Chapter 6:
A First Look at Classes

Starting Out with Java:
From Control Structures through Objects

Fifth Edition

by Tony Gaddis

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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

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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*.

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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.

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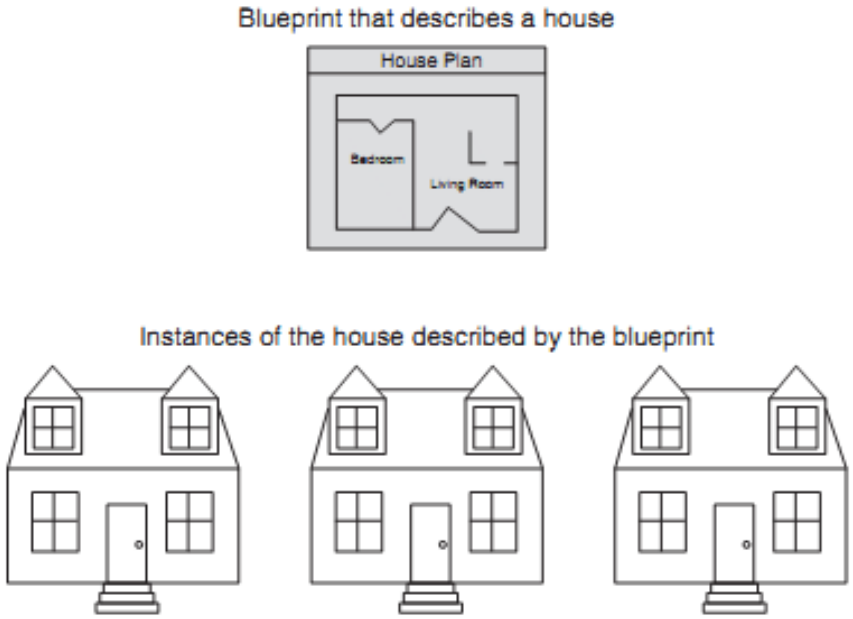
Objects and Classes

- 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.

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Objects and Classes

Figure 6-1 A blueprint and houses built from the blueprint



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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.

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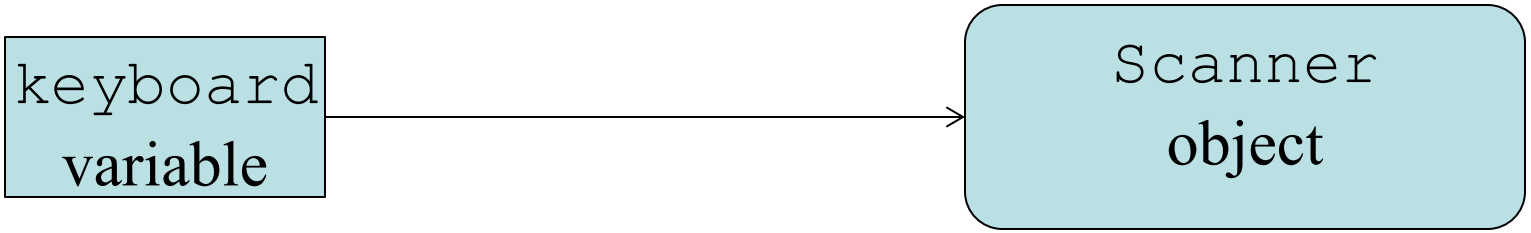
Objects and Classes

Example:

This expression creates a `Scanner` object in memory.

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

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



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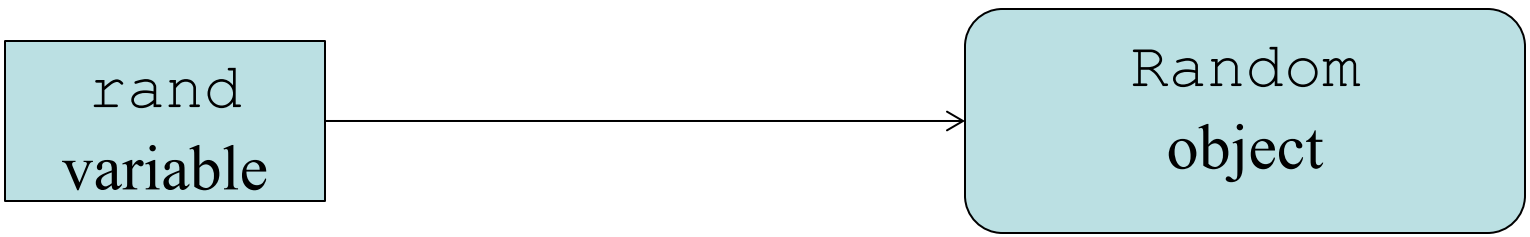
Objects and Classes

Example:

This expression creates a `Random` object in memory.

