an instance of the class under test,
12        // plus the input and expected output
13        Calculator calculator = new Calculator(); Instance creation
14        int input1 = 5; Define the inputs designed by us
15        int input2 = 3; Define the EXPECTED output
16        int Expected = 8;
17
18        // Call Part
19        // Calling the method to be tested with some inputs.
20        int ActualResult = calculator.add(input1, input2); Actual output we get
21
22        // Assertion Part
23        // Asserting that the method returned the expected value.
24        assertEquals(Expected, ActualResult, message: "Message we want to show");
25    }
26 }
```

method (expected (1st var), actual (2nd var), msg (optional))

1.3.1 A Junit Test Example

Sometime...

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

public class Calculator{

    public static int add(int x,int y) {
        return x + y;
    }

    // The Test class itself
    // Often named after the class it's testing
    // (e.g., CalculatorTest for Calculator class)

    @Test // Marks the method as a test method.
    public void CalculatorTest() {
        // Setup part - Creating an instance of the class under test,
        // plus the input and expected output
        Calculator calculator = new Calculator();
        int input1 =5;
        int input2 = 3;
        int Expected = 8;

        // Call Part
        // Calling the method to be tested with some inputs.
        int ActualResult = calculator.add(input1, input2);

        // Assertion Part
        // Asserting that the method returned the expected value.
        assertEquals(Expected, ActualResult, message: "Message we want to show");
    }
}
```

Class being tested
and its test class can
be in the same class

```
@Test // Marks the method as a test method.
public void CalculatorTest() {
    // Setup part - Creating an instance of the class under test,
    // plus the input and expected output
    Calculator calculator = new Calculator();

    // Call Part
    // Calling the method to be tested with some inputs.
    int ActualResult = calculator.add(x: 5, y: 3);

    // Assertion Part
    // Asserting that the method returned the expected value.
    assertEquals(expected: 8, ActualResult, message: "Message we want to show");
}
```

Input directly defined
in the call part

Expected output directly defined in the assertion part

1.3.2 Junit Test Verdicts

A *verdict* is the result of executing a single test case.

Pass

- The test case execution was completed
- The function being tested performed as expected

Fail

- The test case execution was completed
- The function being tested did *not* perform as expected

Error

- The test case execution was not completed, due to
 - an unexpected event, exceptions, or
 - improper set up of the test case, etc.

1.3.2 Junit Test Verdicts (cont.)

- If the tests run correctly, a test method does nothing but shows the results in **Green**

```
int input1 =5;  
int input2 = 3;  
int Expected = 8;
```

A screenshot of a terminal window. At the top, there is a toolbar with icons for back, forward, search, and other navigation functions. Below the toolbar, a green box highlights the text "✓ Tests passed: 1 of 1 test – 12 ms". Below this, the command "C:\Users\NINGMEI\.jdk\openjdk-22\bin\java.exe ..." is shown. At the bottom, the text "Process finished with exit code 0" is displayed.

```
✓ Tests passed: 1 of 1 test – 12 ms  
C:\Users\NINGMEI\.jdk\openjdk-22\bin\java.exe ...  
  
Process finished with exit code 0
```

1.3.2 Junit Test Verdicts (cont.)

- If a test fails

```
int input1 = 5;  
int input2 = 3;  
int Expected = 9;
```

The screenshot shows an IDE window with a Java file containing a JUnit test. The test code is as follows:

```
30 assertEquals(Expected, ActualResult, message: "Message we want to show");  
31 }
```

Below the code, the IDE displays the test results in the 'Console' tab. The test has failed, and the error message is displayed. Red boxes and arrows highlight specific parts of the output:

- Result in Red:** A red box highlights the status bar message: "Tests failed: 1 of 1 test - 16ms".
- Error Msg we typed, changable:** A red box highlights the error message: "Message we want to show ==>".
- Details:** A red box highlights the details of the failure: "Expected :9 Actual :8".
- Where:** A red box highlights the stack trace, starting with "at Calculator.CalculatorTest(Calculator.java:30)".
- Logs:** A red box highlights the final log message: "Process finished with exit code -1".

Arrows point from the code in the Java file to the corresponding parts of the test output. For example, an arrow points from the `assertEquals` call to the error message, and another points from the `Expected` variable to the expected value in the details.

1.3.2 Junit Test Verdicts (cont.)

- If an error happens

```
Calculator calculator = new Calculatorsss();  
int input1 = 5;  
int input2 = 3;  
int Expected = 8;
```



