CMSC 131: Chapter 6 (Supplement)
Introduction to Objects

Objects

Object: is the fundamental entity around which Java programs are designed.

State:

Behavior:

Examples:

Bank account:

State: account number, owner's name and address, current account balance.

Behaviors: credit (increase balance), debit (decrease balance), change address, add interest, print monthly statement, …

Voice-mail system:

State: caller's greeting, list of messages, number of the current message.

Behaviors: rewind messages, play current message, erase current message, change caller's greeting, …

Object-oriented programming:

Classes

Class: a **definition** or "**blueprint**" for an object.

Instance Data:

Methods:

Example: Bank account

Instance data:

```
String accountNumber;
String ownersName;
String ownersAddress;
double currentBalance;
```

Methods:

```
debit: decrease the current balance by a given amount
credit: increase the current balance by a given amount
addInterest: compute interest and add it to the balance
...
```

Encapsulation: A class is a way of combining all the data and functions that are involved with a bank account in one place.

Creating Objects

Before discussing how to define objects, we discuss how to **create** and **use** them. In Java a variable can hold either:

Primitive type value:

Reference to an object:

Variable declaration:

Primitive types:

Class object:

Examples:

```
int x = 52;
String s = new String( "Schultzie" );
String t = "von Wienerschnitzel";
```

Under the Hood: What does "new" do?

What happens when "new" is called:

```
String s = new String( "Schultzie" );
```

- Space for a new string object is **allocated** in a special area of memory called the **heap**.
- This storage is **initialized** with the characters comprising the name.
- The **address** in memory where the object has been created is returned by new.
- This address, also known as a **reference**, is stored in the variable s.

The Java Class Library

Java's class library: One of Java's nicest features. The library is organized into packages.

java.lang: General support (String, Integer, Float, Math, …).
java.util: General utilities (random numbers, currency, calendar, useful data structures).
java.text: Contains utilities for formatting text (dates, currency, etc)
java.awt: Abstract Window Toolkit, basic support for graphics and graphical user interfaces (GUI's).
javax.swing: Extension of java.awt with more advanced GUI elements. (e.g., JOptionPane).
java.io: A variety of functions for input/output and formatting.
java.applet: Used for writing Java applets (programs that run in a Web browser).

See also **Appendix M** in L&L and Sun's Java **API Specs** (a link can be found in the Resources class web page).

Accessing the Class Library

Fully qualified name:

To access a class from the library you generally need to specify the package and the class.

Example:

The **JOptionPane** class is part of **javax.swing**.

```
javax.swing.JOptionPane.showMessageDialog( null, "This is really inconvenient!" );
String input = javax.swing.JOptionPane.showInputDialog( "I agree!" );
```

The Import Statement

Import Statement:

Java allows you to "**import**" the entire class description into your program.

```
import java.util.Random;                // import class Random from java.util
…
double r = Random.nextDouble( );        // no need for "java.util" anymore
```

Importing All the Classes:

Rather than import each class individually, you can use '*' to make **all** the classes accessible from a package.

```
import java.util.*;                     // import all classes from java.util
import javax.swing.*;                   // import all classes from javax.swing
```

java.lang: This package is so widely used it is **automatically imported** into all programs.

The cmsc131 Picture Library

In addition to the Java class library, you can define your own libraries. We have defined one such library for image manipulation, called **cmsc131PictureLib**.

Importing the library:

```
import cmsc131PictureLib.*;
```

PictureLib's classes:

Image: This is an object that contains a single image.
To create a new image, give it the web address or path name of an image file (e.g. a jpeg file).

```
Image myImage = new Image( "C:\\My Pictures\\mom.jpg" );
```

This creates a new Image object, but does not display it.

The cmsc131 Picture Library

PictureLib's classes: (cont)

PictureUtil: This class contains some utility functions for displaying images. The following command displays an image on your screen.

```
PictureUtil.show( myImage );          // display an image
```

The following command clears all the images from your screen.

```
PictureUtil.clearScreen( );           // clear the screen of images
```

(The images will also go away when you execute **System.exit(0)**.)

The cmsc131 Picture Library

PictureLib's classes: (cont) There are a number of image manipulation classes. Each class takes one or more images and produces a new image.

BlackAndWhite: Produces an image that is the black and white image equivalent of the original.

```
BlackAndWhite d = new BlackAndWhite( myImage );
```

SelectComponents: Produces an image by filtering the red, green, and blue components of the original.

```
SelectComponents p = new SelectComponents( myImage, true, false, true );
```

CombineTopBottom: Combines two images, one atop the other.

```
CombineTopBottom ctb = new CombineTopBottom( topImage, bottomImage );
```

CombineLeftRight: Combines images, one to the left of the other.

