CLASS DESIGN II

CIS*2430 (Fall 2010)

Static Methods

- A *static method* belongs to a class but can be used without a calling object

- 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);
```

Pitfall with Static Methods

- A static method cannot refer to an instance variable of the class. Nor can it invoke a non-static 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.

Tip: Add main in Any Class

- Although the main method is often defined 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 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

Class with main Method (1/4)

Display 5.3 Another Class with a `main` Added

```
1   import java.util.Scanner;

2   /**
3   Class for a temperature (expressed in degrees Celsius).
4   */
5   public class Temperature
6   {
7       private double degrees; //Celsius

8       public Temperature()
9       {
10          degrees = 0;
11      }

12      public Temperature(double initialDegrees)
13      {
14          degrees = initialDegrees;
15      }

16      public void setDegrees(double newDegrees)
17      {
18          degrees = newDegrees;
19      }
```

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

(continued)

Class with main Method (2/4)

Display 5.3 Another Class with a `main` Added

```
20      public double getDegrees()
21      {
22          return degrees;
23      }

24      public String toString()
25      {
26          return (degrees + " C");
27      }
28
29      public boolean equals(Temperature otherTemperature)
30      {
31          return (degrees == otherTemperature.degrees);
32      }
```

(continued)

Class with main Method (3/4)

Display 5.3 Another Class with a `main` Added

```
33      /**
34       Returns number of Celsius degrees equal to
35       degreesF Fahrenheit degrees.
36      */
37      public static double toCelsius(double degreesF)
38      {
39
40           return 5*(degreesF - 32)/9;
41      }

42      public static void main(String[] args)
43      {
44          double degreesF, degreesC;
45
46          Scanner keyboard = new Scanner(System.in);
47          System.out.println("Enter degrees Fahrenheit:");
48          degreesF = keyboard.nextDouble();
49
50          degreesC = toCelsius(degreesF);
51
```

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

(continued)

Class with main Method (4/4)

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

```
52          Temperature temperatureObject = new Temperature(degreesC);
53          System.out.println("Equivalent Celsius temperature is "
54                             + temperatureObject.toString());
55      }
56  }
```

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
```

Arguments for main

- Here is a program that expects three string arguments:

```
public class SomeProgram
{
  public static void main(String[] args)
  {
   if (args.length > 2)
    System.out.println(args[0] + " " +
                       args[2] + args[1]);
  }
}
```

- Arguments for the **`main`** method must be provided from the command line when the program is run

```
java SomeProgram Hi ! there
```

Static Variables

- A *static variable* belongs to the class, not to any specific object
  - Only one copy of a static variable per class, unlike an instance variable 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

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

- It is always preferable to explicitly initialize static variables rather than rely on the default initialization

Static Variables

- A static variable should always be defined private, unless it is a constant
  - The value of a static defined constant cannot be altered, therefore it is safe to make it **`public`**

```
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;
```

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`** (the base of the natural logarithm system) and **`PI`** (3.1415)

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

Wrapper Classes

- *Wrapper classes* provide a class type corresponding to each of the primitive types
  - The wrapper classes for the primitive types **`byte`**, **`short`**, **`long`**, **`float`**, **`double`**, and **`char`** are **`Byte`**, **`Short`**, **`Long`**, **`Float`**, **`Double`**, and **`Character`**, respectively

- Wrapper classes also contain a number of useful predefined constants and static methods

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);
```

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();
```

