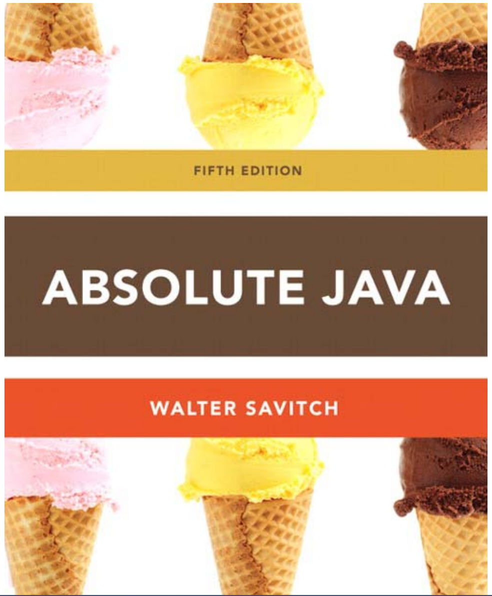

Chapter 5

Defining Classes II

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PEARSON ALWAYS LEARNING

Static Methods

- A *static method* is one that can be used without a calling object
- A static method still belongs to a class, and its definition is given inside the class definition
- When a static method is defined, the keyword **`static`** is placed in the method header

```
public static returnedType myMethod(parameters)
{ . . . }
```

- Static methods are invoked using the class name in place of a calling object

```
returnedValue = MyClass.myMethod(arguments);
```

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Pitfall: Invoking a Nonstatic Method Within a Static Method

- A static method cannot refer to an instance variable of the class, and it cannot invoke a nonstatic method of the class
  - A static method has no **`this`**, so it cannot use an instance variable or method that has an implicit or explicit **`this`** for a calling object
  - A static method can invoke another static method, however

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Tip: You Can Put a **`main`** in any Class

- Although the main method is often by itself in a class separate from the other classes of a program, it can also be contained within a regular class definition
  - In this way the class in which it is contained can be used to create objects in other classes, or it can be run as a program
  - A main method so included in a regular class definition is especially useful when it contains diagnostic code for the class

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Another Class with a **main** Added (Part 1 of 4)

Display 5.3 **Another Class with a main Added**

```
import java.util.Scanner;

/**
Class for a temperature (expressed in degrees Celsius).
*/
public class Temperature
{
    private double degrees; //Celsius

    public Temperature()
    {
        degrees = 0;
    }

    public Temperature(double initialDegrees)
    {
        degrees = initialDegrees;
    }

    public void setDegrees(double newDegrees)
    {
        degrees = newDegrees;
    }
```

Note that this class has a `main` *method and both static and nonstatic methods.*

(continued)

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Another Class with a **main** Added (Part 2 of 4)

Display 5.3 **Another Class with a main Added**

```
    public double getDegrees()
    {
        return degrees;
    }

    public String toString()
    {
        return (degrees + " C");
    }

    public boolean equals(Temperature otherTemperature)
    {
        return (degrees == otherTemperature.degrees);
    }
```

(continued)

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Another Class with a **main** Added (Part 3 of 4)

Display 5.3 **Another Class with a main Added**

```
    /**
     Returns number of Celsius degrees equal to
     degreesF Fahrenheit degrees.
    */
    public static double toCelsius(double degreesF)
    {

        return 5*(degreesF - 32)/9;
    }

    public static void main(String[] args)
    {
        double degreesF, degreesC;

        Scanner keyboard = new Scanner(System.in);
        System.out.println("Enter degrees Fahrenheit:");
        degreesF = keyboard.nextDouble();

        degreesC = toCelsius(degreesF);

```

Because this is in the definition of the class `Temperature`, *this is equivalent to* `Temperature.toCelsius(degreesF)`.

(continued)

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Another Class with a **main** Added (Part 4 of 4)

Display 5.3 **Another Class with a main Added**

```
        Temperature temperatureObject = new Temperature(degreesC);
        System.out.println("Equivalent Celsius temperature is "
                          + temperatureObject.toString());
    }
}
```

Because `main` *is a static method,* `toString` *must have a specified calling object like* `temperatureObject`.

Sample Dialogue

```
Enter degrees Fahrenheit:
212
Equivalent Celsius temperature is 100.0 C
```

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Static Variables

- A *static variable* is a variable that belongs to the class as a whole, and not just to one object
  - There is only one copy of a static variable per class, unlike instance variables where each object has its own copy
- All objects of the class can read and change a static variable
- Although a static method cannot access an instance variable, a static method can access a static variable
- A static variable is declared like an instance variable, with the addition of the modifier `static`

```
private static int myStaticVariable;
```

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Static Variables

- Static variables can be declared and initialized at the same time

```
private static int myStaticVariable = 0;
```

- If not explicitly initialized, a static variable will be automatically initialized to a default value
  - `boolean` static variables are initialized to `false`
  - Other primitive types static variables are initialized to the zero of their type
  - Class type static variables are initialized to `null`
- It is always preferable to explicitly initialize static variables rather than rely on the default initialization

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Static Variables

- A static variable should always be defined private, unless it is also a defined constant
  - The value of a static defined constant cannot be altered, therefore it is safe to make it `public`
  - In addition to `static`, the declaration for a static defined constant must include the modifier `final`, which indicates that its value cannot be changed

```
public static final int BIRTH_YEAR = 1954;
```

- When referring to such a defined constant outside its class, use the name of its class in place of a calling object

```
int year = MyClass.BIRTH_YEAR;
```

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The **`Math`** Class

- The `Math` class provides a number of standard mathematical methods
  - It is found in the `java.lang` package, so it does not require an `import` statement
  - All of its methods and data are static, therefore they are invoked with the class name `Math` instead of a calling object
  - The `Math` class has two predefined constants, `E` (e, the base of the natural logarithm system) and `PI` (π, 3.1415 . . .)

```
area = Math.PI * radius * radius;
```

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Some Methods in the Class **Math** (Part 1 of 5)

Display 5.6 **Some Methods in the Class Math**

The Math class is in the `java.lang` package, so it requires no `import` statement.

```
public static double pow(double base, double exponent)
```

Returns base to the power exponent.

