

Lesson 3

Classes and Objects

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OBJECTIVES

In this chapter you'll learn:

- What classes, objects, methods and instance variables are.
- How to declare a class and use it to create an object.
- How to declare methods in a class to implement the class's behaviors.
- How to declare instance variables in a class to implement the class's attributes.
- How to call an object's methods to make those methods perform their tasks.
- The differences between instance variables of a class and local variables of a method.
- How to use a constructor to ensure that an object's data is initialized when the object is created.
- The differences between primitive and reference types.

- 3.1 Introduction
- 3.2 Classes, Objects, Methods and Instance Variables
- 3.3 Declaring a Class with a Method and Instantiating an Object of a Class
- 3.4 Declaring a Method with a Parameter
- 3.5 Instance Variables, *set* Methods and *get* Methods
- 3.6 Primitive Types vs. Reference Types
- 3.7 Initializing Objects with Constructors
- 3.8 Floating-Point Numbers and Type **double**
- 3.9 (Optional) GUI and Graphics Case Study: Using Dialog Boxes
- 3.10 Wrap-Up

Laboratory Session: Exercises on classes

3.2 Classes, Objects, Methods and Instance Variables

- ▶ Analogy to help you understand classes and their contents.
 - Suppose you want to **drive a car and make it go faster** by pressing down on its accelerator pedal.
 - Before you can drive a car, someone has to **design** it.
 - A car typically begins as **engineering drawings**, similar to the blueprints used to design a house.
 - These include the **design for an accelerator pedal** to make the car go faster.

3.2 Classes, Objects, Methods and Instance Variables (Cont.)

- ▶ Analogy to help you understand classes and their contents.
 - The pedal “hides” from the driver the complex mechanisms that actually make the car go faster, just as the brake pedal “hides” the mechanisms that slow the car and the steering wheel “hides” the mechanisms that turn the car.
 - This enables people with little or no knowledge of how engines work to drive a car easily.
 - Before you can drive a car, it must be built from the engineering drawings that describe it.
 - A completed car has an actual accelerator pedal to make the car go faster, but even that’s not enough—the car won’t accelerate on its own, so the driver must press the accelerator pedal.

3.2 Classes, Objects, Methods and Instance Variables (Cont.)

- ▶ Performing a task in a program **requires a method**.
 - The method **describes the mechanisms** that actually perform its tasks.
 - **Hides** from its user the complex tasks that it performs, just as the accelerator pedal of a car hides from the driver the complex mechanisms of making the car go faster.
- ▶ In Java, a class **houses a method**, just as a car's engineering drawings house the design of an accelerator pedal.
- ▶ In a class, you provide **one or more methods** that are designed to perform the class's tasks.

3.2 Classes, Objects, Methods and Instance Variables (Cont.)

- ▶ You must **build an object** of a class before a program can perform the tasks the class describes how to do.
 - That is one reason Java is known as an **object-oriented programming language**.
- ▶ When you drive a car, pressing its gas pedal sends a message to the car to perform a task—make the car go faster.
- ▶ You **send messages** to an object—each message is implemented as a **method call** that tells a method of the object to perform its task.

3.2 Classes, Objects, Methods and Instance Variables (Cont.)

- ▶ A car has many **attributes**
 - Color, the number of doors, the amount of gas in its tank, its current speed and its total miles driven.
- ▶ Attributes are represented as **part of** a car's design in its engineering diagrams.
- ▶ Every car maintains **its own attributes**.
 - Each car knows how much gas is in its own gas tank, but not how much is in the tanks of other cars.

3.2 Classes, Objects, Methods and Instance Variables (Cont.)

- ▶ An object has **attributes that are carried** with the object as it's used in a program.
 - Specified as part of the object's class.
 - A bank account object has a balance attribute that represents the amount of money in the account.
 - Each bank account object knows the balance in the account it represents, but not the balances of the other accounts in the bank.
- ▶ Attributes are specified by the class's **instance variables**.

3.3 Declaring a Class with a Method and Instantiating an Object of a Class

- ▶ Create a new class (`GradeBook`)
- ▶ Use it to create an object.
- ▶ Each class declaration that begins with keyword `public` must be stored in a file that has the same name as the class and ends with the `.java` file-name extension.
- ▶ Keyword `public` is an **access modifier**.
 - Indicates that the class is “available to the public”



Common Programming Error 3.1

Declaring more than one `public` class in the same file is a compilation error.

```
1  // Fig. 3.1: GradeBook.java
2  // Class declaration with one method.
3
4  public class GradeBook
5  {
6      // display a welcome message to the GradeBook user
7      public void displayMessage()
8      {
9          System.out.println( "Welcome to the Grade Book!" );
10     } // end method displayMessage
11 } // end class GradeBook
```

Performs the task of displaying a message on the screen; method `displayMessage` must be called to perform this task

Fig. 3.1 | Class declaration with one method.

