Chapter 6:
A First Look at Classes

Starting Out with Java:
From Control Structures through Objects

Fourth Edition

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Chapter Topics

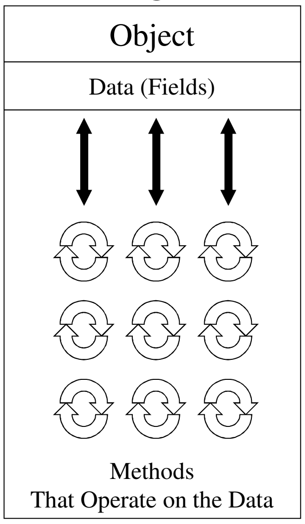
Chapter 6 discusses the following main topics:

– Classes and Objects
– Instance Fields and Methods
– Constructors
– Overloading Methods and Constructors
– Scope of Instance Fields
– Packages and Import Statements

Object-Oriented Programming

- Object-oriented programming is centered on creating objects rather than procedures.
- Objects are a melding of data and procedures that manipulate that data.
- Data in an object are known as *fields*.
- Procedures in an object are known as *methods*.

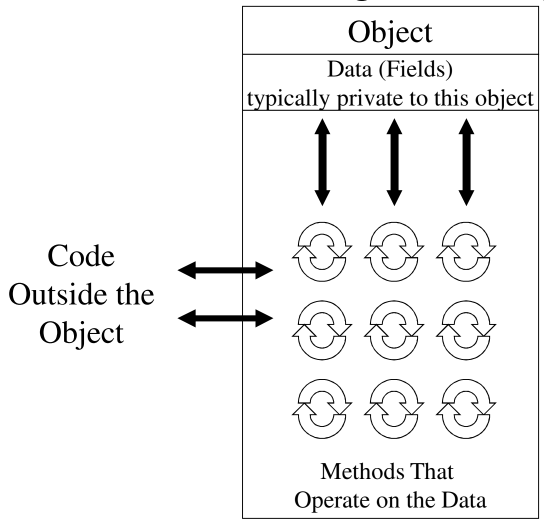
Object-Oriented Programming



Object-Oriented Programming

- Object-oriented programming combines data and behavior via *encapsulation*.
- *Data hiding* is the ability of an object to hide data from other objects in the program.
- Only an object's methods should be able to directly manipulate its data.
- Other objects are allowed manipulate an object's data via the object's methods.

Object-Oriented Programming



Object-Oriented Programming
Data Hiding

- Data hiding is important for several reasons.
  - It protects the data from accidental corruption by outside objects.
  - It hides the details of how an object works, so the programmer can concentrate on using it.
  - It allows the maintainer of the object to have the ability to modify the internal functioning of the object without “breaking” someone else's code.

Object-Oriented Programming
Code Reusability

- Object-Oriented Programming (OOP) has encouraged object reusability.
- A software object contains data and methods that represents a specific concept or service.
- An object is not a stand-alone program.
- Objects can be used by programs that need the object’s service.
- Reuse of code promotes the rapid development of larger software projects.

An Everyday Example of an Object— An Alarm Clock

- Fields define the state that the alarm is currently in.
  - The current second (a value in the range of 0-59)
  - The current minute (a value in the range of 0-59)
  - The current hour (a value in the range of 1-12)
  - The time the alarm is set for (a valid hour and minute)
  - Whether the alarm is on or off (“on” or “off”)

An Everyday Example of an Object— An Alarm Clock

- Methods are used to change a field’s value
  - Set time
  - Set alarm time
  - Turn alarm on
  - Turn alarm off
  - Increment the current second
  - Increment the current minute
  - Increment the current hour
  - Sound alarm

