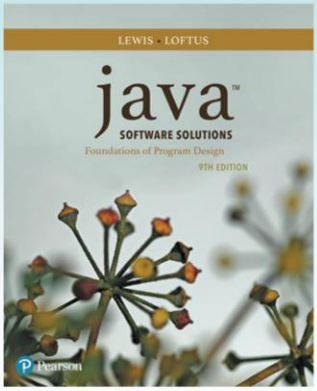
Chapter 7
Object-Oriented Design



Java Software Solutions
Foundations of Program Design
9th Edition

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Object-Oriented Design

- Now we can extend our discussion of the design of classes and objects
- Chapter 7 focuses on:
  - software development activities
  - determining the classes and objects that are needed for a program
  - the relationships that can exist among classes
  - the static modifier
  - writing interfaces
  - the design of enumerated type classes
  - method design and method overloading

Outline

- Software Development Activities
- Identifying Classes and Objects
- Static Variables and Methods
- Class Relationships
- Interfaces
- Enumerated Types Revisited
- Method Design
- Testing

Interfaces

- A Java *interface* is a collection of abstract methods and constants
- An *abstract method* is a method header without a method body
- An abstract method can be declared using the modifier `abstract`, but because all methods in an interface are abstract, usually it is left off
- An interface is used to establish a set of methods that a class will implement

-Note an abstract method contains the header (name, parameters) **without** any code (implementation)

abstract public void function(int);

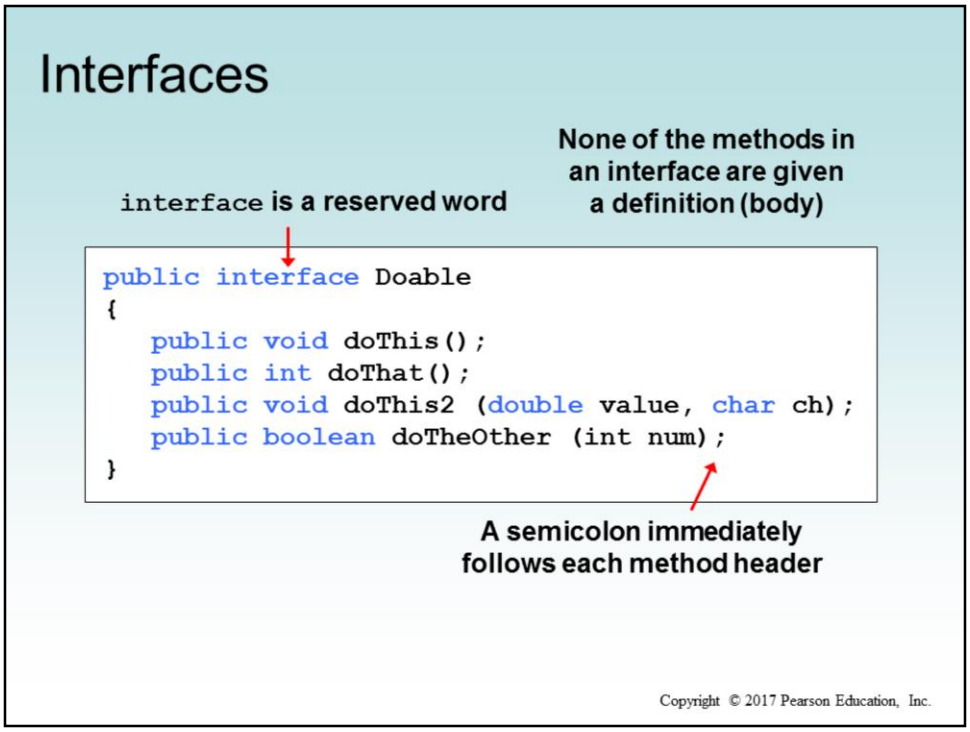
-Note there are no braces containing statements, only the method header (name, parameters)

-An interface is used to describe functionality that classes might want to implement

-Classes that use an interface must define what this functionality is for their purpose

-They accomplish this by “filling in” the empty abstract methods with their own definitions

-In this way, we say that classes “implement” an interface



-Note how a Java interface is similar to a Java class

-The difference is that an interface can **only** contain constants and **abstract** methods

-It is not necessary to specify the abstract modifier on the methods (they are abstract by default)