C:\Users\NINGMEI\IdeaProjects\123123\src\Calculator.java:19:37

java: 找不到符号

符号: 类 Calculatorsss

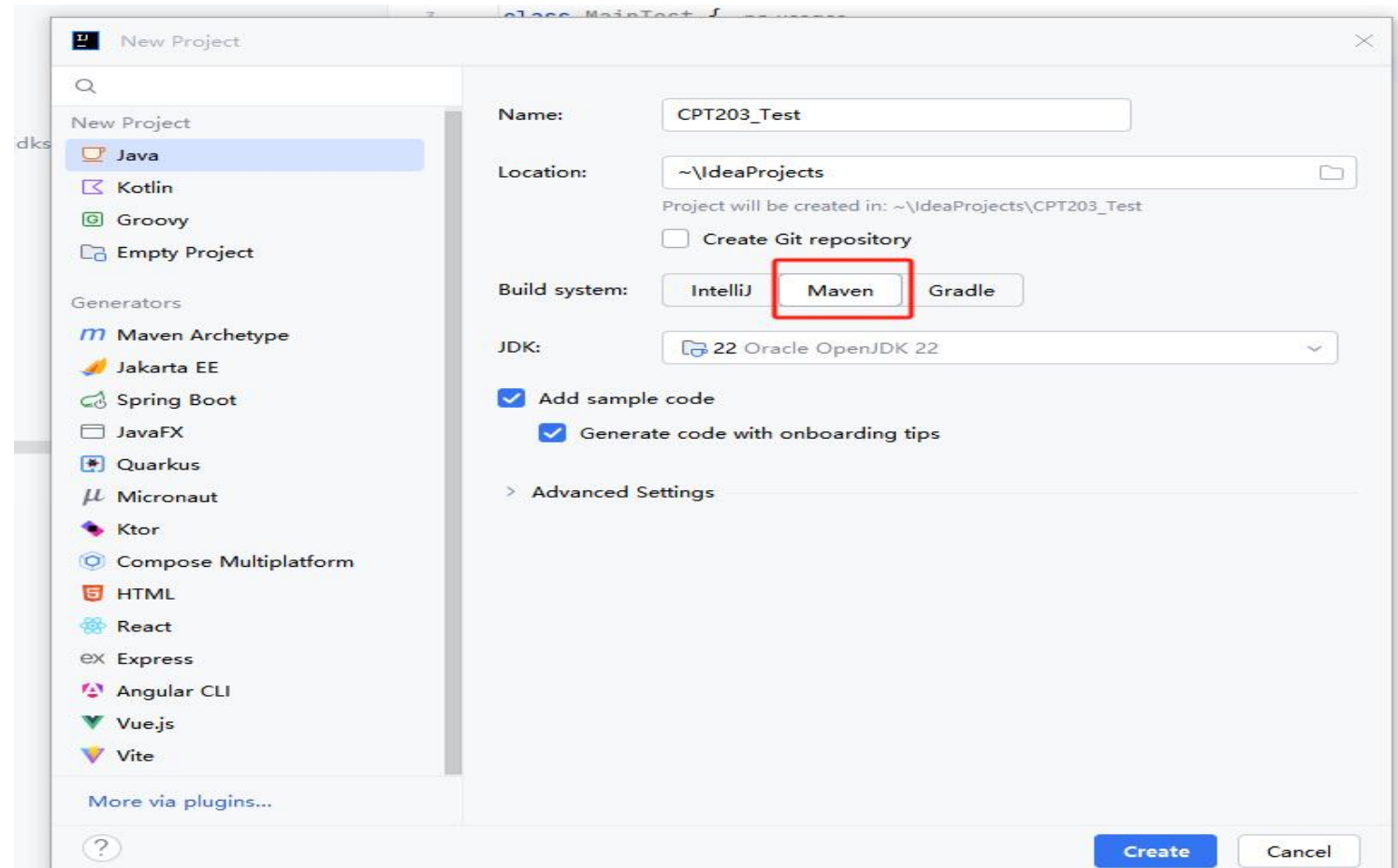
位置: 类 Calculator

1.4 JUnit Best Practices

- Tests need *failure atomically* (ability to know exactly what failed).
 - Each test should have a clear, long, descriptive name.
 - Assertions should always have clear messages to know what failed.
 - Write many small tests, not one big test.
 - Each test should have roughly just 1 assertion at its end.
- Test for expected errors / exceptions.
- Choose a descriptive assert method, not always `assertTrue`.
- Choose representative test cases from equivalent input classes.
- Avoid complex logic in test methods if possible.

1.5 Configure JUnit in IntelliJ

- Create a New Project (e.g., Maven)



1.5 Run JUnit in IntelliJ (cont.)

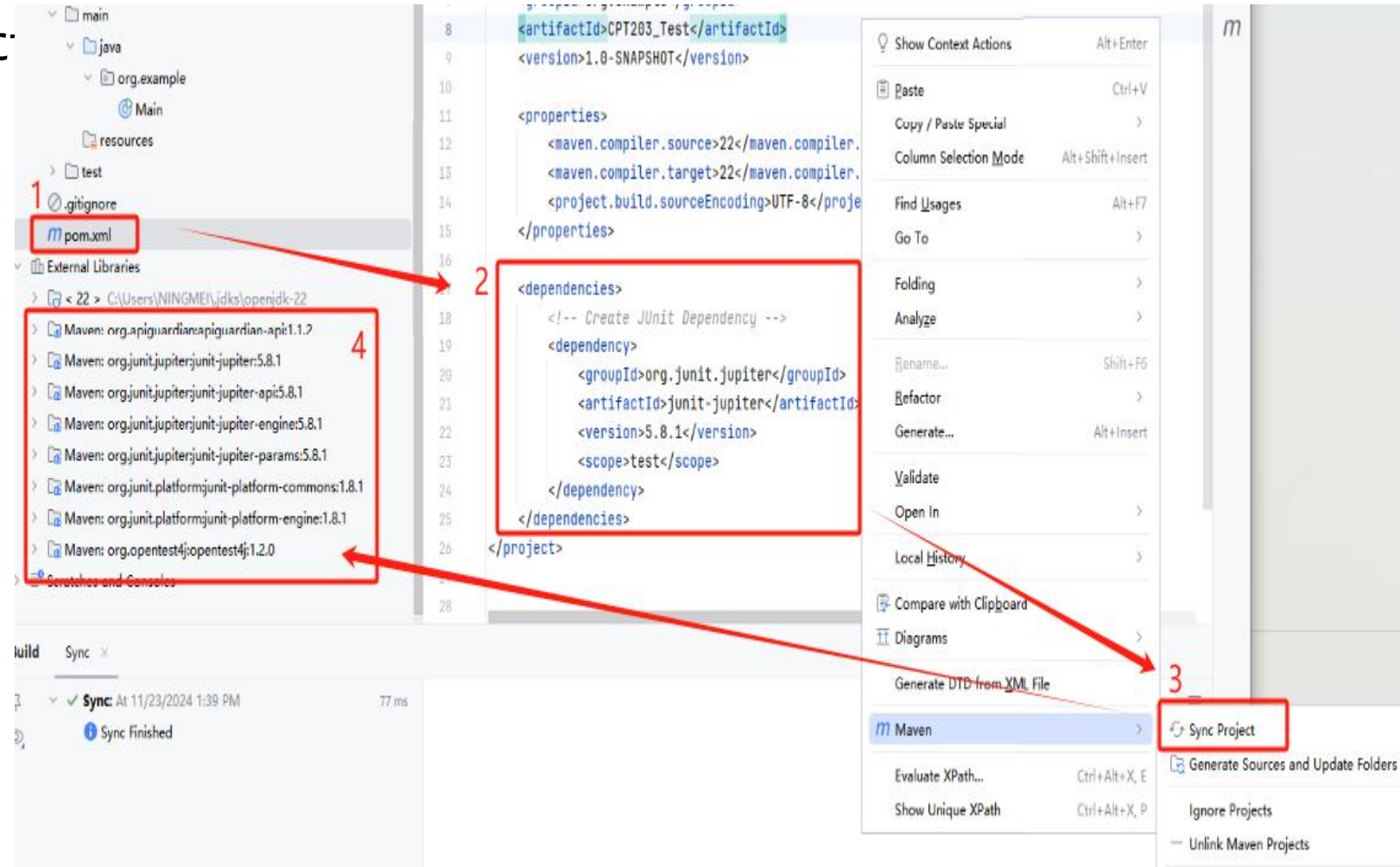
1. Click “pom.xml” in the project root directory