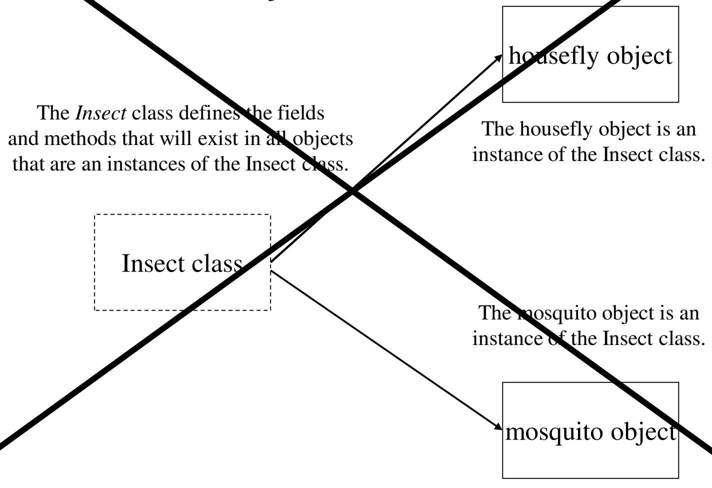
Public methods are accessed by users outside the object.

Private methods are part of the object’s internal design.

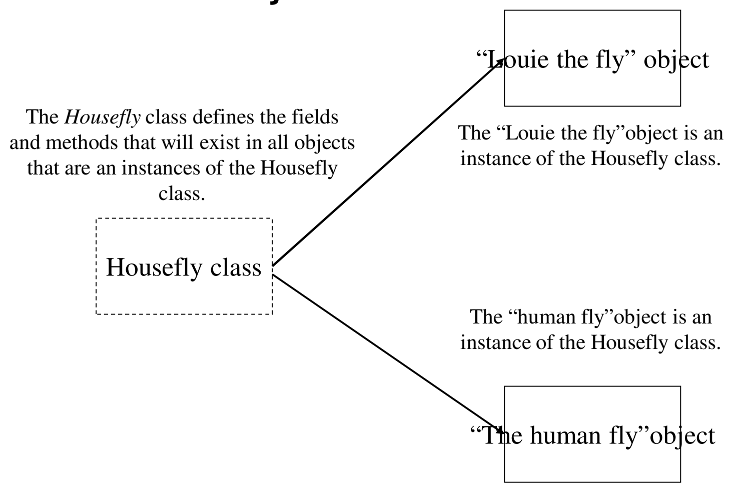
Classes and Objects

- The programmer determines the fields and methods needed, and then creates a class.
- A class can specify the fields and methods that a particular type of object may have.
- A class is a “blueprint” that objects may be created from.
- A class is not an object, but it can be a description of an object.
- An object created from a class is called an *instance* of the class.

Classes and Objects


housefly object
The *Insect* class defines the fields and methods that will exist in all objects that are an instances of the Insect class.
The housefly object is an instance of the Insect class.
Insect class
The mosquito object is an instance of the Insect class.
mosquito object

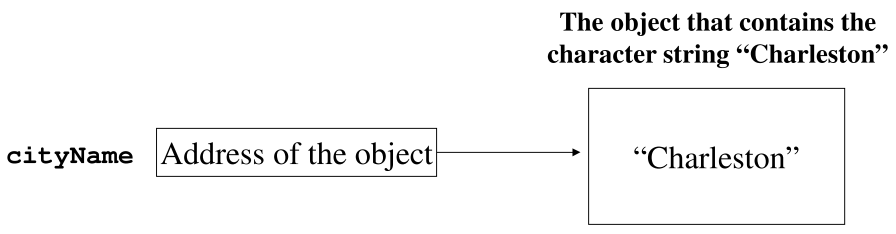
Classes and Objects


"Louie the fly" object
The *Housefly* class defines the fields and methods that will exist in all objects that are an instances of the Housefly class.
The "Louie the fly"object is an instance of the Housefly class.
Housefly class
The "human fly"object is an instance of the Housefly class.
"The human fly"object

Classes

- From chapter 2, we learned that a reference variable contains the address of an object.

```
String cityName = "Charleston";
```



Classes

- The `length()` method of the `String` class returns and integer value that is equal to the length of the string.

```
int stringLength = cityName.length();
```