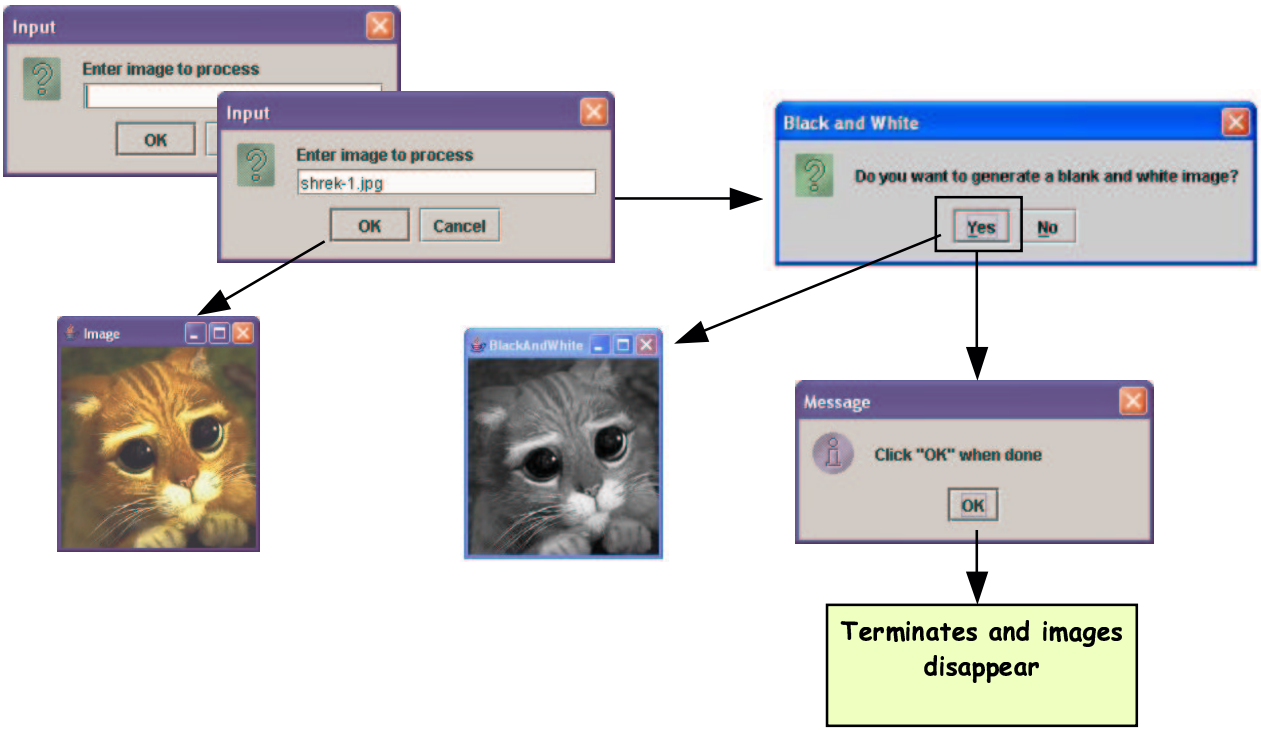
```
CombineLeftRight clr = new CombineLeftRight( leftImage, rightImage );
```

After creating any of these images, you can call **PictureUtil.show** to display them.

cmsc131PictureLib Example

```
/* A simple demonstration of the cmsc 131 picture library */
import javax.swing.*;
import cmsc131PictureLib.*;

public class PictureDemo {

    public static void main( String[ ] args ) {
          String imageName = JOptionPane.showInputDialog( "Enter image to process" );

          Image myImage = new Image( imageName );        // create new Image object
          PictureUtil.show( myImage );                   // display the image

          int answer = JOptionPane.showConfirmDialog( null,
                              "Do you want to generate a black and white image?" );
          if (answer == JOptionPane.YES_OPTION) {
             BlackAndWhite blackAndWhiteImage = new BlackAndWhite( myImage );
             PictureUtil.show( blackAndWhiteImage );                  // display the new image
          }
          JOptionPane.showMessageDialog( null, "Click \"OK\" when done" );
          System.exit(0);                                // terminate
    }
}
```

cmsc131PictureLib Example



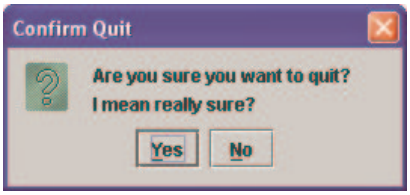
JOptionPane - Revisited

JOptionPane: provides a few other features that we have not discussed yet.

```
JOptionPane.showConfirmDialog( null,        // (always null for us)
        "Your prompt here",                 // prompt for the user
        "Window title here",                // title for the window
        optionType);                        // what options to give the user
```