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

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



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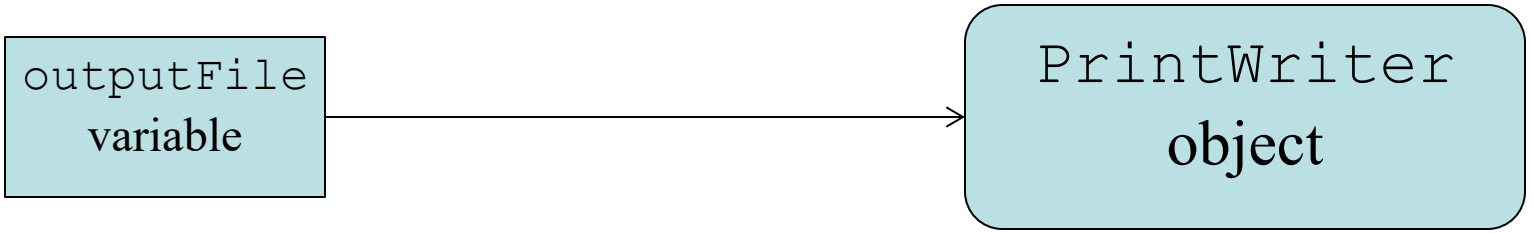
Objects and Classes

Example:

This expression creates a `PrintWriter` object in memory.

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

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



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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

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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.

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Writing a Class, Step by Step

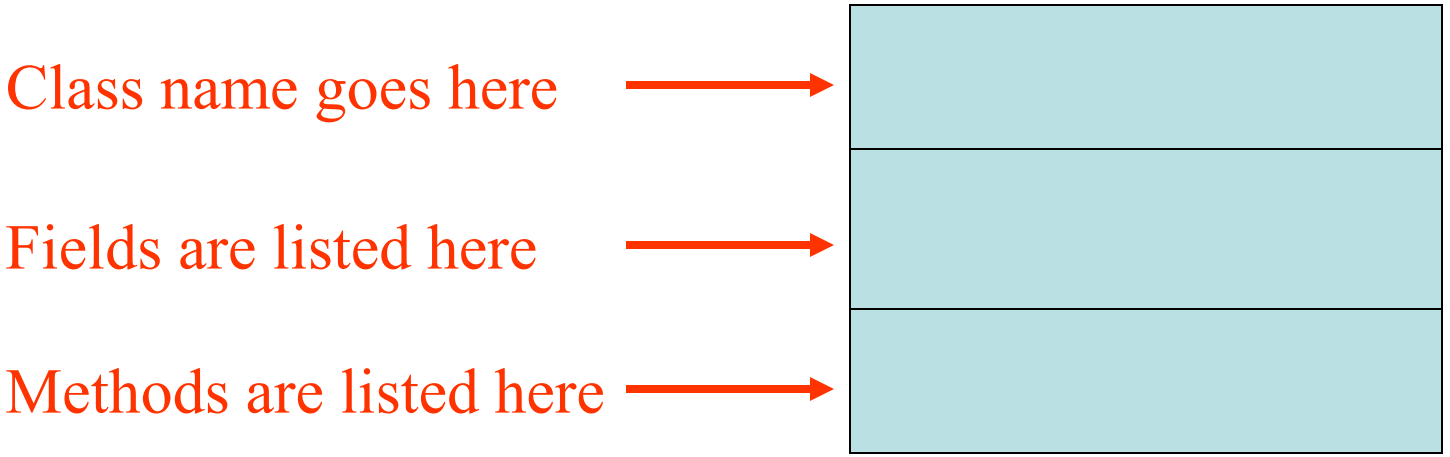
- The `Rectangle` class will also have the following methods:
  - **`setLength`**. The `setLength` method will store a value in an object's `length` field.
  - **`setWidth`**. The `setWidth` method will store a value in an object's `width` field.
  - **`getLength`**. The `getLength` method will return 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`.

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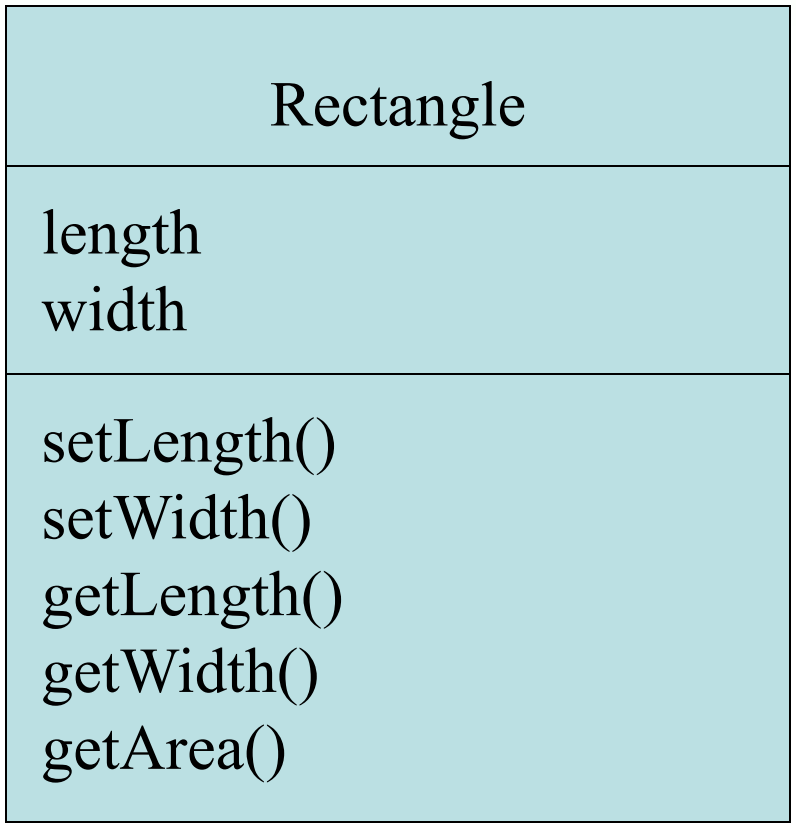
UML Diagram