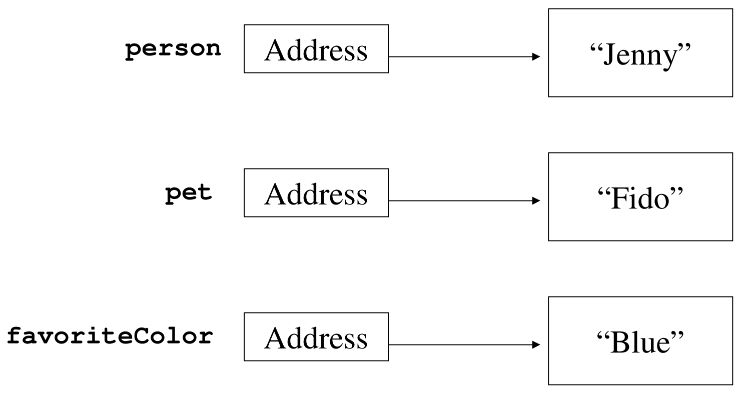
- Class objects normally have methods that perform useful operations on their data.
- Primitive variables can only store data and have no methods.

Classes and Instances

- Many objects can be created from a class.
- Each object is independent of the others.

```
String person = "Jenny";
String pet = "Fido";
String favoriteColor = "Blue";
```

Classes and Instances



Classes and Instances

- Each instance of the `String` class contains different data.
- The instances all share the same design.
- Each instance has all of the attributes and methods that were defined in the `String` class.
- Classes are defined to represent a single concept or service.

Building a `Rectangle` class

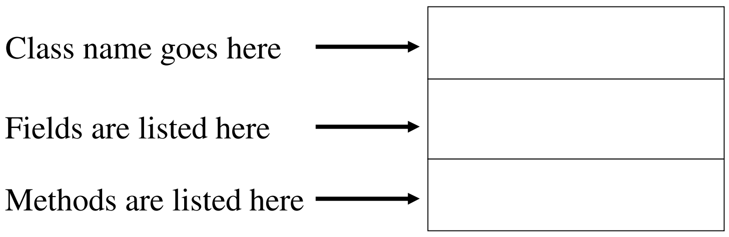
- A `Rectangle` object will have the following fields:
  - `length`. The length field will hold the rectangle's length.
  - `width`. The width field will hold the rectangle's width.

Building a `Rectangle` class

- 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.



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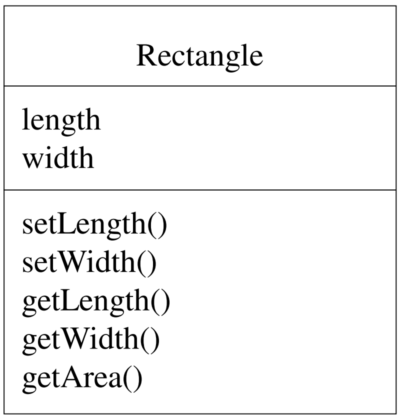
UML Diagram for `Rectangle` class



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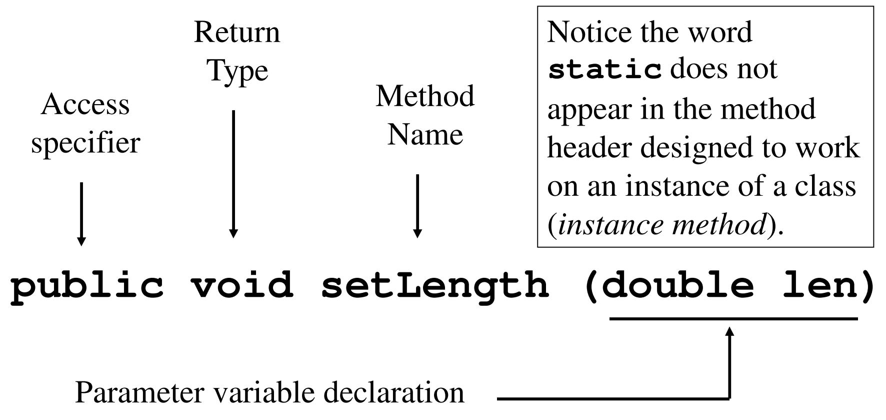
Writing the Code for the Class Fields