EXAMPLE

`Math.pow(2.0,3.0)` returns 8.0.

(continued)

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Some Methods in the Class **Math** (Part 2 of 5)

Display 5.6 **Some Methods in the Class Math**

```
public static double abs(double argument)
public static float abs(float argument)
public static long abs(long argument)
public static int abs(int argument)
```

Returns the absolute value of the argument. (The method name abs is overloaded to produce four similar methods.)

EXAMPLE

`Math.abs(−6)` and `Math.abs(6)` both return 6. `Math.abs(−5.5)` and `Math.abs(5.5)` both return 5.5.

```
public static double min(double n1, double n2)
public static float min(float n1, float n2)
public static long min(long n1, long n2)
public static int min(int n1, int n2)
```

Returns the minimum of the arguments n1 and n2. (The method name min is overloaded to produce four similar methods.)

EXAMPLE

`Math.min(3, 2)` returns 2.

(continued)

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Some Methods in the Class **Math** (Part 3 of 5)

Display 5.6 **Some Methods in the Class Math**

```
public static double max(double n1, double n2)
public static float max(float n1, float n2)
public static long max(long n1, long n2)
public static int max(int n1, int n2)
```

Returns the maximum of the arguments n1 and n2. (The method name max is overloaded to produce four similar methods.)

EXAMPLE

`Math.max(3, 2)` returns 3.

```
public static long round(double argument)
public static int round(float argument)
```

Rounds its argument.

EXAMPLE

`Math.round(3.2)` returns 3; `Math.round(3.6)` returns 4.

(continued)

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Some Methods in the Class **Math** (Part 4 of 5)

Display 5.6 **Some Methods in the Class Math**

```
public static double ceil(double argument)
```

Returns the smallest whole number greater than or equal to the argument.

EXAMPLE

`Math.ceil(3.2)` and `Math.ceil(3.9)` both return 4.0.

(continued)

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Some Methods in the Class **Math** (Part 5 of 5)

Display 5.6 **Some Methods in the Class Math**

`public static double floor(double argument)`

Returns the largest whole number less than or equal to the argument.

EXAMPLE

`Math.floor(3.2)` and `Math.floor(3.9)` both return `3.0`.

`public static double sqrt(double argument)`

Returns the square root of its argument.

EXAMPLE

`Math.sqrt(4)` returns `2.0`.

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Random Numbers

- The **Math** class also provides a facility to generate pseudo-random numbers

  `public static double random()`

  - A pseudo-random number appears random but is really generated by a deterministic function
    - There is also a more flexible class named **Random**
- Sample use: `double num = Math.random();`
- Returns a pseudo-random number greater than or equal to 0.0 and less than 1.0

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Wrapper Classes

- *Wrapper classes* provide a class type corresponding to each of the primitive types
  - This makes it possible to have class types that behave somewhat like primitive types
  - The wrapper classes for the primitive types `byte`, `short`, `long`, `float`, `double`, and `char` are (in order) `Byte`, `Short`, `Long`, `Float`, `Double`, and `Character`
- Wrapper classes also contain a number of useful predefined constants and static methods

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Wrapper Classes

- *Boxing*: the process of going from a value of a primitive type to an object of its wrapper class
  - To convert a primitive value to an "equivalent" class type value, create an object of the corresponding wrapper class using the primitive value as an argument
  - The new object will contain an instance variable that stores a copy of the primitive value
  - Unlike most other classes, a wrapper class does not have a no-argument constructor

```
Integer integerObject = new Integer(42);
```

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Wrapper Classes

- *Unboxing*: the process of going from an object of a wrapper class to the corresponding value of a primitive type
  – The methods for converting an object from the wrapper classes **Byte**, **Short**, **Integer**, **Long**, **Float**, **Double**, and **Character** to their corresponding primitive type are (in order) **byteValue**, **shortValue**, **intValue**, **longValue**, **floatValue**, **doubleValue**, and **charValue**
  – None of these methods take an argument

```
int i = integerObject.intValue();
```

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Automatic Boxing and Unboxing

- Starting with version 5.0, Java can automatically do boxing and unboxing
- Instead of creating a wrapper class object using the **new** operation (as shown before), it can be done as an automatic type cast:

```
Integer integerObject = 42;
```

- Instead of having to invoke the appropriate method (such as **intValue**, **doubleValue**, **charValue**, etc.) in order to convert from an object of a wrapper class to a value of its associated primitive type, the primitive value can be recovered automatically

```
int i = integerObject;
```

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Constants and Static Methods in Wrapper Classes

- Wrapper classes include useful constants that provide the largest and smallest values for any of the primitive number types
  – For example, **Integer.MAX_VALUE**, **Integer.MIN_VALUE**, **Double.MAX_VALUE**, **Double.MIN_VALUE**, etc.
- The **Boolean** class has names for two constants of type **Boolean**
  – **Boolean.TRUE** and **Boolean.FALSE** are the Boolean objects that correspond to the values **true** and **false** of the primitive type **boolean**

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Constants and Static Methods in Wrapper Classes

- Wrapper classes have static methods that convert a correctly formed string representation of a number to the number of a given type
  – The methods **Integer.parseInt**, **Long.parseLong**, **Float.parseFloat**, and **Double.parseDouble** do this for the primitive types (in order) **int**, **long**, **float**, and **double**
- Wrapper classes also have static methods that convert from a numeric value to a string representation of the value
  – For example, the expression

```
Double.toString(123.99);
```

  returns the string value **"123.99"**
- The **Character** class contains a number of static methods that are useful for string processing

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Some Methods in the Class **`Character`** (Part 1 of 3)

Display 5.8 **Some Methods in the Class Character**

The class `Character` is in the `java.lang` package, so it requires no `import` statement.