3.3 Declaring a Class with a Method and Instantiating an Object of a Class (Cont.)

- ▶ The `main` method is **called automatically** by the Java Virtual Machine (JVM) when you execute an application.
- ▶ Normally, you must call methods explicitly to tell them to perform their tasks.
- ▶ A `public` is “available to the public”
 - **It can be called from methods of other classes.**
- ▶ The **return type** specifies the type of data the method returns after performing its task.
- ▶ Return type `void` indicates that a method will perform a task but will *not* return (i.e., give back) any information to its **calling method** when it completes its task.

3.3 Declaring a Class with a Method and Instantiating an Object of a Class (Cont.)

- ▶ Method name follows the return type.
- ▶ By convention, method names **begin with a lowercase** first letter and subsequent words in the name begin with a capital letter.
- ▶ **Empty parentheses** after the method name indicate that the method does not require additional information to perform its task.
- ▶ Together, everything in the first line of the method is typically called the **Method header**
- ▶ Every method's **body is delimited** by left and right braces.
- ▶ The method body contains one or more statements that perform the method's task.

3.3 Declaring a Class with a Method and Instantiating an Object of a Class (Cont.)

- ▶ Use class `GradeBook` in an application.
- ▶ Class `GradeBook` is **not an application** because it does not contain `main`.
- ▶ Can't execute `GradeBook`; will receive an error message like:
 - Exception in thread "main"
`java.lang.NoSuchMethodError: main`
- ▶ Must either declare a separate class that contains a `main` method or place a `main` method in class `GradeBook`.
- ▶ To help you prepare for the larger programs, **use a separate class** containing method `main` to test each new class.
- ▶ Some programmers refer to such a class as a **driver class**.

```
1 // Fig. 3.2: GradeBookTest.java
2 // Creating a GradeBook object and calling its displayMessage method.
3
4 public class GradeBookTest
5 {
6     // main method begins program execution
7     public static void main( String[] args )
8     {
9         // create a GradeBook object and assign it to myGradeBook
10        GradeBook myGradeBook = new GradeBook();
11
12        // call myGradeBook's displayMessage method
13        myGradeBook.displayMessage();
14    } // end main
15 } // end class GradeBookTest
```

Creates a GradeBook object and assigns it to variable myGradeBook

Invokes method displayMessage on the GradeBook object that was assigned to variable myGradeBook

Welcome to the Grade Book!

Fig. 3.2 | Creating a GradeBook object and calling its displayMessage method.

3.3 Declaring a Class with a Method and Instantiating an Object of a Class (Cont.)

- ▶ A `static` method (such as `main`) is **special**
 - It can be called **without first creating an object** of the class in which the method is declared.
- ▶ Typically, you **cannot call a method** that belongs to another class **until you create an object** of that class.
- ▶ Declare a variable of the class type.
 - Each new class you create becomes a new type that can be used to declare variables and create objects.
 - You can declare new class types as needed; this is one reason why Java is known as an **extensible language**.

3.3 Declaring a Class with a Method and Instantiating an Object of a Class (Cont.)

- ▶ Class instance creation expression
 - Keyword `new` creates a new object of the class specified to the right of the keyword.
 - Used to initialize a variable of a class type.
 - The parentheses to the right of the class name are required.
 - Parentheses in combination with a class name represent a call to a `constructor`, which is similar to a method but is used only at the time an object is `created` to initialize the object's data.

3.3 Declaring a Class with a Method and Instantiating an Object of a Class (Cont.)

- ▶ Call a method via the class-type variable
 - Variable name followed by a dot separator (.), the method name and parentheses.
 - Call causes the method to perform its task.
- ▶ Any class can contain a main method.
 - The JVM invokes the main method only in the class used to execute the application.
 - If multiple classes that contain main, then one that is invoked is the one in the class named in the java command.

