Chapter 4

Classes, Objects, and Methods

- Class and Method Definitions
- Information Hiding and Encapsulation
- Objects and Reference
- Parameter passing

Learn by Doing

- All programs in the book are available on the CD that comes with the book
- It is a good idea to run the programs as you read about them
- Do not forget that you will need the `SavitchIn.java` file for keyboard input
- Classes are used to define objects and provide methods to act on the objects
- Classes are also programs that declare these objects and process them to solve the problem

Classes

- *Class*—definition of a kind of object
- Like an outline or plan for constructing specific objects
  - » see next slide or diagram in text
- Example: an Automobile class
  - » Object that satisfies the `Automobile` definition *instantiates* the `Automobile` class
- Class specifies what kind of data objects of that class have
  - » Each object has the same data items but can have different values
- Class specifies what methods each object will have
  - » All objects of the same class have the exact same methods

Class as an Outline

Class Definition

Class Name: Automobile
Data:
amount of fuel _____
speed _____
license plate _____
Methods (actions):
increaseSpeed:
How: Press on gas pedal.
stop:
How: Press on brake pedal.

Objects that are instantiations of the class

First Instantiation:
Object name: patsCar
amount of fuel: 10 **gallons**
speed: 55 **miles per hour**
license plate: "135 XJK"

Second Instantiation:
Object name: suesCar
amount of fuel: 14 **gallons**
speed: 0 **miles per hour**
license plate: "SUES CAR"

Third Instantiation:
Object name: ronsCar
amount of fuel: 2 **gallons**
speed: 75 **miles per hour**
license plate: "351 WLF"

Objects

- Objects are variables that are named instances of a class
  - » the class is their type
- Objects have both data and methods
- Both the data items and methods of a class are *members* of the object
- Data items are also called *fields* or *instance variables*
- *Invoking* a method means to *call* the method, i.e. execute the method
  - » Syntax for invoking an object's method: the dot operator `object_Variable_Name.method()`
  - » `object_Variable_Name` is the *calling object*

Example: `String` Class

- `String` is a class
  - » it stores a sequence of characters
  - » its `length` method returns the number of characters

- Example: read characters typed in by user from the keyboard and output the number of characters entered

```
String userInput;
userInput = SavitchIn.readLine();
System.out.println(userInput.length());
```

Class Files

- Each Java class definition should be a separate file
- Use the same name for the class and the file, except add ".java" to the file name
- Good programming practice:
  Start the class (and file) name a capital letter and capitalize inner words upper case
  - » e.g. MyClass.java for the class MyClass
- For now put all the classes you need to run a program in the same directory

Instance Variables

- `SpeciesFirstTry` class has three instance variables: `name`, `population`, and `growthRate`:

```
public String name;
public int population;
public double growthRate;
```

- `public` means that there are no restrictions on how these instance variables are used.
- Later we'll see that these should be declared `private` instead of `public`.

Instantiating (Creating) Objects

- Syntax:
  ```
  class_Name instance_Name = new class_Name();
  ```
- Note the keyword *new*

- For example, the text defines a class named `SpeciesFirstTry`

```
//instantiate an object of this class
   SpeciesFirstTry speciesOfTheMonth =
                          new SpeciesFirstTry();
```

- Public instance variables can be accessed using the dot operator:

```
SpeciesOfTheMonth.name = "Klingon ox";
```


Return Type of Methods

- Some methods perform an action *and return a single value*
- Some methods just perform an action (e.g. print a message or read in a value from the keyboard) and do not return a value
- All methods require that the return type be specified
- Return types may be:
  - » a primitive data type, such as `char`, `int`, `double`, etc.
  - » a class, such as `String`, `SpeciesFirstTry`, etc.
  - » `void` if no value is returned
- You can use a method anyplace where it is legal to use its return type, for example the `readLineInt()` method of `SavitchIn` returns an integer, so this is legal:

```
int next = SavitchIn.readLineInt();
```

Return Statement

- Methods that return a value must execute a `return` statement that includes the value to return
- For example:

```
public int getCount()
{
   return count;
}
public int count = 0;
```


`void` Method Example

- The definition of the `writeOutput` method of `SpeciesFirstTry`:

```
public void writeOutput()
{
  System.out.println("Name = " + name);
  System.out.println("Population = " + population);
  System.out.println("Growth = " + growthRate + "%");
}
```

- Assuming instance variables `name`, `population`, and `growthRate` have been defined and assigned values, this method performs an action (writes values to the screen) but does not return a value

Method and Class Naming Conventions

Good Programming Practice

- Use verbs to name void methods
  - » they perform an *action*
- Use nouns to name methods that return a value
  - » they create (return) a piece of data, a *thing*
- Start class names with a capital letter
- Start method names with a lower case letter

The **`main`** Method

- A program written to solve a problem (rather than define an object) is written as a class with one method, `main`
- Invoking the class name invokes the `main` method
- See the text: `SpeciesFirstTryDemo`
- Note the basic structure:

```
public class SpeciesFirstTryDemo
{
   public static void main(String[] args)
   {
      <statements that define the main method>
   }
}
```

