

Chapter 2: Data and Expressions

Lab Exercises

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Do the lab exercises in this order:

- 1) Two Meanings of Plus
 - 2) Names and Places
 - 3) A Table of Student Grades
 - 4) Area and Circumference of a Circle
- Parts 1 and 2 only

The Chapter and Section numbers from the textbook that are mentioned in the Labs do not always match (apparently, the Labs were written for an earlier edition of the textbook and never updated to match later editions). I have tried to add a Note with a reference to the correct Chapter, Section, and/or page numbers of the edition we are using, but do not guarantee that I got them all.

Names and Places

The goal in this exercise is to develop a program that will print out a list of student names together with other information for each. The *tab character* (an escape sequence) is helpful in getting the list to line up nicely. A program with only two names is in the file *Names.java*.

```
// *****
//   Names.java
//
//   Prints a list of student names with their hometowns
//   and intended major
// *****

public class Names
{
    // -----
    // main prints the list
    // -----
    public static void main (String[] args)
    {
        System.out.println ();
        System.out.println ("\tName\t\tHometown");
        System.out.println ("\t===\t\t=====");
        System.out.println ("\tSally\t\tRoanoke");
        System.out.println ("\tAlexander\tWashington");
        System.out.println ();
    }
}
```

1. Save Names.java to your directory. Compile and run it to see how it works.
2. Modify the program so that your name and hometown and the name and hometown of at least two classmates sitting near you in lab also are printed. Save, compile and run the program. Make sure the columns line up.
3. Modify the program to add a third column with the intended major of each person (assume Sally's major is Computer Science and Alexander's major is Math). Be sure to add a label at the top of the third column and be sure everything is lined up (use tab characters!).

Hometown -> the town where you were born!

A Table of Student Grades

Write a Java program that prints a table with a list of at least 5 students together with their grades earned (lab points, bonus points, and the total) in the format below. Name your program "StudentGrades".

```
////////////////////////////////\////////////////////////////////\
==          Student Points          ==
\\//////////////////////////////////////////////////////////////////

Name          Lab      Bonus      Total
----          -
Joe           43       7          50
William       50       8          58
Mary Sue      39       10         49
```

To get one backslash into a String, you actually have to type 2 backslashes, i.e. `\\`. This is because one backslash, `\`, is used to start other "escape sequences" such as `\t` (tab), `\r` (carriage return), `\n` (new line), etc

The requirements for the program are as follows:

1. Print the border on the top as illustrated (using the slash and backslash characters).
2. Use tab characters to get your columns aligned and you must use the `+` operator both for addition and string concatenation. (see A below)
3. Make up your own student names and points—the ones shown are just for illustration purposes. You need 5 names.

A) for example, `"Joe\t\t" + 43 + "\t" + 7 + "\t" + (43 + 7)` is an expression where `+` is used for both String concatenation and addition

Two Meanings of Plus

In Java, the symbol `+` can be used to add numbers or to concatenate strings. This exercise illustrates both uses.

When using a string literal (a sequence of characters enclosed in double quotation marks) in Java the complete string must fit on one line. The following is NOT legal (it would result in a compile-time error).

```
System.out.println ("It is NOT okay to go to the next line
                    in a LONG string!!!");
```

The solution is to break the long string up into two shorter strings that are joined using the *concatenation* operator (which is the `+` symbol). This is discussed in Section 2.1 in the text. So the following would be legal

```
System.out.println ("It is OKAY to break a long string into " +
                    "parts and join them with a + symbol.");
```

So, when working with strings the `+` symbol means to concatenate the strings (join them). BUT, when working with numbers the `+` means what it has always meant—add!

1. **Observing the Behavior of `+`** To see the behavior of `+` in different settings do the following:

a. Study the program below, which is in file *PlusTest.java*.

```
// *****
//   PlusTest.java
//
//   Demonstrate the different behaviors of the + operator
// *****

public class PlusTest
{
    // -----
    // main prints some expressions using the + operator
    // -----
    public static void main (String[] args)
    {
        System.out.println ("This is a long string that is the " +
                            "concatenation of two shorter strings.");

        System.out.println ("The first computer was invented about" + 55 +
                            "years ago.");

        System.out.println ("8 plus 5 is " + 8 + 5);

        System.out.println ("8 plus 5 is " + (8 + 5));

        System.out.println (8 + 5 + " equals 8 plus 5.");
    }
}
```

b. Save *PlusTest.java* to your directory.

c. Compile and run the program. For each of the last three output statements (the ones dealing with 8 plus 5) write down what was printed. Now for each explain why the computer printed what it did given that the following rules are used for `+`. Write out complete explanations.

