Chapter Topics

Chapter 6 discusses the following main topics:

- Objects and Classes
- Writing a Simple Class, Step by Step
- Instance Fields and Methods
- Constructors
- Passing Objects as Arguments
- Overloading Methods and Constructors
- Scope of Instance Fields
- Packages and `import` Statements
Objects and Classes

• An object exists in memory, and performs a specific task.

• Objects have two general capabilities:
  – Objects can store data. The pieces of data stored in an object are known as *fields*.
  – Objects can perform operations. The operations that an object can perform are known as *methods*. 
Objects and Classes

• You have already used the following objects:
  – Scanner objects, for reading input
  – Random objects, for generating random numbers
  – PrintWriter objects, for writing data to files

• When a program needs the services of a particular type of object, it creates that object in memory, and then calls that object's methods as necessary.
Objects and Classes

• Classes: Where Objects Come From
  – A class is code that describes a particular type of object. It specifies the data that an object can hold (the object's fields), and the actions that an object can perform (the object's methods).

  – You can think of a class as a code "blueprint" that can be used to create a particular type of object.
Objects and Classes

- When a program is running, it can use the class to create, in memory, as many objects of a specific type as needed.

- Each object that is created from a class is called an *instance* of the class.
**Objects and Classes**

*Example:*

This expression creates a *Scanner* object in memory.

```java
Scanner keyboard = new Scanner(System.in);
```

The object's memory address is assigned to the `keyboard` variable.

**Diagram:**

```
keyboard variable  Scanner object
```
Objects and Classes

Example:

This expression creates a Random object in memory.

```
Random rand = new Random();
```

The object's memory address is assigned to the `rand` variable.
Objects and Classes

Example:

This expression creates a PrintWriter object in memory.

```java
PrintWriter outputFile = new PrintWriter("numbers.txt");
```

The object's memory address is assigned to the `outputFile` variable.
Objects and Classes

- The Java API provides many classes
  - So far, the classes that you have created objects from are provided by the Java API.
  - Examples:
    - Scanner
    - Random
    - PrintWriter
- See [ObjectDemo.java](#)
Writing a Class, Step by Step

• A Rectangle object will have the following fields:
  – length. The length field will hold the rectangle’s length.
  – width. The width field will hold the rectangle’s width.
Writing a Class, Step by Step

- The Rectangle class will also have the following methods:
  - `setLength`. The `setLength` method will store a value in an object’s `length` field.
  - `setWidth`. The `setWidth` method will store a value in an object’s `width` field.
  - `getLength`. The `getLength` method will return the value in an object’s `length` field.
  - `getWidth`. The `getWidth` method will return the value in an object’s `width` field.
  - `getArea`. The `getArea` method will return the area of the rectangle, which is the result of the object’s `length` multiplied by its `width`. 
UML Diagram

- Unified Modeling Language (UML) provides a set of standard diagrams for graphically depicting object-oriented systems.

Class name goes here

Fields are listed here

Methods are listed here
UML Diagram for Rectangle class

Rectangle

length
width

setLength()
setWidth()
getLength()
getWidth()
getArea()
Writing the Code for the Class Fields

public class Rectangle
{
    private double length;
    private double width;
}

Access Specifiers

• An access specifier is a Java keyword that indicates how a field or method can be accessed.
  
• public
  – When the `public` access specifier is applied to a class member, the member can be accessed by code inside the class or outside.

• private
  – When the `private` access specifier is applied to a class member, the member cannot be accessed by code outside the class. The member can be accessed only by methods that are members of the same class.
Header for the `setLength` Method

- **Access specifier**: `public`
- **Return Type**: `void`
- **Method Name**: `setLength`
- **Parameter variable declaration**: `(double len)`

Notice the word `static` does not appear in the method header designed to work on an instance of a class (instance method).
Writing and Demonstrating the `setLength` Method

/**
   The setLength method stores a value in the length field.
   @param len The value to store in length.
*/

public void setLength(double len) {
    length = len;
}

Examples: Rectangle.java, LengthDemo.java
Creating a Rectangle object

Rectangle box = new Rectangle ();

The box variable holds the address of the Rectangle object.

A Rectangle object

- length: 0.0
- width: 0.0
Calling the `setLength` Method

```java
box.setLength(10.0);
```

The `box` variable holds the address of the `Rectangle` object.

A Rectangle object

- **address**
- **length**: 10.0
- **width**: 0.0

This is the state of the `box` object after the `setLength` method executes.
Writing the `getLength` Method

```java
/**
 * The `getLength` method returns a Rectangle object's length.
 * @return The value in the length field.
 */
public double getLength() {
    return length;
}
```

Similarly, the `setWidth` and `getWidth` methods can be created.