3.3 Declaring a Class with a Method and Instantiating an Object of a Class (Cont.)

- ▶ Compiling an Application with Multiple Classes
 - Compile the classes in Fig. 3.1 and Fig. 3.2 before executing.
 - Type the command

```
javac GradeBook.java GradeBookTest.java
```
 - If the directory containing the application includes only this application's files, you can compile all the classes in the directory with the command

```
javac *.java
```

3.3 Declaring a Class with a Method and Instantiating an Object of a Class (Cont.)

- ▶ Figure 3.3: UML class diagram for class `GradeBook`.
- ▶ Each class is modeled in a class diagram as a rectangle with three compartments.
 - Top: contains the class name centered horizontally in boldface type.
 - Middle: contains the class's attributes, which correspond to instance variables (Section 3.5).
 - Bottom: contains the class's operations, which correspond to methods.
- ▶ Operations are modeled by listing the operation name preceded by an access modifier (in this case `+`) and followed by a set of parentheses.
- ▶ The plus sign (`+`) corresponds to the keyword `public`.

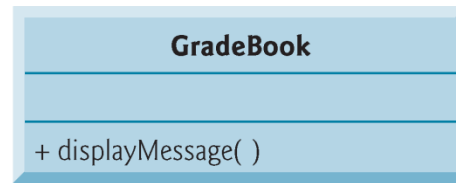


Fig. 3.3 | UML class diagram indicating that class `GradeBook` has a `public displayMessage` operation.

3.4 Declaring a Method with a Parameter

- ▶ Car analogy
 - Pressing a car's gas pedal sends a message to the car to perform a task—make the car go faster.
 - The farther down you press the pedal, the faster the car accelerates.
 - Message to the car includes the task to perform and **additional information** that helps the car perform the task.
- ▶ **Parameter**: Additional information a method needs to perform its task.

3.4 Declaring a Method with a Parameter (Cont.)

- ▶ A method can require one or more parameters that represent additional information it needs to perform its task.
 - Defined in a comma-separated **parameter list**
 - Located in the parentheses that follow the method name
 - Each parameter must specify a **type and an identifier**.
- ▶ A method call supplies values — called arguments — for each of the method's parameters.


```
1 // Fig. 3.4: GradeBook.java
2 // Class declaration with a method that has a parameter.
3
4 public class GradeBook
5 {
6     // display a welcome message to the GradeBook user
7     public void displayMessage( String courseName )
8     {
9         System.out.printf( "Welcome to the grade book for\n%s!\n",
10             courseName );
11     }
12 } // end class GradeBook
```

Parameter `courseName` provides the additional information that the method requires to perform its task

Parameter `courseName`'s value is displayed as part of the output

Fig. 3.4 | Class declaration with one method that has a parameter.

```
1 // Fig. 3.5: GradeBookTest.java
2 // Create GradeBook object and pass a String to
3 // its displayMessage method.
4 import java.util.Scanner; // program uses Scanner
5
6 public class GradeBookTest
7 {
8     // main method begins program execution
9     public static void main( String[] args )
10    {
11        // create Scanner to obtain input from command window
12        Scanner input = new Scanner( System.in );
13
14        // create a GradeBook object and assign it to myGradeBook
15        GradeBook myGradeBook = new GradeBook();
16
17        // prompt for and input course name
18        System.out.println( "Please enter the course name:" );
19        String nameOfCourse = input.nextLine(); // read a line of text
20        System.out.println(); // outputs a blank line
21    }
```

Reads a String from
the user

Fig. 3.5 | Creating a GradeBook object and passing a String to its displayMessage method. (Part 1 of 2.)

```
22      // call myGradeBook's displayMessage method
23      // and pass nameOfCourse as an argument
24      myGradeBook.displayMessage( nameOfCourse );
25  } // end main
26 } // end class GradeBookTest
```

Passes the value of `nameOfCourse` as the argument to method `displayMessage`

```
Please enter the course name:
CS101 Introduction to Java Programming
```

```
Welcome to the grade book for
CS101 Introduction to Java Programming!
```

Fig. 3.5 | Creating a `GradeBook` object and passing a `String` to its `displayMessage` method. (Part 2 of 2.)

3.4 Declaring a Method with a Parameter (Cont.)

- ▶ **Scanner** method `nextLine`
 - Reads characters typed by the user **until the newline character is encountered**
 - Returns a **String** containing the characters up to, but not including, the newline
 - Press *Enter* to submit the string to the program.
 - Pressing *Enter* inserts a newline character at the end of the characters the user typed.
 - The newline character is discarded by `nextLine`.
- ▶ **Scanner** method `next`
 - **Reads individual words**
 - Reads characters **until a white-space character is encountered**, then returns a **String** (the white-space character is discarded).
 - Information after the first white-space character can be read by other statements that call the **Scanner**'s methods later in the program.

3.4 Declaring a Method with a Parameter (Cont.)

- ▶ More on Arguments and Parameters
 - The **number of arguments** in a method call **must match** the number of parameters in the parameter list of the method's declaration.
 - The **argument types** in the method call must be “**consistent with**” the types of the corresponding parameters in the method's declaration.