If both operands are numbers `+` is treated as ordinary addition. (NOTE: in the expression `a + b` the `a` and `b` are called the operands.)

If at least one operand is a string the other operand is converted to a string and `+` is the concatenation operator.

If an expression contains more than one operation expressions inside parentheses are evaluated first. If there are no parentheses the expression is evaluated left to right.

d. The statement about when the computer was invented is too scrunched up. How should that be fixed?

2. **Writing Your Own Program With +** Now write a complete Java program that prints out the following sentence:

Ten robins plus 13 canaries is 23 birds.

Your program must use only one statement that invokes the *println* method. It must use the + operator both to do arithmetic and string concatenation.

Name your program **Robins.java** and make sure the class name in the code matches.

Area and Circumference of a Circle

Study the program below, which uses both variables and constants:

```
//*****  
// Circle.java  
//  
// Print the area of a circle with two different radii  
//*****  
  
public class Circle  
{  
    public static void main(String[] args)  
    {  
        final double PI = 3.14159;  
  
        int radius = 10;  
        double area = PI * radius * radius;  
  
        System.out.println("The area of a circle with radius " + radius +  
                           " is " + area);  
  
        radius = 20;  
        area = PI * radius * radius;  
  
        System.out.println("The area of a circle with radius " + radius +  
                           " is " + area);  
    }  
}
```

Some things to notice:

The first three lines inside *main* are declarations for PI, radius, and area. Note that the type for each is given in these lines: *final double* for PI, since it is a floating point constant; *int* for radius, since it is an integer variable, and *double* for area, since it will hold the product of the radius and PI, resulting in a floating point value. These first three lines also hold initializations for PI, radius, and area. These could have been done separately, but it is often convenient to assign an initial value when a variable is declared. The next line is simply a print statement that shows the area for a circle of a given radius. The next line is an assignment statement, giving variable radius the value 20. Note that this is not a declaration, so the *int* that was in the previous radius line does not appear here. The same memory location that used to hold the value 10 now holds the value 20—we are not setting up a new memory location. Similar for the next line—no *double* because area was already declared. The final print statement prints the newly computed area of the circle with the new radius.

Save this program, which is in file *Circle.java*, into your directory and modify it as follows:

1. The circumference of a circle is two times the product of Pi and the radius. Add statements to this program so that it computes the circumference in addition to the area for both circles. You will need to do the following:
 - Declare a new variable to store the circumference.
 - Store the circumference in that variable each time you compute it.
 - Add two additional print statements to print your results.Be sure your results are clearly labeled.
2. When the radius of a circle doubles, what happens to its circumference and area? Do they double as well? You can determine this by dividing the second area by the first area. Unfortunately, as it is now the program overwrites the first area with the second area (same for the circumference). You need to save the first area and circumference you compute instead of overwriting them with the second set of computations. So you'll need two area variables and two

circumference variables, which means they'll have to have different names (e.g., `area1` and `area2`). Remember that each variable will have to be declared. Modify the program as follows:

Change the names of the area and circumference variables so that they are different in the first and second calculations. Be sure that you print out whatever you just computed.

At the end of the program, compute the area change by dividing the second area by the first area. This gives you the factor by which the area grew. Store this value in an appropriately named variable (which you will have to declare).

Add a `println` statement to print the change in area that you just computed.

Now repeat the last two steps for the circumference.

Look at the results. Is this what you expected?

3. In the program above, you showed what happened to the circumference and area of a circle when the radius went from 10 to 20. Does the same thing happen whenever the radius doubles, or were those answers just for those particular values? To figure this out, you can write a program that reads in values for the radius from the user instead of having it written into the program ("hardcoded"). Modify your program as follows:

At the very top of the file, add the line

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

This tells the compiler that you will be using methods from the `Scanner` class. In the main method create a `Scanner` object called `scan` to read from `System.in`.

Instead of initializing the radius in the declaration, just declare it without giving it a value. Now add two statements to read in the radius from the user:

A *prompt*, that is, a print statement that tells the user what they are supposed to do (e.g., "Please enter a value for the radius.");

A read statement that actually reads in the value. Since we are assuming that the radius is an integer, this will use the `nextInt()` method of the `Scanner` class.

When the radius gets its second value, make it be twice the original value.

Compile and run your program. Does your result from above hold?