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



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UML Diagram for `Rectangle` class



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Writing the Code for the Class Fields

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

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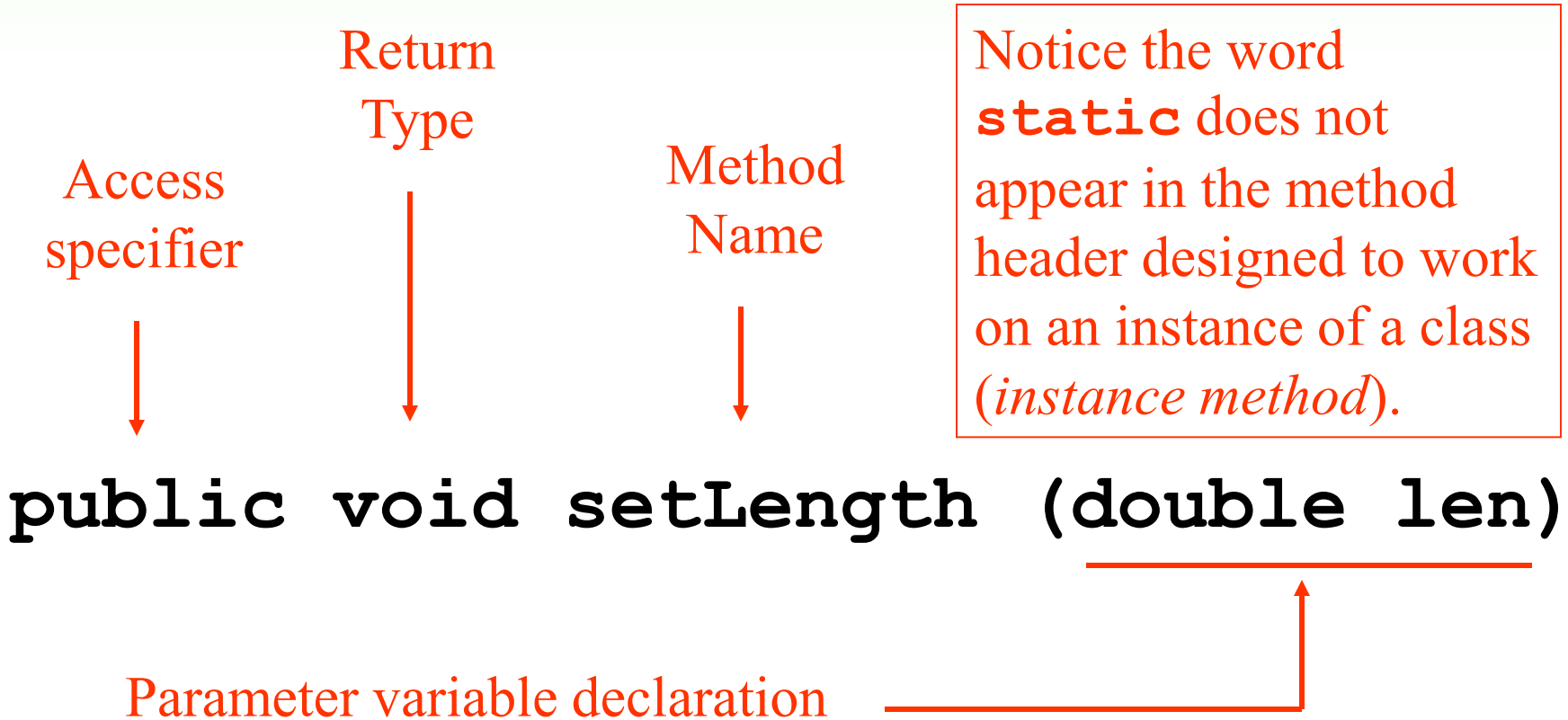
Access Specifiers

- 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.

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Header for the `setLength` Method



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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

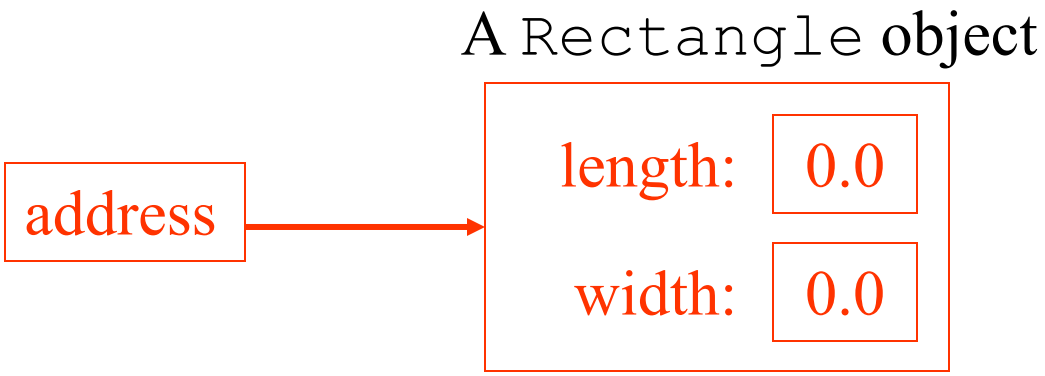
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Creating a `Rectangle` object

```
Rectangle box = new Rectangle ();
```