Examples:  [Rectangle.java](#), [LengthWidthDemo.java](#)
Writing and Demonstrating the `getArea` Method

/**
 * The getArea method returns a Rectangle object's area.
 * @return The product of length times width.
 */
public double getArea() {
    return length * width;
}

Examples:  Rectangle.java, RectangleDemo.java
Accessor and Mutator Methods

- Because of the concept of data hiding, fields in a class are private.
- The methods that retrieve the data of fields are called *accessors*.
- The methods that modify the data of fields are called *mutators*.
- Each field that the programmer wishes to be viewed by other classes needs an accessor.
- Each field that the programmer wishes to be modified by other classes needs a mutator.
Accessors and Mutators

- For the Rectangle example, the accessors and mutators are:
  - `setLength` : Sets the value of the length field.
    ```java
    public void setLength(double len) ...
    ```
  - `setWidth` : Sets the value of the width field.
    ```java
    public void setLength(double w) ...
    ```
  - `getLength` : Returns the value of the length field.
    ```java
    public double getLength() ...
    ```
  - `getWidth` : Returns the value of the width field.
    ```java
    public double getWidth() ...
    ```

- Other names for these methods are *getters* and *setters*. 
Data Hiding

• An object hides its internal, private fields from code that is outside the class that the object is an instance of.
• Only the class's methods may directly access and make changes to the object’s internal data.
• Code outside the class must use the class's public methods to operate on an object's private fields.
Data Hiding

• Data hiding is important because classes are typically used as components in large software systems, involving a team of programmers.

• Data hiding helps enforce the integrity of an object's internal data.
Stale Data

- Some data is the result of a calculation.
- Consider the area of a rectangle.
  - \( \text{length} \times \text{width} \)
- It would be impractical to use an \textit{area} variable here.
- Data that requires the calculation of various factors has the potential to become \textit{stale}.
- To avoid stale data, it is best to calculate the value of that data within a method rather than store it in a variable.
Stale Data

• Rather than use an area variable in a Rectangle class:

```java
public double getArea() {
    return length * width;
}
```

• This dynamically calculates the value of the rectangle’s area when the method is called.

• Now, any change to the length or width variables will not leave the area of the rectangle stale.
UML Data Type and Parameter Notation

• UML diagrams are language independent.
• UML diagrams use an independent notation to show return types, access modifiers, etc.

Access modifiers are denoted as:
+ public
- private

Rectangle
- width : double
+ setWidth(w : double) : void
UML Data Type and Parameter Notation

- UML diagrams are language independent.
- UML diagrams use an independent notation to show return types, access modifiers, etc.

Variable types are placed after the variable name, separated by a colon.

<table>
<thead>
<tr>
<th>Rectangle</th>
</tr>
</thead>
<tbody>
<tr>
<td>- width : double</td>
</tr>
<tr>
<td>+ setWidth(w : double) : void</td>
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UML Data Type and Parameter Notation

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Method return types are placed after the method declaration name, separated by a colon.
UML Data Type and Parameter Notation

- UML diagrams are language independent.
- UML diagrams use an independent notation to show return types, access modifiers, etc.

Method parameters are shown inside the parentheses using the same notation as variables.

```
Rectangle
- width : double
+ setWidth(w : double) : void
```
Putting all of this information together, a Java class file can be built easily using the UML diagram.

The UML diagram parts match the Java class file structure.
Converting the UML Diagram to Code

The structure of the class can be compiled and tested without having bodies for the methods. Just be sure to put in dummy return values for methods that have a return type other than void.

```
public class Rectangle {
    private double width;  // width : double
    private double length; // length : double

    public void setWidth(double w) {}  // setWidth(w : double) : void
    public void setLength(double len) {} // setLength(len : double) : void

    public double getWidth() {        // getWidth() : double
        return 0.0;
    }

    public double getLength() {       // getLength() : double
        return 0.0;
    }

    public double getArea() {         // getArea() : double
        return 0.0;
    }
}
```
Once the class structure has been tested, the method bodies can be written and tested.

```java
public class Rectangle {
    private double width;
    private double length;

    public void setWidth(double w) {
        width = w;
    }

    public void setLength(double len) {
        length = len;
    }

    public double getWidth() {
        return width;
    }

    public double getLength() {
        return length;
    }

    public double getArea() {
        return length * width;
    }
}
```

Rectangle

- width : double
- length : double

+ setWidth(w : double) : void
+ setLength(len : double) : void
+ getWidth() : double
+ getLength() : double
+ getArea() : double
Class Layout Conventions

- The layout of a source code file can vary by employer or instructor.
- A common layout is:
  - Fields listed first
  - Methods listed second
    - Accessors and mutators are typically grouped.
- There are tools that can help in formatting layout to specific standards.
Instance Fields and Methods

- Fields and methods that are declared as previously shown are called *instance fields* and *instance methods*.
- Objects created from a class each have their own copy of instance fields.
- Instance methods are methods that are not declared with a special keyword, `static`.
Instance Fields and Methods

• Instance fields and instance methods require an object to be created in order to be used.
• See example: RoomAreas.java
• Note that each room represented in this example can have different dimensions.