Painting a Room

File *Paint.java* contains the partial program below, which when complete will calculate the amount of paint needed to paint the walls of a room of the given length and width. It assumes that the paint covers 350 square feet per gallon.

```
//*****
//File: Paint.java
//
//Purpose: Determine how much paint is needed to paint the walls
//of a room given its length, width, and height
//*****
import java.util.Scanner;

public class Paint
{
    public static void main(String[] args)
    {
        final int COVERAGE = 350; //paint covers 350 sq ft/gal
        //declare integers length, width, and height;
        //declare double totalSqFt;
        //declare double paintNeeded;
        //declare and initialize Scanner object

        //Prompt for and read in the length of the room

        //Prompt for and read in the width of the room

        //Prompt for and read in the height of the room

        //Compute the total square feet to be painted--think
        //about the dimensions of each wall

        //Compute the amount of paint needed

        //Print the length, width, and height of the room and the
        //number of gallons of paint needed.
    }
}
```

Save this file to your directory and do the following:

1. Fill in the missing statements (the comments tell you where to fill in) so that the program does what it is supposed to. Compile and run the program and correct any errors.
2. Suppose the room has doors and windows that don't need painting. Ask the user to enter the number of doors and number of windows in the room, and adjust the total square feet to be painted accordingly. Assume that each door is 20 square feet and each window is 15 square feet.

Ideal Weight

Write a program to compute the ideal weight for both males and females. According to one study, the ideal weight for a female is 100 pounds plus 5 pounds for each inch in height over 5 feet. For example, the ideal weight for a female who is 5'3" would be $100 + 15 = 115$ pounds. For a male the ideal weight is 106 pounds plus 6 pounds for each inch in height over 5 feet. For example, the ideal weight for a male who is 6'2" would be $106 + 14 \times 6 = 190$ pounds. Your program should ask the user to enter his/her height in feet and inches (both as integers—so a person 5'3" would enter the 5 and the 3). It should then compute and print both the ideal weight for a female and the ideal weight for a male. The general outline of your main function would be as follows:

- Declare your variables (think about what variables you need—you need to input two pieces of information (what?), then you need some variables for your calculations (see the following steps))
- Get the input (height in feet and inches) from the user
- Compute the total number of inches of height (convert feet and inches to total inches)
- Compute the ideal weight for a female and the ideal weight for a male (here you basically convert the "word" description above to assignment statements)
- Print the answers

Plan your program, then type it in, compile and run it. Be sure it gives correct answers.

Enhance the Program a Bit The weight program would be a bit nicer if it didn't just give one number as the ideal weight for each sex. Generally a person's weight is okay if it is within about 15% of the ideal. Add to your program so that in addition to its current output it prints an okay range for each sex—the range is from the ideal weight minus 15% to the ideal weight plus 15%. You may do this by introducing new variables and assignment statements OR directly within your print statements.

Lab Grades

Suppose your lab instructor has a somewhat complicated method of determining your grade on a lab. Each lab consists of two out-of-class activities—a pre-lab assignment and a post-lab assignment—plus the in-class activities. The in-class work is 60% of the lab grade and the out-of-class work is 40% of the lab grade. Each component of the grade is based on a different number of points (and this varies from lab to lab)—for example, the pre-lab may be graded on a basis of 20 points (so a student may earn 17 out of 20 points) whereas the post-lab is graded on a basis of 30 points and the in-class 25 points. To determine the out-of-class grade the instructor takes the total points earned (pre plus post) divided by the maximum possible number of points, multiplied by 100 to convert to percent; the in-class grade is just the number of points earned divided by the maximum points, again converted to percent.

The program *LabGrade.java* is supposed to compute the lab grade for a student. To do this it gets as input the number of points the student earned on the prelab assignment and the maximum number of points the student could have earned; the number of points earned on the lab itself and the maximum number of points; the number of points earned on the postlab assignment and the maximum number of points. The lab grade is computed as described above: the in-class and out-of-class grades (in percent) are computed separately then a weighted average of these is computed. The program currently assumes the out-of-class work counts 40% and the in-class counts 60%. Do the following:

1. First carefully hand trace the program assuming the input stream contains the values 17, 20, 23, 25, 12, 15. Trace the program exactly as it is written (it is not correct but it will compile and run so the computer would not know it isn't correct). Fill in the answers to the following questions:
 - a. Show exactly how the computer would execute the assignment statement that computes the out of class average for this set of input. Show how the expression will be evaluated (the order in which the operations are performed) and what the result will be.
 - b. Show how the computer would execute the assignment statement that computes the in-class average. What will the result be?
 - c. Show how the computer would execute the assignment statement that computes the lab grade.
2. Now run the program, typing in the input you used in your trace. Compare your answers to the output. Clearly the output is incorrect! Correct the program. This involves writing the expressions to do calculations correctly. The correct answers for the given input should be an out of class average of 82.857 (the student earned 29 points out of a possible 35 which is approximately 82.857%), an in-class average of 92 (23 points out of 25), and a lab grade of 88.34 (40% of 82.857 plus 60% of 92).
3. Modify the program to make the weights for the two components of the grade variable rather than the constants 0.4 and 0.6. To do this, you need to do four things:
 - a. Change the declarations so the weights (*IN_WEIGHT* and *OUT_WEIGHT*) are variables rather than constants. Note that you should also change their names from all capital letters (the convention for constants) to lowercase letters with capitals starting new words (the convention for variables). So *IN_WEIGHT* should become *inWeight*. Of course, you'll also have to change it where it's used in the program.
 - b. In the input section, add statements that will prompt the user for the weight (in decimal form—for example .4 for 40%) to be assigned to the in-class work, then read the input. Note that your prompt should explain to the user that the weight is expected to be in decimal form.
 - c. In the section that calculates the labGrade add an assignment statement that calculates the weight to be assigned to the out of class work (this will be 1 minus the in-class weight).Compile and run your program to make sure it is correct.

```
// *****
// LabGrade.java
// This program computes a student's lab grade from
// the grades on the three components of lab: the pre-lab
// assignment, the lab itself, and the post-lab assignment.
// *****

import java.util.Scanner;
```

```

public class LabGrade
{
    public static void main (String[] args)
    {
        // Declare constants
        final double IN_WEIGHT = 0.6; // in-class weight is 60%
        final double OUT_WEIGHT = 0.4; // out-of-class weight is 40%

        // Declare variables
        int preLabPts; //number of points earned on the pre-lab assignment
        int preLabMax; //maximum number of points possible for pre-lab
        int labPts; //number of poitns earned on the lab
        int labMax; //maximum number of points possible for lab
        int postLabPts; //number of points earned on the post-lab assignment
        int postLabMax; //maximum number of points possible for the post-lab
        int outClassAvg; //average on the out of class (pre and post) work
        int inClassAvg; //average on the in-class work
        double labGrade; //final lab grade

        Scanner scan = new Scanner(System.in);

        // Get the input
        System.out.println("\nWelcome to the Lab Grade Calculator\n");
        System.out.print("Enter the number of points you earned on the pre-lab: ");
        preLabPts = scan.nextInt();
        System.out.print("What was the maximum number of points you could have earned? ");
        preLabMax = scan.nextInt();
        System.out.print("Enter the number of points you earned on the lab: ");
        labPts = scan.nextInt();
        System.out.print("What was the maximum number of points for the lab? ");
        labMax = scan.nextInt();
        System.out.print("Enter the number of points you earned on the post-lab: ");
        postLabPts = scan.nextInt();
        System.out.print("What was the maximum number of points for the post-lab? ");
        postLabMax = scan.nextInt();
        System.out.println();

        // Calculate the average for the out of class work
        outClassAvg = preLabPts + postLabPts / preLabMax + postLabMax * 100;

        // Calculate the average for the in-class work
        inClassAvg = labPts / labMax * 100;

        // Calculate the weighted average taking 40% of the out-of-class average
        // plus 60% of the in-class
        labGrade = OUT_WEIGHT * outClassAvg + IN_WEIGHT * inClassAvg;

        // Print the results
        System.out.println("Your average on out-of-class work is " + outClassAvg + "%");
        System.out.println("Your average on in-class work is " + inClassAvg + "%");
        System.out.println("Your lab grade is " + labGrade + "%");
        System.out.println();
    }
}

```

Base Conversion

One algorithm for converting a base 10 number to another base b involves repeatedly dividing by b . Each time a division is performed the remainder and quotient are saved. At each step, the dividend is the quotient from the preceding step; the divisor is always b . The algorithm stops when the quotient is 0. The number in the new base is the sequence of remainders in reverse order (the last one computed goes first; the first one goes last).