2. Add dependency

```
<dependencies>
<dependency>
  <groupId>org.junit.jupiter</groupId>
  <artifactId>junit-jupiter</artifactId>
  <version>5.8.1</version>
  <scope>test</scope>
</dependency>
</dependencies>
```

3. Right click -> Maven -> Sync Project

4. You see the dependencies



1.5 Run JUnit in IntelliJ (cont.)

The first screenshot shows a code editor with the following code:

```
3 public class Main {  
4     public static void main(String[] args) {  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65  
66  
67  
68  
69  
70  
71  
72  
73  
74  
75  
76  
77  
78  
79  
80  
81  
82  
83  
84  
85  
86  
87  
88  
89  
90  
91  
92  
93  
94  
95  
96  
97  
98  
99  
100  
101  
102  
103  
104  
105  
106  
107  
108  
109  
110  
111  
112  
113  
114  
115  
116  
117  
118  
119  
120  
121  
122  
123  
124  
125  
126  
127  
128  
129  
130  
131  
132  
133  
134  
135  
136  
137  
138  
139  
140  
141  
142  
143  
144  
145  
146  
147  
148  
149  
150  
151  
152  
153  
154  
155  
156  
157  
158  
159  
160  
161  
162  
163  
164  
165  
166  
167  
168  
169  
170  
171  
172  
173  
174  
175  
176  
177  
178  
179  
180  
181  
182  
183  
184  
185  
186  
187  
188  
189  
190  
191  
192  
193  
194  
195  
196  
197  
198  
199  
200  
201  
202  
203  
204  
205  
206  
207  
208  
209  
210  
211  
212  
213  
214  
215  
216  
217  
218  
219  
220  
221  
222  
223  
224  
225  
226  
227  
228  
229  
230  
231  
232  
233  
234  
235  
236  
237  
238  
239  
240  
241  
242  
243  
244  
245  
246  
247  
248  
249  
250  
251  
252  
253  
254  
255  
256  
257  
258  
259  
260  
261  
262  
263  
264  
265  
266  
267  
268  
269  
270  
271  
272  
273  
274  
275  
276  
277  
278  
279  
280  
281  
282  
283  
284  
285  
286  
287  
288  
289  
290  
291  
292  
293  
294  
295  
296  
297  
298  
299  
300  
301  
302  
303  
304  
305  
306  
307  
308  
309  
310  
311  
312  
313  
314  
315  
316  
317  
318  
319  
320  
321  
322  
323  
324  
325  
326  
327  
328  
329  
330  
331  
332  
333  
334  
335  
336  
337  
338  
339  
340  
341  
342  
343  
344  
345  
346  
347  
348  
349  
350  
351  
352  
353  
354  
355  
356  
357  
358  
359  
360  
361  
362  
363  
364  
365  
366  
367  
368  
369  
370  
371  
372  
373  
374  
375  
376  
377  
378  
379  
380  
381  
382  
383  
384  
385  
386  
387  
388  
389  
390  
391  
392  
393  
394  
395  
396  
397  
398  
399  
400  
401  
402  
403  
404  
405  
406  
407  
408  
409  
410  
411  
412  
413  
414  
415  
416  
417  
418  
419  
420  
421  
422  
423  
424  
425  
426  
427  
428  
429  
430  
431  
432  
433  
434  
435  
436  
437  
438  
439  
440  
441  
442  
443  
444  
445  
446  
447  
448  
449  
450  
451  
452  
453  
454  
455  
456  
457  
458  
459  
460  
461  
462  
463  
464  
465  
466  
467  
468  
469  
470  
471  
472  
473  
474  
475  
476  
477  
478  
479  
480  
481  
482  
483  
484  
485  
486  
487  
488  
489  
490  
491  
492  
493  
494  
495  
496  
497  
498  
499  
500  
501  
502  
503  
504  
505  
506  
507  
508  
509  
510  
511  
512  
513  
514  
515  
516  
517  
518  
519  
520  
521  
522  
523  
524  
525  
526  
527  
528  
529  
530  
531  
532  
533  
534  
535  
536  
537  
538  
539  
540  
541  
542  
543  
544  
545  
546  
547  
548  
549  
550  
551  
552  
553  
554  
555  
556  
557  
558  
559  
560  
561  
562  
563  
564  
565  
566  
567  
568  
569  
570  
571  
572  
573  
574  
575  
576  
577  
578  
579  
580  
581  
582  
583  
584  
585  
586  
587  
588  
589  
590  
591  
592  
593  
594  
595  
596  
597  
598  
599  
600  
601  
602  
603  
604  
605  
606  
607  
608  
609  
610  
611  
612  
613  
614  
615  
616  
617  
618  
619  
620  
621  
622  
623  
624  
625  
626  
627  
628  
629  
630  
631  
632  
633  
634  
635  
636  
637  
638  
639  
640  
641  
642  
643  
644  
645  
646  
647  
648  
649  
650  
651  
652  
653  
654  
655  
656  
657  
658  
659  
660  
661  
662  
663  
664  
665  
666  
667  
668  
669  
670  
671  
672  
673  
674  
675  
676  
677  
678  
679  
680  
681  
682  
683  
684  
685  
686  
687  
688  
689  
690  
691  
692  
693  
694  
695  
696  
697  
698  
699  
700  
701  
702  
703  
704  
705  
706  
707  
708  
709  
710  
711  
712  
713  
714  
715  
716  
717  
718  
719  
720  
721  
722  
723  
724  
725  
726  
727  
728  
729  
730  
731  
732  
733  
734  
735  
736  
737  
738  
739  
740  
741  
742  
743  
744  
745  
746  
747  
748  
749  
750  
751  
752  
753  
754  
755  
756  
757  
758  
759  
760  
761  
762  
763  
764  
765  
766  
767  
768  
769  
770  
771  
772  
773  
774  
775  
776  
777  
778  
779  
780  
781  
782  
783  
784  
785  
786  
787  
788  
789  
790  
791  
792  
793  
794  
795  
796  
797  
798  
799  
800  
801  
802  
803  
804  
805  
806  
807  
808  
809  
810  
811  
812  
813  
814  
815  
816  
817  
818  
819  
820  
821  
822  
823  
824  
825  
826  
827  
828  
829  
830  
831  
832  
833  
834  
835  
836  
837  
838  
839  
840  
841  
842  
843  
844  
845  
846  
847  
848  
849  
850  
851  
852  
853  
854  
855  
856  
857  
858  
859  
860  
861  
862  
863  
864  
865  
866  
867  
868  
869  
870  
871  
872  
873  
874  
875  
876  
877  
878  
879  
880  
881  
882  
883  
884  
885  
886  
887  
888  
889  
890  
891  
892  
893  
894  
895  
896  
897  
898  
899  
900  
901  
902  
903  
904  
905  
906  
907  
908  
909  
910  
911  
912  
913  
914  
915  
916  
917  
918  
919  
920  
921  
922  
923  
924  
925  
926  
927  
928  
929  
930  
931  
932  
933  
934  
935  
936  
937  
938  
939  
940  
941  
942  
943  
944  
945  
946  
947  
948  
949  
950  
951  
952  
953  
954  
955  
956  
957  
958  
959  
960  
961  
962  
963  
964  
965  
966  
967  
968  
969  
970  
971  
972  
973  
974  
975  
976  
977  
978  
979  
980  
981  
982  
983  
984  
985  
986  
987  
988  
989  
990  
991  
992  
993  
994  
995  
996  
997  
998  
999  
1000
```