Common Programming Error 3.2

A compilation error occurs if the number of arguments in a method call does not match the number of parameters in the method declaration.



Common Programming Error 3.3

A compilation error occurs if the type of any argument in a method call is not consistent with the type of the corresponding parameter in the method declaration.

3.4 Declaring a Method with a Parameter (Cont.)

- ▶ The UML class diagram of Fig. 3.6 models class **GradeBook** of Fig. 3.4.
- ▶ The UML models a parameter by listing the parameter name, followed by a colon and the parameter type in the parentheses - following the operation name.
- ▶ The UML type **String** corresponds to the Java type **String**.

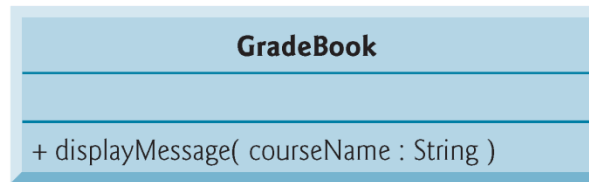


Fig. 3.6 | UML class diagram indicating that class **GradeBook** has a `displayMessage` operation with a `courseName` parameter of UML type `String`.

3.4 Declaring a Method with a Parameter (Cont.)

- ▶ Notes on `import` Declarations
 - Classes `System` and `String` are in package `java.lang`
 - Implicitly imported into every Java program
 - Can use the `java.lang` classes without explicitly importing them
 - Most classes you'll use in Java programs must be imported explicitly.
 - Classes that are compiled in the same directory on disk are in the same package—known as the `default package`.
 - Classes in the same package are implicitly imported into the source-code files of other classes in the same package.
 - An `import` declaration is not required if you always refer to a class via its `fully qualified class name`
 - Package name followed by a dot (`.`) and the class name.

3.5 Instance Variables, *set Methods and get Methods*

▶ Local variables

- Variables declared in the body of a particular method.
- When a method **terminates**, the values of its local variables are **lost**.
- Recall from Section 3.2 that an object has attributes that are **carried with the object** as it's used in a program.
- Such attributes **exist before** a method is called on an object **and after** the method completes execution.

3.5 Instance Variables, set Methods and get Methods (Cont.)

- ▶ A class normally consists of one or more methods that manipulate the attributes that belong to a particular object of the class.
 - **Attributes** are represented as variables in a class declaration.
 - Called **fields**.
 - Declared **inside** a class declaration but **outside** the bodies of the class's method declarations.
- ▶ **Instance variable**
 - When each object of a class maintains its **own copy** of an attribute, the field is an **instance variable**
 - Each object (instance) of the class has a separate instance of the variable in memory.

```
1 // Fig. 3.7: GradeBook.java
2 // GradeBook class that contains a courseName instance variable
3 // and methods to set and get its value.
4
5 public class GradeBook
6 {
7     private String courseName; // course name for this GradeBook
8
9     // method to set the course name
10    public void setCourseName( String name )
11    {
12        courseName = name; // store the course name
13    } // end method setCourseName
14
15    // method to retrieve the course name
16    public String getCourseName()
17    {
18        return courseName;
19    } // end method getCourseName
20
```

Each GradeBook object maintains its own copy of instance variable courseName

Method allows client code to change the courseName

Method allows client code to obtain the courseName

Fig. 3.7 | GradeBook class that contains a courseName instance variable and methods to set and get its value. (Part 1 of 2.)

```
21 // display a welcome message to the GradeBook user
22 public void displayMessage()
23 {
24     // calls getCourseName to get the name of
25     // the course this GradeBook represents
26     System.out.printf( "Welcome to the grade book for\n%s!\n",
27         getCourseName() );
28 } // end method displayMessage
29 } // end class GradeBook
```

No parameter required; all methods in this class already know about instance variable `courseName` and the class's other methods

Good practice to access your instance variables via *set* or *get* methods

Fig. 3.7 | GradeBook class that contains a `courseName` instance variable and methods to set and get its value. (Part 2 of 2.)

3.5 Instance Variables, set Methods and get Methods (Cont.)

- ▶ Every instance (i.e., object) of a class **contains one copy** of each instance variable.
- ▶ Instance variables typically declared **private**.
 - **private** is an access modifier.
 - **private** variables and methods are accessible only to methods of the class in which they are declared.
- ▶ Declaring instance **private** is known as **data hiding** or **information hiding**.
- ▶ **private** variables are encapsulated (hidden) in the object and can be accessed only by methods of the object's class.
 - Prevents instance variables from being **modified accidentally** by a class in another part of the program.
 - *Set* and *get* methods used to access instance variables.



