Object-Oriented Software Analysis and Design

School of Computer Science
University of Windsor

Test-Driven Development

Test-Driven Development

- An excellent practice promoted by the iterative and agile XP method, and applicable to the UP, is **test-driven development (TDD)**. It is also known as **test-first development**.

- TDD covers more than just unit testing (testing individual components), but this introduction will focus on its application to unit testing individual classes.

Test-Driven Development (contd.)

- In OO unit testing TDD-style, test code is written before the class to be tested, and the developer writes unit testing code for nearly all production code.
- The basic rhythm is to write a little test code, then write a little production code, make it pass the test, then write some more test code, and so forth.
- **Key Point:** The test is written first, imagining the code to be tested is written.

Test-Driven Development: Advantages

- The unit tests actually get written
- Programmer satisfaction leading to more consistent test writing
- Clarification of detailed interface and behavior
- Provable, repeatable, automated verification
- The confidence to change things

Software Testing

- As Edsger Dijkstra, an early contributor to the development of software engineering, eloquently stated (Dijkstra et al., 1972):

  "Testing can only show the presence of errors, not their absence"

- Testing is part of a broader process of software **verification** and **validation** (V & V). Verification and validation are not the same thing, although they are often confused.

  Validation: Are we building the right product?

  Verification: Are we building the product right?

Software Testing

- Typically, a commercial software system has to go through three stages of testing:
- **Development testing**, where the system is tested **during development to discover bugs and defects**. System designers and programmers are likely to be involved in the testing process.
- **Release testing**, where a separate testing team **tests a complete version of the system** before it is released to users. The aim of release testing is to check that the system meets the requirements of the system stakeholders.

Software Testing

- **User testing**, where users or potential users of a system **test the system in their own environment**. For software products, the “user” may be an internal marketing group that decides if the software can be marketed, released and sold.
    - **Acceptance testing** is one type of user testing where the customer formally **tests a system to decide if it should be accepted from the system supplier or if further development is required**.

Development Testing

There are three stages of development testing:

- **Unit testing**, where **individual program units or object classes are tested**. Unit testing should **focus on testing the functionality of objects or methods**.
- **Component testing**, where several individual units are integrated to create composite components. Component testing should **focus on testing the component interfaces** that provide access to the component functions.
- **System testing**, where some or all of the components in a system are integrated and the system is **tested as a whole**. System testing should **focus on testing component interactions**.

Unit testing

- Unit testing is the **process of testing program components**, such as methods or object classes.
- Individual functions or methods are the simplest type of component. Your tests should be calls to these routines with different input parameters.
- When you are testing object classes, you should design your tests to provide coverage of all of the features of the object.

Unit testing (contd.)

- Whenever possible, you should automate unit testing.
- In automated unit testing, you **make use of a test automation framework** (such as JUnit) to write and run your program tests.
- Unit testing frameworks provide generic test classes that you extend to create specific test cases.
- They can then run all of the tests that you have implemented and report, on the success or failure of the tests.
- An entire test suite can often be run in a few seconds so it is possible to execute all the tests every time you make a change to the program.

The Test Pyramid[1]

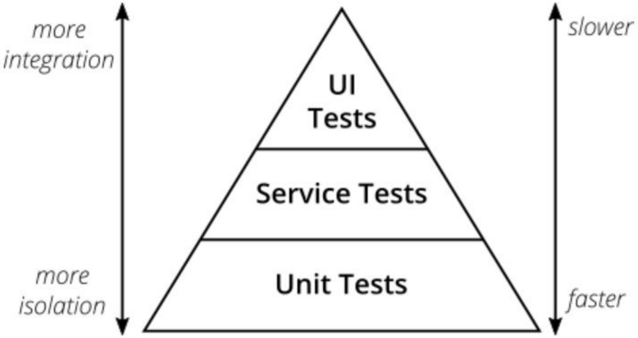


Figure 2: The Test Pyramid

[1] from Martin Fowler's article

Choosing Unit Test Cases

- Testing is expensive and time consuming, so it is important that you choose effective unit test cases. Effectiveness, in this case, means two things:
    - The test cases should show that, when used as expected, the component that you are testing does what it is supposed to do.
    - If there are defects in the component, these should be revealed by test cases.

JUnit Testing

JUnit

- JUnit is an open source unit testing framework for the Java programming language.

