CHAPTER 42

Testing Using JUnit

Objectives

- To know what JUnit is and how JUnit works (§42.2).
- To create and run a JUnit test class from the command window (§42.2).
- To create and run a JUnit test class from NetBeans (§42.3).
- To create and run a JUnit test class from Eclipse (§42.4).

42.1 Introduction

Key Point: JUnit is a tool for testing Java programs.

At the very beginning of this book in Section 2.16, we introduced software development process that includes requirements specification, analysis, design, implementation, testing, deployment, and maintenance. Testing is an important part of this process. This chapter introduces how to test Java classes using JUnit.

42.2 JUnit Basics

Key Point: To test a class, you need to write a class and run it through JUnit to generate a report

for the class.

<key term>JUnit
<key term>test runner
<key term>test class
JUnit is the de facto framework for testing Java programs. JUnit is a third-party open source library packed in a jar file. The jar file contains a tool called *test runner*, which is used to run test programs. Suppose you have a class named A. To test this class, you write a test class named ATest. This test class, called a *test class*, contains the methods you write for testing class A. The test runner executes ATest to generate a test report, as shown in Figure 42.1.

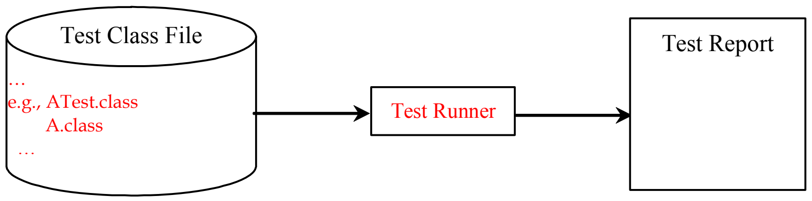


Figure 42.1

JUnit test runner executes the test class to generate a test report.

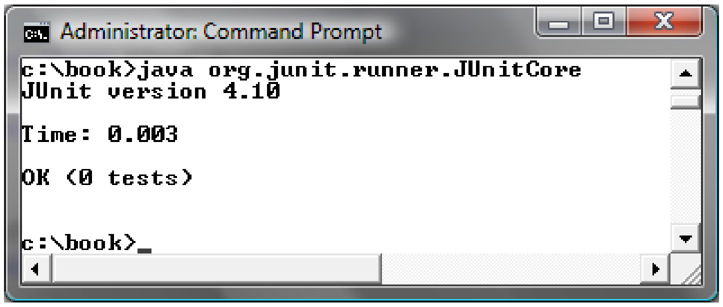
You will see how JUnit works from an example. To create the example, first you need to download JUnit from http://sourceforge.net/projects/junit/files/. At present, the latest version is junit-4.10.jar. Download this file to c:\book\lib and add it to the classpath environment variable as follows:

```
set classpath=.;%classpath%;c:\book\lib\junit-4.10.jar
```

To test if this environment variable is set correctly, open a new command window, and type the following command:

```
java org.junit.runner.JUnitCore
```

You should see the message displayed as shown in Figure 42.2.



```
c:\book>java org.junit.runner.JUnitCore
JUnit version 4.10

Time: 0.003

OK (0 tests)


c:\book>_
```

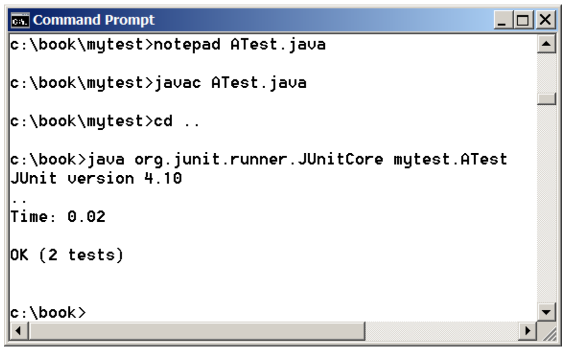
Figure 42.2

The JUnit test runner displays the JUnit version.

To use JUnit, create a test class. By convention, if the class to be tested is named A, the test class should be named ATest. A simple template of a test class may look like this:

```
package mytest;

import org.junit.*;
import static org.junit.Assert.*;

public class ATest {
  @Test
  public void m1() {
    // Write a test method
  }

  @Test
  public void m2() {
    // Write another test method
  }

  @Before
  public void setUp() throws Exception {
    // Common objects used by test methods may be set up here
  }
}
```

This class should be placed in a directory under mytest. Suppose the class is placed under c:\book\mytest. You need to compile it from the mytest directory and run it from c:\book as shown in the following screen shot.



```
c:\book\mytest>notepad ATest.java

c:\book\mytest>javac ATest.java

c:\book\mytest>cd ..

c:\book>java org.junit.runner.JUnitCore mytest.ATest
JUnit version 4.10
..
Time: 0.02

OK (2 tests)


c:\book>
```

Note that the command to run the test from the console is

```
java org.junit.runner.JUnitCore mytest.ATest
```

*<key term>**JUnitCore***
When this command is executed, JUnitCore controls the execution of ATest. It first executes the setUp() method to set up the common objects used for the test, and then executes test methods m1 and m2 in this order. You may define multiple test methods if desirable.

The following methods can be used to implement a test method:

assertTrue(booleanExpression)
The method reports success if the booleanExpression evaluates true.

assertEquals(Object, Object)
The method reports success if the two objects are the same using the equals method.

assertNull(Object)
The method reports success if the object reference passed is null.

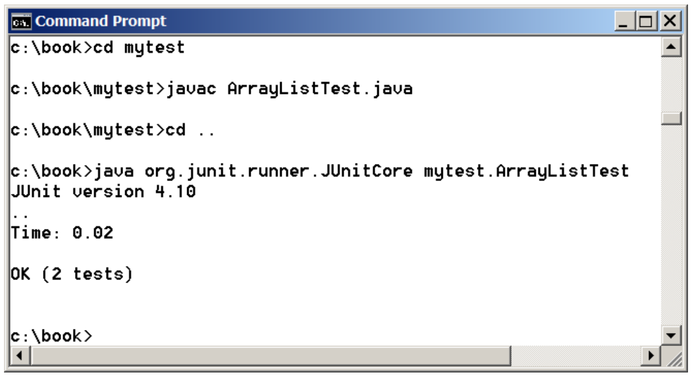
fail(String)
The method causes the test to fail and prints out the string.