`public static char toUpperCase(char argument)`

Returns the uppercase version of its `argument`. If the `argument` is not a letter, it is returned unchanged.

EXAMPLE

`Character.toUpperCase('a')` and `Character.toUpperCase('A')` both return `'A'`.

`public static char toLowerCase(char argument)`

Returns the lowercase version of its `argument`. If the `argument` is not a letter, it is returned unchanged.

EXAMPLE

`Character.toLowerCase('a')` and `Character.toLowerCase('A')` both return `'a'`.

`public static boolean isUpperCase(char argument)`

Returns `true` if its `argument` is an uppercase letter; otherwise returns `false`.

EXAMPLE

`Character.isUpperCase('A')` returns `true`. `Character.isUpperCase('a')` and `Charac-ter.isUpperCase('%')` both return `false`.

(continued)

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Some Methods in the Class **`Character`** (Part 2 of 3)

Display 5.8 **Some Methods in the Class Character**

`public static boolean isLowerCase(char argument)`

Returns `true` if its `argument` is a lowercase letter; otherwise returns `false`.

EXAMPLE

`Character.isLowerCase('a')` returns `true`. `Character.isLowerCase('A')` and `Charac-ter.isLowerCase('%')` both return `false`.

`public static boolean isWhitespace(char argument)`

Returns `true` if its `argument` is a whitespace character; otherwise returns `false`. Whitespace characters are those that print as white space, such as the space character (blank character), the tab character (`'\t'`), and the line break character (`'\n'`).

EXAMPLE

`Character.isWhitespace(' ')` returns `true`. `Character.isWhitespace('A')` returns `false`.

(continued)

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Some Methods in the Class **`Character`** (Part 3 of 3)

Display 5.8 **Some Methods in the Class Character**

`public static boolean isLetter(char argument)`

Returns `true` if its `argument` is a letter; otherwise returns `false`.

EXAMPLE

`Character.isLetter('A')` returns `true`. `Character.isLetter('%')` and `Character.isLet-ter('5')` both return `false`.

`public static boolean isDigit(char argument)`

Returns `true` if its `argument` is a digit; otherwise returns `false`.

EXAMPLE

`Character.isDigit('5')` returns `true`. `Character.isDigit('A')` and `Charac-ter.isDigit('%')` both return `false`.

`public static boolean isLetterOrDigit(char argument)`

Returns `true` if its `argument` is a letter or a digit; otherwise returns `false`.

EXAMPLE

`Character.isLetterOrDigit('A')` and `Character.isLetterOrDigit('5')` both return `true`. `Character.isLetterOrDigit('&')` returns `false`.

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Variables and Memory

- A computer has two forms of memory
- *Secondary memory* is used to hold files for "permanent" storage
- *Main memory* is used by a computer when it is running a program
  - Values stored in a program's variables are kept in main memory

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Variables and Memory

- Main memory consists of a long list of numbered locations called *bytes*
  - Each byte contains eight *bits*: eight 0 or 1 digits
- The number that identifies a byte is called its *address*
  - A data item can be stored in one (or more) of these bytes
  - The address of the byte is used to find the data item when needed

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Variables and Memory

- Values of most data types require more than one byte of storage
  - Several adjacent bytes are then used to hold the data item
  - The entire chunk of memory that holds the data is called its *memory location*
  - The address of the first byte of this memory location is used as the address for the data item
- A computer's main memory can be thought of as a long list of memory locations of *varying sizes*

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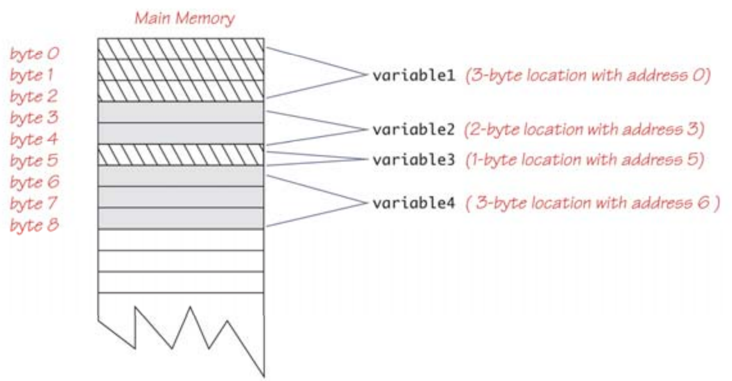
Variables in Memory

Display 5.10 **Variables in Memory**



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References

- Every variable is implemented as a location in computer memory
- When the variable is a primitive type, the value of the variable is stored in the memory location assigned to the variable
  - Each primitive type always require the same amount of memory to store its values

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References

- When the variable is a class type, only the memory address (or *reference*) where its object is located is stored in the memory location assigned to the variable
  - The object named by the variable is stored in some other location in memory
  - Like primitives, the value of a class variable is a fixed size
  - Unlike primitives, the value of a class variable is a memory address or reference
  - The object, whose address is stored in the variable, can be of any size

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References

- Two reference variables can contain the same reference, and therefore name the same object
  - The assignment operator sets the reference (memory address) of one class type variable equal to that of another
  - Any change to the object named by one of theses variables will produce a change to the object named by the other variable, since they are the same object

```
variable2 = variable1;
```

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Class Type Variables Store a Reference (Part 1 of 2)

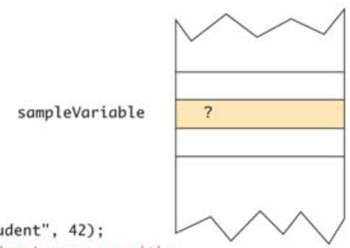
Display 5.12 **Class Type Variables Store a Reference**

```
public class ToyClass
{
    private String name;
    private int number;
```