Some JUnit Annotations

Annotation	Description
@Test	Denotes that a method is a test method.
@DisplayName	Declares a custom display name for the test class or test method.
@BeforeEach	Denotes that the annotated method should be executed before each test method in the test class.
@AfterEach	Denotes that the annotated method should be executed after each test method in the test class.
@BeforeAll	Denotes that the annotated method should be executed before all test methods in the test class.
@AfterAll	Denotes that the annotated method should be executed after all test methods in the test class.
@Tag	Used to declare tags for filtering tests, either at the class or method level
@Disabled	Used to disable a test class or test method.

Writing Tests: Assertions

- Use the various *assertXXX()* methods to test different conditions.
- `junit.framework.TestCase`, the base class for all test cases, extends from `junit.framework.Assert`, which defines numerous overloaded *assertXXX()* methods. Your tests function by calling these methods.

Writing Tests: Assertions

Method	Description
assertEquals( )	Compares two values for equality. The test passes if the values are equal.
assertFalse( )	Evaluates a boolean expression. The test passes if the expression is false.
assertNotNull( )	Compares an object reference to null. The test passes if the reference is not null.
assertNotSame( )	Compares the memory address of two object references using the == operator. The test passes if both refer to different objects.
assertNull( )	Compares an object reference to null. The test passes if the reference is null.
assertSame( )	Compares the memory address of two object references using the == operator. The test passes if both refer to the same object.
assertTrue( )	Evaluates a boolean expression. The test passes if the expression is true.

It's Quiz Time

1. JUnit provides Assertions for testing expected results. (True or False)

Writing Tests: Example-2

- CalcJUnit

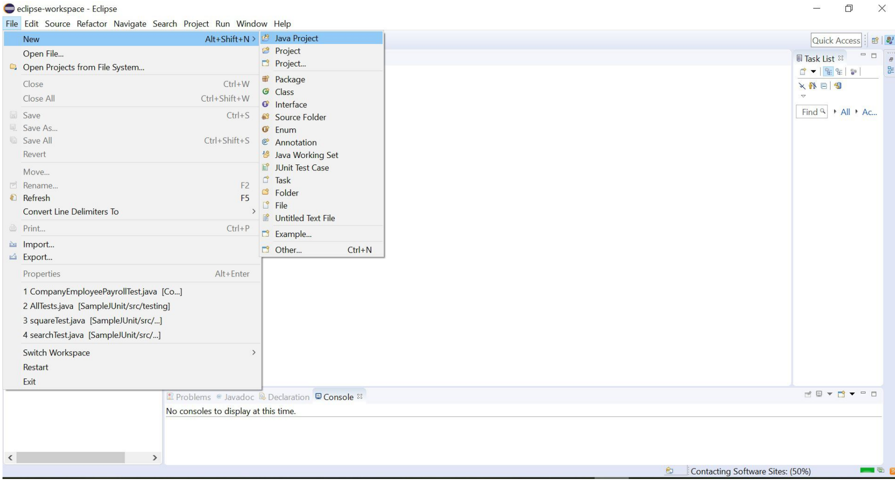
Writing Tests: Example-3

- CustomerJUnit

Writing Tests: Example-4

- EmployeeJUnit

Step-by-step instructions to create a Java project in Eclipse


eclipse-workspace - Eclipse
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Open Projects from File System...
Close Ctrl+W
Close All Ctrl+Shift+W
Save Ctrl+S
Save As...
Save All Ctrl+Shift+S
Revert
Move...
Rename... F2
Refresh F5
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Print... Ctrl+P
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Export...
Properties Alt+Enter
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2 AllTests.java [SampleJUnit/src/testing]
3 squareTest.java [SampleJUnit/src/...]
4 searchTest.java [SampleJUnit/src/...]
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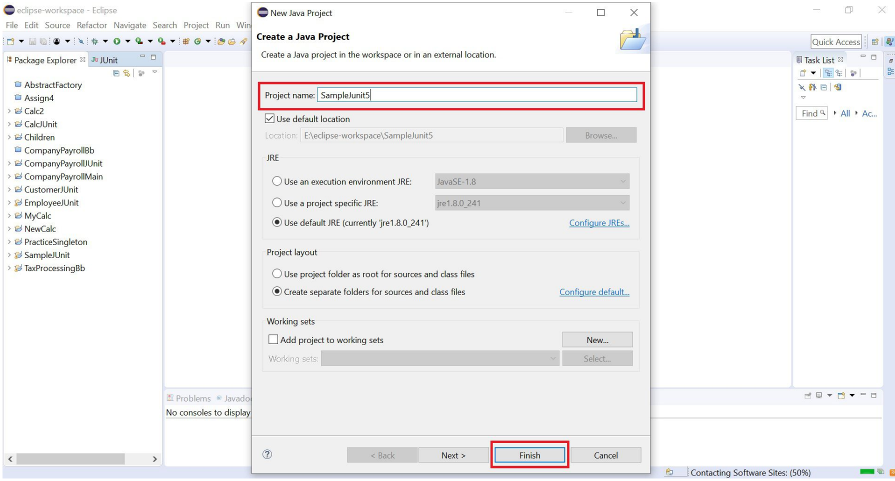
Contacting Software Sites: (50%)



New Java Project

Create a Java Project

Create a Java project in the workspace or in an external location.