The Reserved Word **this**

- The word `this` has a special meaning for objects
- It is a *reserved* word, which means you should not use it as an identifier for a variable, class or method
  - » other examples of reserved words are `int`, `char`, `main`, etc.
- `this` stands for the name of the calling object
- Java allows you to omit `this` .
  - » It is automatically understood that an instance variable name without the keyword `this` refers to the calling object

Example Using **this**

- Using the same example as for the `void` method, but including the keyword `this`:

```
public void writeOutput()
{
   System.out.println("Name = " + this.name);
   System.out.println("Population = " +
  this.population);
   System.out.println("Growth rate = " +
  this.growthRate + "%");
}
```

- `this` refers to the name of the calling object that invoked the `writeOutput` method

Local Variables and *Blocks*

- A *block* (a *compound statement)* is the set of statements between a pair of matching braces (curly brackets)
- A variable declared inside a block is known only inside that block
  - » it is *local* to the block, therefor it is called a *local variable*
  - » when the block finishes executing, local variables disappear
  - » references to it outside the block cause a compile error

Local Variables and *Blocks*

- Some programming languages (e.g. C and C++) allow the variable name to be reused outside the local block
  - » it is confusing and not recommended, nevertheless, it is allowed
- However, a variable name in Java can be declared only *once for a method*
  - » although the variable does not exist outside the block, other blocks in the same method cannot reuse the variable's name

When and Where to Declare Variables

- Declaring variables outside all blocks but within the method definition makes them available within all the blocks

Good programming Practice:

- declare variables just before you use them
- initialize variables when you declare them
- do not declare variables inside loops
  - » it takes time during execution to create and destroy variables, so it is better to do it just once for loops)
- it is ok to declare loop counters in the ***`Initialization`*** field of `for` loops, e.g.
  `for(int i=0; i <10; i++)…`
  - » the ***`Initialization`*** field executes only once, when the `for` loop is first entered

Passing Values to a Method: Parameters

- Some methods can be more flexible (therefor useful) if we pass them input values
- Input values for methods are called *passed* values or *parameters*
- Parameters and their data types must be specified inside the parentheses of the heading in the method definition
  - » these are called *formal* parameters
- The calling object must put values of the same data type, in the same order, inside the parentheses of the method invocation
  - » these are called *arguments*, or *actual* parameters

Parameter Passing Example

```
//Definition of method to double an integer
public int doubleValue(int numberIn)
{
   return 2 * numberIn;
}
//Invocation of the method... somewhere in main...
...
int next = SavitchIn.readLineInt();
System.out.println("Twice next = " +
doubleValue(next));
```

- What is the formal parameter in the method definition?
  - » `numberIn`
- What is the argument in the method invocation?
  - » `next`

Pass-By-Value: *Primitive* Data Types as Parameters

- When the method is called, the *value* of each argument is *copied* (assigned) to its corresponding formal parameter
- The number of arguments must be the same as the number of formal parameters
- The data types of the arguments must be the same as the formal parameters and in the same order
- Formal parameters are initialized to the values passed
- Formal parameters are local to their method
- Variables used as arguments cannot be changed by the method
  - » the method only gets a copy of the variable's value

Summary of Class Definition Syntax

```
/*****************************************
 * Class description
 * Preconditions (see the text)
 * Postconditions (see the text)
 *****************************************/
public class Class_Name
{
   //Method definitions of the form
   /*******************************
    * Method description
    *******************************/
   public returnType class Class_Name(type1
  parmameter1, ...)
   {
      <statements defining the method>
   }

   <Instance variable definitions - accessible to all
  methods>
}
```


Information Hiding and Encapsulation

- Cornerstones of Object Oriented Programming (OOP)
- Both are forms of abstraction

Information hiding

- protect data inside an object
- do not allow direct access
- use `private` modifier for instance variable declarations
- use `public` methods to access data
  - » called *accessor methods*

Encapsulation

- Use classes and objects
- Objects include both data items and methods to act on the data

Formalized Abstraction: ADTs

ADT: Abstract data type

- An Object-Oriented approach used by several languages
- A term for *class* implementation
  - » a container for both data items and methods to act on the data
- Implements information hiding and encapsulation
- Provides a public *user interface* so the user knows how to use the class
  - » descriptions, parameters, and names of its methods
- Implementation:
  - » private instance variables
  - » method definitions are usually public but always hidden from the user
  - » the user cannot see or change the implementation
  - » the user only sees the interface

Sound Complicated?

Not really! Just create classes as previously described, except:

- Use the `private` modifier when declaring instance variables
- Do *not* give the user the class definition file
- *Do* give the user the interface - a file with just the class and method descriptions and headings
  - » the headings give the names and parameters of the methods
  - » it tells the user how to use the class and its methods
  - » it is all the user needs to know

Variables: Class Type vs. Primitive Type

What does a variable hold?