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;
```

Static Constants and Methods

- Wrapper classes include useful constants that provide the largest and smallest values for any of the primitive number types
  - E.g., `Integer.MAX_VALUE`, `Integer.MIN_VALUE`, `Double.MAX_VALUE`, `Double.MIN_VALUE`, …
- 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 `int`, `long`, `float`, and `double`

References

- Every variable is assigned a location in memory
- For a primitive type, the value of the variable is stored in the memory location assigned to the variable
- For 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 actually stored in somewhere else in memory
  - The object, whose address is stored in the variable, can be of any size

References

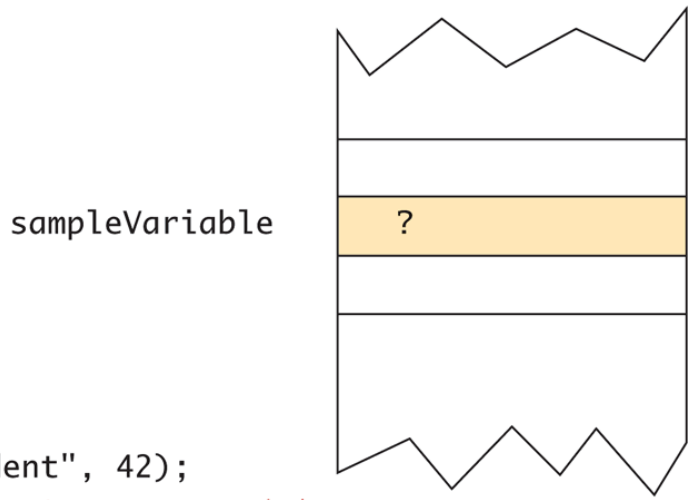
Display 5.12 Class Type Variables Store a Reference

```
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.*



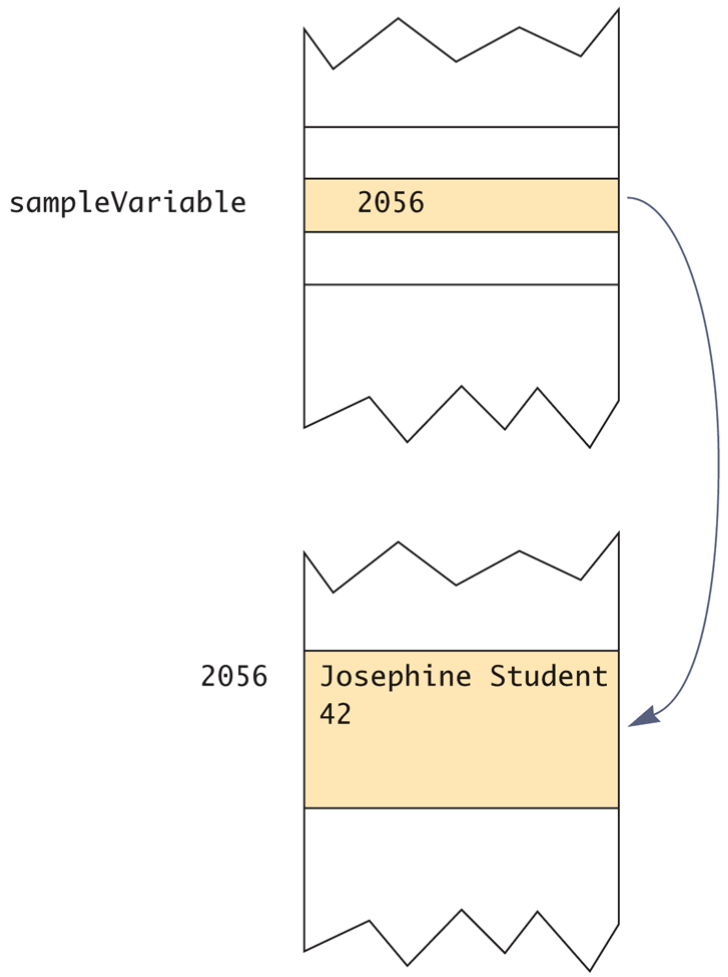

```
sampleVariable =
new ToyClass("Josephine Student", 42);
```

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)