Example:

```
JOptionPane.showConfirmDialog( null,
        "Are you sure you want to quit?\nI mean really sure?",
        "Confirm Quit",
        JOptionPane.YES_NO_OPTION);
```



The String Class – Revisited

Let:

```
String s = new String( "Schultzie" );
String t = new String( "sCHultZIE" );
```

Length:

```
int i = s.length( );                    // returns 9
```

Comparisons:

```
boolean a = s.equals( t );              // false: case sensitive
boolean b = s.equalsIgnoreCase( t );    // true: ignores case
int j = s.compareTo( t );               // ??: (avoid) depends on case ordering
int k = s.compareToIgnoreCase( t );     // 0: (okay)
```

Access character at a given index: (index runs from 0 to length-1)

```
char c = s.charAt( 0 );                 // returns 'S'
char d = s.charAt( 2 );                 // returns 'h'
```

Change Case:

```
String x = t.toLowerCase( );            // returns "schultzie"
String y = t.toUpperCase( );            // returns "SCHULTZIE"
```

(See Page 89 in L&L for more examples.)

The Math Class

Math: is a class that offers many common math functions.

Absolute value: (Can be used with int, long, float, and double)

```
double x = Math.abs( -14.3 );        // returns +14.3
```

Square Root:

```
double y = Math.sqrt( 2.0 );         // returns √2 = 1.4142…
```

Trig functions: (provides all the trigonometric functions)

```
double pi = Math.PI;                 // returns π = 3.14159…
double c = Math.cos( pi );           // returns cosine(π) = -1.0
double s = Math.sin( pi );           // returns sine(π) = 0.0
…
```

Powers:

```
double z = Math.pow( 2.0, 3.0 );     // returns 2^3 =8.0
```

Random Numbers:

```
double r = Math.random( );           // random double from 0.0 to 1.0
```

The NumberFormat Class

NumberFormat: This class provides capabilities for formatting text in useful ways, e.g. currency and percentages.

Import:

```
import java.text.*;
```

Currency Conversion: First generate a currency object:

```
NumberFormat money = NumberFormat.getCurrencyInstance( );
```

Then to generate a string:

```
double amount = 123.6;
System.out.println( money.format(amount) );        // output: "$123.60"
```

Percentage Conversion: First generate a percent object:

```
NumberFormat percent = NumberFormat.getPercentInstance( );
```

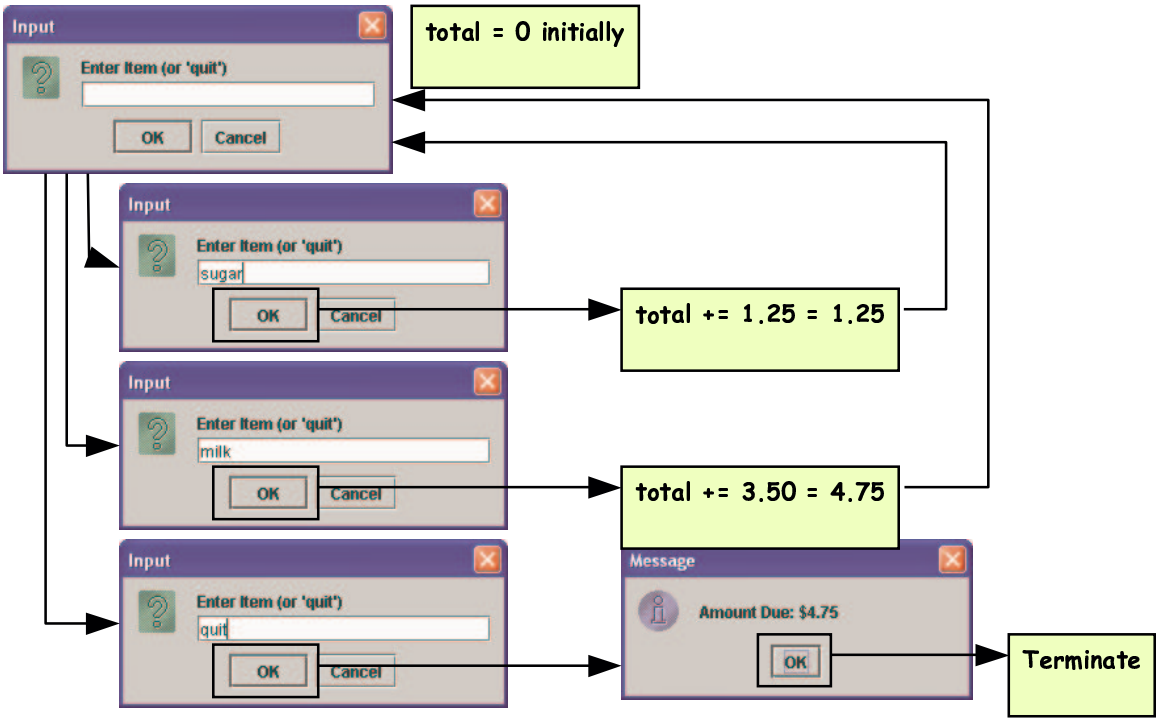
Then to generate a string:

```
double taxRate = 0.0793;
System.out.println( percent.format(taxRate) );     // output: "8%"
```