The second screenshot shows the 'Generate' dialog with the following options:

- Constructor
- toString()
- Override Methods... (Ctrl+O)
- Test...**
- Copyright

The third screenshot shows the 'Create Test' dialog with the following settings:

- Testing library: JUnit5
- Class name: MainTest
- Superclass: (empty)
- Destination package: org.example
- Generate: ☐ setUp/@Before, ☐ tearDown/@After
- Generate test methods for: ☐ Show inherited methods
- Member: ☐ main(args:String[]):void

5. To verify we can use Junit now, reight click in the Main class, and select **Generate**
6. Select **Test**
7. Select **OK**

1.5 Run JUnit in IntelliJ (cont.)

The screenshot shows the IntelliJ IDEA interface for a project named 'CPT203_Test'. On the left, the 'Project' view shows the directory structure: 'CPT203_Test' (C:\Users\NINGMEI\IdeaProjects\CPT203_Test) contains '.idea', 'src', and 'test'. The 'test' directory is highlighted with a red box, and its contents are shown in a separate pane: 'java' (containing 'org.example' which contains 'MainTest', highlighted with a red box and a red '8'). On the right, the 'MainTest.java' file is open, showing the following code:

```
1 package org.example;  
2  
3 import static org.junit.jupiter.api.Assertions.*;  
4  
5 class MainTest { no usages  
6  
7 }
```