Project name: SampleJunit5

[✓] Use default location

Location: E:\eclipse-workspace\SampleJunit5 Browse...

JRE

( ) Use an execution environment JRE: JavaSE-1.8

( ) Use a project specific JRE: jre1.8.0_241

(●) Use default JRE (currently 'jre1.8.0_241') Configure JREs...

Project layout

( ) Use project folder as root for sources and class files

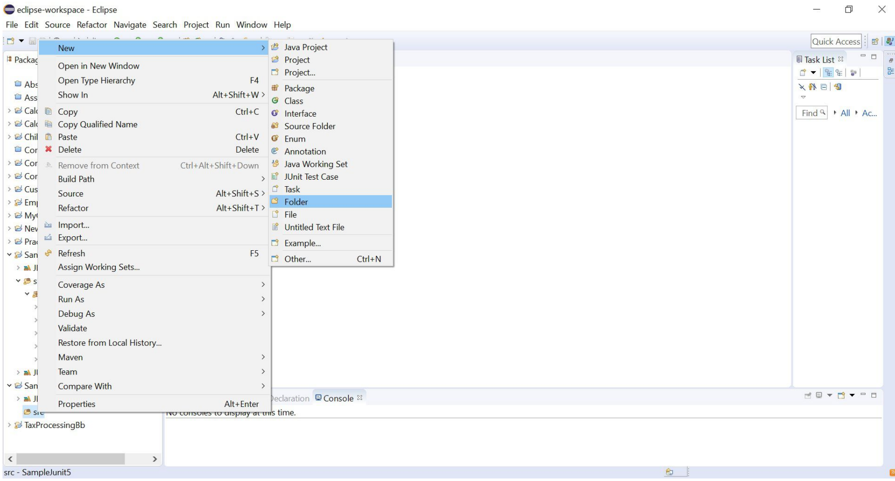
(●) Create separate folders for sources and class files Configure default...

Working sets

[ ] Add project to working sets New...

Working sets: Select...

< Back | Next > | Finish | Cancel


eclipse-workspace - Eclipse
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Coverage As
Run As
Debug As
Validate
Restore from Local History...
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Project...
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Source Folder
Enum
Annotation
Java Working Set
JUnit Test Case
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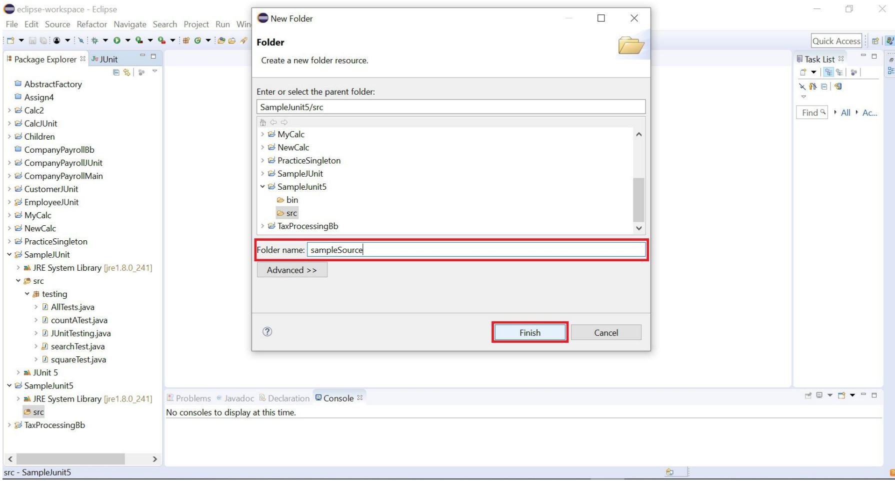
TaxProcessingBb
src - SampleJunit5



New Folder

Folder

Create a new folder resource.