Example of Currency Conversion

```
/* This is a simple cashier checkout program */
import java.text.*;
import javax.swing.*;

public class Cashier {
    public static void main( String[ ] args ) {
        double priceOfMilk   = 3.50;                // item prices
        double priceOfSugar = 1.25;
        double total = 0.0;                         // initialize total price
        String item;
        do {                                        // read items until 'quit'
            item = JOptionPane.showInputDialog( "Enter Item (or 'quit') " );
            if ( item.equals( "milk" ) )
                total += priceOfMilk;
            else if ( item.equals( "sugar" ) )
                total += priceOfSugar;
        } while ( ! item.equals( "quit" ) );
                                                    // convert to currency
        NumberFormat money = NumberFormat.getCurrencyInstance( );
        JOptionPane.showMessageDialog( null, "Amount Due: " + money.format( total ) );
        System.exit( 0 );
    }
}
```

Example of Currency Conversion



Under the Hood: Objects vs. Primitive Types

Technical Question: Why does Java treat primitive types and objects differently?

All primitive types use a **predictable** amount of storage (e.g. all int variables use 4 bytes).

But…objects of the same type may involve vastly **different** amounts of storage. Suppose we change a string's value:

```
String s = "Schultzie";
s = "this might be a ridiculously long string…";
```

If s contained the actual characters, we would need to allocate additional memory for the new string. This would disrupt all the variables around s. By storing a reference in s, we can simply change the reference.

Under the Hood: Assignment and Aliasing

Just for Strings:

```
String t = "von Wienerschnitzel";
```

is convenient shorthand for what Java really does:

```
String t = new String( "von Wienerschnitzel" );
```

Aliasing: When one object reference is assigned to another, the memory address is copied, but not the object itself.

```
String u = t;                 // copies the address (reference)
String w = new String( t );   // creates a new string initialized to t
```

The variable u is effectively an **alias** for t, that is, a different name for the same object.

Under the Hood: '==' and 'equals' Revisited

Start with the initializations:

```
String t = new String( "von Wienerschnitzel" );
String u = t;                 // copies the reference (address)
String w = new String( t );   // creates a new string initialized to t
```

Consider now the difference between == and equals( ) .

==: Tests whether the references (addresses) are equal.

equals( ): Tests whether the contents are equal.

```
if ( u == t ) …     // true: u and t refer to the same object
if ( w == t ) …     // false: w and t refer to different objects
if ( u.equals(w) )  // true: u's and w's contents are equal
```

The "null" Reference

Must every reference refer to an instance of some object?

No: it is possible to have a reference refer to nothing. The special reference **null** does this. (Let u and t be as before.)

```
u = null;                  // now u does not refer to any object
int i = t.length( );       // okay: returns 19
int j = u.length( );       // Error! null pointer exception
System.out.println( u );   // Error? prints the word "null"
```

Note: There is difference between a **null reference** and an **empty string** (sometimes called a null string).

Under the Hood: Garbage Collection

Garbage: When we change an object reference, we may produce a chunk of memory that **cannot be accessed**, called **garbage**.

```
int x = 52;
String s = new String( "Schultzie" );
String t = new String( "von Wienerschnitzel" );
s = new String( "Another string" );
```

Garbage Collection: Garbage tends to accumulate. When you start running out of memory, Java automatically does **garbage collection**, to recover this space, so you don't run out of memory.