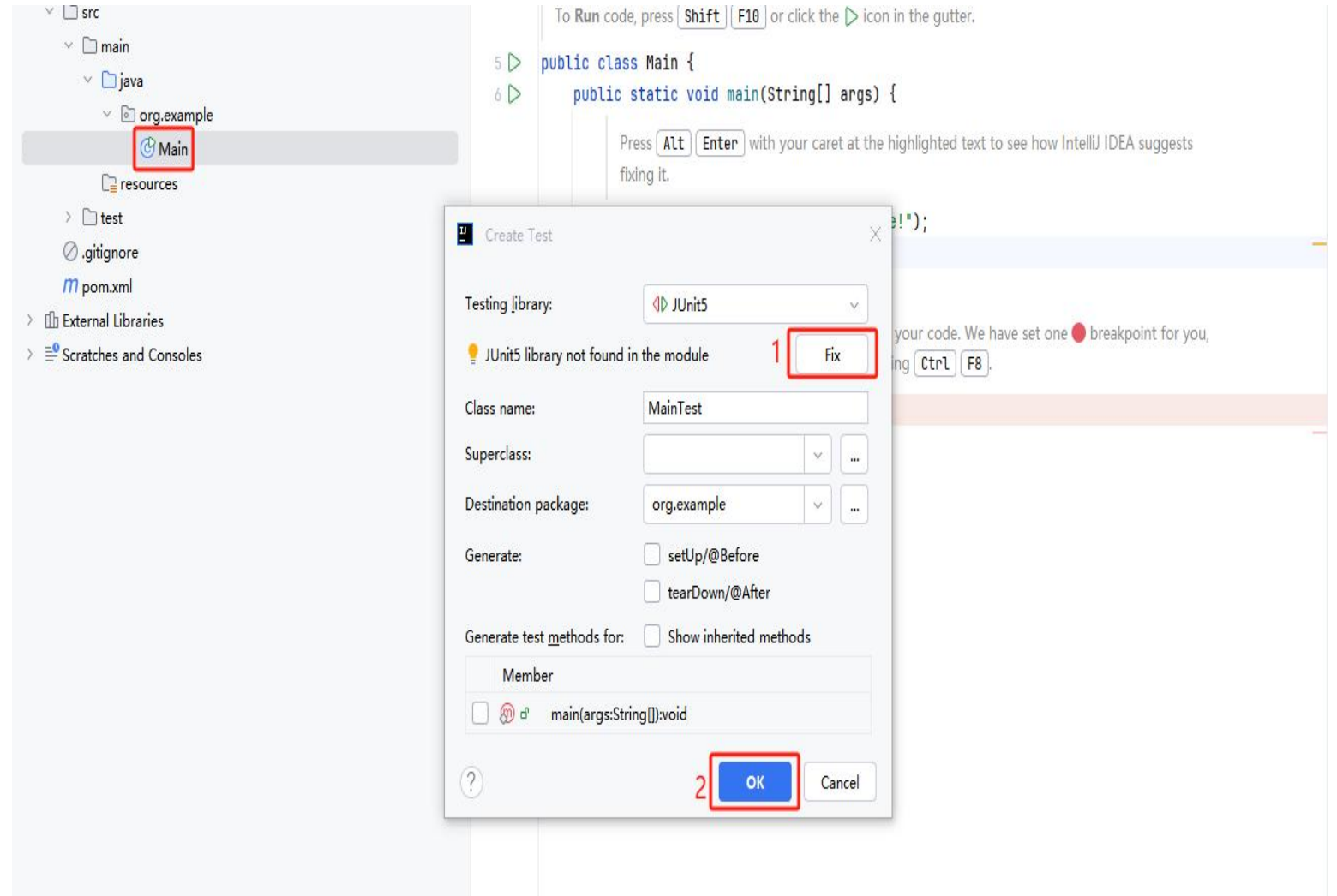
The 'import static org.junit.jupiter.api.Assertions.*;' line is highlighted with a red box. Below the code, two red arrows point to text annotations: one points to the 'MainTest' class declaration with the text 'Where we can code tests now', and the other points to the static import line with the text 'Enable us to use all the static assert methods now'.

8. A test class named MainTest is generated under test file (becasue we were generating test in the Main class)

1.5 Run JUnit in IntelliJ (cont.)

Or a much quicker way

- Create a Maven Project
- Right click in Main class -> Generate -> Test
- At the window popped up, click Fix and then OK
- Done :)



2. *Assertion Methods*

2.1 AssertTrue/AssertFalse

- Assert a Boolean condition is true or false

`assertTrue(condition)`

`assertFalse(condition)`

- Optionally, include a failure message

`assertTrue(condition, message)`

`assertFalse(condition, message)`

```
public class NumberChecker { 2 usages
    public boolean isPositive(int number) { 1 usage
        return number > 0;
    }
}
```

```
package org.example;

import org.junit.jupiter.api.Test;

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

class NumberCheckerTest {

    @Test
    public void testIsPositive() {
        NumberChecker checker = new NumberChecker();
        boolean isPositive = checker.isPositive(5);
        assertTrue(isPositive);
        assertFalse(isPositive, message: "This failure message is optional");
    }
}
```

2.2 AssertSame/AssertNotSame

- Assert two object references are identical

`assertSame(expected, actual)`

- True if: `expected == actual`

`assertNotSame(expected, actual)`

- True if: `expected != actual`

- With a failure message

`assertSame(expected, actual, (optional) message)`

`assertNotSame(expected, actual, (optional) message)`

- Note: Compare if two objects are exactly the same one, NOT the value

2.2 AssertSame/AssertNotSame (cont.)

```
package org.example;

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

public class assertSame {
    @Test
    public void assertSameShowcase() {
        String s1 = new String( original: "Hello");
        String s2 = new String( original: "Hello");
        Assertions.assertSame(s1, s2);
    }
}
```

Tests failed: 1 of 1 test - 15 ms

C:\Users\NINGMEI\.jdk\openjdk-22\bin\java.exe ...

org.opentest4j.AssertionFailedError: expected: java.lang.String@491666ad<Hello> but was: java.lang.String@176d53b2<Hello>

Expected :Hello

Actual :Hello

[Click to see difference](#)

> <5 internal lines>

> at org.example.assertSame.assertSameShowcase([assertSame.java:11](#)) <29 internal lines>

> at java.base/java.util.ArrayList.forEach([ArrayList.java:1597](#)) <9 internal lines>

> at java.base/java.util.ArrayList.forEach([ArrayList.java:1597](#)) <27 internal lines>

Process finished with exit code -1

2 object references (in hash code) are different, indicating they are stored in different memory location in Java

2.3 AssertEquals/AssertNotEquals

- Assert two objects are equal to each regarding value/content
- It doesn't matter if expected and actual are the same object or different object; as long as their content is equal, the test will pass.