The complete definition of the class `ToyClass` *is given in Display 5.11.*

```
ToyClass sampleVariable;
```

Creates the variable `sampleVariable` *in memory but assigns it no value.*




```
sampleVariable =
new ToyClass("Josephine Student", 42);
```

Creates an object, places the object someplace in memory, and then places the address of the object in the variable `sampleVariable`*. We do not know what the address of the object is, but let's assume it is* `2056`*. The exact number does not matter.*

(continued)

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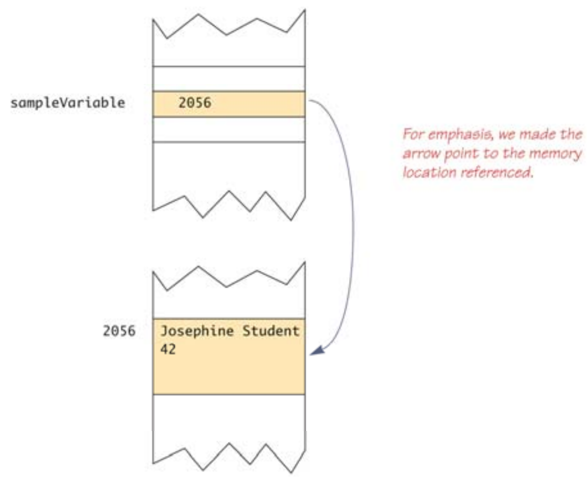
Class Type Variables Store a Reference (Part 2 of 2)

Display 5.12 **Class Type Variables Store a Reference**



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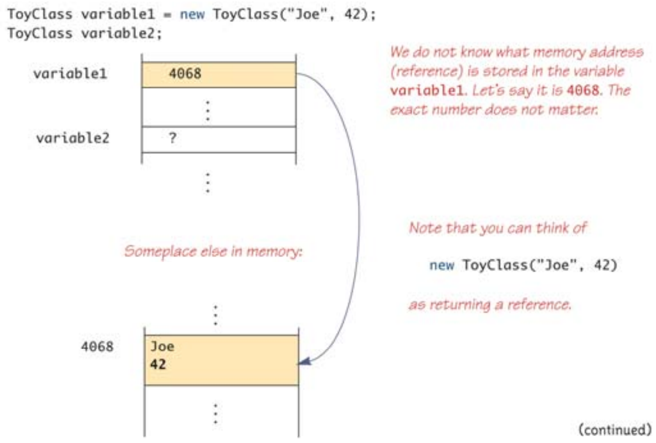
Assignment Operator with Class Type Variables (Part 1 of 3)

Display 5.13 **Assignment Operator with Class Type Variables**



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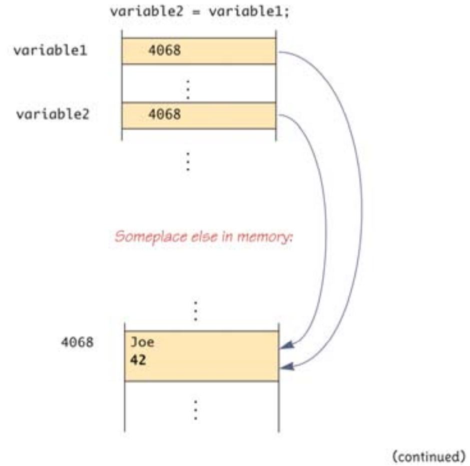
Assignment Operator with Class Type Variables (Part 2 of 3)

Display 5.13 **Assignment Operator with Class Type Variables**



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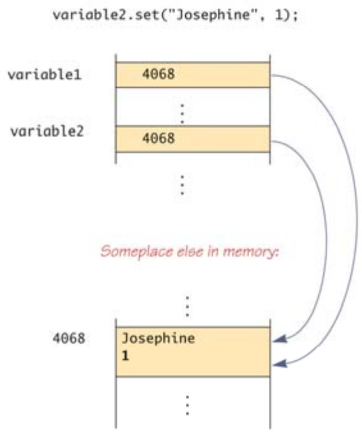
Assignment Operator with Class Type Variables (Part 3 of 3)

Display 5.13 **Assignment Operator with Class Type Variables**



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Class Parameters

- All parameters in Java are *call-by-value* parameters
  - A parameter is a *local variable* that is set equal to the value of its argument
  - Therefore, any change to the value of the parameter cannot change the value of its argument
- Class type parameters appear to behave differently from primitive type parameters
  - They appear to behave in a way similar to parameters in languages that have the *call-by-reference* parameter passing mechanism

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Class Parameters

- The value plugged into a class type parameter is a reference (memory address)
  - Therefore, the parameter becomes another name for the argument
  - Any change made to the object named by the parameter (i.e., changes made to the values of its instance variables) will be made to the object named by the argument, because they are the same object
  - Note that, because it still is a call-by-value parameter, any change made to the class type parameter itself (i.e., its address) will not change its argument (the reference or memory address)

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Parameters of a Class Type

Display 5.14 **Parameters of a Class Type**

ToyClass is defined in Display 5.11.

```
public class ClassParameterDemo
{
    public static void main(String[] args)
    {
        ToyClass anObject = new ToyClass("Mr. Cellophane", 0);
        System.out.println(anObject);
        System.out.println(
                "Now we call changer with anObject as argument.");
        ToyClass.changer(anObject);
        System.out.println(anObject);
    }
}
```

Notice that the method changer changed the instance variables in the object anObject.