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

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



`public void setLength (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

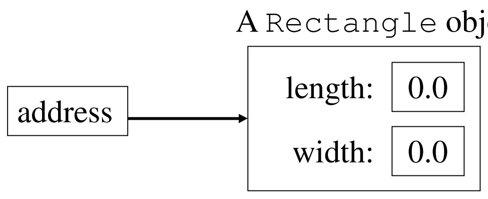
```
/**
   The setLength method stores a value in the
   length field.
   @param len The value to store in length.
*/
public void setLength(double len)
{
   length = len;
}
```

Examples: Rectangle.java, LengthDemo.java

Creating a `Rectangle` object

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

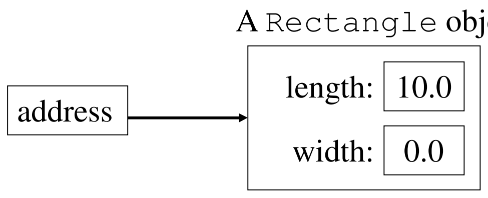
The `box` variable holds the address of the Rectangle object.



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.*

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

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.
    `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*.

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.

Stale Data

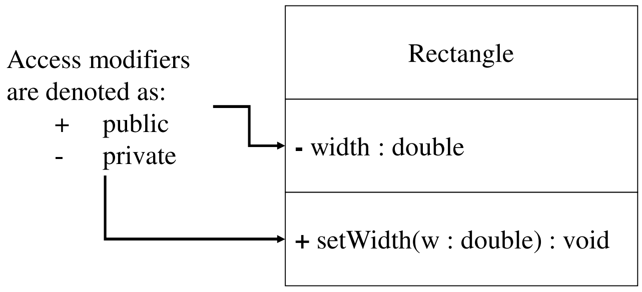
- Rather than use an `area` variable in a `Rectangle` class:

```
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.

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

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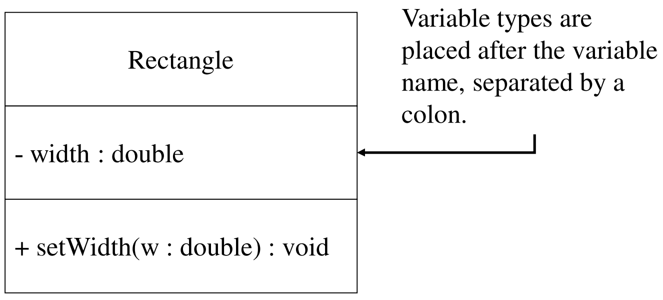
Rectangle
- width : double
+ setWidth(w : double) : void
Variable types are placed after the variable name, separated by a colon.

UML Data Type and Parameter Notation

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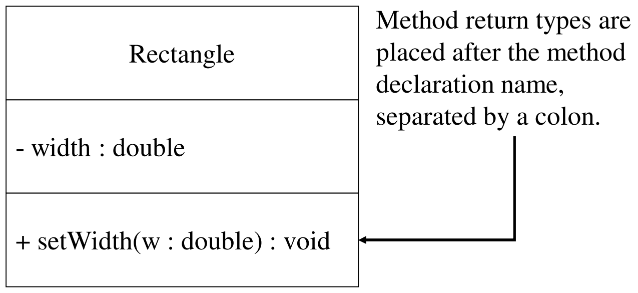
Rectangle
- width : double
+ setWidth(w : double) : void
Method return types are placed after the method declaration name, separated by a colon.

UML Data Type and Parameter Notation

- UML diagrams are language independent.
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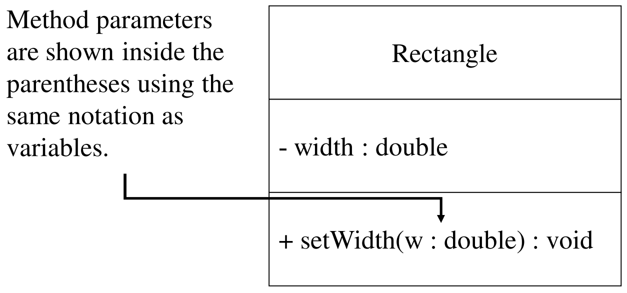

Method parameters are shown inside the parentheses using the same notation as variables.
Rectangle
- width : double
+ setWidth(w : double) : void

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
}
```