`assertEquals(expected, actual, (optional) message)`

- Not only for int type, but also for other values (e.g., string, float, ...)

```
package org.example;

public class StringCase { 2 usages
    public String combining(String one, String two) { 1 usage
        return one + two;
    }
}
```

```
package org.example;

import org.junit.jupiter.api.Test;

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

public class assertEquals {

    @Test
    public void testCombining() {
        StringCase SC = new StringCase();

        String expected = "HelloWorld";
        String actual = SC.combining(one: "Hello", two: "World");

        assertEquals(expected, actual);
    }
}
```

2.4 AssertArrayEquals

- Assert two arrays are equal:
`assertArrayEquals(expected, actual, (optional) message)`
 - arrays must have same length
 - Recursively check for each valid index `i`,

```
public class Array { 1 usage  
  
    public static int[] generateArray() { 1 usage  
        return new int[] {1,2,3};  
    }  
}
```

```
package org.example;  
  
import org.junit.jupiter.api.Test;  
  
import static org.junit.jupiter.api.Assertions.*;  
  
class ArrayTest {  
    @Test  
    public void testArray() {  
        int[] expectedArray = new int[] {3, 2, 1};  
        int[] actualArray = Array.generateArray();  
        assertArrayEquals(expectedArray, actualArray);  
    }  
}
```


2.5 AssertThrows

- Used to test that a specific type of exception is thrown during the execution of a block of code
- `assertThrows(expectedExceptionClass, executable)`
 - expectedExceptionClass is the type of exception you expect
 - executable is a *lambda expression* or a method reference that executes the code under test
- Particularly useful for negative test cases where you want to ensure that your code fails under certain conditions

2.5 AssertThrows (cont.)

```
package org.example;
```

```
public class AssertThrowsCalCase { no usages
    public double divide(int numerator, int denominator) { no usages
        if (denominator == 0) {
            throw new ArithmeticException("Division by zero is not allowed");
        }
        return (double) numerator / denominator;
    }
}
```

```
class AssertThrowsCalCaseTest {
    @Test
    public void testDivisionByZeroThrowsException() {
        // Create an instance of the AssertThrowsCalCase class.
        // This class contains the 'divide' method we want to test.
        AssertThrowsCalCase calculator = new AssertThrowsCalCase();

        // Use assertThrows to test that an ArithmeticException is thrown.
        // assertThrows takes two main parameters:
        // 1. The class of the exception we expect to be thrown.
        // 2. A lambda expression that executes the code we're testing.
        assertThrows(
            //The expected exception type.
            //Here, we expect an ArithmeticException.
            ArithmeticException.class,
            // This is the lambda expression.
            // It is used to execute the 'divide' method of the calculator object.
            // The 'divide' method is called with arguments 10 and 0.
            () -> calculator.divide( numerator: 10, denominator: 0));
    }
}
```

1. Parameter List 2. operator 3. Body: method being tested with the case (10 and 0)

2.5 AssertThrows (cont.)

Why use Lambda (Correct Approach):

- `assertThrows(ArithmeticException.class, () -> calculator.divide(10, 0));`
- This approach delays the execution of `divide` until `assertThrows` can catch the exception.

Otherwise (Problematic):

- `assertThrows(ArithmeticException.class, calculator.divide(10, 0));`
- In this case, `divide` is executed immediately, and if it throws an exception, it happens before `assertThrows` can catch it, leading to a test error.

3. JUnit Test Cycle and Annotation

3.1 Life Cycle

- Normally, a test class contains multiple test methods. JUnit manages the execution of each test method in form of a lifecycle.
- The complete lifecycle of a test case can be seen in three phases with the help of annotations.

3.2 Life Cycle Phases

1. **Setup:** This phase puts the test infrastructure in place. JUnit provides class level setup (*@BeforeAll*) and method level setup (*@BeforeEach*). Generally, heavy objects like database connections are created in class level setup while lightweight objects like test objects are reset in the method level setup.
2. **Test Execution:** In this phase, the test execution and assertion happen. The execution result will signify a success or failure.
3. **Cleanup:** This phase is used to cleanup the test infrastructure setup in the first phase. Just like setup, teardown also happen at class level (*@AfterAll*) and method level (*@AfterEach*).