References

Display 5.12 Class Type Variables Store a Reference

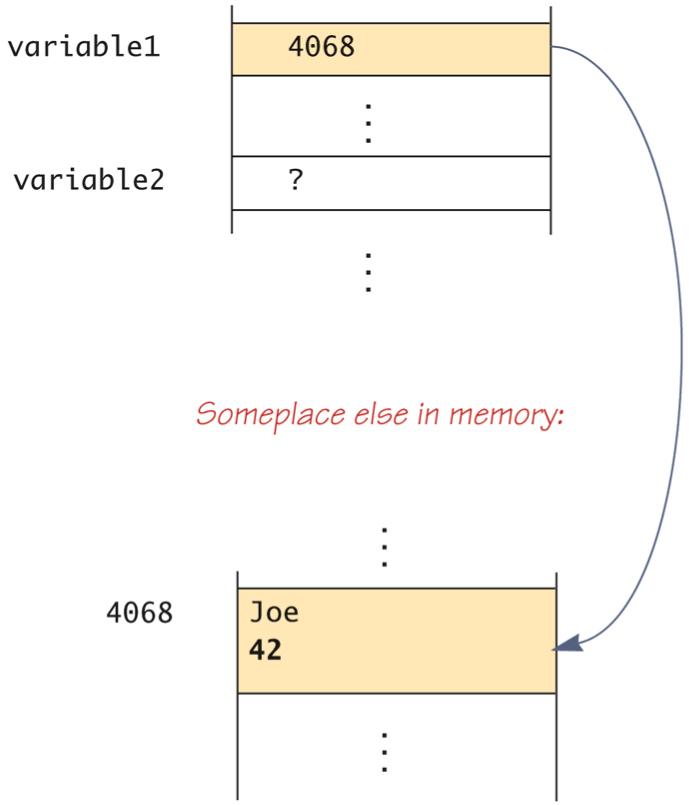


For emphasis, we made the arrow point to the memory location referenced.

Assignments with References

Display 5.13 Assignment Operator with Class Type Variables

```
ToyClass variable1 = new ToyClass("Joe", 42);
ToyClass variable2;
```



We do not know what memory address (reference) is stored in the variable `variable1`. *Let's say it is* `4068`. *The exact number does not matter.*