Enter or select the parent folder:

SampleJunit5/src

- MyCalc
- NewCalc
- PracticeSingleton
- SampleJUnit
- SampleJunit5
  - bin
  - src
- TaxProcessingBb

Folder name: sampleSource

Advanced >>

Finish Cancel

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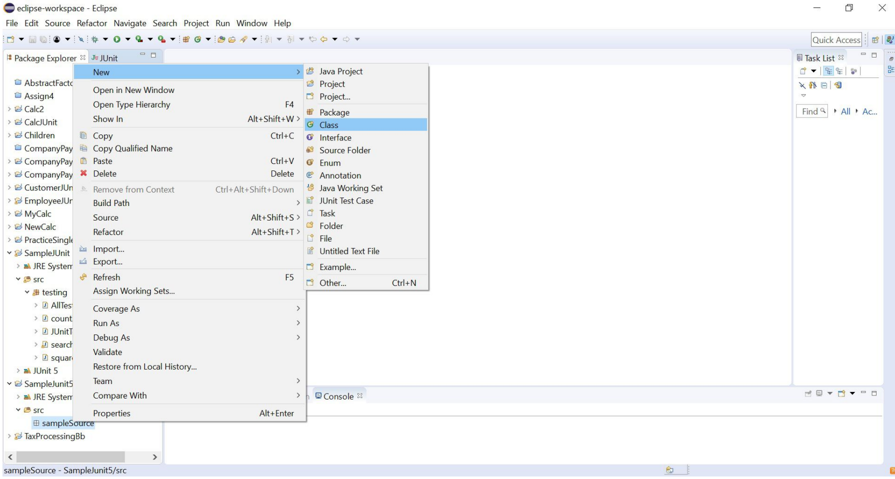
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EmployeeJUn
MyCalc
NewCalc
PracticeSingle
SampleJUnit
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src
testing
AllTes
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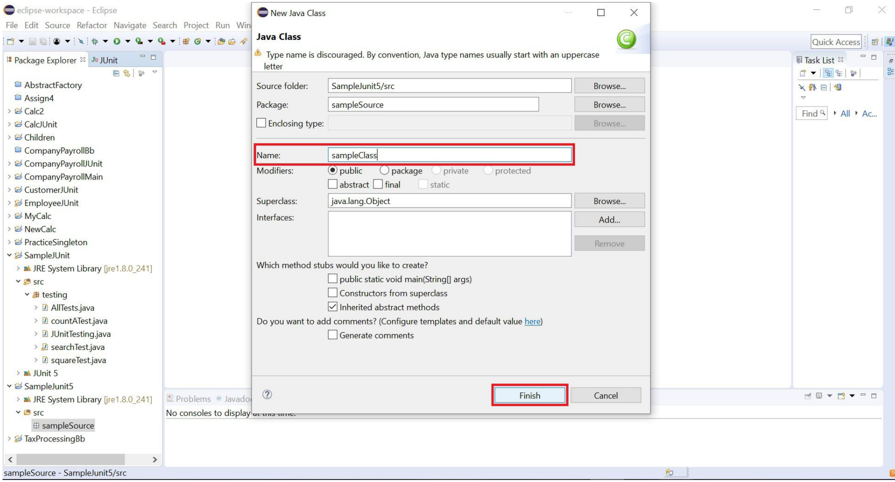
JUnitT
search
squar
JUnit 5
SampleJunit5
JRE System
src
sampleSource
TaxProcessingBb
New
Open in New Window
Open Type Hierarchy F4
Show In Alt+Shift+W
Copy Ctrl+C
Copy Qualified Name
Paste Ctrl+V
Delete Delete
Remove from Context Ctrl+Alt+Shift+Down
Build Path
Source Alt+Shift+S
Refactor Alt+Shift+T
Import...
Export...
Refresh F5
Assign Working Sets...
Coverage As
Run As
Debug As
Validate
Restore from Local History...
Team
Compare With
Properties Alt+Enter
Java Project
Project
Project...
Package
Class
Interface
Source Folder
Enum
Annotation
Java Working Set
JUnit Test Case
Task
Folder
File
Untitled Text File
Example...
Other... Ctrl+N
Console
sampleSource - SampleJunit5/src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Children
CompanyPayrollBb
CompanyPayrollJUnit
CompanyPayrollMain
CustomerJUnit
EmployeeJUnit
MyCalc
NewCalc
PracticeSingleton
SampleJUnit
JRE System Library [jre1.8.0_241]
src
testing
AllTests.java
countATest.java
JUnitTesting.java
searchTest.java
squareTest.java
JUnit 5
SampleJunit5
JRE System Library [jre1.8.0_241]
src
sampleSource
TaxProcessingBb

No consoles to display at this time.

sampleSource - SampleJunit5/src

New Java Class

Java Class

Type name is discouraged. By convention, Java type names usually start with an uppercase letter