Listing 42.1 is an example of a test class for testing java.util.ArrayList.

Listing 42.1 ArrayListTest.java

```
package mytest;

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

public class ArrayListTest {
  private ArrayList<String> list = new ArrayList<String>();

  @Before
  public void setUp() throws Exception {
  }

  @Test
  public void testInsertion() {
    list.add("Beijing");
    assertEquals("Beijing", list.get(0));
    list.add("Shanghai");
    list.add("Hongkong");
    assertEquals("Hongkong", list.get(list.size() - 1));
  }

  @Test
  public void testDeletion() {
    list.clear();
    assertTrue(list.isEmpty());

    list.add("A");
    list.add("B");
    list.add("C");
    list.remove("B");
    assertEquals(2, list.size());
  }
}
```

A test run of the program is shown in Figure 42.3. Note that you have to first compile ArrayListTest.java. The ArrayListTest class is placed in the mytest package. So you should place ArrayListTest.java in the directory named mytest.



```
c:\book>cd mytest

c:\book\mytest>javac ArrayListTest.java

c:\book\mytest>cd ..

c:\book>java org.junit.runner.JUnitCore mytest.ArrayListTest
JUnit version 4.10
..
Time: 0.02

OK (2 tests)


c:\book>
```

Figure 42.3

The test report is displayed from running ArrayListTest.

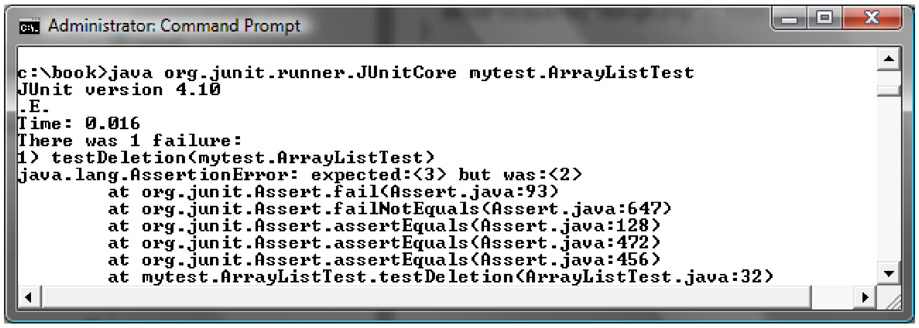
No errors are reported in this JUnit run. If you mistakenly change

```
assertEquals(2, list.size());
```

in line 32 to

```
assertEquals(3, list.size());
```

Run ArrayListTest now. You will see an error reported as shown in Figure 42.4.



```
c:\book>java org.junit.runner.JUnitCore mytest.ArrayListTest
JUnit version 4.10
.E.
Time: 0.016
There was 1 failure:
1) testDeletion(mytest.ArrayListTest)
java.lang.AssertionError: expected:<3> but was:<2>
        at org.junit.Assert.fail(Assert.java:93)
        at org.junit.Assert.failNotEquals(Assert.java:647)
        at org.junit.Assert.assertEquals(Assert.java:128)
        at org.junit.Assert.assertEquals(Assert.java:472)
        at org.junit.Assert.assertEquals(Assert.java:456)
        at mytest.ArrayListTest.testDeletion(ArrayListTest.java:32)
```

Figure 42.4

The test report reports an error.

You can define any number of test methods. In this example, two test methods testInsertion and testDeletion are defined. JUnit executes testInsertion and testDeletion in this order.

> NOTE: The test class must be placed in a named package such as mytest in this example. The JUnit will not work if the test class is placed a default package.

Listing 42.2 gives a test class for testing the Loan class in Listing 10.2. For convenience, we create Loan.java in the same directory with LoanTest.java. The Loan class is shown in Listing 42.3.

Listing 42.2 LoanTest.java

```
package mytest;

import org.junit.*;
import static org.junit.Assert.*;

public class LoanTest {
  @Before
  public void setUp() throws Exception {
  }

  @Test
  public void testPaymentMethods() {
    double annualInterestRate = 2.5;
    int numberOfYears = 5;
    double loanAmount = 1000;
    Loan loan = new Loan(annualInterestRate, numberOfYears,
      loanAmount);

    assertTrue(loan.getMonthlyPayment() ==
      getMonthlyPayment(annualInterestRate, numberOfYears,
      loanAmount));
    assertTrue(loan.getTotalPayment() ==
      getTotalPayment(annualInterestRate, numberOfYears,
      loanAmount));
  }

  /** Find monthly payment */
  private double getMonthlyPayment(double annualInterestRate,
      int numberOfYears, double loanAmount) {
    double monthlyInterestRate = annualInterestRate / 1200;
    double monthlyPayment = loanAmount * monthlyInterestRate / (1 -
      (1 / Math.pow(1 + monthlyInterestRate, numberOfYears * 12)));
    return monthlyPayment;
  }

  /** Find total payment */
  public double getTotalPayment(double annualInterestRate,
      int numberOfYears, double loanAmount) {
    return getMonthlyPayment(annualInterestRate, numberOfYears,
      loanAmount) * numberOfYears * 12;
  }
}
```