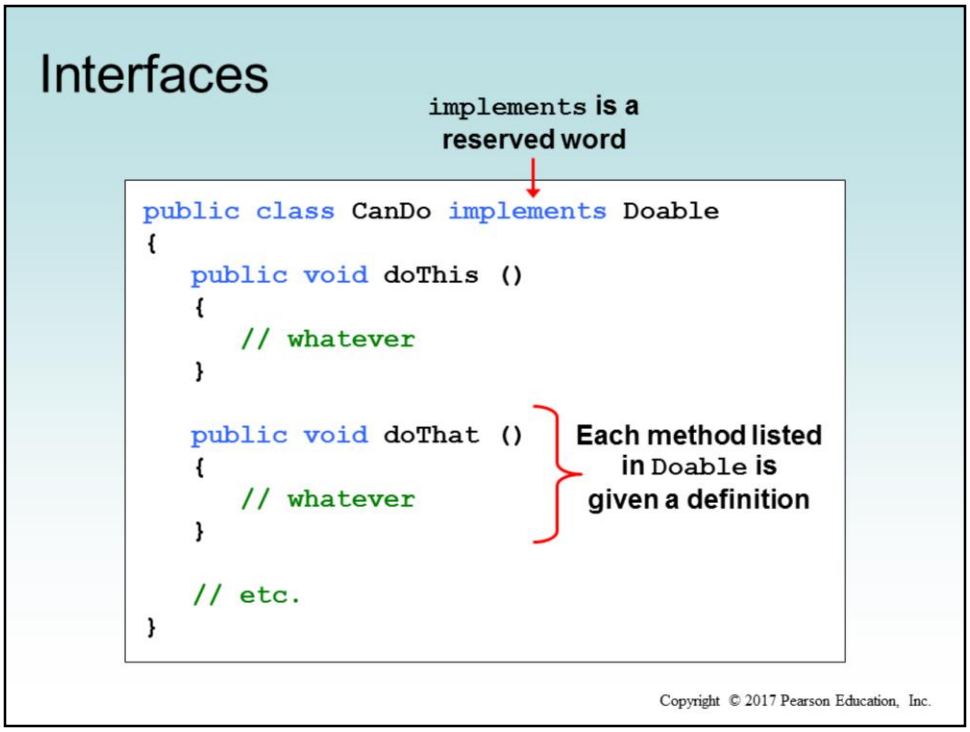
Interfaces

- An interface cannot be instantiated
- Methods in an interface have public visibility by default
- A class formally implements an interface by:
  - stating so in the class header
  - providing implementations for every abstract method in the interface
- If a class declares that it implements an interface, it must define all methods in the interface

-Unlike classes, objects **cannot** be created from interfaces; in other words, we **cannot** specify:

Doable do = new Doable();

-Instead interfaces are **used by classes** to implement their designated functionality (methods)



-This example shows how a class **implements** (or uses) an interface

-Note the use of the reserved word **implements** followed by the name of the interface

-The class must then provide definitions for **each** of the abstract methods declared in the interface

Interfaces

- In addition to (or instead of) abstract methods, an interface can contain constants
- When a class implements an interface, it gains access to all its constants
- A class that implements an interface can implement other methods as well
- See `Complexity.java`
- See `Question.java`
- See `MiniQuiz.java`

```
//********************************************************************
//  Complexity.java       Author: Lewis/Loftus
//
//  Represents the interface for an object that can be assigned an
//  explicit complexity.
//********************************************************************

public interface Complexity
{
   public void setComplexity (int complexity);
   public int getComplexity();
}
```

```
//********************************************************************
//  Question.java       Author: Lewis/Loftus
//
//  Represents a question (and its answer).
//********************************************************************

public class Question implements Complexity
{
   private String question, answer;
   private int complexityLevel;

   //-----------------------------------------------------------------
   //  Constructor: Sets up the question with a default complexity.
   //-----------------------------------------------------------------
   public Question (String query, String result)
   {
      question = query;
      answer = result;
      complexityLevel = 1;
   }
```

continue

continue

```
//-----------------------------------------------------------------
//  Sets the complexity level for this question.
//-----------------------------------------------------------------
public void setComplexity (int level)
{
   complexityLevel = level;
}

//-----------------------------------------------------------------
//  Returns the complexity level for this question.
//-----------------------------------------------------------------
public int getComplexity()
{
   return complexityLevel;
}

//-----------------------------------------------------------------
//  Returns the question.
//-----------------------------------------------------------------
public String getQuestion()
{
   return question;
}
```