Software Engineering Observation 3.2

*Precede each field and method declaration with an access modifier. Generally, instance variables should be declared **private** and methods **public**. (We'll see that it's appropriate to declare certain methods **private**, if they'll be accessed only by other methods of the class.)*

3.5 Instance Variables, set Methods and get Methods (Cont.)

- ▶ When a method that specifies a return type other than `void` completes its task, the method returns a result to its calling method.
- ▶ Method `setCourseName` and `getCourseName` each use variable `courseName` even though it was not declared in any of the methods.
 - Can use an instance variable of the class in each of the classes methods.
 - Exception to this is `static` methods (Chapter 8)
- ▶ The order in which methods are declared in a class does not determine when they are called at execution time.
- ▶ One method of a class can call another method of the same class by using just the method name.

3.5 Instance Variables, set Methods and get Methods (Cont.)

- ▶ Unlike local variables, which are **not automatically initialized**, every field has a **default initial value**—a value provided by Java when you do not specify the field's initial value.
- ▶ Fields are **not required to be explicitly initialized** before they are used in a program — unless they must be initialized to values other than their default values.
- ▶ The default value for a field of type `String` is `null`

```
1 // Fig. 3.8: GradeBookTest.java
2 // Creating and manipulating a GradeBook object.
3 import java.util.Scanner; // program uses Scanner
4
5 public class GradeBookTest
6 {
7     // main method begins program execution
8     public static void main( String[] args )
9     {
10         // create Scanner to obtain input from command window
11         Scanner input = new Scanner( System.in );
12
13         // create a GradeBook object and assign it to myGradeBook
14         GradeBook myGradeBook = new GradeBook();
15
16         // display initial value of courseName
17         System.out.printf( "Initial course name is: %s\n\n",
18             myGradeBook.getCourseName() );
19
20         // prompt for and read course name
21         System.out.println( "Please enter the course name:" );
22         String theName = input.nextLine(); // read a line of text
23         myGradeBook.setCourseName( theName ); // set the course name
```

Gets the value of the myGradeBook object's courseName instance variable

Sets the value of the courseName instance variable

Fig. 3.8 | Creating and manipulating a GradeBook object. (Part I of 2.)

```
24      System.out.println(); // outputs a blank line
25
26      // display welcome message after specifying course name
27      myGradeBook.displayMessage();
28  } // end main
29 } // end class GradeBookTest
```

Displays the GradeBook's message, including the value of the `courseName` instance variable

Initial course name is: null

Please enter the course name:

CS101 Introduction to Java Programming

Welcome to the grade book for

CS101 Introduction to Java Programming!

Fig. 3.8 | Creating and manipulating a GradeBook object. (Part 2 of 2.)

3.5 Instance Variables, *set Methods and get Methods (Cont.)*

- ▶ *set* and *get* methods
 - A class's `private` fields can be manipulated only by the class's methods.
 - A *client of an object* calls the class's `public` methods to manipulate the `private` fields of an object of the class.
 - Classes often provide `public` methods to allow clients to *set* (i.e., assign values to) or *get* (i.e., obtain the values of) `private` instance variables.
 - The names of these methods need not begin with *set* or *get*, but this *naming convention is recommended*.

3.5 Instance Variables, set Methods and get Methods (Cont.)

- ▶ Figure 3.9 contains an updated UML class diagram for the version of class **GradeBook** in Fig. 3.7.
 - Models instance variable **courseName** as an attribute in the middle compartment of the class.
 - The UML represents instance variables as attributes by listing the attribute name, followed by a colon and the attribute type.
 - A **minus sign** (–) access modifier corresponds to access modifier **private**.

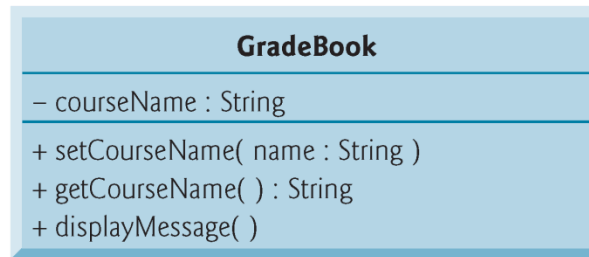


Fig. 3.9 | UML class diagram indicating that class **GradeBook** has a private `courseName` attribute of UML type **String** and three public operations—`setCourseName` (with a `name` parameter of UML type **String**), `getCourseName` (which returns UML type **String**) and `displayMessage`.