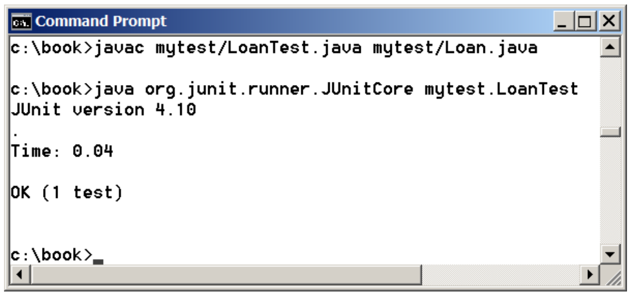
Listing 42.3 Loan.java

```
package mytest;

public class Loan {
  private double annualInterestRate;
  private int numberOfYears;
  private double loanAmount;
  private java.util.Date loanDate;

  /** Default constructor */
  public Loan() {
    this(2.5, 1, 1000);
  }

  /** Construct a loan with specified annual interest rate,
      number of years, and loan amount
    */
  public Loan(double annualInterestRate, int numberOfYears,
      double loanAmount) {
    this.annualInterestRate = annualInterestRate;
    this.numberOfYears = numberOfYears;
    this.loanAmount = loanAmount;
    loanDate = new java.util.Date();
  }

  /** Return annualInterestRate */
  public double getAnnualInterestRate() {
    return annualInterestRate;
  }

  /** Set a new annualInterestRate */
  public void setAnnualInterestRate(double annualInterestRate) {
    this.annualInterestRate = annualInterestRate;
  }

  /** Return numberOfYears */
  public int getNumberOfYears() {
    return numberOfYears;
  }

  /** Set a new numberOfYears */
  public void setNumberOfYears(int numberOfYears) {
    this.numberOfYears = numberOfYears;
  }

  /** Return loanAmount */
  public double getLoanAmount() {
    return loanAmount;
  }

  /** Set a newloanAmount */
  public void setLoanAmount(double loanAmount) {
    this.loanAmount = loanAmount;
  }

  /** Find monthly payment */
  public double getMonthlyPayment() {
    double monthlyInterestRate = annualInterestRate / 1200;
    double monthlyPayment = loanAmount * monthlyInterestRate / (1 -
      (1 / Math.pow(1 + monthlyInterestRate, numberOfYears * 12)));
    return monthlyPayment;
  }

  /** Find total payment */
  public double getTotalPayment() {
    double totalPayment = getMonthlyPayment() * numberOfYears * 12;
    return totalPayment;
  }

  /** Return loan date */
  public java.util.Date getLoanDate() {
    return loanDate;
  }
}
```

The testPaymentMethods() in LoanTest creates an instance of Loan (line 16-17) and tests whether loan.getMonthlyPayment() returns the same value as getMonthlyPayment(annualInterestRate, numberOfYears, loanAmount). The latter method is defined in the LoanTest class (lines 28-34).

The testPaymentMethods() also tests whether loan.getTotalPayment() returns the same value as getTotalPayment(annualInterestRate, numberOfYears, loanAmount). The latter method is defined in the LoanTest class (lines 37-41).

A sample run of the program is shown in Figure 42.5.



```
c:\book>javac mytest/LoanTest.java mytest/Loan.java

c:\book>java org.junit.runner.JUnitCore mytest.LoanTest
JUnit version 4.10
.
Time: 0.04

OK (1 test)


c:\book>
```

Figure 42.5

The JUnit test runner executes LoanTest and reports no errors.

Check point

42.1 What is JUnit?

42.2 What is a JUnit test runner?

42.3 What is a test class? How do you create a test class?

42.4 How do you use the assertTrue method?

42.5 How do you use the assertEquals method?

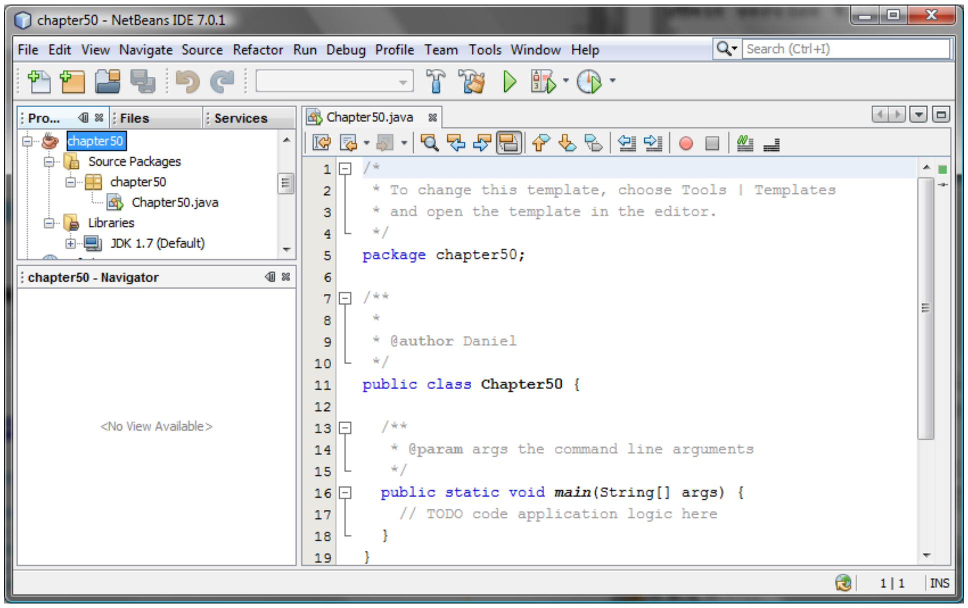
42.3 Using JUnit from NetBeans

Key Point: JUnit is intergrated with NetBeans. Using NetBeans, the test program can be automatically generated and the test process can be automated.

An IDE like NetBeans and Eclipse can greatly simplify the process for creating and running test classes. This section introduces using JUnit from NetBeans and the next section introduces using JUnit from Eclipse.

If you not familiar with NetBeans, see Supplement II.B. Assume you have installed NetBeans 7.0. Create a project named chapter50 as follows:

Step 1: Choose *File*, *New Project* to display the New Project dialog box.
Step 2: Choose Java in the Categories section and Java Application in the Projects section. Click *Next* to display the New Java Application dialog box.
Step 3: Enter chapter50 as the Project Name and c:\book as Project Location. Click *Finish* to create the project as shown in Figure 42.6.



```
/*
 * To change this template, choose Tools | Templates
 * and open the template in the editor.
 */
package chapter50;

/**
 *
 * @author Daniel
 */
public class Chapter50 {

    /**
     * @param args the command line arguments
     */
    public static void main(String[] args) {
        // TODO code application logic here
    }
}
```