Sample Dialogue

```
Mr. Cellophane 0
Now we call changer with anObject as argument.
Hot Shot 42
```

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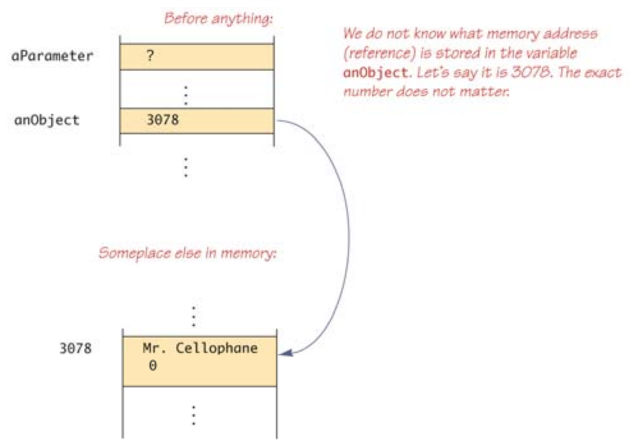
Memory Picture for Display 5.14 (Part 1 of 3)

Display 5.15 **Memory Picture for Display 5.14**



(continued)

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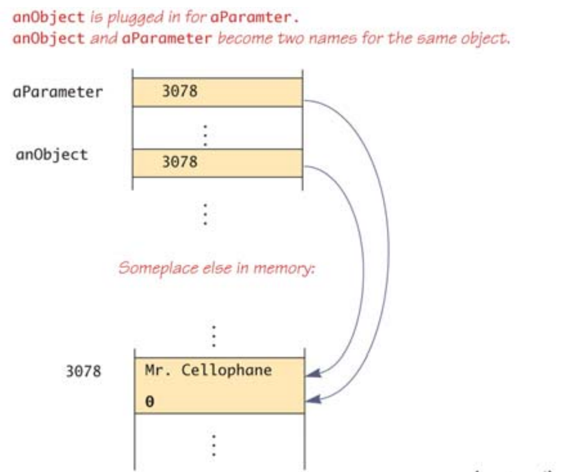
Memory Picture for Display 5.14 (Part 2 of 3)

Display 5.15 **Memory Picture for Display 5.14**



(continued)

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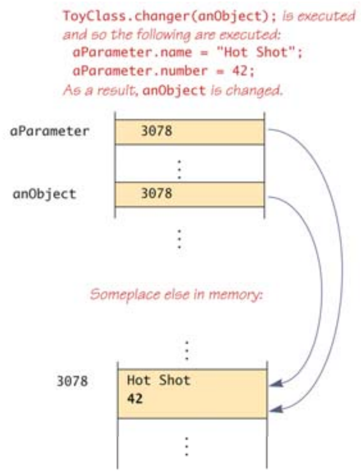
Memory Picture for Display 5.14 (Part 3 of 3)

Display 5.15 **Memory Picture for Display 5.14**



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Differences Between Primitive and Class-Type Parameters

- A method cannot change the value of a variable of a primitive type that is an argument to the method
- In contrast, a method can change the values of the instance variables of a class type that is an argument to the method

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Comparing Parameters of a Class Type and a Primitive Type (Part 1 of 2)

Display 5.16 **Comparing Parameters of a Class Type and a Primitive Type**

```
public class ParametersDemo
{
    public static void main(String[] args)
    {
        ToyClass2 object1 = new ToyClass2(),
                  object2 = new ToyClass2();
        object1.set("Scorpius", 1);
        object2.set("John Crichton", 2);
        System.out.println("Value of object2 before call to method:");
        System.out.println(object2);
        object1.makeEqual(object2);
        System.out.println("Value of object2 after call to method:");
        System.out.println(object2);

        int aNumber = 42;
        System.out.println("Value of aNumber before call to method: "
                     + aNumber);
        object1.tryToMakeEqual(aNumber);
        System.out.println("Value of aNumber after call to method: "
                     + aNumber);
    }
}
```

ToyClass2 is defined in Display 5.17.

(continued)

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Comparing Parameters of a Class Type and a Primitive Type (Part 2 of 2)

Display 5.16 **Comparing Parameters of a Class Type and a Primitive Type**

SAMPLE DIALOGUE

```
Value of object2 before call to method:
John Crichton 2
Value of object2 after call to method:
Scorpius 1
Value of aNumber before call to method: 42
Value of aNumber after call to method: 42
```

An argument of a class type can change.

An argument of a primitive type cannot change.

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A Toy Class to Use in Display 5.16 (Part 1 of 2)

Display 5.17 A Toy Class to Use in Display 5.16

```
public class ToyClass2
{
    private String name;
    private int number;

    public void set(String newName, int newNumber)
    {
        name = newName;
        number = newNumber;
    }

    public String toString()
    {
        return (name + " " + number);
    }
```

(continued)

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A Toy Class to Use in Display 5.16 (Part 2 of 2)

Display 5.17 A Toy Class to Use in Display 5.16

```
    public void makeEqual(ToyClass2 anObject)
    {
        anObject.name = this.name;
        anObject.number = this.number;
    }

    public void tryToMakeEqual(int aNumber)
    {
        aNumber = this.number;
    }

    public boolean equals(ToyClass2 otherObject)
    {
        return ( (name.equals(otherObject.name))
                 && (number == otherObject.number) );
    }

<Other methods can be the same as in Display 5.11, although no
    other methods are needed or used in the current discussion.>
}
```

Read the text for a discussion of the problem with this method.