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

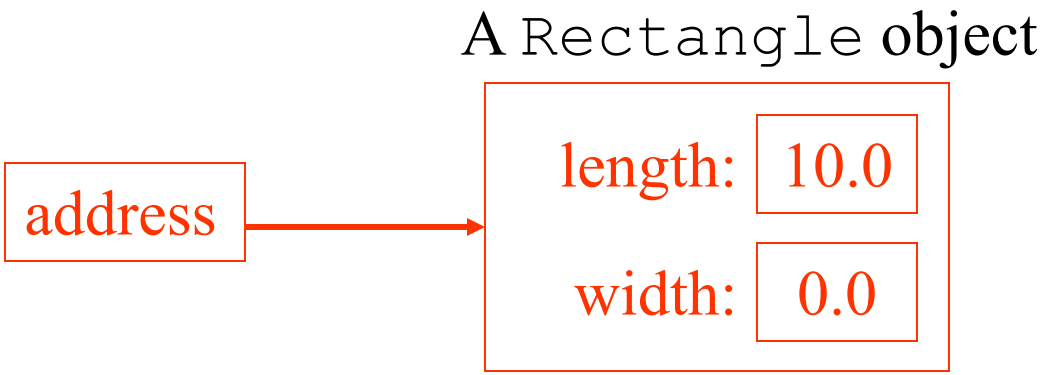


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Calling the `setLength` Method