continue

continue

```
   //-----------------------------------------------------------------
   //  Returns the answer to this question.
   //-----------------------------------------------------------------
   public String getAnswer()
   {
      return answer;
   }

   //-----------------------------------------------------------------
   //  Returns true if the candidate answer matches the answer.
   //-----------------------------------------------------------------
   public boolean answerCorrect (String candidateAnswer)
   {
      return answer.equals(candidateAnswer);
   }

   //-----------------------------------------------------------------
   //  Returns this question (and its answer) as a string.
   //-----------------------------------------------------------------
   public String toString()
   {
      return question + "\n" + answer;
   }
}
```

```
//********************************************************************
//  MiniQuiz.java       Author: Lewis/Loftus
//
//  Demonstrates the use of a class that implements an interface.
//********************************************************************

import java.util.Scanner;

public class MiniQuiz
{
   //-----------------------------------------------------------------
   //  Presents a short quiz.
   //-----------------------------------------------------------------
   public static void main (String[] args)
   {
      Question q1, q2;
      String possible;

      Scanner scan = new Scanner (System.in);

      q1 = new Question ("What is the capital of Jamaica?",
                         "Kingston");
      q1.setComplexity (4);

      q2 = new Question ("Which is worse, ignorance or apathy?",
                         "I don't know and I don't care");
      q2.setComplexity (10);
```

continue

continue

```
      System.out.print (q1.getQuestion());
      System.out.println (" (Level: " + q1.getComplexity() + ")");
      possible = scan.nextLine();
      if (q1.answerCorrect(possible))
         System.out.println ("Correct");
      else
         System.out.println ("No, the answer is " + q1.getAnswer());

      System.out.println();
      System.out.print (q2.getQuestion());
      System.out.println (" (Level: " + q2.getComplexity() + ")");
      possible = scan.nextLine();
      if (q2.answerCorrect(possible))
         System.out.println ("Correct");
      else
         System.out.println ("No, the answer is " + q2.getAnswer());
   }
}
```

Sample Run

```
What is the capital of Jamaica? (Level: 4)
Kingston
Correct

Which is worse, ignorance or apathy? (Level: 10)
apathy
No, the answer is I don't know and I don't care
```

```
continu
                                                                    ;
                                                                    ));
        System.out.println();
        System.out.print (q2.getQuestion());
        System.out.println (" (Level: " + q2.getComplexity() + ")");
        possible = scan.nextLine();
        if (q2.answerCorrect(possible))
           System.out.println ("Correct");
        else
           System.out.println ("No, the answer is " + q2.getAnswer());
    }
}
```

Interfaces

- A class can implement multiple interfaces
- The interfaces are listed in the `implements` clause
- The class must implement all methods in all interfaces listed in the header

```
class ManyThings implements interface1, interface2
{
   // all methods of both interfaces
}
```

Interfaces

- The Java API contains many helpful interfaces
- The `Comparable` interface contains one abstract method called `compareTo`, which is used to compare two objects
- We discussed the `compareTo` method of the `String` class in Chapter 5
- The `String` class implements `Comparable`, giving us the ability to put strings in lexicographic order

-The Comparable interface defines functionality to compare two objects (of the same type)

-It is meant to determine whether they are less than, equal to, or greater than one another

-What does that mean for an object of a specific type of class?

-One class might define this meaning to be different than another

-This is **exactly** why the interface doesn't define any methods for it, instead each class does!

-When a class implements this interface, it defines what it means to compare two objects of its class type

-Different classes provide different **meaning**s (method definitions) for the same abstract method name!

-The object-oriented term for this important, fundamental concept is called **polymorphism**

The Comparable Interface

- Any class can implement `Comparable` to provide a mechanism for comparing objects of that type

```
if (obj1.compareTo(obj2) < 0)
   System.out.println ("obj1 is less than obj2");
```

- The value returned from `compareTo` should be negative is `obj1` is less that `obj2`, 0 if they are equal, and positive if `obj1` is greater than `obj2`
- It's up to the programmer to determine what makes one object less than another

The Iterator Interface

- As we discussed in Chapter 5, an iterator is an object that provides a means of processing a collection of objects one at a time
- An iterator is created formally by implementing the `Iterator` interface, which contains three methods
  - The `hasNext` method returns a boolean result – true if there are items left to process
  - The `next` method returns the next object in the iteration
  - The `remove` method removes the object most recently returned by the `next` method

The Iterable Interface

- Another interface, `Iterable`, establishes that an object provides an iterator
- The `Iterable` interface has one method, `iterator`, that returns an `Iterator` object
- Any `Iterable` object can be processed using the for-each version of the `for` loop
- Note the difference: an `Iterator` has methods that perform an iteration; an `Iterable` object provides an iterator on request

-The Iterable interface is primarily used with an advanced topic known as Java collections