Note that you can think of

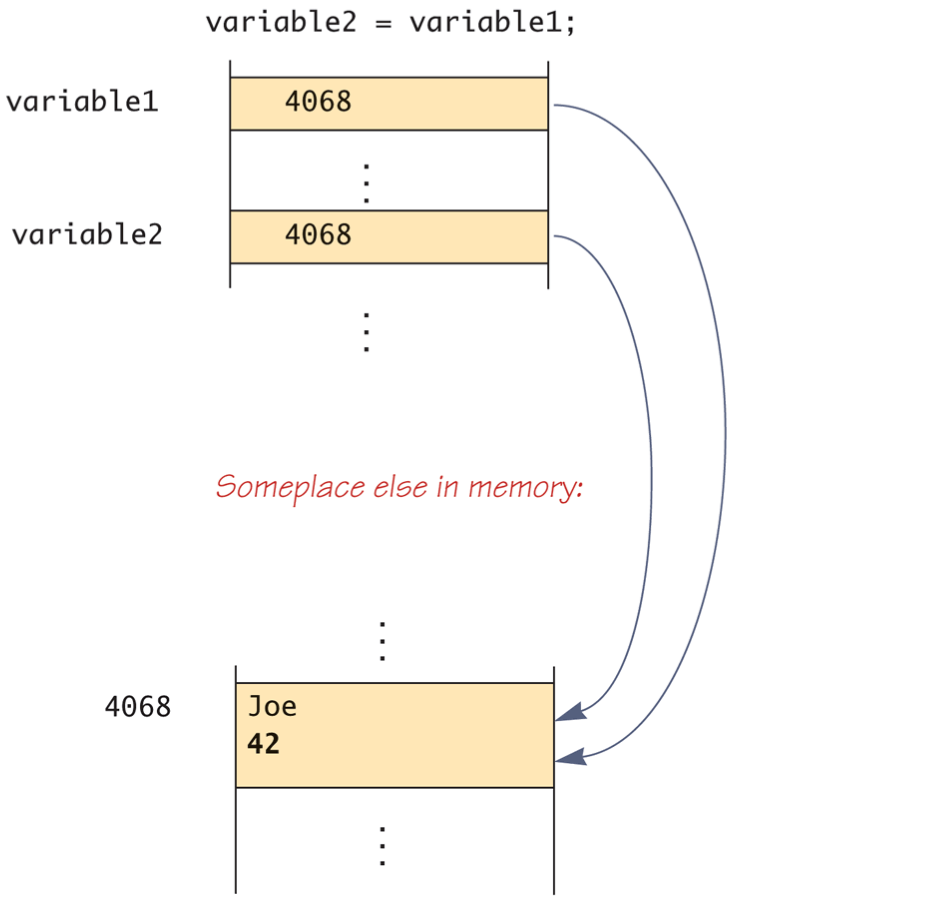
```
new ToyClass("Joe", 42)
```

as returning a reference.

(continued)

Assignments with References

Display 5.13 Assignment Operator with Class Type Variables



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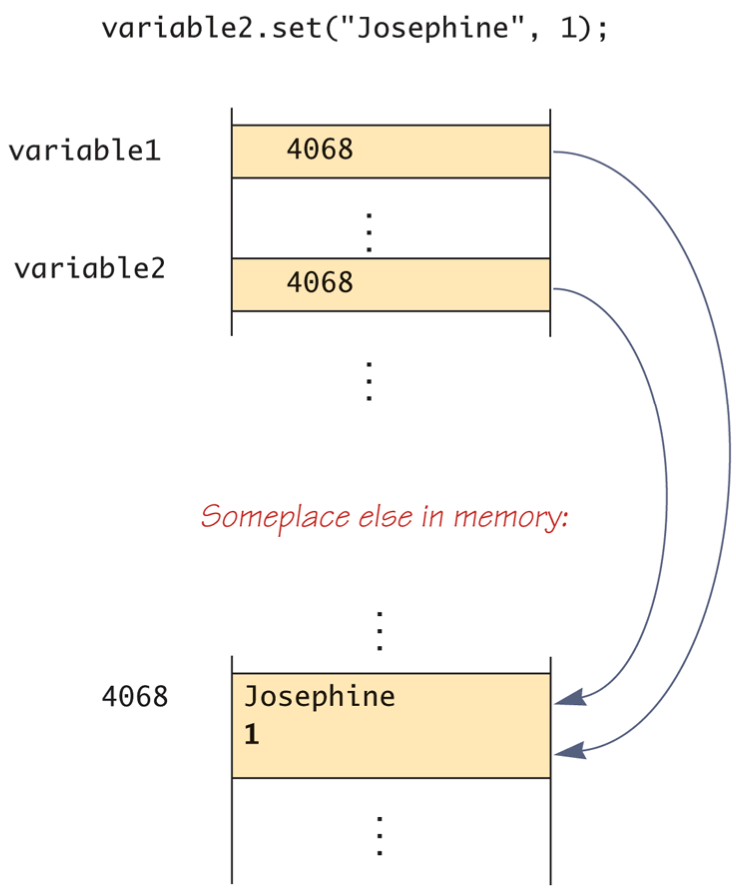
Assignments with References

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



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 similar to parameters in languages that have the *call-by-reference* parameter passing mechanism

Class vs. Primitive Parameters

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

```
1  public class ParametersDemo
2  {
3      public static void main(String[] args)
4      {
5          ToyClass2 object1 = new ToyClass2(),
6                    object2 = new ToyClass2();
7          object1.set("Scorpius", 1);
8          object2.set("John Crichton", 2);
9          System.out.println("Value of object2 before call to method:");
10         System.out.println(object2);
11         object1.makeEqual(object2);
12         System.out.println("Value of object2 after call to method:");
13         System.out.println(object2);
14
15         int aNumber = 42;
16         System.out.println("Value of aNumber before call to method: "
17                     + aNumber);
18         object1.tryToMakeEqual(aNumber);
19         System.out.println("Value of aNumber after call to method: "
20                     + aNumber);
21     }
22 }
```

ToyClass2 *is defined in Display 5.17.*

(continued)

Class vs. Primitive Parameters

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.