Source folder:	SampleJunit5/src	Browse...
Package:	sampleSource	Browse...
☐ Enclosing type:		Browse...
Name:	sampleClass	
Modifiers:	● public ○ package ○ private ○ protected	
	☐ abstract ☐ final ☐ static	
Superclass:	java.lang.Object	Browse...
Interfaces:		Add... / Remove

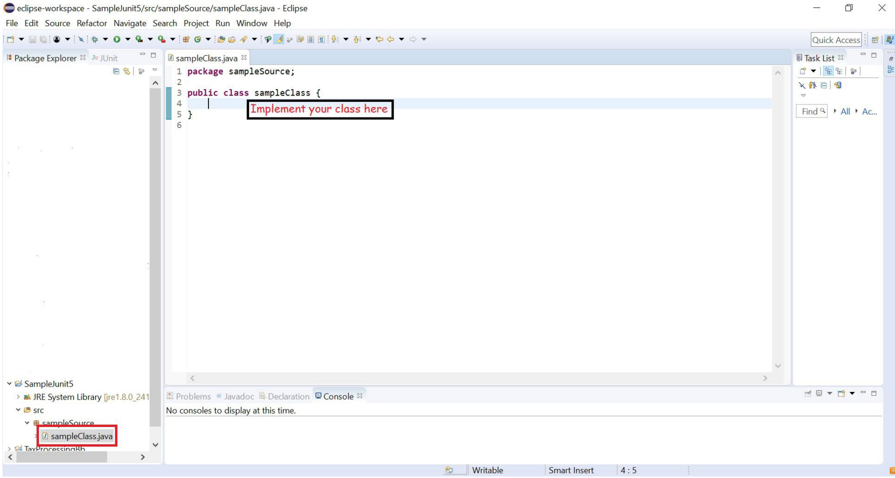
Which method stubs would you like to create?

- ☐ public static void main(String[] args)
- ☐ Constructors from superclass
- ☑ Inherited abstract methods

Do you want to add comments? (Configure templates and default value here)

- ☐ Generate comments

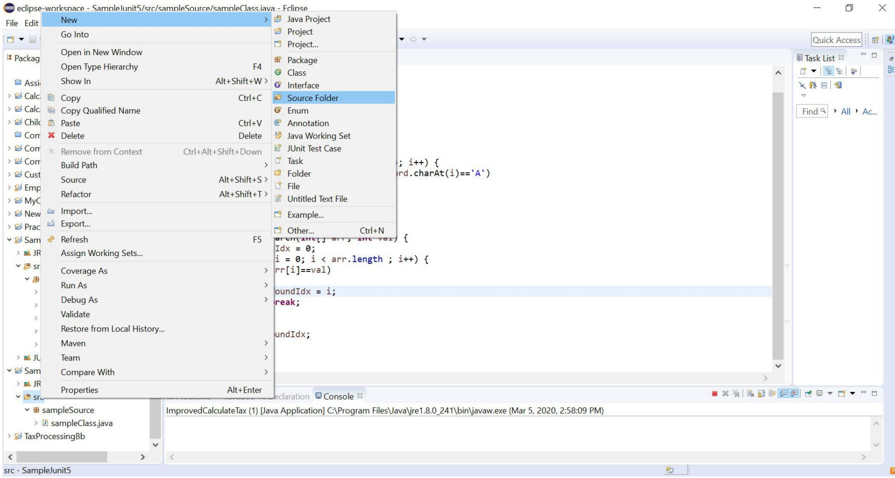
Finish Cancel



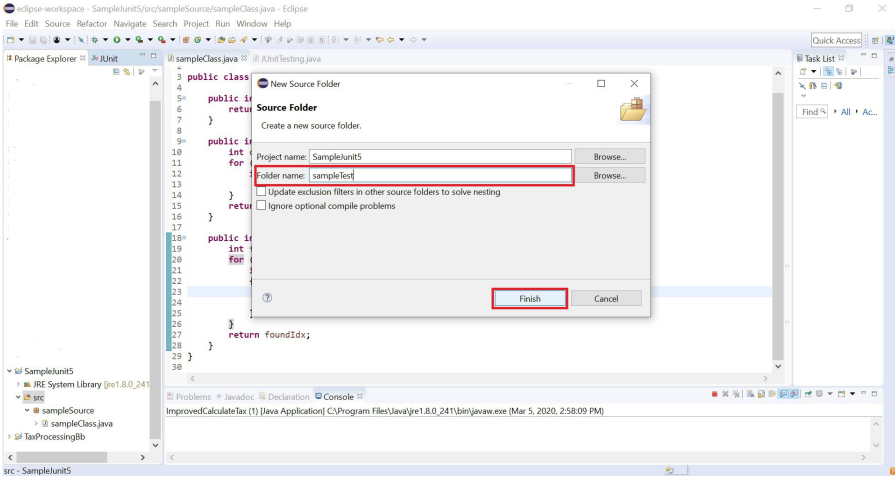
```java
package sampleSource;

public class sampleClass {
	
}
```

Implement your class here

No consoles to display at this time.