3.2 Life Cycle Phases (cont.)

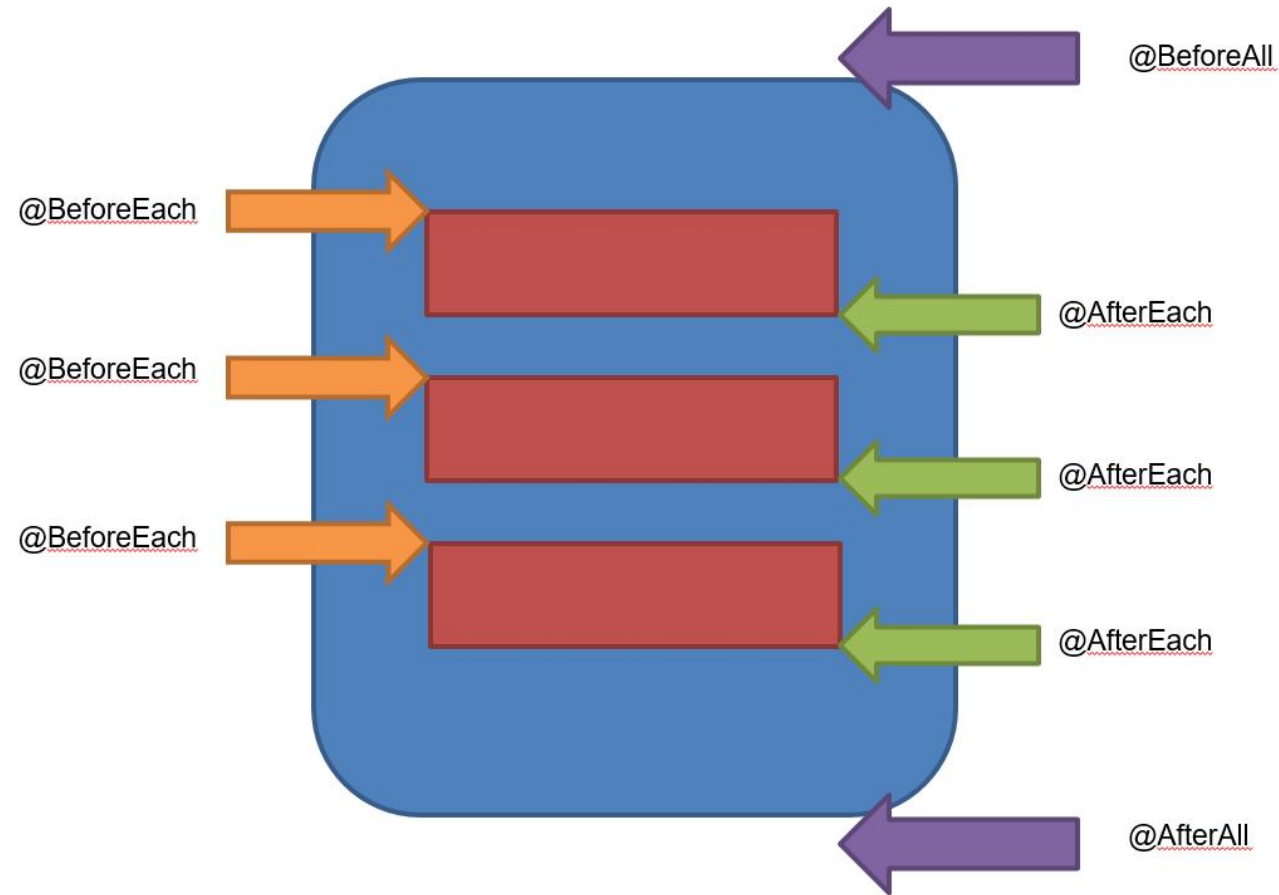
In the test life cycle, we will primarily need to have some annotated methods to setup and cleanup the test environment or test data on which the tests run.

In JUnit, by default, for each test method – a new instance of test is created.

1. **@BeforeAll** and **@AfterAll** annotations – clear by their name – should be called only once in the entire tests execution cycle. So they must be declared **static**.
2. **@BeforeEach** and **@AfterEach** are invoked for each instance of test so they should not be static.



3.2 Life Cycle Phases (cont.)



3.2 Life Cycle Phases (cont.)

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

public class JunitLifecycle {

    // Class level setup - runs once before all tests
    @BeforeAll e.g., link to the whole database
    static void setupClass() {
        // Code to set up database connections or other heavy resources
    }

    // Method level setup - runs before each test
    @BeforeEach e.g., select a specific dataset for the test below
    void setupTest() {
        // Code to initialize or reset test objects
    }

    // Actual test case
    @Test Test implementation
    void testExample() {
        // Test execution and assertions
        assertEquals( expected: 2, actual: 1 + 1);
    }

    // Method level cleanup - runs after each test
    @AfterEach e.g., clean up the specific dataset for next round of test
    void tearDownTest() {
        // Code to reset or clean up after each test
    }

    // Class level cleanup - runs once after all tests
    @AfterAll e.g., Disconnect the whole database and end test
    static void tearDownClass() {
        // Code to clean up database connections or other heavy resources
    }
}
```

3.3 Junit 5 Annotations

Annotation	Description
<code>@BeforeEach</code>	The annotated method will be run before each test method in the test class.
<code>@AfterEach</code>	The annotated method will be run after each test method in the test class.
<code>@BeforeAll</code>	The annotated method will be run before all test methods in the test class. This method must be static.
<code>@AfterAll</code>	The annotated method will be run after all test methods in the test class. This method must be static.
<code>@Test</code>	It is used to mark a method as a junit test.
<code>@DisplayName</code>	Used to provide any custom display name for a test class or test method
<code>@Disable</code>	It is used to disable or ignore a test class or test method from the test suite.
<code>@Nested</code>	Used to create nested test classes
<code>@Tag</code>	Mark test methods or test classes with tags for test discovering and filtering
<code>@TestFactory</code>	Mark a method is a test factory for dynamic tests.

3.3.1 @DisplayName

- @DisplayName // to display meaningful name appear in the test report

```
@DisplayName("I need a name")
//@RepeatedTest(3)

@Test
void test1()
{
    System.out.println("=====TEST ONE EXECUTED=====");
    assertEquals( expected: 4 , Calculator.add( x: 2, y: 2));
}
```



The screenshot shows a test report with a toolbar at the top. The test suite is 'testAnnotations (org, 10 ms)' and it passed. A specific test, 'I need a name', is highlighted with a red box and took 10 ms. The test output shows the execution of @BeforeAll, @BeforeEach, the test itself (printing '=====TEST ONE EXECUTED====='), @AfterEach, and @AfterAll. The process finished with exit code 0.