In this exercise you will use this algorithm to write a program that converts a base 10 number to a 4-digit number in another base (you don't know enough programming yet to be able to convert any size number). The base 10 number and the new base (between 2 and 9) will be input to the program. The start of the program is in the file *BaseConvert.java*. Save this file to your directory, then modify it one step at a time as follows:

1. The program will only work correctly for base 10 numbers that fit in 4 digits in the new base. We know that in base 2 the maximum unsigned integer that will fit in 4 bits is 1111_2 which equals 15 in base 10 (or $2^4 - 1$). In base 8, the maximum number is 7777_8 which equals 4095 in base 10 (or $8^4 - 1$). In general, the maximum base 10 number that fits in 4 base b digits is $b^4 - 1$. Add an assignment statement to the program to compute this value for the base that is input and assign it to the variable *maxNumber*. Add a statement that prints out the result (appropriately labeled). Compile and run the program to make sure it is correct so far.
2. Now add the code to do the conversion. The comments below guide you through the calculations—replace them with the appropriate Java statements.

```
// First compute place0 -- the units place. Remember this comes
// from the first division so it is the remainder when the
// base 10 number is divided by the base (HINT %).
// Then compute the quotient (integer division / will do it!) -
// You can either store the result back in base10Num or declare a
// new variable for the quotient

// Now compute place1 -- this is the remainder when the quotient
// from the preceding step is divided by the base.
// Then compute the new quotient

// Repeat the idea from above to compute place2 and the next quotient

// Repeat again to compute place3
```

3. So far the program does not print out the answer. Recall that the answer is the sequence of remainders written in reverse order—note that this requires concatenating the four digits that have been computed. Since they are each integers, if we just add them the computer will perform arithmetic instead of concatenation. So, we will use a variable of type String. Note near the top of the program a variable named *baseBNum* has been declared as an object of type String and initialized to an empty string. Add statements to the program to concatenate the digits in the new base to *baseBNum* and then print the answer. Compile and run your program. Test it using the following values: Enter 2 for the base and 13 for the base 10 number—the program should print 1101 as the base 2 value; enter 8 for the base and 1878 for the number—the program should print 3526 for the base 8 value; enter 3 for the base and 50 for the number—the program should print 1212.

```

// *****
//   BaseConvert.java
//
//   Converts base 10 numbers to another base
//   (at most 4 digits in the other base).  The
//   base 10 number and the base are input.
// *****

import java.util.Scanner;

public class BaseConvert
{
    public static void main (String[] args)
    {
        int base;          // the new base
        int base10Num;      // the number in base 10
        int maxNumber;      // the maximum number that will fit
                           // in 4 digits in the new base

        int place0;        // digit in the 1's (base^0) place
        int place1;        // digit in the base^1 place
        int place2;        // digit in the base^2 place
        int place3;        // digit in the base^3 place

        String baseBNum = new String (""); // the number in the new base
        Scanner scan = new Scanner(System.in);

        // read in the base 10 number and the base
        System.out.println();
        System.out.println ("Base Conversion Program");
        System.out.println();
        System.out.print ("Please enter a base (2 - 9): ");
        base = scan.nextInt();

        // Compute the maximum base 10 number that will fit in 4 digits
        // in the new base and tell the user what range the number they
        // want to convert must be in

        System.out.print ("Please enter a base 10 number to convert: ");
        base10Num = scan.nextInt();

        // Do the conversion (see notes in lab)

        // Print the result (see notes in lab)
    }
}

```

Introduction to HTML

HTML is the HyperText Markup Language. It is used to describe how text, images, and multimedia are displayed by Web browsers. In this lab you will learn a little about HTML so that you can create a web page containing headings, interesting fonts, lists, and links as well as applets.

HTML uses *tags* to describe the layout of a document; the browser then uses these tags to figure out how to display the document. Tags are enclosed in angle brackets. For example, <title> is a tag that indicates that this section contains the title of the document. Many tags, including <title>, have corresponding end tags that indicate where the section ends. The end tags look just like the start tags except that they start with the character /, e.g., </title>. So the following text indicates that the title of the document is Introduction to HTML:

```
<title>Introduction to HTML</title>
```

There are a few tags that almost every document will have: <html>, <head>, <title>, and <body>. Here is an example of a simple HTML document:

```
<HTML>
  <HEAD>
    <TITLE>Introduction to HTML</TITLE>
  </HEAD>

  <BODY>
    In this lab you will learn about HTML, which is lots of fun
    to use. In particular, you will learn how to use fonts,
    paragraphs, lists, links and applets in a web page. Now you
    can make your own web page for your friends to visit!
  </BODY>
</HTML>
```

To see what this looks like, open the file in the web browser. Change the size of the browser window (click and drag any corner) and see how the text is reformatted as the window changes. Note that the title appears on the window, not as part of the document.

The HEAD of a document (everything between <HEAD> and </HEAD>) contains the introduction to the document. The title goes in the head, but for now we won't use the head for anything else. The BODY of a document (everything between <BODY> and </BODY>) contains everything that will be displayed as part of the document. Both the HEAD and the BODY are enclosed by the HTML tags, which begin and end the document.