ImprovedCalculateTax (1) [Java Application] C:\Program Files\Java\jre1.8.0_241\bin\javaw.exe (Mar 5, 2020, 2:58:09 PM)


eclipse-workspace - SampleJunit5/src/sampleSource/sampleClass.java - Eclipse

```
public class
    public in
        retur
    }

    public in
        int
        for

        }
        retur
    }

    public in
        int
        for

        }
        return foundIdx;
    }
}
```

New Source Folder

Source Folder

Create a new source folder.

Project name: SampleJunit5

Folder name: sampleTest

☐ Update exclusion filters in other source folders to solve nesting

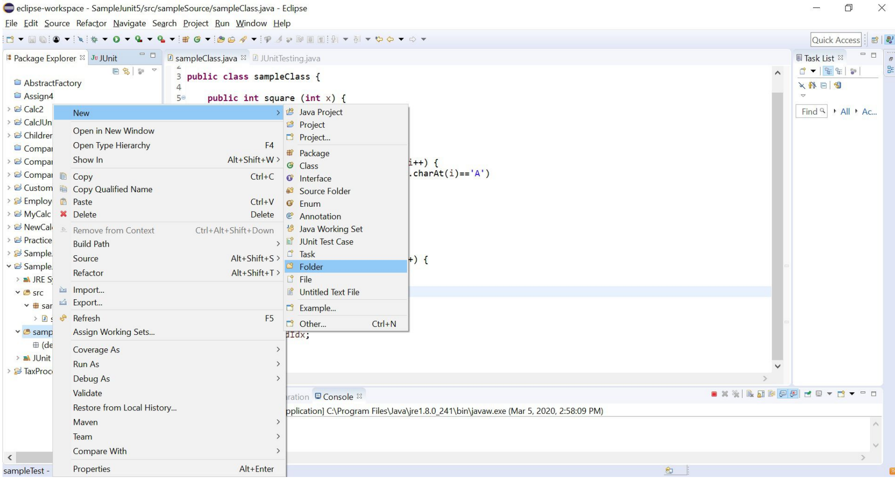
☐ Ignore optional compile problems

SampleJunit5
- JRE System Library [jre1.8.0_241
- src
  - sampleSource
    - sampleClass.java

TaxProcessingBb

```
ImprovedCalculateTax (1) [Java Application] C:\Program Files\Java\jre1.8.0_241\bin\javaw.exe (Mar 5, 2020, 2:58:09 PM)
```

src - SampleJunit5



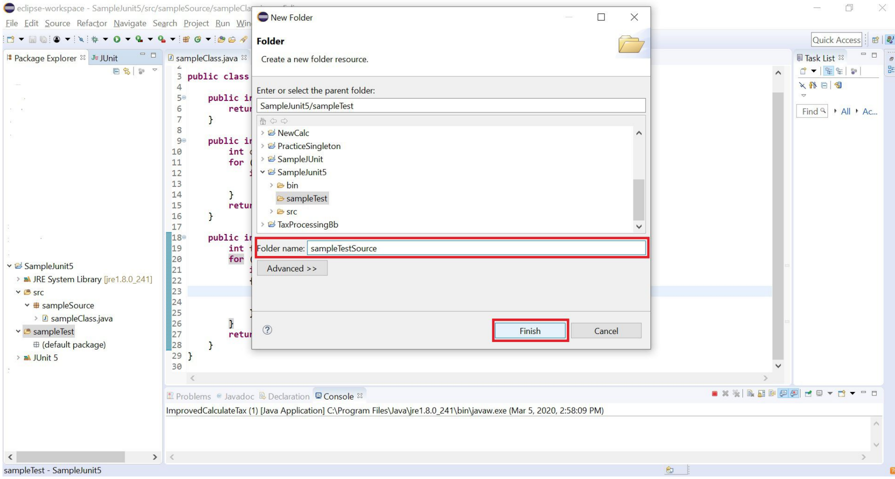
```
public class sampleClass {

    public int square (int x) {
```

```
i++) {
.charAt(i)=='A')
```

```
+) {
```

```
dIdx;
```

```
pplication] C:\Program Files\Java\jre1.8.0_241\bin\javaw.exe (Mar 5, 2020, 2:58:09 PM)
```