ClassName
Fields
Methods

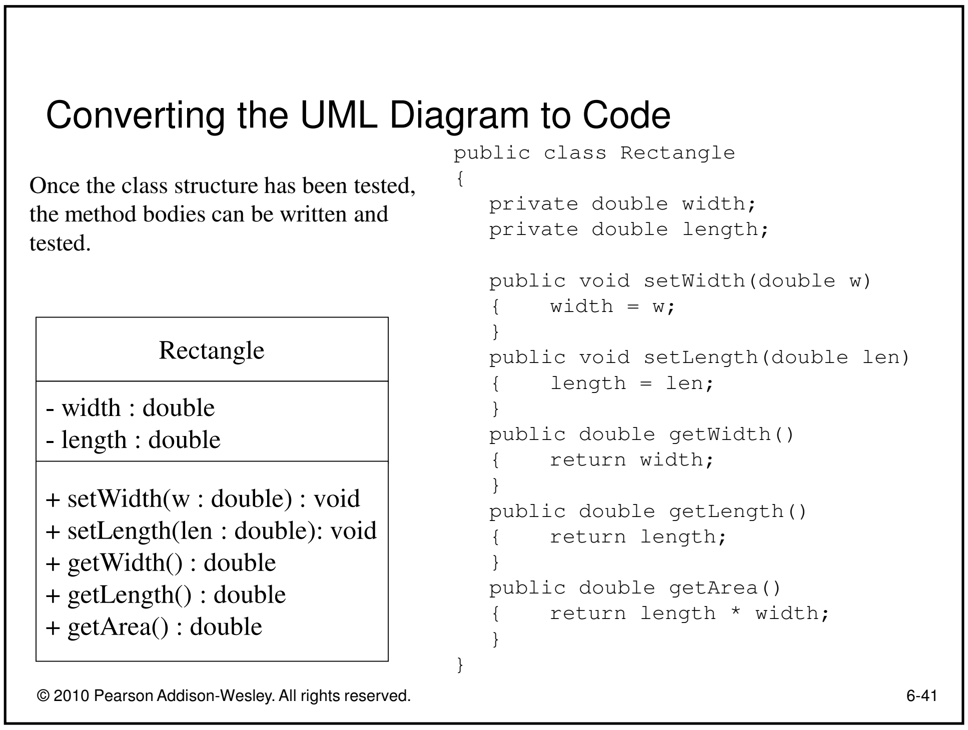
Converting the UML Diagram to Code

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.

Rectangle
- width : double - length : double
+ setWidth(w : double) : void + setLength(len : double): void + getWidth() : double + getLength() : double + getArea() : double

```
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;
   }
}
```