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Pitfall: Use of = and == with Variables of a Class Type

- Used with variables of a class type, the assignment operator (**=**) produces two variables that name the same object
  - This is very different from how it behaves with primitive type variables
- The test for equality (**==**) also behaves differently for class type variables
  - The **==** operator only checks that two class type variables have the same memory address
  - Unlike the **`equals`** method, it does not check that their instance variables have the same values
  - Two objects in two different locations whose instance variables have exactly the same values would still test as being "not equal"

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The Constant `null`

- **`null`** is a special constant that may be assigned to a variable of any class type

```
YourClass yourObject = null;
```

- It is used to indicate that the variable has no "real value"
  - It is often used in constructors to initialize class type instance variables when there is no obvious object to use
- **`null`** is not an object: It is, rather, a kind of "placeholder" for a reference that does not name any memory location
  - Because it is like a memory address, use **==** or **!=** (instead of **`equals`**) to test if a class variable contains null

```
if (yourObject == null)  . . .
```

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Pitfall: Null Pointer Exception

- Even though a class variable can be initialized to **`null`**, this does not mean that **`null`** is an object
  - **`null`** is only a placeholder for an object
- A method cannot be invoked using a variable that is initialized to **`null`**
  - The calling object that must invoke a method does not exist
- Any attempt to do this will result in a "Null Pointer Exception" error message
  - For example, if the class variable has not been initialized at all (and is not assigned to **`null`**), the results will be the same

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The **new** Operator and Anonymous Objects

- The **`new`** operator invokes a constructor which initializes an object, and returns a reference to the location in memory of the object created
  - This reference can be assigned to a variable of the object's class type
- Sometimes the object created is used as an argument to a method, and never used again
  - In this case, the object need not be assigned to a variable, i.e., given a name
- An object whose reference is not assigned to a variable is called an **`anonymous object`**

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Another Approach to Keyboard Input Using **`Double.parseDouble`** (Part 1 of 3)

Display 5.18 **Use of the method `Double.parseDouble`**

```
import java.util.Scanner;
import java.util.StringTokenizer;

public class InputExample
{
    public static void main(String[] args)
    {
        Scanner keyboard = new Scanner(System.in);

        System.out.println("Enter two numbers on a line.");
        System.out.println("Place a comma between the numbers.");
        System.out.println("Extra blank space is OK.");
        String inputLine = keyboard.nextLine();

        String delimiters = ", "; //Comma and blank space
        StringTokenizer numberFactory =
              new StringTokenizer(inputLine, delimiters);
```

(continued)

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Another Approach to Keyboard Input Using **`Double.parseDouble`** (Part 2 of 3)

Display 5.18 **Use of the method `Double.parseDouble`**

```
        String string1 = null;
        String string2 = null;
        if (numberFactory.countTokens() >= 2)
        {
            string1 = numberFactory.nextToken();
            string2 = numberFactory.nextToken();
        }
        else
        {
            System.out.println("Fatal Error.");
            System.exit(0);
        }

        double number1 = Double.parseDouble(string1);
        double number2 = Double.parseDouble(string2);

        System.out.print("You input ");
        System.out.println(number1 + " and " + number2);
    }
}
```

(continued)

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Another Approach to Keyboard Input Using **Double.parseDouble** (Part 3 of 3)

Display 5.18 **Use of the method `Double.parseDouble`**

SAMPLE DIALOGUE

```
Enter two numbers on a line.
Place a comma between the numbers.
Extra blank space is OK.
    41.98,  42
You input is 41.98 and 42.0
```

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Using and Misusing References

- When writing a program, it is very important to insure that private instance variables remain truly private
- For a primitive type instance variable, just adding the **`private`** modifier to its declaration should insure that there will be no *privacy leaks*
- For a class type instance variable, however, adding the **`private`** modifier alone is not sufficient

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Designing A **Person** Class: Instance Variables

- A simple **`Person`** class could contain instance variables representing a person's name, the date on which they were born, and the date on which they died
- These instance variables would all be class types: name of type **`String`**, and two dates of type **`Date`**
- As a first line of defense for privacy, each of the instance variables would be declared **`private`**

```
public class Person
{
  private String name;
  private Date born;
  private Date died;  //null is still alive
        . . .
```

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Designing a **Person** Class: Constructor

- In order to exist, a person must have (at least) a name and a birth date
  - Therefore, it would make no sense to have a no-argument **`Person`** class constructor
- A person who is still alive does not yet have a date of death
  - Therefore, the **`Person`** class constructor will need to be able to deal with a **`null`** value for date of death
- A person who has died must have had a birth date that preceded his or her date of death
  - Therefore, when both dates are provided, they will need to be checked for consistency

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A **Person** Class Constructor

```
public Person(String initialName, Date birthDate,
                                  Date deathDate)
{
  if (consistent(birthDate, deathDate))
  { name = initialName;
    born = new Date(birthDate);
    if (deathDate == null)
      died = null;
    else
      died = new Date(deathDate);
  }
  else
  { System.out.println("Inconsistent dates.");
    System.exit(0);
  }
}
```

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Designing a **Person** Class: the Class Invariant

- A statement that is always true for every object of the class is called a *class invariant*
  - A class invariant can help to define a class in a consistent and organized way
- For the **Person** class, the following should always be true:
  - An object of the class **Person** has a date of birth (which is not **null**), and if the object has a date of death, then the date of death is equal to or later than the date of birth
- Checking the **Person** class confirms that this is true of every object created by a constructor, and all the other methods (e.g., the private method **consistent**) preserve the truth of this statement

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Designing a **Person** Class: the Class Invariant

```
/**  Class invariant: A Person always has a date of birth,
     and if the Person has a date of death, then the date of
     death is equal to or later than the date of birth.
     To be consistent, birthDate must not be null. If there
     is no date of death (deathDate == null), that is
     consistent with any birthDate. Otherwise, the birthDate
     must come before or be equal to the deathDate.
*/
private static boolean consistent(Date birthDate, Date
                                             deathDate)
{
    if (birthDate == null)  return false;
    else if (deathDate == null)  return true;
    else  return (birthDate.precedes(deathDate ||
                  birthDate.equals(deathDate));
 }
```

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Designing a **Person** Class: the **equals** and **datesMatch** Methods

- The definition of **equals** for the class **Person** includes an invocation of **equals** for the class **String**, and an invocation of the method **equals** for the class **Date**
- Java determines which **equals** method is being invoked from the type of its calling object
- Also note that the **died** instance variables are compared using the **datesMatch** method instead of the equals method, since their values may be **null**