3.6 Primitive Types vs. Reference Types

- ▶ Types are divided into **primitive types** and **reference types**.
- ▶ The primitive types are **boolean**, **byte**, **char**, **short**, **int**, **long**, **float** and **double**.
- ▶ All nonprimitive types are reference types.
- ▶ A primitive-type variable can store exactly one value of its declared type at a time.
- ▶ Primitive-type instance variables are initialized by default — variables of types **byte**, **char**, **short**, **int**, **long**, **float** and **double** are initialized to 0, and variables of type **boolean** are initialized to **false**.
- ▶ You can specify your own initial value for a primitive-type variable by **assigning the variable a value in its declaration**.



Error-Prevention Tip 3.1

An attempt to use an uninitialized local variable causes a compilation error.

3.7 Primitive Types vs. Reference Types

- ▶ Programs use **variables of reference types** (normally called **references**) to store the locations of objects in the computer's memory.
 - Such a variable is said to **refer to an object** in the program.
- ▶ Objects that are referenced may each contain many instance variables and methods.
- ▶ Reference-type instance variables are initialized by default to the value **null**
 - A reserved word that represents a “reference to nothing.”
- ▶ When using an object of another class, a reference to the object is required to **invoke** (i.e., call) its methods.
 - Also known as sending messages to an object.



Software Engineering Observation 3.3

A variable's declared type (e.g., `int`, `double` or `GradeBook`) indicates whether the variable is of a primitive or a reference type. If a variable's type is not one of the eight primitive types, then it's a reference type.

3.8 Initializing Objects with Constructors

- ▶ When an object of a class is created, its instance variables are **initialized by default**.
- ▶ Each class can provide a **constructor** that initializes an object of a class when the object is created.
- ▶ Java **requires a constructor call** for *every* object that is created.
- ▶ Keyword **new** requests memory from the system to store an object, then calls the corresponding class's constructor to initialize the object.
- ▶ A constructor *must* have **the same name as the class**.

3.8 Initializing Objects with Constructors (Cont.)

- ▶ By default, the compiler provides a **default constructor** with no parameters in any class that does not explicitly include a constructor.
 - Instance variables are initialized to their **default values**.
- ▶ Can provide **your own constructor** to specify custom initialization for objects of your class.
- ▶ A constructor's **parameter list** specifies the data it requires to perform its task.
- ▶ Constructors **cannot return values**, so they cannot specify a return type.
- ▶ Normally, constructors are declared `public`.
- ▶ If you **declare any constructors** for a class, the Java compiler will not create a default constructor for that class.

```
1 // Fig. 3.10: GradeBook.java
2 // GradeBook class with a constructor to initialize the course name.
3
4 public class GradeBook
5 {
6     private String courseName; // course name for this GradeBook
7
8     // constructor initializes courseName with String argument
9     public GradeBook( String name )
10    {
11        courseName = name; // initializes courseName
12    } // end constructor
13
14    // method to set the course name
15    public void setCourseName( String name )
16    {
17        courseName = name; // store the course name
18    } // end method setCourseName
19
```

← Constructor that initializes
courseName to the specified value

Fig. 3.10 | GradeBook class with a constructor to initialize the course name. (Part I of 2.)

```
20    // method to retrieve the course name
21    public String getCourseName()
22    {
23        return courseName;
24    } // end method getCourseName
25
26    // display a welcome message to the GradeBook user
27    public void displayMessage()
28    {
29        // this statement calls getCourseName to get the
30        // name of the course this GradeBook represents
31        System.out.printf( "Welcome to the grade book for\n%s!\n",
32                           getCourseName() );
33    } // end method displayMessage
34 } // end class GradeBook
```

Fig. 3.10 | GradeBook class with a constructor to initialize the course name. (Part 2 of 2.)

```
1 // Fig. 3.11: GradeBookTest.java
2 // GradeBook constructor used to specify the course name at the
3 // time each GradeBook object is created.
4
5 public class GradeBookTest
6 {
7     // main method begins program execution
8     public static void main( String[] args )
9     {
10         // create GradeBook object
11         GradeBook gradeBook1 = new GradeBook(
12             "CS101 Introduction to Java Programming" );
13         GradeBook gradeBook2 = new GradeBook(
14             "CS102 Data Structures in Java" );
15
16         // display initial value of courseName for each GradeBook
17         System.out.printf( "gradeBook1 course name is: %s\n",
18             gradeBook1.getCourseName() );
19         System.out.printf( "gradeBook2 course name is: %s\n",
20             gradeBook2.getCourseName() );
21     } // end main
22 } // end class GradeBookTest
```

Class instance creation expression
initializes the `GradeBook` and returns a
reference that is assigned to variable
`gradeBook1`

Class instance creation expression
initializes the `GradeBook` and returns a
reference that is assigned to variable
`gradeBook1`

Fig. 3.11 | `GradeBook` constructor used to specify the course name at the time
each `GradeBook` object is created. (Part I of 2.)

```
gradeBook1 course name is: CS101 Introduction to Java Programming  
gradeBook2 course name is: CS102 Data Structures in Java
```

Fig. 3.11 | GradeBook constructor used to specify the course name at the time each GradeBook object is created. (Part 2 of 2.)