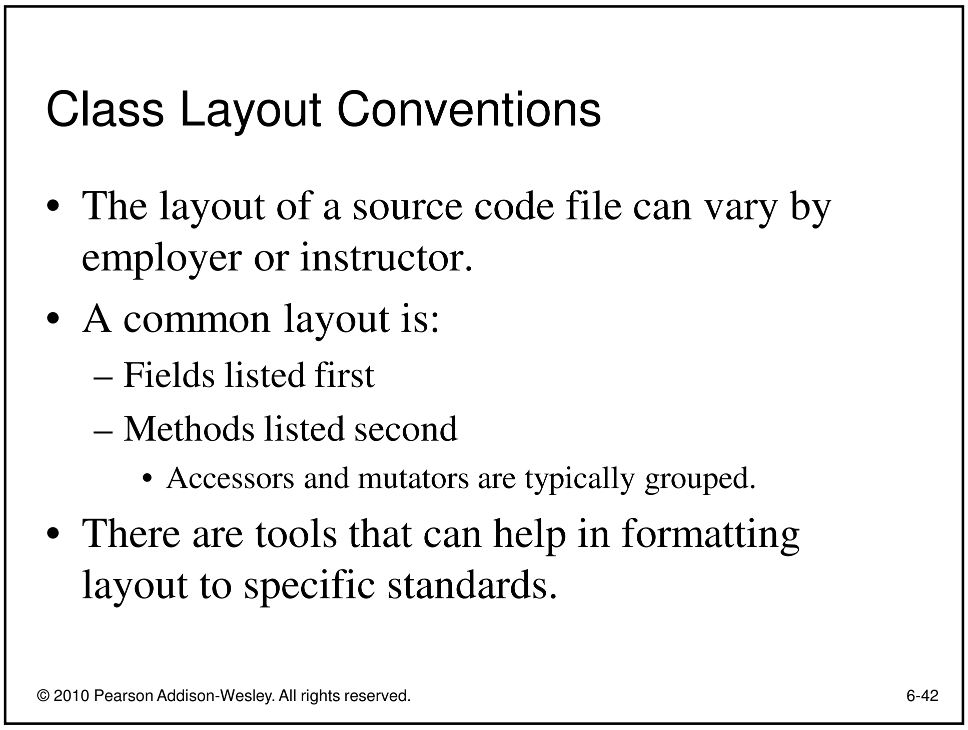
Converting the UML Diagram to Code

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

Rectangle
- width : double - length : double
+ setWidth(w : double) : void + setLength(len : double): void + getWidth() : double + getLength() : double + getArea() : double

```
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;
   }
}
```



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

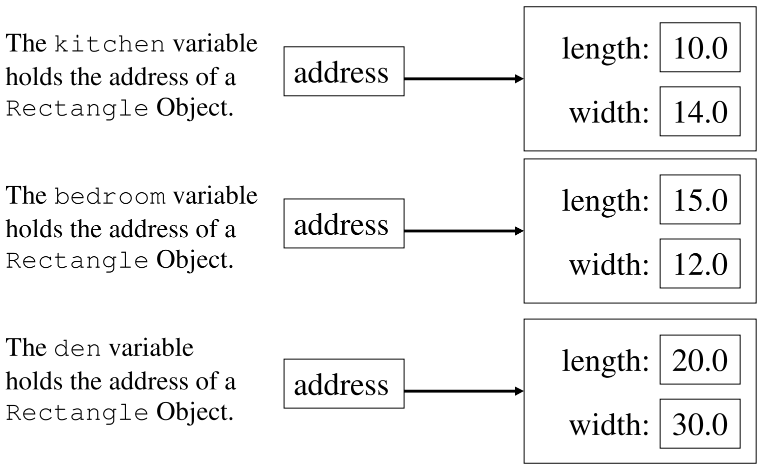
- Fields and methods that are declared as previously shown are called *instance fields* and *instance methods*.
- Objects created from a class each have their own copy of instance fields.
- Instance methods are methods that are not declared with a special keyword, `static`.

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.
address
length: 10.0
width: 14.0
The bedroom variable holds the address of a Rectangle Object.
address
length: 15.0
width: 12.0
The den variable holds the address of a Rectangle Object.
address
length: 20.0
width: 30.0

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.

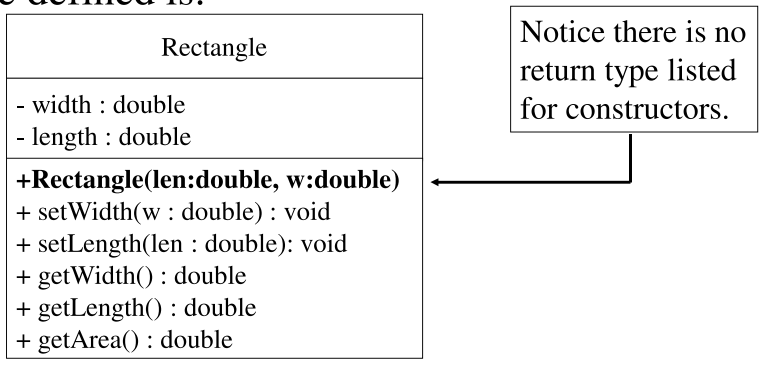
Constructor for `Rectangle` Class

```
/**
   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:



Notice there is no return type listed for constructors.

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.

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

```
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:

```
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";
```

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`

```
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.