This document contains only plain text, but an HTML document can have much more structure: headings, paragraphs, lists, bold and italic text, images, links, tables, and so on. Here is a document containing a heading, two paragraphs, and some fancy fonts:

```

<HTML>
  <HEAD>
    <TITLE>Introduction to HTML</TITLE>
  </HEAD>

  <BODY BGCOLOR="lightgreen">
    <H1 align="center">Introduction to HTML</H1>

    <P>In this lab you will learn about <I>HTML</I>, which
    is lots of fun
    to use. In particular, you will learn how to use fonts,
    paragraphs, lists, links, and colors in a web page. Now you
    can make your <B>own</B> web page for your friends to visit!</P>

    <P>Later in this lab you will do some fancier stuff with
    applets and graphics and include an applet on your web page.
    Can't you just feel the job offers start rolling in?</P>
    <U>Yippee!</U>
  </BODY>
</HTML>

```

Run the HTML document to see what this looks like in the browser.

In this document the <H1> tag creates a level 1 heading. This is the biggest heading; it might be used at the beginning of the document or the start of a new chapter. Level 2 through level 6 headings are also available with the <H2> through <H6> tags.

The <P> tag creates a new paragraph. Most browsers leave a blank line between paragraphs. The tag creates bold text, the <I> tag creates italic text, and the <U> tag creates underlined text. Note that each of these tags is closed with the corresponding end tag. The BGCOLOR attribute on the BODY tag sets the background color.

Note that line breaks and blank lines in the HTML document do not matter—the browser will format paragraphs to fit the window. If it weren't for the <P> tag, the blank line between the paragraphs in this document would not show up in the displayed document.

Exercise #1: For a file to be visible on the Web, it must be where the web server knows how to find it. *** Instruct students how to create and/or access the public html directory on the local system. ***

Open a new file called MyPage.html in a directory where it will be accessible from the web. Write a simple web page about things that interest you. Your page should contain at least the following:

- A title (using the <TITLE> tag)
- Two different levels of headings
- Two paragraphs
- Some bold, italic, or underlined text

Your name should appear somewhere in the document.

When you are done, view your document from the browser. Just type in the URL, don't use File | Open Page.

More HTML

Lists We often want to add a list to a document. HTML provides two kinds of lists, *ordered* (e.g., 1, 2, 3) and *unordered* (e.g., bulleted). A list is introduced with the or tag, depending on whether it is ordered or unordered. Each list item is introduced with a tag and ended with the tag. The entire list is then ended with or , as appropriate. For example, the code below creates the list shown; replacing the and tags with and would produce the same list with bullets instead of numbers.

Things I like:

```
<OL>
<LI>chocolate
<LI>rabbits
<LI>chocolate rabbits
</OL>
```

Things I like:

1. chocolate
2. rabbits
3. chocolate rabbits

Exercise #2: Add a list, either ordered or unordered, of at least three elements to your document.

Links Links connect one document to another. Links are created in HTML with the <A> (anchor) tag. When creating a link you have to specify two things:

The URL of the document to go to when the link is clicked. This is given as the HREF attribute of the A element.
How the link should be displayed (that is, what text or image to click on to go to the linked document). This appears between the <A> and tags.

For example, the code below creates the link shown, which goes to a page about the history of computing:

```
Learn more about <A HREF="http://ei.cs.vt.edu/~history">the history of
computing.</A>
```

Learn more about the history of computing.

Exercise #3: Add at least one link that ties in to the material on your page.

Drawing Shapes

The following is a simple applet that draws a blue rectangle on a yellow background.

```
// *****
//   Shapes.java
//
//   The program will draw two filled rectangles and a
//   filled oval.
// *****

import javax.swing.JApplet;
import java.awt.*;

public class Shapes extends JApplet
{
    public void paint (Graphics page)
    {
        // Declare size constants
        final int MAX_SIZE = 300;
        final int PAGE_WIDTH = 600;
        final int PAGE_HEIGHT = 400;

        // Declare variables
        int x, y;    // x and y coordinates of upper left-corner of each shape
        int width, height; // width and height of each shape

        // Set the background color
        setBackground (Color.yellow);

        // Set the color for the next shape to be drawn
        page.setColor (Color.blue);

        // Assign the corner point and width and height
        x = 200;
        y = 150;
        width = 100;
        height = 70;

        // Draw the rectangle
        page.fillRect(x, y, width, height);
    }
}
```

Study the code, noting the following:

The program imports `javax.swing.JApplet` because this is an applet, and it imports `java.awt.*` because it uses graphics. There is no *main* method—instead there is a *paint* method. The *paint* method is automatically invoked when an applet is displayed, just as the *main* method is automatically invoked when an application is executed. Most of the methods that draw shapes (see the list in Figure 2.12) require parameters that specify the upper left-hand corner of the shape (using the coordinate system described in Section 2.9) and the width and height of the shape. You can see this in the calls to *fillRect*, which draws a rectangle filled with the current foreground color. This applet will be drawn assuming the window for drawing (the *Graphics* object - named *page* here) is 600 pixels wide and 400 pixels high. These numbers are defined in constants at the beginning of the program. (They currently have no use but you will use them later). The width and height of the applet are actually specified in the HTML file that instructs the Web browser to run the applet (remember applets are executed by Web browsers and Web browsers get their instructions from HTML documents—note that the code executed by the browser is the *bytecode* for the program, the *Shapes.class* file). The code in the HTML document is as follows:

```
<html>
<applet code="Shapes.class" width=600 height=400>
</applet>
</html>
```

Save the files *Shapes.java* and *Shapes.html* to your directory. Now do the following:

1. Compile *Shapes.java*, but don't run it—this is an applet, so it is run through a browser or a special program called the Applet Viewer.
2. Run the program through your browser. You should see a blue rectangle on a yellow background.
3. Now run the program through the Applet Viewer by typing the command

```
appletviewer Shapes.html
```

You should see a new window open displaying the rectangle.

4. Now open the program in your text editor and change the *x* and *y* variables both to 0. Save and recompile the program, then view it in the Applet Viewer (this is generally less trouble when making lots of changes than using the browser). What happened to the rectangle?
5. Now change the width to 200 and the height to 300. Save, recompile and run to see how this affects the rectangle.
6. Change *x* to 400, *y* to 40, width to 50 and height to 200. Test the program to see the effect.
7. Modify the program so that it draws four rectangles in all, as follows:
 - One rectangle should be entirely contained in another rectangle.
 - One rectangle should overlap one of the first two but not be entirely inside of it.
 - The fourth rectangle should not overlap any of the others.
8. One last touch to the program ... Change the colors for at least three of the shapes so the background and each of the three shapes are different colors (a list of colors is in Figure 2.10 of the text). Also change two of the *fillRect* methods to *fillOval* so the final program draws two rectangles and two ovals. Be sure that the overlap rules are still met.

The Java Coordinate System

The Java coordinate system is discussed in Section 2.7 & 2.9 of the text. Under this system, the upper left-hand corner of the window is the point (0,0). The X axis goes across the window, and the Y axis goes down the window. So the bigger the X value, the farther a point is to the right. The bigger the Y value, the farther it is down. There are no negative X or Y values in the Java coordinate system. Actually, you can use negative values, but since they're off the screen they won't show up!

1. Save files *Coords.java* and *Coords.html* to your directory. File *Coords.java* contains an applet that draws a rectangle whose upper lefthand corner is at 0,0. Use the applet viewer to run this applet. Remember that you have to do it through the html file: *appletviewer Coords.html*.
2. Modify the applet so that instead of 0,0 for the upper lefthand corner, you use the coordinates of the middle of the applet window. This applet is set up to be 600 pixels wide and 400 pixels high, so you can figure out where the middle is. Save, compile, and view your applet. Does the rectangle appear to be in the middle of the screen? Modify the coordinates so that it does appear to be in the middle.
3. Now add four more rectangles to the applet, one in each corner. Each rectangle should just touch one corner of the center rectangle and should go exactly to the edges of the window.
4. Make each rectangle be a different color. To do this, use the *setColor* method of the *Graphics* class to change the color (this is already done once). **Do not change the background color once it has been set!** Doing so causes the screen to flicker between colors.

```
// *****
//   Coords.java
//
//   Draw rectangles to illustrate the Java coordinate system
//
// *****

import javax.swing.JApplet;
import java.awt.*;

public class Coords extends JApplet
{
    public void paint (Graphics page)
    {
        // Declare size constants
        final int MAX_SIZE = 300;
        final int PAGE_WIDTH = 600;
        final int PAGE_HEIGHT = 400;

        // Declare variables
        int x, y;    // x and y coordinates of upper left-corner of each shape
        int width, height; // width and height of each shape

        // Set the background color
        setBackground (Color.yellow);

        // Set the color for the next shape to be drawn
        page.setColor (Color.blue);

        // Assign the corner point and width and height
        x = 0;
        y = 0;
```

```
        width = 150;
        height = 100;

        page.fillRect(x, y, width, height);
    }
}
```

Coords.html

```
<html>
<applet code="Coords.class" width=600 height=400>
</applet>
</html>
```

Drawing a Face

Write an applet that draws a smiling face. Give the face eyes with pupils, ears, a nose, and a mouth. Use at least three different colors, and fill in some of the features. Name this file `Face.java`, and create a corresponding `.html` file. View your applet using the applet viewer.