Error-Prevention Tip 3.2

Unless default initialization of your class's instance variables is acceptable, provide a constructor to ensure that your class's instance variables are properly initialized with meaningful values when each new object of your class is created.

3.8 Initializing Objects with Constructors (Cont.)

- ▶ The UML class diagram of Fig. 3.12 models class **GradeBook** of Fig. 3.10, which has a constructor that has a **name** parameter of type **String**.
- ▶ Like operations, the UML models constructors in the third compartment of a class in a class diagram.
- ▶ To distinguish a constructor, the UML requires that the word “constructor” be placed between **guillemets** (« and ») (or **angle quotes**) before the constructor’s name.
- ▶ List constructors before other operations in the third compartment.

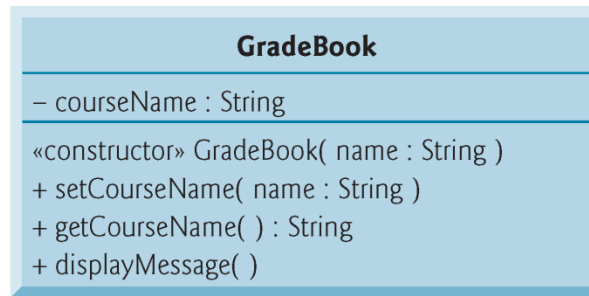


Fig. 3.12 | UML class diagram indicating that class **GradeBook** has a constructor that has a name parameter of UML type **String**.

3.9 Floating-Point Numbers and Type `double`

- ▶ **Floating-point number**
 - A number with a decimal point, such as 7.33, 0.0975 or 1000.12345).
 - `float` and `double` primitive types
 - `double` variables can store numbers with **larger magnitude** and finer detail than `float` variables.
- ▶ `float` represents **single-precision floating-point numbers** up to seven significant digits.
- ▶ `double` represents **double-precision floating-point numbers** that require twice as much memory as `float` and provide 15 significant digits — approximately double the precision of `float` variables.

3.9 Floating-Point Numbers and Type `double` (Cont.)

- ▶ Java treats all **floating-point literals** (such as 7.33 and 0.0975) as `double` values by default.
- ▶ Appendix D, Primitive Types shows the ranges of values for `floats` and `doubles`.

```
1 // Fig. 3.13: Account.java
2 // Account class with a constructor to validate and
3 // initialize instance variable balance of type double.
4
5 public class Account
6 {
7     private double balance; // instance variable that stores the balance
8
9     // constructor
10    public Account( double initialBalance )
11    {
12        // validate that initialBalance is greater than 0.0;
13        // if it is not, balance is initialized to the default value 0.0
14        if ( initialBalance > 0.0 )
15            balance = initialBalance;
16    } // end Account constructor
17
18    // credit (add) an amount to the account
19    public void credit( double amount )
20    {
21        balance = balance + amount; // add amount to balance
22    } // end method credit
```

Floating-point number for the account balance

Parameter used to initialize the balance instance variable

Validating the parameter's value to ensure that it is greater than 0

Initializes gradeCounter to 1; indicates first grade about to be input

Fig. 3.13 | Account class with a constructor to validate and initialize instance variable balance of type double. (Part 1 of 2.)

```
23
24 // return the account balance
25 public double getBalance()
26 {
27     return balance; // gives the value of balance to the calling method
28 } // end method getBalance
29 } // end class Account
```

Returns the value of the balance
instance variable as a double

Fig. 3.13 | Account class with a constructor to validate and initialize instance variable balance of type double. (Part 2 of 2.)