» It depends on the type of type, *primitive* type or *class* type

- A primitive type variable holds the value of the variable
- Class types are more complicated
  - » they have methods and instance variables
- A class type variable holds the *memory address* of the object
  - » the variable does not actually hold the value of the object
  - » in fact, as stated above, objects generally do not have a single value and they also have methods, so it does not make sense to talk about its "value"

Assignment with Variables of a Class Type

```
klingon.set(“Klingon ox”, 10, 15);
earth.set(“Black rhino”, 11, 2);
earth = klingon;
earth.set(“Elephant”, 100, 12);
System.out.println(“earth:”);
earth.writeOutput();
System.out.println(“klingon:”);
klingon.writeOutput();
```

What will the output be?

(see the next slide)

Assignment with Variables of a Class Type

```
klingon.set("Klingon ox", 10, 15);
earth.set("Black rhino", 11, 2);
earth = klingon;
earth.set("Elephant", 100, 12);
System.out.println("earth:");
earth.writeOutput();
System.out.println("klingon:");
klingon.writeOutput();
```

What will the output be?

`klingon` and `earth` both print elephant.

Why do they print the same thing?

(see the next slide)

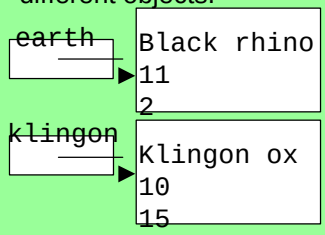
Output:

```
earth:
Name = Elephant
Population = 100
Growth Rate = 12%
klingon:
Name = Elephant
Population = 100
Growth Rate = 12%
```


Assignment with Variables of a Class Type

```
klingon.set("Klingon ox", 10, 15);
earth.set("Black rhino", 11, 2);
earth = klingon;
earth.set("Elephant", 100, 12);
System.out.println("earth:");
earth.writeOutput();
System.out.println("klingon:");
klingon.writeOutput();
```

Before the assignment statement, earth and klingon refer to two different objects.

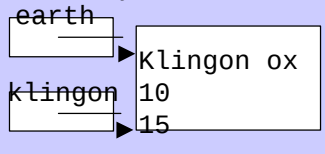


Why do they print the same thing?

The assignment statement makes `earth` and `klingon` refer to the same object.

When `earth` is changed to "`Elephant`", `klingon` is changed also.

After the assignment statement, `earth` and `klingon` refer to the same object.



Gotcha: Comparing Class Variables

- A class variable returns a number, but it is not its value
- It returns the *memory address* where the object with that variable name is stored

If two class variables are compared using ==,
it is the addresses, not the values that are compared!
This is rarely what you want to do!

- Use the class's `.equals()` method to compare the *values* of class variables

Example: Comparing Class Variables

```
//User enters first string
String firstLine = SavitchIn.readLine();

//User enters second string
String secondLine = SavitchIn.readLine();

if(firstLine == secondLine)
//this compares their addresses
{
   <body of if statement>
}

if(firstLine.equals(secondLine)
//this compares their values
{
   <body of if statement>
}
```

Use `.equals` method (not the double-equals sign) to compare values

Pass the Address: *Class* Types as Method Parameters

- In the same way, class variable names used as parameters in a method call copy the argument's ***address*** (not the value) to the formal parameter
- So the formal parameter name also contains the address of the argument
- It is as if the formal parameter name is an alias for the argument name

> Any action taken on the formal parameter is actually taken on the original argument!

- Unlike the situation with primitive types, the original argument is not protected for class types!

Example: Class Type as a Method Parameter

```
//Method definition with a DemoSpecies class
parameter
public void makeEqual(DemoSpecies otherObject)
{
   otherObject.name = this.name;
   otherObject.population = this.population;
   otherObject.growthRate = this.growthRate;
}

//Method invocation
DemoSpecies s1 = new DemoSpecies("Crepek", 10, 20);
DemoSpecies s2 = new DemoSpecies();
s1.makeEqual(s2);
```

- The method call makes `otherObject` an alias for `s2`, therefore *the method acts on `s2`, the `DemoSpecies` object passed to the method!*
- This is *unlike* primitive types, where the passed variable cannot be changed.

Summary
Part 1

- Classes have instance variables to store data and methods to perform actions
- Declare instance variables to be private so they can be accessed only within the same class
- There are two kinds of methods: those that return a value and *`void`*-methods
- Methods can have parameters of both primitive type and class type

Summary
Part 2

- Parameters of a primitive type work differently than those of a class type
  - » primitive type parameters are call-by-value, so the calling object's variable is protected within the called method (the called method cannot change it)
  - » class type parameters pass the address of the calling object so it is *un*protected (the called method *can* change it)
- For similar reasons, the operators = and == do not behave the same for class types as they do for primitive types (they operate on the address of object and not its values)
- Therefor you should usually define an `equals` method for classes you define (to allow the values of objects to be compared)