  Rectangle kitchen = new Rectangle();
  Rectangle bedroom = new Rectangle();
  Rectangle den = new Rectangle();
States of Three Different Rectangle Objects

The kitchen variable holds the address of a Rectangle Object.

The bedroom variable holds the address of a Rectangle Object.

The den variable holds the address of a Rectangle Object.
Constructors

• Classes can have special methods called *constructors*.  
• A constructor is a method that is **automatically** called when an object is created.  
• Constructors are used to perform operations at the time an object is created.  
• Constructors typically initialize instance fields and perform other object initialization tasks.
Constructors

- Constructors have a few special properties that set them apart from normal methods.
  - Constructors have the same name as the class.
  - Constructors have no return type (not even `void`).
  - Constructors may not return any values.
  - Constructors are typically public.
Constructor for Rectangle Class

/**
   Constructor
   @param len The length of the rectangle.
   @param w The width of the rectangle.
*/
public Rectangle(double len, double w) {
    length = len;
    width = w;
}

Examples:  Rectangle.java, ConstructorDemo.java
Constructors in UML

- In UML, the most common way constructors are defined is:

<table>
<thead>
<tr>
<th>Rectangle</th>
</tr>
</thead>
<tbody>
<tr>
<td>- width : double</td>
</tr>
<tr>
<td>- length : double</td>
</tr>
<tr>
<td>+Rectangle(len:double, w:double)</td>
</tr>
<tr>
<td>+ setWidth(w : double) : void</td>
</tr>
<tr>
<td>+ setLength(len : double): void</td>
</tr>
<tr>
<td>+ getWidth() : double</td>
</tr>
<tr>
<td>+ getLength() : double</td>
</tr>
<tr>
<td>+ getArea() : double</td>
</tr>
</tbody>
</table>

Notice there is no return type listed for constructors.
Uninitialized Local Reference Variables

- Reference variables can be declared without being initialized.
  
  ```java
  Rectangle box;
  ```

- This statement does not create a `Rectangle` object, so it is an uninitialized local reference variable.

- A local reference variable must reference an object before it can be used, otherwise a compiler error will occur.
  
  ```java
  box = new Rectangle(7.0, 14.0);
  ```

- `box` will now reference a `Rectangle` object of length 7.0 and width 14.0.
The Default Constructor

• When an object is created, its constructor is always called.
• If you do not write a constructor, Java provides one when the class is compiled. The constructor that Java provides is known as the *default constructor*.
  – It sets all of the object’s numeric fields to 0.
  – It sets all of the object’s boolean fields to false.
  – It sets all of the object’s reference variables to the special value *null*. 
The Default Constructor

- The default constructor is a constructor with no parameters, used to initialize an object in a default configuration.
- The **only** time that Java provides a default constructor is when you do not write **any** constructor for a class.
  - See example: First version of `Rectangle.java`
- A default constructor is **not** provided by Java if a constructor is already written.
  - See example: `Rectangle.java` with Constructor
Writing Your Own No-Arg Constructor

- A constructor that does not accept arguments is known as a no-arg constructor.
- The default constructor (provided by Java) is a no-arg constructor.
- We can write our own no-arg constructor

```java
public Rectangle() {
    length = 1.0;
    width = 1.0;
}
```
The `String` Class Constructor

- One of the `String` class constructors accepts a string literal as an argument.
- This string literal is used to initialize a `String` object.
- For instance:

```java
String name = new String("Michael Long");
```
The **String** Class Constructor

- This creates a new reference variable `name` that points to a **String** object that represents the name “Michael Long”
- Because they are used so often, **String** objects can be created with a shorthand:

```
String name = "Michael Long";
```
Passing Objects as Arguments

• When you pass a object as an argument, the thing that is passed into the parameter variable is the object's memory address.

• As a result, parameter variable references the object, and the receiving method has access to the object.

• See DieArgument.java
Overloading Methods and Constructors

- Two or more methods in a class may have the same name as long as their parameter lists are different.
- When this occurs, it is called method overloading. This also applies to constructors.
- Method overloading is important because sometimes you need several different ways to perform the same operation.
Overloaded Method `add`

```java
public int add(int num1, int num2) {
    int sum = num1 + num2;
    return sum;
}

public String add(String str1, String str2) {
    String combined = str1 + str2;
    return combined;
}
```
Method Signature and Binding

- A method signature consists of the method’s name and the data types of the method’s parameters, in the order that they appear. The return type is not part of the signature.

  \[
  \text{add(int, int)} \\
  \text{add(String, String)}
  \]

- The process of matching a method call with the correct method is known as \textit{binding}. The compiler uses the method signature to determine which version of the overloaded method to bind the call to.