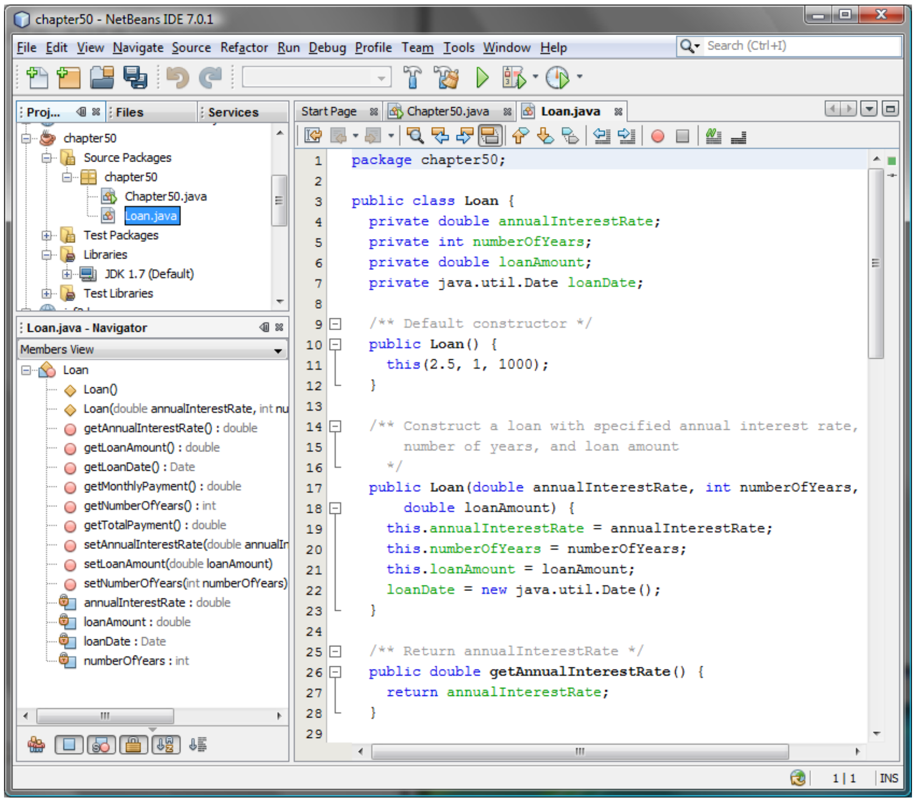
Figure 42.6

A new project named chapter50 is created.

To demonstrate how to create a test class, we first create class to be tested. Let the class be Loan from Listing 10.2. Here are the steps to create the Loan class under chapter42.

Step 1: Right-click the project node chapter50 and choose *New*, *Java Class* to display the New Java Class dialog box.
Step 2: Enter Loan as Class Name and chapter50 in the Package field and click *Finish* to create the class.

Step 3: Copy the code in Listing 10.2 to the Loan class and make sure the first line is package chapter50, as shown in Figure 42.7.


chapter50 - NetBeans IDE 7.0.1
File Edit View Navigate Source Refactor Run Debug Profile Team Tools Window Help
Search (Ctrl+I)
Proj... Files Services
chapter50
Source Packages
chapter50
Chapter50.java
Loan.java
Test Packages
Libraries
JDK 1.7 (Default)
Test Libraries
Loan.java - Navigator
Members View
Loan
Loan()
Loan(double annualInterestRate, int nu
getAnnualInterestRate() : double
getLoanAmount() : double
getLoanDate() : Date
getMonthlyPayment() : double
getNumberOfYears() : int
getTotalPayment() : double
setAnnualInterestRate(double annualIr
setLoanAmount(double loanAmount)
setNumberOfYears(int numberOfYears)
annualInterestRate : double
loanAmount : double
loanDate : Date
numberOfYears : int
Start Page
Chapter50.java
Loan.java
1 | 1
INS

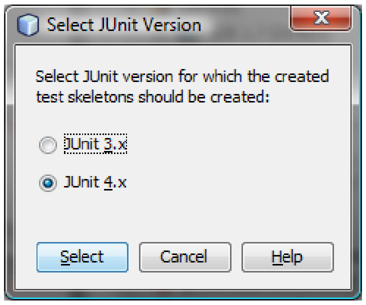
```java
package chapter50;

public class Loan {
  private double annualInterestRate;
  private int numberOfYears;
  private double loanAmount;
  private java.util.Date loanDate;

  /** Default constructor */
  public Loan() {
    this(2.5, 1, 1000);
  }

  /** Construct a loan with specified annual interest rate,
      number of years, and loan amount
    */
  public Loan(double annualInterestRate, int numberOfYears,
      double loanAmount) {
    this.annualInterestRate = annualInterestRate;
    this.numberOfYears = numberOfYears;
    this.loanAmount = loanAmount;
    loanDate = new java.util.Date();
  }

  /** Return annualInterestRate */
  public double getAnnualInterestRate() {
    return annualInterestRate;
  }

```

Figure 42.7

The Loan class is created.

Now you can create a test class to test the Loan class as follows:

Step 1: Right-click Loan.java in the project to display a context menu and choose *Tools*, *Create JUnit Test* to display the Select JUnit version dialog box, as shown in Figure 42.8.
Step 2: Choose JUnit 4.x. You will see the Create Tests dialog box displayed as shown in Figure 42.9. Click *OK* to generate a Test class named LoanTest as shown in Figure 42.10. Note that LoanTest.java is placed under the Test Packages node in the project.

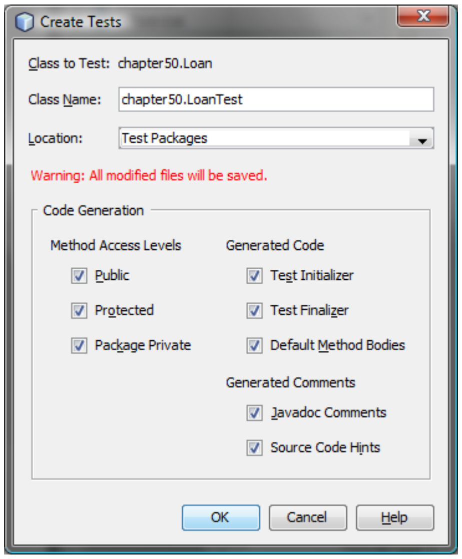


Select JUnit version for which the created test skeletons should be created:

JUnit 3.x [✓ JUnit 4.x]

Figure 42.8

You should select JUnit 4.x framework to create test classes.



Class to Test: chapter50.Loan

Class Name: chapter50.LoanTest

Location: Test Packages

Warning: All modified files will be saved.