Toy Class (1/2)

Display 5.17 **A Toy Class to Use in Display 5.16**

```
1   public class ToyClass2
2   {
3       private String name;
4       private int number;

5       public void set(String newName, int newNumber)
6       {
7           name = newName;
8           number = newNumber;
9       }

10      public String toString()
11      {
12          return (name + " " + number);
13      }
```

(continued)

Toy Class (2/2)

Display 5.17 A Toy Class to Use in Display 5.16

```
14        public void makeEqual(ToyClass2 anObject)
15        {
16            anObject.name = this.name;
17            anObject.number = this.number;
18        }

19        public void tryToMakeEqual(int aNumber)
20        {
21            aNumber = this.number;
22        }

23        public boolean equals(ToyClass2 otherObject)
24        {
25            return ( (name.equals(otherObject.name))
26                       && (number == otherObject.number) );
27        }

    <Other methods can be the same as in Display 5.11, although no
          other methods are needed or used in the current discussion.>
28    }
29
```

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

Pitfall with = and ==

- With variables of a class type, the assignment operator (=) produces two references to the same object
  - Different from how it behaves with primitive type variables
- The equality (==) also behaves differently for class type variables
  - The == operator only checks if two class type variables have the same memory address
  - Two objects in two different locations whose instance variables have exactly the same values would still test as being "not equal"

Null-Pointer Exception

- Although 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`
- Any attempt to do this will result in a "Null Pointer Exception" error message

Person Class (1/4)

- For privacy, each of the instance variables are declared **private**

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

- Class invariant: a statement that is true for all objects of the class:
  - 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
  - Make no sense to have a no-argument constructor

Person Class (2/4)

```
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);
  }
}
```

Person Class (3/4)

```
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));
}

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

Person Class (4/4)

```
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));
}

public String toString( )
{
  String diedString;
  if (died == null)
     diedString = ""; //Empty string
  else
     diedString = died.toString( );
  return (name + ", " + born + "-" + diedString);
}
```

Copy Constructor

- The copy constructor should create a separate, independent object

```
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;
}
```

Unsafe Copy Constructor

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

Safe Copy Constructor

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

Pitfall: Privacy Leaks

- As illustrated with the **`Person`** class, an incorrect definition of a constructor can result in a *privacy leak*

- A similar problem can occur with incorrectly defined mutator or accessor methods:

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

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

Mutable 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

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

Packages

- Java uses *packages* to form libraries of classes

- A package is a group of classes placed in a directory or folder, which can be imported to another program:
  - The import statement must be located at the start of a program: only blank lines, comments, and package statements may precede it

  - The program can be in a different directory from the package

The import Statements

- 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

- 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

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
  - The package statement must precede any import statements

Package Names & Directories

- A package name is the path name for the directory that contains the related classes

- To find the full path for a package, Java needs to know both the name of the package and the value of the **CLASSPATH** variable
  - The **CLASSPATH** variable contains a list of directories (including the current directory, "**.**") in which Java looks for packages on a particular computer
  - Java searches the list of directories in order, and uses the first directory on the list in which the package is found

Pitfall for Subdirectories

- When a package is stored in a subdirectory of another directory, importing the top package does not automatically import the subdirectory package

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

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

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
- Pitfall: the current directory must be included in the **`CLASSPATH`** variable; otherwise, Java may not even find the `.class` files for the program itself

Name Clashes

- In addition to keeping class libraries organized, packages provide a way to deal with *name clashes*:
  - 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