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

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



This is the state of the box object after the `setLength` *method executes.*

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Writing the `getLength` Method

```
/**
   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

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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

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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.

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Accessors and Mutators

- For the `Rectangle` example, the accessors and mutators are:
  - **`setLength`** : Sets the value of the `length` field.
    ```
    public void setLength(double len) ...
    ```
  - **`setWidth`** : Sets the value of the `width` field.
    ```
    public void setLength(double w) ...
    ```
  - **`getLength`** : Returns the value of the `length` field.
    ```
    public double getLength() ...
    ```
  - **`getWidth`** : Returns the value of the `width` field.
    ```
    public double getWidth() ...
    ```
- Other names for these methods are *getters* and *setters*.

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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.

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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.

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Stale Data

- Some data is the result of a calculation.
- Consider the area of a rectangle.
  - *length* × *width*
- It would be impractical to use an *area* variable here.
- Data that requires the calculation of various factors has the potential to become *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.

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Stale Data

- Rather than use an `area` variable in a `Rectangle` class:

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

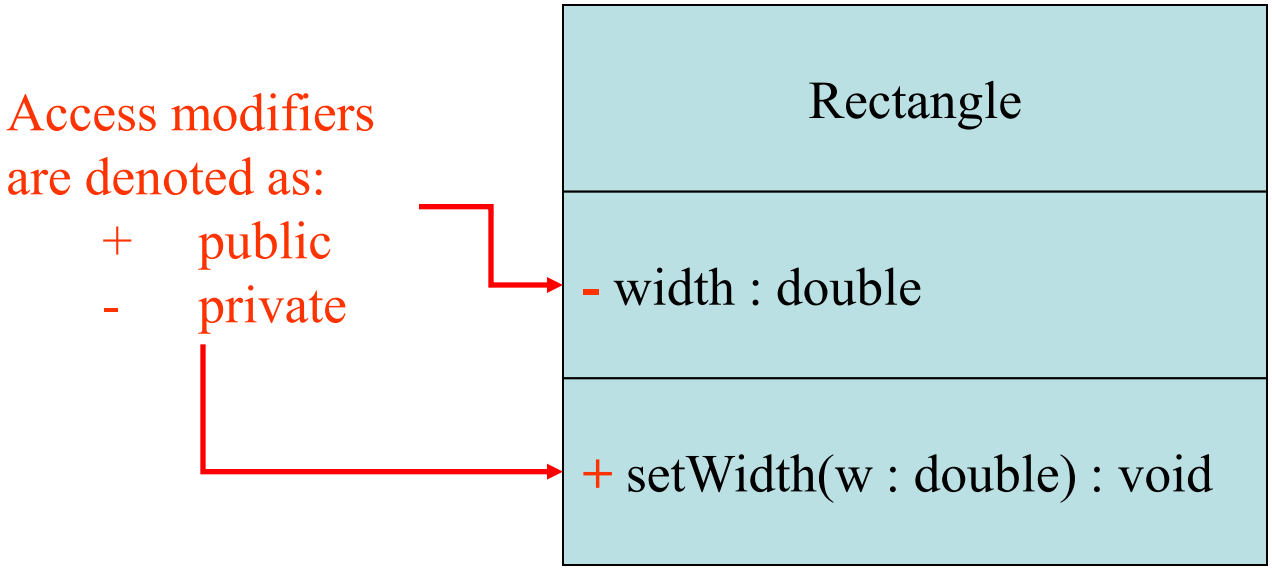
- This dynamically calculates the value of the rectangle's area when the method is called.
- Now, any change to the `length` or `width` variables will not leave the area of the rectangle stale.

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UML Data Type and Parameter Notation

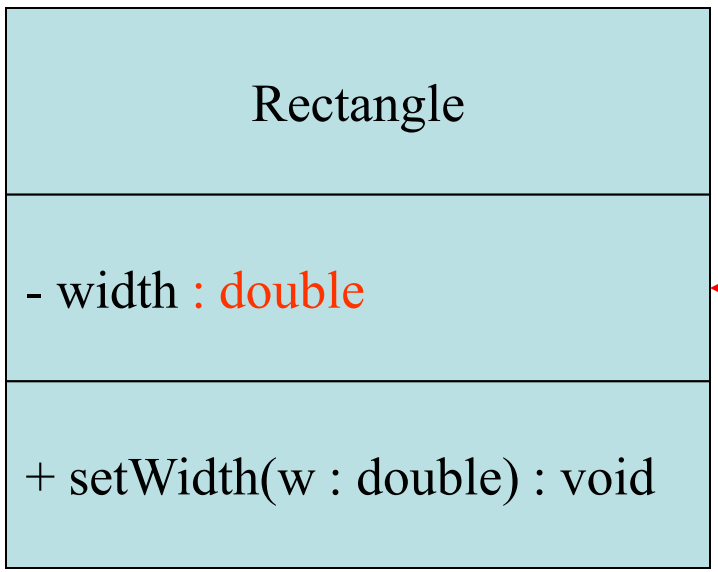
- UML diagrams are language independent.
- UML diagrams use an independent notation to show return types, access modifiers, etc.



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UML Data Type and Parameter Notation

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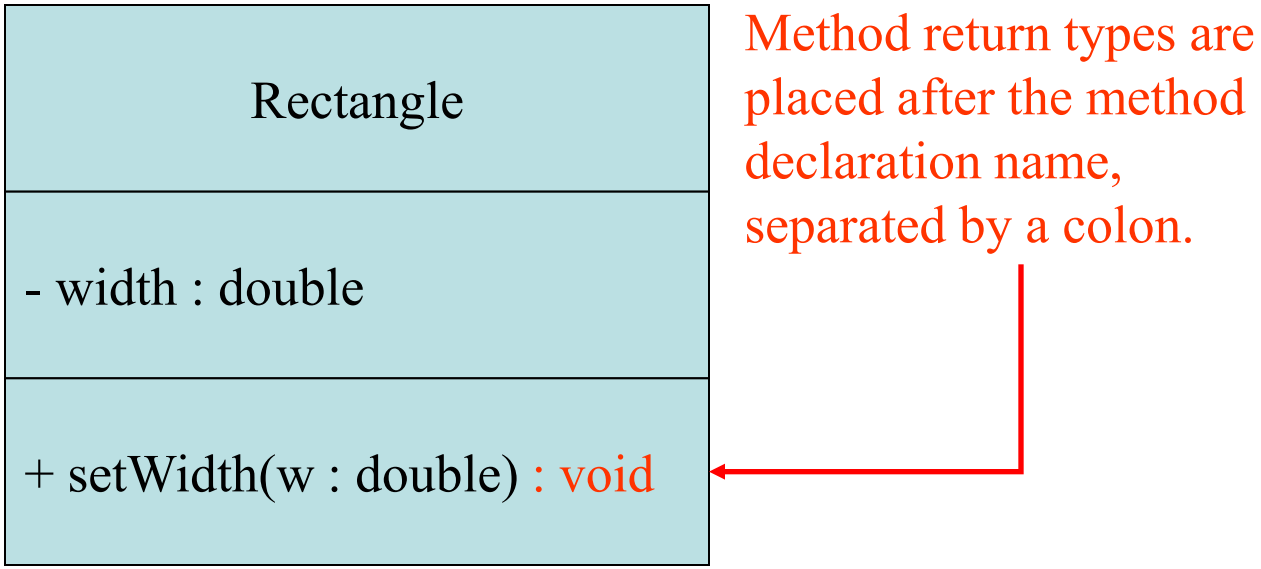
Variable types are placed after the variable name, separated by a colon.

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UML Data Type and Parameter Notation

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

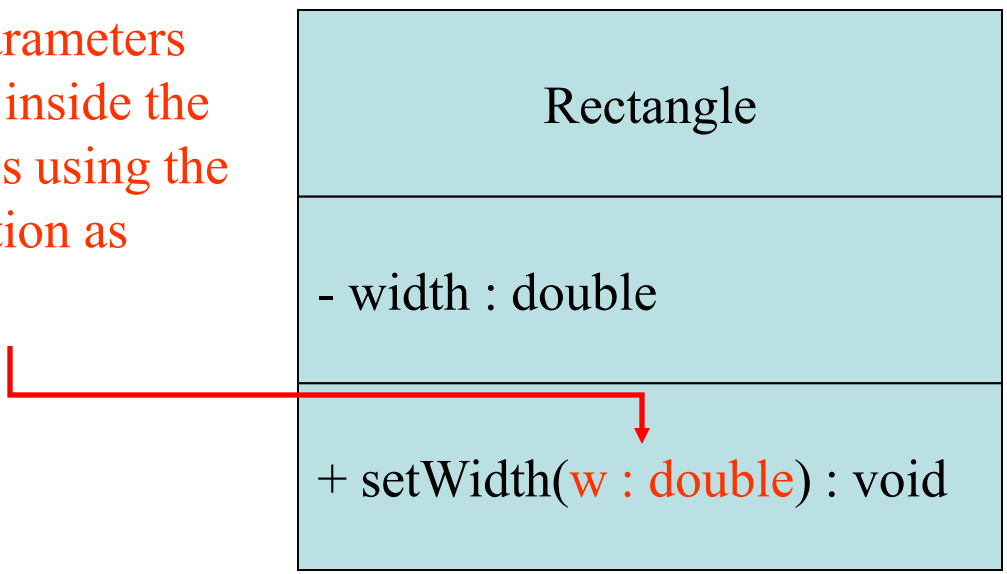


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UML Data Type and Parameter Notation

- 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.

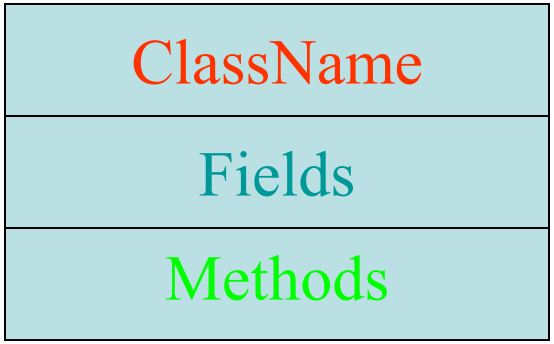


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Converting the UML Diagram to Code

- 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.

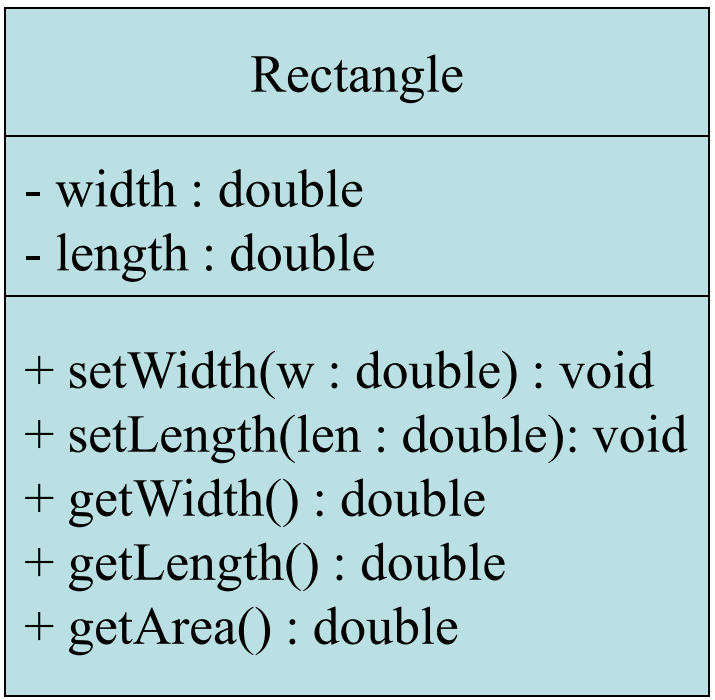
```
class header
{
   Fields
   Methods
}
```



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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;
   private double length;

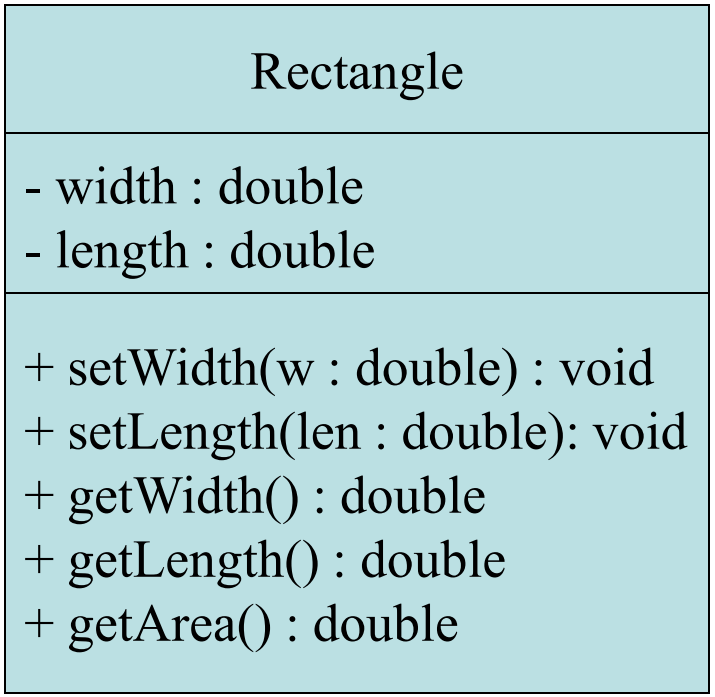
   public void setWidth(double w)
   {
   }
   public void setLength(double len)
   {
   }
   public double getWidth()
   {    return 0.0;
   }
   public double getLength()
   {    return 0.0;
   }
   public double getArea()
   {    return 0.0;
   }
}
```