Code Generation

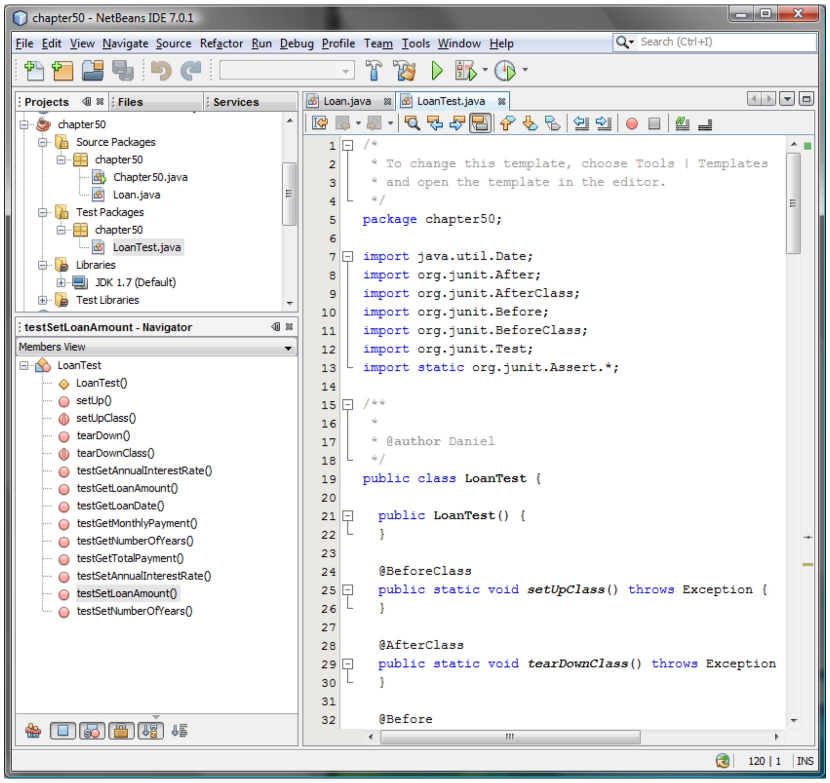
Method Access Levels
- [✓] Public
- [✓] Protected
- [✓] Package Private

Generated Code
- [✓] Test Initializer
- [✓] Test Finalizer
- [✓] Default Method Bodies

Generated Comments
- [✓] Javadoc Comments
- [✓] Source Code Hints

Figure 42.9

The Create Tests dialog box creates a Test class.

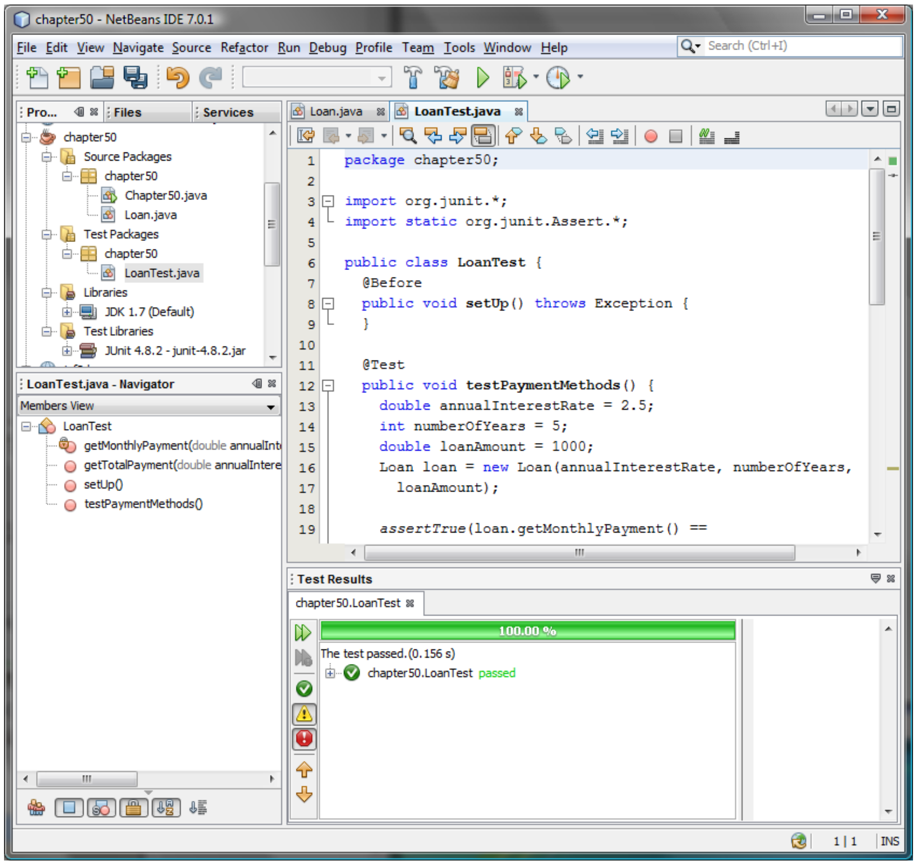


```
/*
 * To change this template, choose Tools | Templates
 * and open the template in the editor.
 */
package chapter50;

import java.util.Date;
import org.junit.After;
import org.junit.AfterClass;
import org.junit.Before;
import org.junit.BeforeClass;
import org.junit.Test;
import static org.junit.Assert.*;

/**
 *
 * @author Daniel
 */
public class LoanTest {

  public LoanTest() {
  }

  @BeforeClass
  public static void setUpClass() throws Exception {
  }

  @AfterClass
  public static void tearDownClass() throws Exception
  }

  @Before
```

Figure 42.10

The LoanTest class is automatically generated.