\textit{Signatures of the add methods of previous slide}
Rectangle Class Constructor Overload

If we were to add the no-arg constructor we wrote previously to our Rectangle class in addition to the original constructor we wrote, what would happen when we execute the following calls?

```java
Rectangle box1 = new Rectangle();
Rectangle box2 = new Rectangle(5.0, 10.0);
```
Rectangle Class Constructor Overload

If we were to add the no-arg constructor we wrote previously to our Rectangle class in addition to the original constructor we wrote, what would happen when we execute the following calls?

```java
Rectangle box1 = new Rectangle();
Rectangle box2 = new Rectangle(5.0, 10.0);
```

The first call would use the no-arg constructor and `box1` would have a length of 1.0 and width of 1.0.
The second call would use the original constructor and `box2` would have a length of 5.0 and a width of 10.0.
The BankAccount Example

BankAccount.java
AccountTest.java

Overloaded Constructors

Overloaded deposit methods

Overloaded withdraw methods

Overloaded setBalance methods

<table>
<thead>
<tr>
<th>BankAccount</th>
</tr>
</thead>
<tbody>
<tr>
<td>-balance:double</td>
</tr>
<tr>
<td>+BankAccount()</td>
</tr>
<tr>
<td>+BankAccount(startBalance:double)</td>
</tr>
<tr>
<td>+BankAccount(strString):</td>
</tr>
<tr>
<td>+deposit(amount:double):void</td>
</tr>
<tr>
<td>+deposit(str:String):void</td>
</tr>
<tr>
<td>+withdraw(amount:double):void</td>
</tr>
<tr>
<td>+withdraw(str:String):void</td>
</tr>
<tr>
<td>+setBalance(b:double):void</td>
</tr>
<tr>
<td>+setBalance(str:String):void</td>
</tr>
<tr>
<td>+getBalance():double</td>
</tr>
</tbody>
</table>
Scope of Instance Fields

- Variables declared as instance fields in a class can be accessed by any instance method in the same class as the field.
- If an instance field is declared with the `public` access specifier, it can also be accessed by code outside the class, as long as an instance of the class exists.
Shadowing

- A parameter variable is, in effect, a local variable.
- Within a method, variable names must be unique.
- A method may have a local variable with the same name as an instance field.
- This is called *shadowing*.
- The local variable will *hide* the value of the instance field.
- Shadowing is discouraged and local variable names should not be the same as instance field names.
Packages and import Statements

- Classes in the Java API are organized into packages.
- Explicit and Wildcard import statements
  - Explicit imports name a specific class
    - `import java.util.Scanner;`
  - Wildcard imports name a package, followed by an *
    - `import java.util.*;`

- The `java.lang` package is automatically made available to any Java class.
Some Java Standard Packages

<table>
<thead>
<tr>
<th>Package</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>java.applet</td>
<td>Provides the classes necessary to create an applet.</td>
</tr>
<tr>
<td>java.awt</td>
<td>Provides classes for the Abstract Windowing Toolkit. These classes are used in</td>
</tr>
<tr>
<td></td>
<td>drawing images and creating graphical user interfaces.</td>
</tr>
<tr>
<td>java.io</td>
<td>Provides classes that perform various types of input and output.</td>
</tr>
<tr>
<td>java.lang</td>
<td>Provides general classes for the Java language. This package is automatically</td>
</tr>
<tr>
<td></td>
<td>imported.</td>
</tr>
<tr>
<td>java.net</td>
<td>Provides classes for network communications.</td>
</tr>
<tr>
<td>java.security</td>
<td>Provides classes that implement security features.</td>
</tr>
<tr>
<td>java.sql</td>
<td>Provides classes for accessing databases using structured query language.</td>
</tr>
<tr>
<td>java.text</td>
<td>Provides various classes for formatting text.</td>
</tr>
<tr>
<td>java.util</td>
<td>Provides various utility classes.</td>
</tr>
<tr>
<td>javax.swing</td>
<td>Provides classes for creating graphical user interfaces.</td>
</tr>
</tbody>
</table>
Object Oriented Design
Finding Classes and Their Responsibilities

• Finding the classes
  – Get written description of the problem domain
  – Identify all nouns, each is a potential class
  – Refine list to include only classes relevant to the problem

• Identify the responsibilities
  – Things a class is responsible for knowing
  – Things a class is responsible for doing
  – Refine list to include only classes relevant to the problem
Object Oriented Design
Finding Classes and Their Responsibilities

– Identify the responsibilities
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