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Converting the UML Diagram to Code

Once the class structure has been tested, the method bodies can be written and tested.




```
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;
   }
}
```

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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.

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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`.

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Instance Fields and Methods

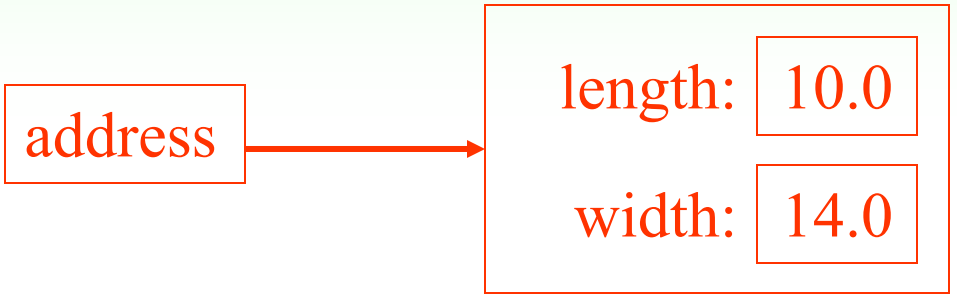
- Instance fields and instance methods require an object to be created in order to be used.
- See example: RoomAreas.java
- Note that each room represented in this example can have different dimensions.

```
Rectangle kitchen = new Rectangle();
Rectangle bedroom = new Rectangle();
Rectangle den = new Rectangle();
```

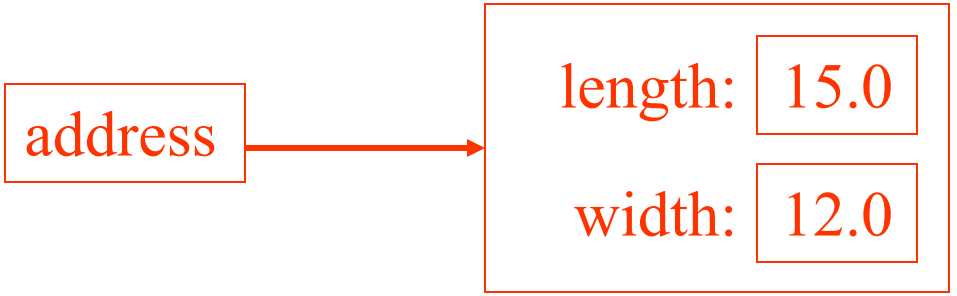
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States of Three Different Rectangle Objects

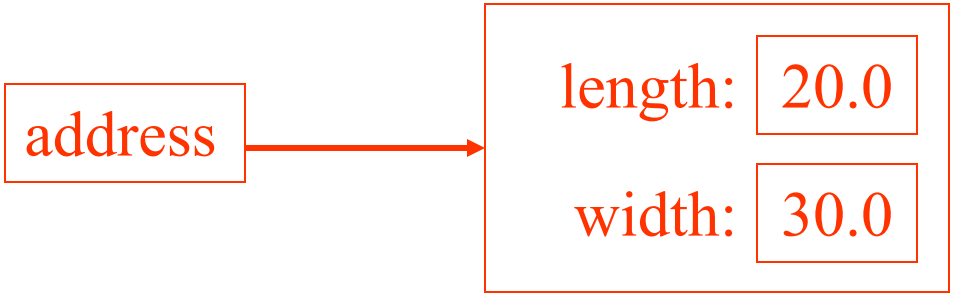
The `kitchen` variable holds the address of a `Rectangle` Object.



The `bedroom` variable holds the address of a `Rectangle` Object.



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



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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.

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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.

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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;
}
```

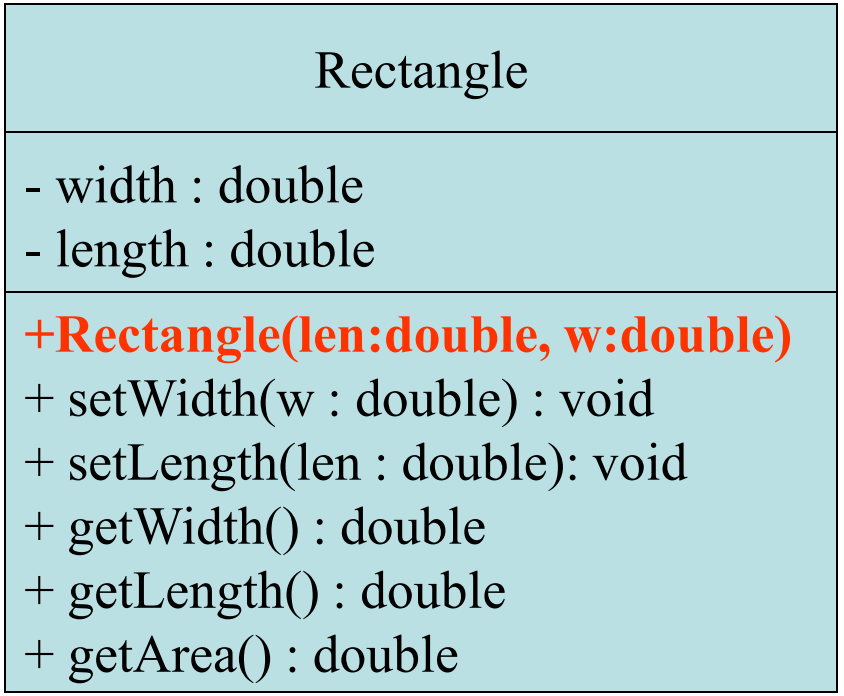
Examples: Rectangle.java, ConstructorDemo.java

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Constructors in UML

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



Notice there is no return type listed for constructors.

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Uninitialized Local Reference Variables

- Reference variables can be declared without being initialized.

```
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.

```
box = new Rectangle(7.0, 14.0);
```

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

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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*.