You can now modify LoanTest by copying the code from Listing 42.2. Run LoanTest.java. You will see the test report as shown in Figure 42.11.



```java
package chapter50;

import org.junit.*;
import static org.junit.Assert.*;

public class LoanTest {
  @Before
  public void setUp() throws Exception {
  }

  @Test
  public void testPaymentMethods() {
    double annualInterestRate = 2.5;
    int numberOfYears = 5;
    double loanAmount = 1000;
    Loan loan = new Loan(annualInterestRate, numberOfYears,
      loanAmount);

    assertTrue(loan.getMonthlyPayment() ==
```

```
100.00 %
The test passed.(0.156 s)
chapter50.LoanTest passed
```

Figure 42.11

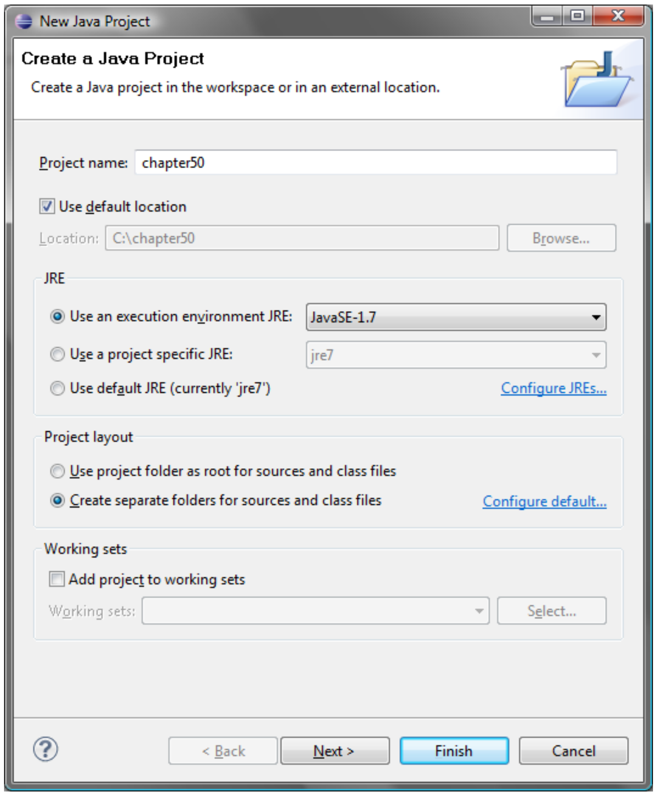
The test report is displayed after the LoanTest class is executed.

42.4 Using JUnit from Eclipse

Key Point: JUnit is intergrated with Eclipse. Using Eclipse, the test program can be automatically generated and the test process can be automated.

This section introduces using JUnit from Eclipse. If you are not familiar with Eclipse, see Supplement II.D. Assume you have installed Eclipse 3.7. Create a project named chapter50 as follows:

Step 1: Choose *File*, *New Java Project* to display the New Java Project dialog box, as shown in Figure 42.12.
Step 2: Enter chapter50 in the project name field and click *Finish* to create the project.


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

Project name: chapter50

[✓] Use default location

Location: C:\chapter50 Browse...

JRE

(●) Use an execution environment JRE: JavaSE-1.7

( ) Use a project specific JRE: jre7

( ) Use default JRE (currently 'jre7') 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

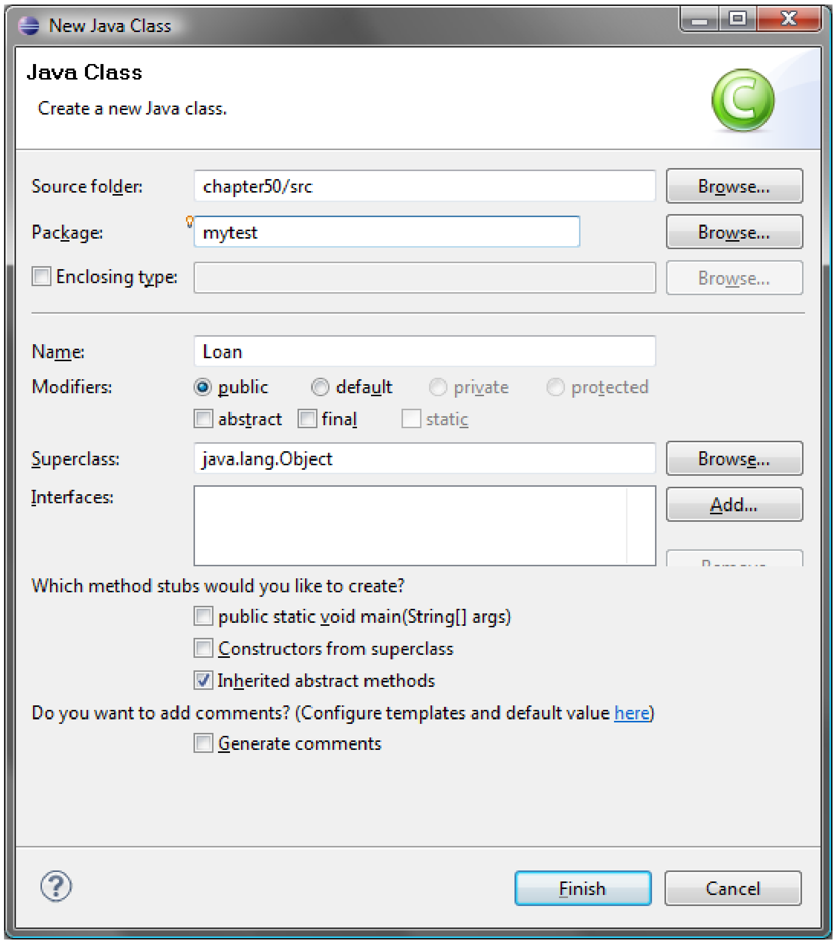
Working sets: Select...

Figure 42.12

The New Java Project dialog creates a new project.

To demonstrate how to create a test class, we first create class to be tested. Let the class be Loan from Listing 10.2. Here are the steps to create the Loan class under chapter42.