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Designing a **Person** Class: the **equals** Method

```
public boolean equals(Person otherPerson)
{
  if (otherPerson == null)
    return false;
  else
    return (name.equals(otherPerson.name) &&
            born.equals(otherPerson.born) &&
            datesMatch(died, otherPerson.died));
}
```

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Designing a **Person** Class: the **matchDate** Method

```
/**  To match date1 and date2 must either be the
     same date or both be null.
*/
private static boolean datesMatch(Date date1,
                                  Date date2)
{
  if (date1 == null)
    return (date2 == null);
  else if (date2 == null) //&& date1 != null
    return false;
  else // both dates are not null.
    return(date1.equals(date2));
}
```

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Designing a **Person** Class: the **toString** Method

- Like the **equals** method, note that the **Person** class **toString** method includes invocations of the **Date** class **toString** method

```
public String toString( )
{
  String diedString;
  if (died == null)
    diedString = ""; //Empty string
  else
    diedString = died.toString( );

  return (name + ", " + born + "-" + diedString);
}
```

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Copy Constructors

- A *copy constructor* is a constructor with a single argument of the same type as the class
- The copy constructor should create an object that is a separate, independent object, but with the instance variables set so that it is an exact copy of the argument object
- Note how, in the **Date** copy constructor, the values of all of the primitive type private instance variables are merely copied

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Copy Constructor for a Class with Primitive Type Instance Variables

```
public Date(Date aDate)
{
  if (aDate == null) //Not a real date.
  {
    System.out.println("Fatal Error.");
    System.exit(0);
  }

  month = aDate.month;
  day = aDate.day;
  year = aDate.year;
}
```

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Copy Constructor for a Class with Class Type Instance Variables

- Unlike the **Date** class, the **Person** class contains three class type instance variables
- If the **born** and **died** class type instance variables for the new **Person** object were merely copied, then they would simply rename the **born** and **died** variables from the original **Person** object

```
born = original.born //dangerous
died = original.died //dangerous
```

  - This would not create an independent copy of the original object

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Copy Constructor for a Class with Class Type Instance Variables

- The actual copy constructor for the **Person** class is a "safe" version that creates completely new and independent copies of **born** and **died**, and therefore, a completely new and independent copy of the original **Person** object
  - For example:

```
born = new Date(original.born);
```

- Note that in order to define a correct copy constructor for a class that has class type instance variables, copy constructors must already be defined for the instance variables' classes

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Copy Constructor for a Class with Class Type Instance Variables

```
public Person(Person original)
{
  if (original == null)
  {
    System.out.println("Fatal error.");
    System.exit(0);
  }
  name = original.name;
  born = new Date(original.born);
  if (original.died == null)
    died = null;
  else
    died = new Date(original.died);
}
```

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Pitfall: Privacy Leaks

- The previously illustrated examples from the **`Person`** class show how an incorrect definition of a constructor can result in a *privacy leak*
- A similar problem can occur with incorrectly defined mutator or accessor methods
  - For example:

```
public Date getBirthDate()
{
   return born;  //dangerous
}
```

  - Instead of:

```
public Date getBirthDate()
{
   return new Date(born);  //correct
}
```

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Mutable and Immutable Classes

- The accessor method **`getName`** from the **`Person`** class appears to contradict the rules for avoiding privacy leaks:

```
public String getName()
{
  return name; //Isn't this dangerous?
}
```

- Although it appears the same as some of the previous examples, it is not: The class **`String`** contains no mutator methods that can change any of the data in a **`String`** object

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Mutable and Immutable Classes

- A class that contains no methods (other than constructors) that change any of the data in an object of the class is called an *immutable class*
  - Objects of such a class are called *immutable objects*
  - It is perfectly safe to return a reference to an immutable object because the object cannot be changed in any way
  - The **`String`** class is an immutable class

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Mutable and Immutable Classes

- A class that contains public mutator methods or other public methods that can change the data in its objects is called a *mutable class*, and its objects are called *mutable objects*
  - Never write a method that returns a mutable object
  - Instead, use a copy constructor to return a reference to a completely independent copy of the mutable object

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Deep Copy Versus Shallow Copy

- A *deep copy* of an object is a copy that, with one exception, has no references in common with the original
  - Exception: References to immutable objects are allowed to be shared
- Any copy that is not a deep copy is called a *shallow copy*
  - This type of copy can cause dangerous privacy leaks in a program

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Packages and Import `Statements`

- Java uses *packages* to form libraries of classes
- A package is a group of classes that have been placed in a directory or folder, and that can be used in any program that includes an *import statement* that names the package
  - The import statement must be located at the beginning of the program file: Only blank lines, comments, and package statements may precede it
  - The program can be in a different directory from the package

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Import `Statements`

- We have already used import statements to include some predefined packages in Java, such as `Scanner` from the `java.util` package

```
import java.util.Scanner;
```

- It is possible to make all the classes in a package available instead of just one class:

```
import java.util.*;
```

  - Note that there is no additional overhead for importing the entire package

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The `package` Statement

- To make a package, group all the classes together into a single directory (folder), and add the following package statement to the beginning of each class file:

```
package package_name;
```

  - Only the `.class` files must be in the directory or folder, the `.java` files are optional
  - Only blank lines and comments may precede the package statement
  - If there are both import and package statements, the package statement must precede any import statements

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The Package java.lang

- The package **java.lang** contains the classes that are fundamental to Java programming
  - It is imported automatically, so no import statement is needed
  - Classes made available by **java.lang** include **Math**, **String**, and the wrapper classes

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Package Names and Directories

- A package name is the path name for the directory or subdirectories that contain the package classes
- Java needs two things to find the directory for a package: the name of the package and the value of the **CLASSPATH** variable
  - The **CLASSPATH** environment variable is similar to the **PATH** variable, and is set in the same way for a given operating system
  - The **CLASSPATH** variable is set equal to the list of directories (including the current directory, "**.**") in which Java will look for packages on a particular computer
  - Java searches this list of directories in order, and uses the first directory on the list in which the package is found