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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

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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

```
public Rectangle()
{
      length = 1.0;
      width = 1.0;
}
```

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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:

```
String name = new String("Michael Long");
```

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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";
```

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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

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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.

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Overloaded Method `add`

```
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;
}
```

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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.

```
add(int, int)
add(String, String)
```

Signatures of the `add` *methods of previous slide*

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

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`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?

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

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`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?

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

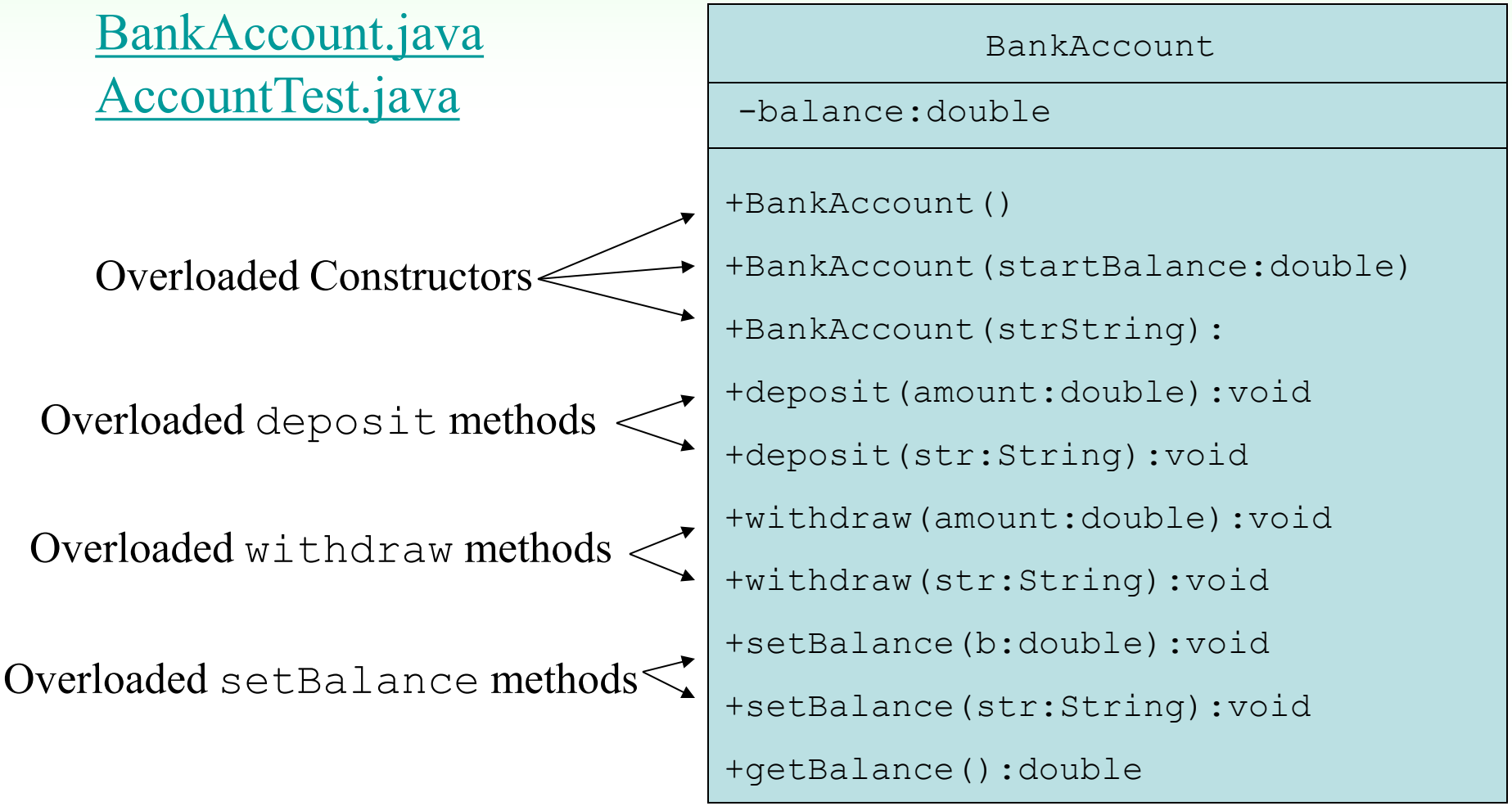
The first call would use the no-arg constructor and `box1` would have a length of 1.0 and width of 1.0.

The second call would use the original constructor and `box2` would have a length of 5.0 and a width of 10.0.

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The `BankAccount` Example

BankAccount.java
AccountTest.java



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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.

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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.

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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.

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Some Java Standard Packages

Table 6-2 A few of the standard Java packages

Package	Description
`java.applet`	Provides the classes necessary to create an applet.
`java.awt`	Provides classes for the Abstract Windowing Toolkit. These classes are used in drawing images and creating graphical user interfaces.
`java.io`	Provides classes that perform various types of input and output.
`java.lang`	Provides general classes for the Java language. This package is automatically imported.
`java.net`	Provides classes for network communications.
`java.security`	Provides classes that implement security features.
`java.sql`	Provides classes for accessing databases using structured query language.
`java.text`	Provides various classes for formatting text.
`java.util`	Provides various utility classes.
`javax.swing`	Provides classes for creating graphical user interfaces.

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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

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Object Oriented Design
Finding Classes and Their Responsibilities

- Identify the responsibilities
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