3.9 Floating-Point Numbers and Type `double` (Cont.)

- ▶ `System.out.printf`
 - Format specifier `%.2f`
 - `%f` is used to output values of type `float` or `double`.
 - `.2` represents the number of decimal places (2) to output to the right of the decimal point—known as the number's **precision**.
 - Any floating-point value output with `%.2f` will be rounded to the hundredths position.
- ▶ `Scanner` method `nextDouble` returns a `double` value entered by the user.

```
1 // Fig. 3.14: AccountTest.java
2 // Inputting and outputting floating-point numbers with Account objects.
3 import java.util.Scanner;
4
5 public class AccountTest
6 {
7     // main method begins execution of Java application
8     public static void main( String[] args )
9     {
10         Account account1 = new Account( 50.00 ); // create Account object
11         Account account2 = new Account( -7.53 ); // create Account object
12
13         // display initial balance of each object
14         System.out.printf( "account1 balance: $%.2f\n",
15             account1.getBalance() );
16         System.out.printf( "account2 balance: $%.2f\n\n",
17             account2.getBalance() );
18
19         // create Scanner to obtain input from command window
20         Scanner input = new Scanner( System.in );
21         double depositAmount; // deposit amount read from user
```

Output floating-point values with two-digits of precision

Fig. 3.14 | Inputting and outputting floating-point numbers with Account objects.
(Part I of 3.)

```
22
23 System.out.print( "Enter deposit amount for account1: " ); // prompt
24 depositAmount = input.nextDouble(); // obtain user input
25 System.out.printf( "\nadding %.2f to account1 balance\n\n",
26     depositAmount );
27 account1.credit( depositAmount ); // add to account1 balance
28
29 // display balances
30 System.out.printf( "account1 balance: $%.2f\n",
31     account1.getBalance() );
32 System.out.printf( "account2 balance: $%.2f\n\n",
33     account2.getBalance() );
34
35 System.out.print( "Enter deposit amount for account2: " ); // prompt
36 depositAmount = input.nextDouble(); // obtain user input
37 System.out.printf( "\nadding %.2f to account2 balance\n\n",
38     depositAmount );
39 account2.credit( depositAmount ); // add to account2 balance
40
41 // display balances
42 System.out.printf( "account1 balance: $%.2f\n",
43     account1.getBalance() );
```

Returns a double value typed by the user

Fig. 3.14 | Inputting and outputting floating-point numbers with Account objects.
(Part 2 of 3.)

```
44      System.out.printf( "account2 balance: $%.2f\n",
45                          account2.getBalance() );
46  } // end main
47 } // end class AccountTest
```

```
account1 balance: $50.00
account2 balance: $0.00

Enter deposit amount for account1: 25.53

adding 25.53 to account1 balance

account1 balance: $75.53
account2 balance: $0.00

Enter deposit amount for account2: 123.45

adding 123.45 to account2 balance

account1 balance: $75.53
account2 balance: $123.45
```

Fig. 3.14 | Inputting and outputting floating-point numbers with `Account` objects.
(Part 3 of 3.)

3.9 Floating-Point Numbers and Type `double` (Cont.)

- ▶ The UML class diagram in Fig. 3.15 models class `Account` of Fig. 3.13.

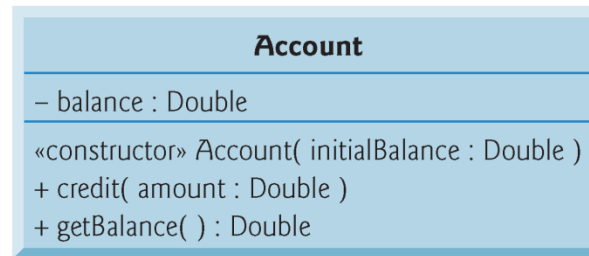


Fig. 3.15 | UML class diagram indicating that class **Account** has a **private** **balance** attribute of UML type **Double**, a constructor (with a parameter of UML type **Double**) and two **public** operations—**credit** (with an **amount** parameter of UML type **Double**) and **getBalance** (returns UML type **Double**).



Laboratory Session

Exercises

▶ Invoice

- Java program that models and implements an invoice
- Each invoice has a number of parts and each part has a part-number, a description and a price.
- The program should create some invoices and print their information

▶ Employee

- Java program that models employees
- Each employee has name and surname and a monthly salary
- The program should create some employees and then increase their salary by 10%, and print their information.

Exercises

▶ Heart Rate

- Java program that models heart rates, maximum heart rate and the maximum and minimum target heart rate.
- The heart rate should be modeled with a class and should have name, surname, birthYear and currentYear.
- The maximum heart rate MHR is based on the formula $220 - \text{age}$.
- The minimum target HR is based on: $0.5 * \text{MHR}$
- The maximum target HR is based on: $0.85 * \text{MHR}$
- The program should create some objects of type Heart Rate and print their information.

Exercises

- ▶ Date
 - Create a Java program that models the date
 - The date has three attributes: day, month, year.
 - Create some objects Date and print their information

Readings

- ▶ Java: How to Program. 8th ed.
 - Chapter 3

End of class