```
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.

`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);
```

`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?

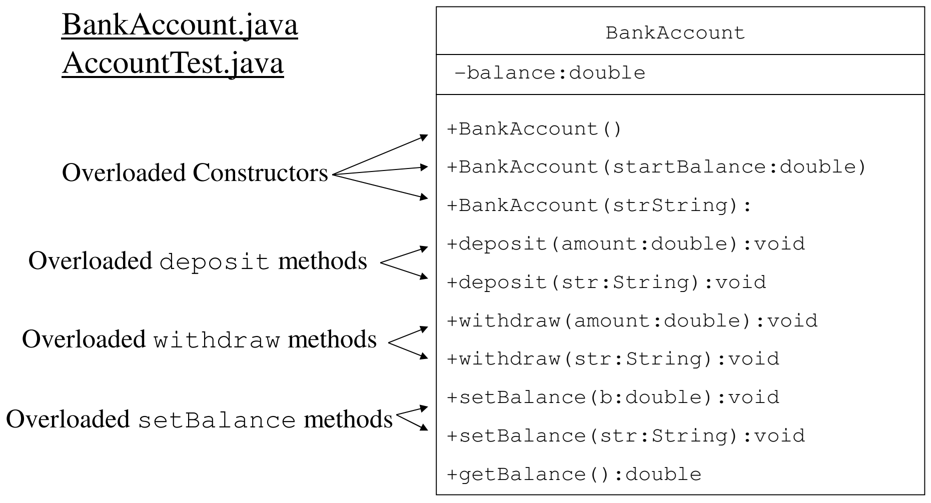
```
Rectangle box1 = new Rectangle();
Rectangle box2 = new Rectangle(5.0, 10.0);
```

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.

The `BankAccount` Example

BankAccount.java
AccountTest.java


BankAccount
-balance:double
+BankAccount()
+BankAccount(startBalance:double)
+BankAccount(strString):
+deposit(amount:double):void
+deposit(str:String):void
+withdraw(amount:double):void
+withdraw(str:String):void
+setBalance(b:double):void
+setBalance(str:String):void
+getBalance():double
Overloaded Constructors
Overloaded deposit methods
Overloaded withdraw methods
Overloaded setBalance methods

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

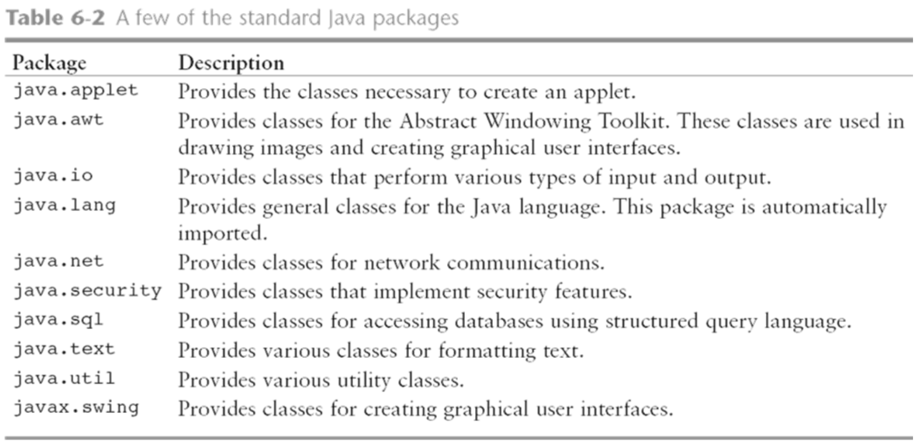


Table 6-2 A few of the standard Java packages

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.

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

You can read this section (Chapter 6, Section 7), but we will not cover it in CSP1150/4150