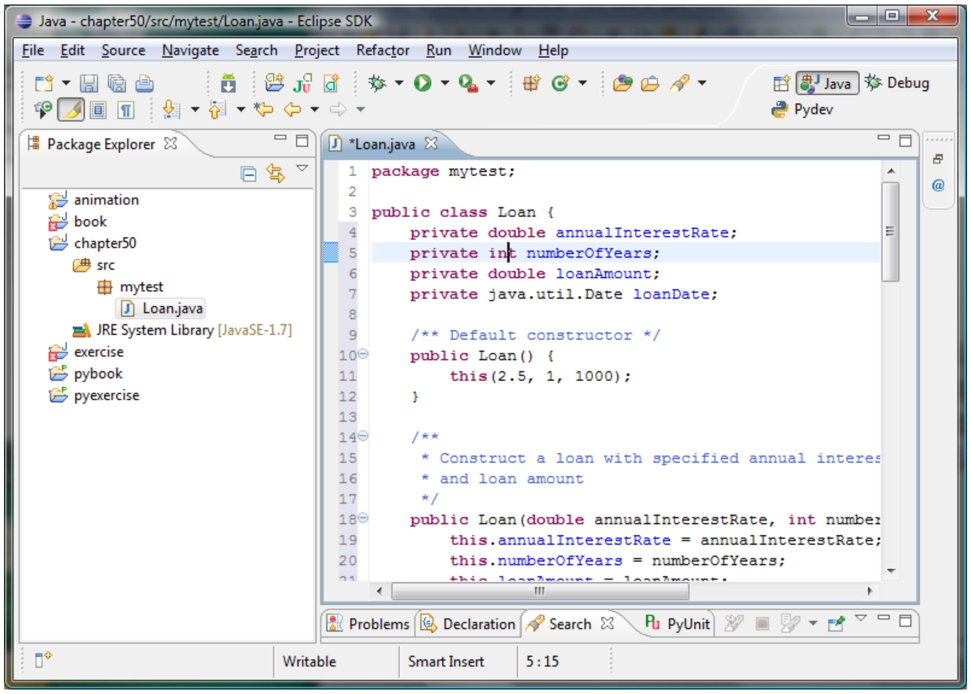
Step 1: Right-click the project node chapter50 and choose *New*, *Class* to display the New Java Class dialog box, as shown in Figure 42.13.
Step 2: Enter mytest in the Package field and click *Finish* to create the class.
Step 3: Copy the code in Listing 10.2 to the Loan class and make sure the first line is package mytest, as shown in Figure 42.14.



Source folder: chapter50/src
Package: mytest
Enclosing type: ☐
Name: Loan
Modifiers: [✓ public] default private protected
☐ abstract ☐ final ☐ static
Superclass: java.lang.Object
Interfaces:
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

Figure 42.13

The New Java Class dialog creates a new Java class.



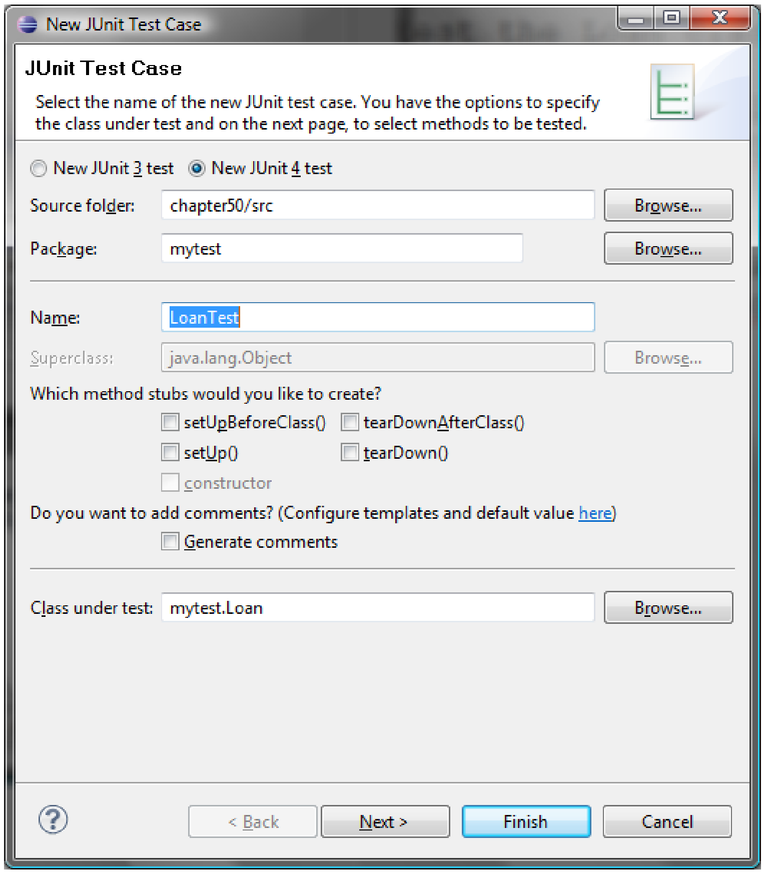
```
package mytest;

public class Loan {
    private double annualInterestRate;
    private int numberOfYears;
    private double loanAmount;
    private java.util.Date loanDate;

    /** Default constructor */
    public Loan() {
        this(2.5, 1, 1000);
    }

    /**
     * Construct a loan with specified annual interes
     * and loan amount
     */
    public Loan(double annualInterestRate, int number
        this.annualInterestRate = annualInterestRate;
        this.numberOfYears = numberOfYears;
```

Figure 42.14

The Loan class is created.

Now you can create a test class to test the Loan class as follows:

Step 1: Right-click Loan.java in the project to display a context menu and choose *New*, *JUnit Test Case* to display the New JUnit Test Case dialog box, as shown in Figure 42.15.
Step 2: Click *Finish*. You will see a dialog prompting you to add JUnit 4 to the project build path. Click *OK* to add it. Now a test class named LoanTest is created as shown in Figure 42.16.



JUnit Test Case

Select the name of the new JUnit test case. You have the options to specify the class under test and on the next page, to select methods to be tested.

New JUnit 3 test [✓ New JUnit 4 test]

Source folder: chapter50/src

Package: mytest

Name: LoanTest

Superclass: java.lang.Object

Which method stubs would you like to create?