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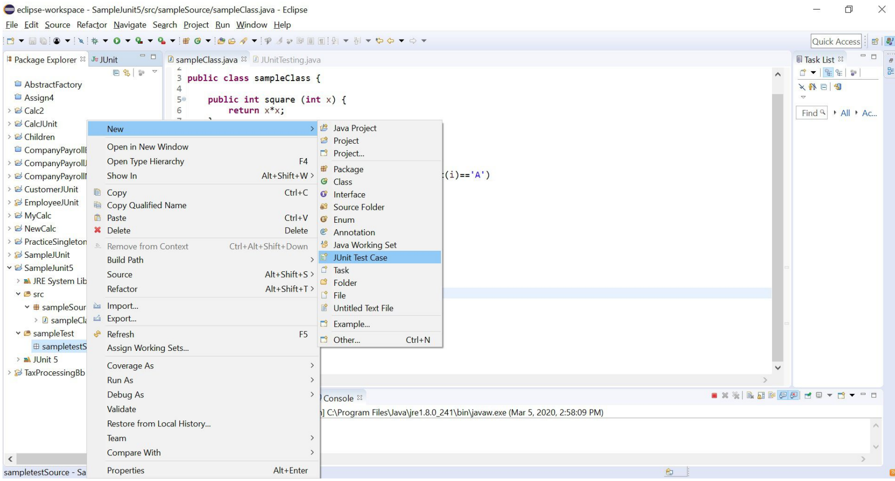
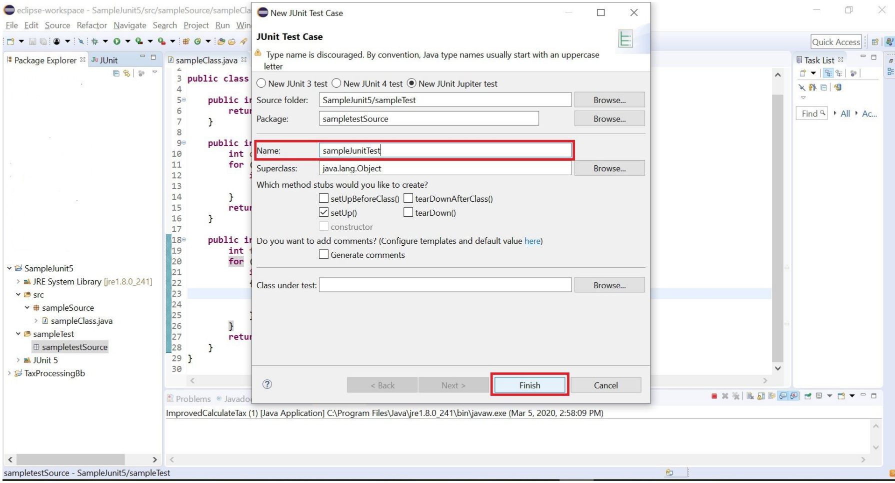


```
public class sampleClass {

    public int square (int x) {
        return x*x;
```

```
(i)=='A')
```

```
] C:\Program Files\Java\jre1.8.0_241\bin\javaw.exe (Mar 5, 2020, 2:58:09 PM)
```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New JUnit Test Case

JUnit Test Case

Type name is discouraged. By convention, Java type names usually start with an uppercase letter

New JUnit 3 test [✓ New JUnit Jupiter test] New JUnit 4 test

Source folder:	SampleJunit5/sampleTest	Browse...
Package:	sampletestSource	Browse...
Name:	sampleJunitTest	
Superclass:	java.lang.Object	Browse...

Which method stubs would you like to create?

- ☐ setUpBeforeClass()
- ☐ tearDownAfterClass()
- ☑ setUp()
- ☐ tearDown()
- ☐ constructor

Do you want to add comments? (Configure templates and default value here)

- ☐ Generate comments

Class under test:

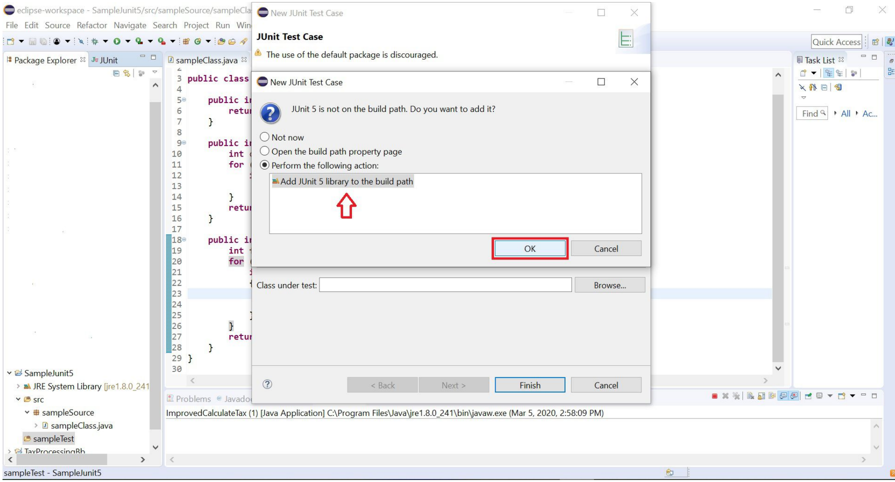
< Back Next > Finish Cancel

```
public class
    public in
        retur
    }
    public in
        int
        for
        }
        retur
    }
    public in
        int
        for
        }
        retur
    }
}
```