-The Iterable interface also uses the advanced concept of generics that we'll study later

-For now, just know that it is simply another type of interface in the Java API

Interfaces

- You could write a class that implements certain methods (such as `compareTo`) without formally implementing the interface (`Comparable`)
- However, formally establishing the relationship between a class and an interface allows Java to deal with an object in certain ways
- Interfaces are a key aspect of object-oriented design in Java
- We discuss this idea further in Chapter 10

-By creating an interface, you define functionality that can be shared and defined differently among classes

-For example, consider designing an interface to operate a vehicle

-The abstract methods might be named “forward, reverse, start, stop”

-Now consider classes that might want to implement such functionality (e.g. car, boat, plane, bike)

-Each class implementing such an interface would perform “forward, reverse, start, stop” differently!

Outline

- Software Development Activities
- Identifying Classes and Objects
- Static Variables and Methods
- Class Relationships
- Interfaces
- **Enumerated Types Revisited**
- Method Design
- Testing

Enumerated Types

- In Chapter 3 we introduced enumerated types, which define a new data type and list all possible values of that type:

```
enum Season {winter, spring, summer, fall}
```

- Once established, the new type can be used to declare variables

```
Season time;
```

- The only values this variable can be assigned are the ones established in the `enum` definition

Enumerated Types

- An enumerated type definition is a special kind of class
- The values of the enumerated type are objects of that type
- For example, `fall` is an object of type `Season`
- That's why the following assignment is valid:

```
time = Season.fall;
```


-The values of the enum are actually objects stored within the enum class (an enum is a special type of class)

-These objects are referenced by public static object reference variables within the class

-This is how we were able to specify Season.fall (where fall is the object reference variable that is static)!

Enumerated Types

- An enumerated type definition can be more interesting than a simple list of values
- Because they are like classes, we can add additional instance data and methods
- We can define an `enum` constructor as well
- Each value listed for the enumerated type calls the constructor
- See `Season.java`
- See `SeasonTester.java`

```
//********************************************************************
//  Season.java       Author: Lewis/Loftus
//
//  Enumerates the values for Season.
//********************************************************************

public enum Season
{
   winter ("December through February"),
   spring ("March through May"),
   summer ("June through August"),
   fall ("September through November");

   private String span;
```

continue

-Note that winter, spring, summer, fall are actually objects within the enum class

-As objects, they can be created with a constructor

-In the example above, each object is called with a constructor that takes a String argument

-The actual constructor is defined on the next slide

continue

```
   //-----------------------------------------------------------------
   //  Constructor: Sets up each value with an associated string.
   //-----------------------------------------------------------------
   Season (String months)
   {
      span = months;
   }

   //-----------------------------------------------------------------
   //  Returns the span message for this value.
   //-----------------------------------------------------------------
   public String getSpan()
   {
      return span;
   }
}
```


-This constructor assigns an input parameter String to the span variable

```
//********************************************************************
//  SeasonTester.java       Author: Lewis/Loftus
//
//  Demonstrates the use of a full enumerated type.
//********************************************************************

public class SeasonTester
{
   //-----------------------------------------------------------------
   //  Iterates through the values of the Season enumerated type.
   //-----------------------------------------------------------------
   public static void main (String[] args)
   {
      for (Season time : Season.values())
         System.out.println (time + "\t" + time.getSpan());
   }
}
```


-Season.values() returns a list (or an array) of all of the possible values

-Recall the for-each loop (we saw in an earlier chapter) uses an iterator to process each item in the list

-Each time through the loop, the next item is processed

-This loop can be read “for each object in the Season enum class”

```
//**********                                                    **********
//  SeasonTes
//
//  Demonstra
//**********                                                    **********

public class
{
   //-----------------------------------------------------------------
   //  Iterates through the values of the Season enumerated type.
   //-----------------------------------------------------------------
   public static void main (String[] args)
   {
      for (Season time : Season.values())
         System.out.println (time + "\t" + time.getSpan());
   }
}
```

Output

```
winter  December through February
spring  March through May
summer  June through August
fall    September through November
```

Enumerated Types

- Every enumerated type contains a static method called `values` that returns a list of all possible values for that type
- The list returned from `values` can be processed using a for-each loop
- An enumerated type cannot be instantiated outside of its own definition
- A carefully designed enumerated type provides a versatile and type-safe mechanism for managing data

-We cannot create (instantiate) a new enum object outside it's class definition (like we do with other class objects)

-For example, in a main method of a driver class, we **cannot** do:

Season autumn = new Season("leaves and rain");