```
✓ testAnnotations (org, 10 ms)
  ✓ I need a name 10 ms
    C:\Users\NINGMEI\.jdk\openjdk-22\bin\java.exe ...
    @BeforeAll executed
    @BeforeEach executed
    =====TEST ONE EXECUTED=====
    @AfterEach executed
    @AfterAll executed
    Process finished with exit code 0
```

3.3.2 @Timeout

- Useful for simple performance test
 - Network communication
 - Complex computation
- The `@Timeout` annotation
 - Time unit defaults to seconds (`@Timeout(1)`) but is configurable

```
@DisplayName("I need a name")
//@RepeatedTest(3)
@Timeout(value = 1, unit= TimeUnit.MILLISECONDS)
@Test
void test1()
{
    System.out.println("=====TEST ONE EXECUTED=====");
    assertEquals( expected: 4 , Calculator.add( x: 2, y: 2));
}
```

Tests failed: 1 of 1 test – 16 ms

C:\Users\NINGMEI\.jdk\openjdk-22\bin\java.exe ...

@BeforeAll executed

@BeforeEach executed

=====TEST ONE EXECUTED=====

@AfterEach executed

java.util.concurrent.TimeoutException: test1() timed out after 1 millisecond

> <26 internal lines>

> at java.base/java.util.ArrayList.forEach(ArrayList.java:1597) <9 internal lines>

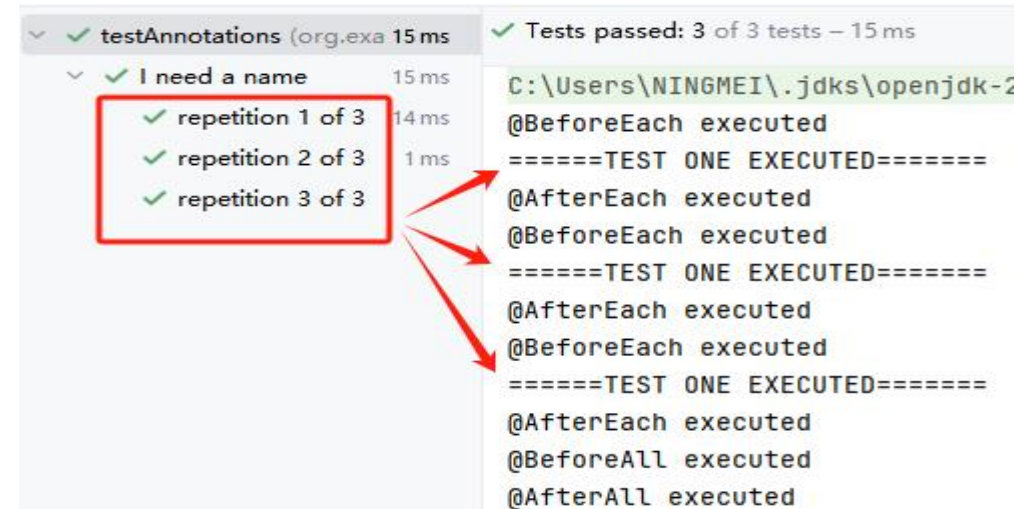
> at java.base/java.util.ArrayList.forEach(ArrayList.java:1597) <27 internal lines>

16ms > 1ms, so failed

3.3.3 @RepeatedTest

- `@RepeatedTest` is used to mark a test method that should repeat a specified number of times with a configurable display name.
- In the given example, the test method uses `@RepeatedTest(3)` annotation. It means that the test will be executed 3 times.
- `@Test` would **NOT** be needed if we are using `@RepeatedTest`

```
@DisplayName("I need a name")
@RepeatedTest(3)
@Test
void test1()
{
    System.out.println("=====TEST ONE EXECUTED=====");
    assertEquals( expected: 4 , Calculator.add( x: 2, y: 2));
}
```



The screenshot displays the test results in an IDE. On the left, a tree view shows the test hierarchy: 'testAnnotations (org.exe 15 ms)' expanded to 'I need a name 15 ms', which is further expanded to show three repetitions: 'repetition 1 of 3 14 ms', 'repetition 2 of 3 1 ms', and 'repetition 3 of 3'. A red box highlights these three repetitions. On the right, the test output shows the execution details for each repetition, including '@BeforeEach executed', '=====TEST ONE EXECUTED=====', '@AfterEach executed', and '@BeforeAll executed'.

Test Name	Duration
testAnnotations (org.exe)	15 ms
I need a name	15 ms
repetition 1 of 3	14 ms
repetition 2 of 3	1 ms
repetition 3 of 3	

Tests passed: 3 of 3 tests – 15 ms

C:\Users\NINGMEI\.jdk\openjdk-2

@BeforeEach executed
=====TEST ONE EXECUTED=====
@AfterEach executed
@BeforeEach executed
=====TEST ONE EXECUTED=====
@AfterEach executed
@BeforeEach executed
=====TEST ONE EXECUTED=====
@AfterEach executed
@BeforeAll executed
@AfterAll executed

3.3.3 @RepeatedTest (cont.)

- `@RepeatedTest` is used to mark a test method that should repeat a specified number of times with a configurable display name.
- In the given example, the test method uses `@RepeatedTest(3)` annotation. It means that the test will be executed 3 times.
- `@Test` would **NOT** be needed if we are using `@RepeatedTest`

```
@DisplayName("I need a name")
@RepeatedTest(3)
//@Test
void test1()
{
    System.out.println("=====TEST ONE EXECUTED=====");
    assertEquals( expected: 4 , Calculator.add( x: 2, y: 2));
}
```

Otherwise, output:

...[A Warning Message (not an error)]... +
This is typically the result of annotating a
method with multiple competing annotations
such as `@Test`, `@RepeatedTest`,
`@ParameterizedTest`, `@TestFactory`, etc