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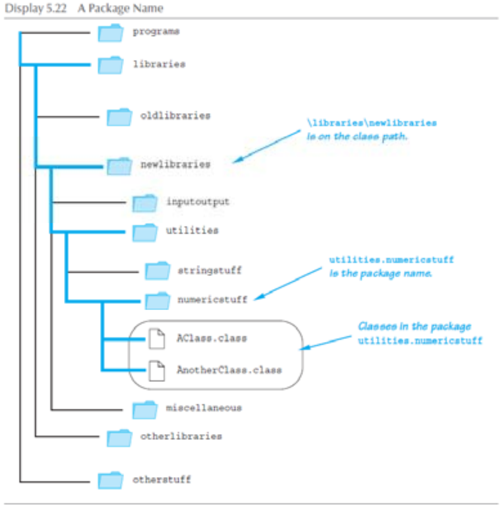
A Package Name

Display 5.22 A Package Name



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Pitfall: Subdirectories Are Not Automatically Imported

- When a package is stored in a subdirectory of the directory containing another package, importing the enclosing package does not import the subdirectory package
- The import statement:

```
import utilities.numericstuff.*;
```

  imports the **utilities.numericstuff** package only
- The import statements:

```
import utilities.numericstuff.*;
import utilities.numericstuff.statistical.*;
```

  import both the **utilities.numericstuff** and **utilities.numericstuff.statistical** packages

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The Default Package

- All the classes in the current directory belong to an unnamed package called the *default package*
- As long as the current directory (`.`) is part of the `CLASSPATH` variable, all the classes in the default package are automatically available to a program

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Pitfall: Not Including the Current Directory in Your Class Path

- If the `CLASSPATH` variable is set, the current directory must be included as one of the alternatives
  - Otherwise, Java may not even be able to find the `.class` files for the program itself
- If the `CLASSPATH` variable is not set, then all the class files for a program must be put in the current directory

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Specifying a Class Path When You Compile

- The class path can be manually specified when a class is compiled
  - Just add `–classpath` followed by the desired class path
  - This will compile the class, overriding any previous `CLASSPATH` setting
- You should use the `–classpath` option again when the class is run

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Name Clashes

- In addition to keeping class libraries organized, packages provide a way to deal with *name clashes*: a situation in which two classes have the same name
  - Different programmers writing different packages may use the same name for one or more of their classes
  - This ambiguity can be resolved by using the *fully qualified name* (i.e., precede the class name by its package name) to distinguish between each class

    `package_name.ClassName`
  - If the fully qualified name is used, it is no longer necessary to import the class (because it includes the package name already)

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Introduction to `javadoc`

- Unlike a language such as C++, Java places both the interface and the implementation of a class in the same file
- However, Java has a program called `javadoc` that automatically extracts the interface from a class definition and produces documentation
  - This information is presented in HTML format, and can be viewed with a Web browser
  - If a class is correctly commented, a programmer need only refer to this *API (Application Programming Interface)* documentation in order to use the class
  - `javadoc` can obtain documentation for anything from a single class to an entire package

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Commenting Classes for `javadoc`

- The `javadoc` program extracts class headings, the headings for some comments, and headings for all public methods, instance variables, and static variables
  - In the normal default mode, no method bodies or private items are extracted
- To extract a comment, the following must be true:
  1. The comment must *immediately precede* a public class or method definition, or some other public item
  2. The comment must be a block comment, and the opening `/*` must contain an extra `*` (`/** . . . */`)
  - Note: Extra options would have to be set in order to extract line comments (`//`) and private items

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Commenting Classes for `javadoc`

- In addition to any general information, the comment preceding a public method definition should include descriptions of parameters, any value returned, and any exceptions that might be thrown
  - This type of information is preceded by the `@` symbol and is called an *@ tag*
  - @ tags come after any general comment, and each one is on a line by itself

```
/**
 General Comments about the method . . .
 @param aParameter Description of aParameter
 @return What is returned
 . . .
*/
```

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@ Tags

- @ tags should be placed in the order found below
- If there are multiple parameters, each should have its own `@param` on a separate line, and each should be listed according to its left-to-right order on the parameter list
- If there are multiple authors, each should have its own `@author` on a separate line

```
@param Parameter_Name Parameter_Description
@return Description_Of_Value_Returned
@throws Exception_Type Explanation
@deprecated
@see Package_Name.Class_Name
@author Author
@version Version_Information
```

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Running `javadoc`

- To run **javadoc** on a package, give the following command:

  javadoc -d Documentation_Directory Package_Name
  - The HTML documents produced will be placed in the **Documentation_Directory**
  - If the **-d** and **Documentation_Directory** are omitted, **javadoc** will create suitable directories for the documentation
- To run **javadoc** on a single class, give the following command from the directory containing the class file: **javadoc ClassName.java**
- To run javadoc on all the classes in a directory, give the following command instead: **javadoc *.java**

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Options for `javadoc`

Display 5.23 **Options for java.doc**

-link *Link_To_Other_Docs*	Provides a link to another set of documentation. Normally, this is used with either a path name to a local version of the Java documentation or the URL of the Sun Web site with standard Java documentation.
-d *Documentation_Directory*	Specifies a directory to hold the documentation generated. *Documentation_Directory* may be a relative or absolute path name.
-author	Includes author information (from @author tags). This information is omitted unless this option is set.
-version	Includes version information (from @version tags). This information is omitted unless this option is set.
-classpath *List_of_Directories*	Overrides the CLASSPATH environment variable and makes *List_of_Directories* the CLASSPATH for the execution of this invocation of javadoc. Does not permanently change the CLASSPATH variable.
-private	Includes private members as well as public members in the documentation.

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