☐ setUpBeforeClass() ☐ tearDownAfterClass()

☐ setUp() ☐ tearDown()

☐ constructor

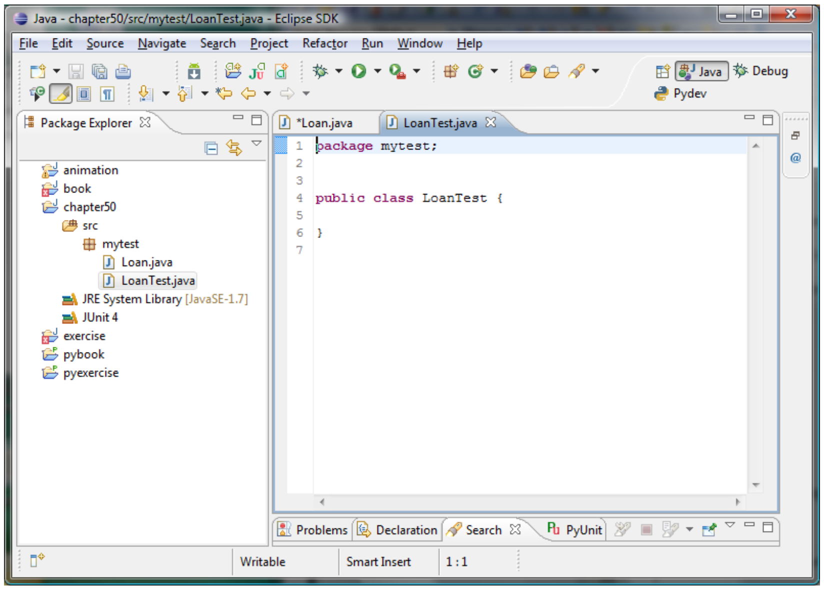
Do you want to add comments? (Configure templates and default value here)

☐ Generate comments

Class under test: mytest.Loan

Figure 42.15

The New JUnit Test Case dialog box creates a Test class.

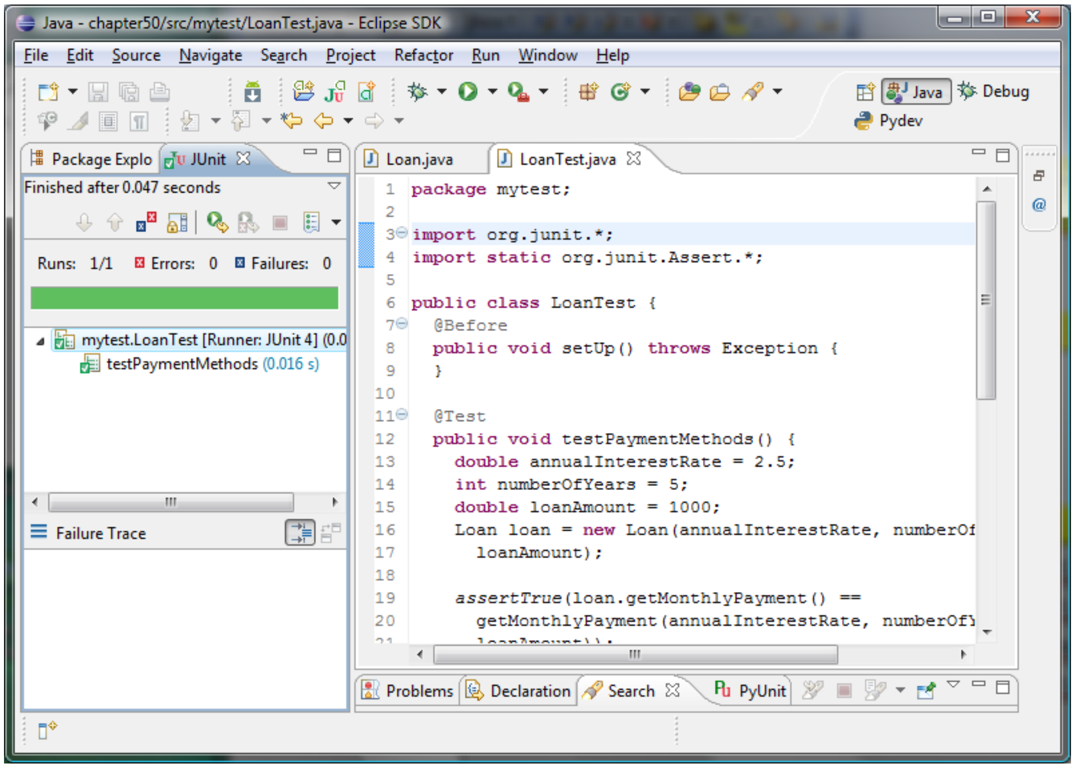


```
package mytest;


public class LoanTest {

}
```

Figure 42.16

The LoanTest class is automatically generated.

You can now modify LoanTest by copying the code from Listing 42.2. Run LoanTest.java. You will see the test report as shown in Figure 42.17.


Java - chapter50/src/mytest/LoanTest.java - Eclipse SDK
File Edit Source Navigate Search Project Refactor Run Window Help
Java
Debug
Pydev
Package Explo
JUnit
Loan.java
LoanTest.java
Failure Trace
Problems
Declaration
Search
PyUnit

```
Finished after 0.047 seconds
Runs: 1/1    Errors: 0    Failures: 0
mytest.LoanTest [Runner: JUnit 4] (0.0
  testPaymentMethods (0.016 s)
```

```java
package mytest;

import org.junit.*;
import static org.junit.Assert.*;

public class LoanTest {
  @Before
  public void setUp() throws Exception {
  }

  @Test
  public void testPaymentMethods() {
    double annualInterestRate = 2.5;
    int numberOfYears = 5;
    double loanAmount = 1000;
    Loan loan = new Loan(annualInterestRate, numberOf
      loanAmount);

    assertTrue(loan.getMonthlyPayment() ==
      getMonthlyPayment(annualInterestRate, numberOfY
```

Figure 42.17

The test report is displayed after the LoanTest class is executed.

Key Terms

- **JUnit**
- **JUnitCore**
- **test class**
- **test runner**

Chapter Summary

1. JUnit is an open source framework for testing Java programs.
2. To test a Java class, you create a test class for the class to be tested and use JUnit’s test runner to execute the test class to generate a test report.
3. You can create and run a test class from the command window or use a tool such as NetBeans and Eclipse.

Quiz

Answer the quiz for this chapter online at www.cs.armstrong.edu/liang/intro10e/quiz.html.

Programming Exercises

42.1

Write a test class to test the methods length, charAt, substring, and indexOf in the java.lang.String class.

42.2

Write a test class to test the methods add, remove, addAll, removeAll, size, isEmpty, and contains in the java.util.HashSet class.

42.3

Write a test class to test the method isPrime in Listing 5.7 PrimeNumberMethod.java.

42.4

Write a test class to test the methods getBMI and getStatus in the BMI class in Listing 10.4.