- SampleJunit5
  - JRE System Library [jre1.8.0_241]
  - src
    - sampleSource
      - sampleClass.java
  - sampleTest
    - sampletestSource
  - JUnit 5
- TaxProcessingBb

ImprovedCalculateTax (1) [Java Application] C:\Program Files\Java\jre1.8.0_241\bin\javaw.exe (Mar 5, 2020, 2:58:09 PM)

sampletestSource - SampleJunit5/sampleTest


eclipse-workspace - SampleJunit5/src/sampleSource/sampleCla
File Edit Source Refactor Navigate Search Project Run Win
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Quick Access
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SampleJunit5
JRE System Library [jre1.8.0_241
src
sampleSource
sampleClass.java
sampleTest
TaxProcessingBb
Problems
Javado
sampleTest - SampleJunit5

```
public class
    public i
        retu
    }
    public i
        int
        for
        }
        retu
    }
    public i
        int
        for
        }
        retu
    }
}
```

New JUnit Test Case

JUnit Test Case

The use of the default package is discouraged.

New JUnit Test Case

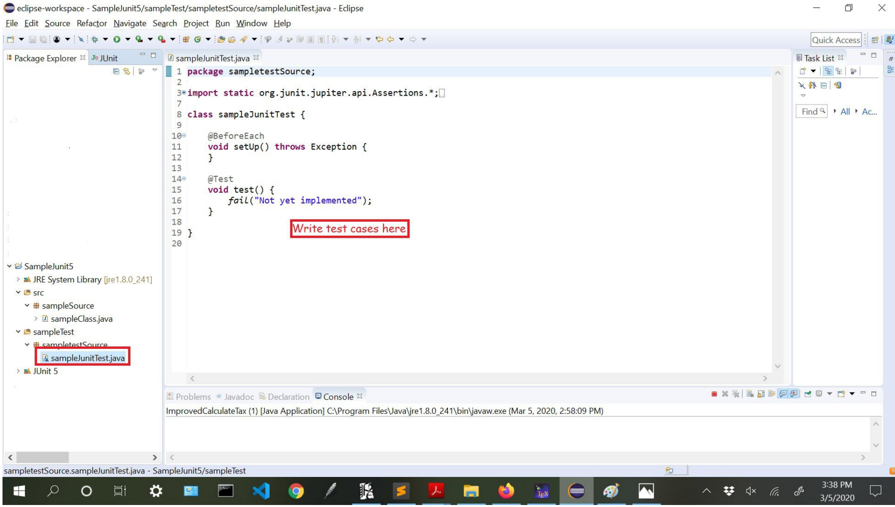
JUnit 5 is not on the build path. Do you want to add it?

- ( ) Not now
- ( ) Open the build path property page
- [✓ Perform the following action:]

Add JUnit 5 library to the build path

Class under test:

ImprovedCalculateTax (1) [Java Application] C:\Program Files\Java\jre1.8.0_241\bin\javaw.exe (Mar 5, 2020, 2:58:09 PM)


eclipse-workspace - SampleJunit5/sampleTest/sampletestSource/sampleJunitTest.java - Eclipse

```java
package sampletestSource;

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

class sampleJunitTest {

    @BeforeEach
    void setUp() throws Exception {
    }

    @Test
    void test() {
        fail("Not yet implemented");
    }

}
```

Write test cases here

- SampleJunit5
  - JRE System Library [jre1.8.0_241]
  - src
    - sampleSource
      - sampleClass.java
  - sampleTest
    - sampletestSource
      - sampleJunitTest.java
  - JUnit 5

ImprovedCalculateTax (1) [Java Application] C:\Program Files\Java\jre1.8.0_241\bin\javaw.exe (Mar 5, 2020, 2:58:09 PM)

sampletestSource.sampleJunitTest.java - SampleJunit5/sampleTest