Now add your face to a web page you created (you may have created one in an earlier lab exercise). You will do this using the `<APPLET>` tag that is in the `.html` file you are using with the applet viewer—you can just copy it out of that file and paste it into your other file. The applet will appear wherever you insert the applet tag.

Creating a Pie Chart

Write an applet that draws a pie chart showing the percentage of household income spent on various expenses. Use the percentages below:

Rent and Utilities	35%
Transportation	15%
Food	15%
Educational	25%
Miscellaneous	10%

Each section of the pie should be in a different color, of course. Label each section of the pie with the category it represents—the labels should appear outside the pie itself.

Embed your applet in an HTML document about managing expenses. It should contain a heading, some text, a relevant list, and at least one link to a relevant page. Your name should also appear somewhere on the page. Embed the applet so that it fits in nicely.

Colors in Java

The basic scheme for representing a picture in a computer is to break the picture down into small elements called *pixels* and then represent the color of each pixel by a numeric code (this idea is discussed in section 1.6 of the text). In most computer languages, including Java, the color is specified by three numbers—one representing the amount of red in the color, another the amount of green, and the third the amount of blue. These numbers are referred to as the *RGB value* of the color. In Java, each of the three primary colors is represented by an 8-bit code. Hence, the possible base 10 values for each have a range of 0-255. Zero means none of that color while 255 means the maximum amount of the color. Pure red is represented by 255 for red, 0 for green, and 0 for blue, while magenta is a mix of red and blue (255 for red, 0 for green, and 255 for blue). In Java you can create your own colors. So far in the graphics programs we have written we have used the pre-defined colors, such as `Color.red`, from the `Color` class. However, we may also create our own `Color` object and use it in a graphics program. One way to create a `Color` object is to declare a variable of type `Color` and instantiate it using the constructor that requires three integer parameters—the first representing the amount of red, the second the amount of green, and the third the amount of blue in the color. For example, the following declares the `Color` object *myColor* and instantiates it to a color with code 255 for red, 0 for green, and 255 for blue.

```
Color myColor = new Color(255, 0, 255);
```

The statement `page.setColor(myColor)` then will set the foreground color for the page to be the color defined by the *myColor* object. The file *Colors.java* contains an applet that defines *myColor* to be a `Color` object with color code (200, 100, 255) - a shade of purple. Save the program and its associated HTML file *Colors.html* to your directory, compile and run it using the appletviewer. Now make the following modifications:

1. Change the constructor so the color code is (0,0,0) --- absence of color. What color should this be? Run the program to check.
2. Try a few other combinations of color codes to see what you get. The description of the `Color` class in Appendix M contains documentation that gives the codes for the pre-defined colors.
3. Notice in the `Color` class in Appendix M there is a constructor that takes a single integer as an argument. The first 8 bits of this integer are ignored while the last 24 bits define the color—8 bits for red, 8 for green, and the last 8 bits for blue. Hence, the bit pattern

```
0000000000000000001111111100000000
```

should represent pure green. Its base 10 value is 65280. Change the declaration of the *myColor* object to

```
Color myColor = new Color (65280);
```

Compile and run the program. Do you see green?

4. The `Color` class has methods that return the individual color codes (for red, green, and blue) for a `Color` object. For example,

```
redCode = myColor.getRed();
```

returns the code for the red component of the *myColor* object (`redCode` should be a variable of type `int`). The methods that return the green and blue components are *getGreen* and *getBlue*, respectively. Add statements to the program, similar to the above, to get the three color codes for *myColor* (you need to declare some variables). Then add statements such as

```
page.drawString("Red: " + redCode, _____ , _____ );
```

to label the rectangle with the three color codes (fill in the blanks with appropriate coordinates so each string is drawn inside the rectangle—you also need to set the drawing color to something such as black so the strings will show up). Compile and run the program; for the pure green color above, you should get 0 for red and blue and 255 for green. Now change the integer you use to create the color from 65280 to 115 and see what you get (can you predict?), then try it again with 2486921 (harder to predict!).

```

// *****
//   Colors.java
//
//   Draw rectangles to illustrate colors and their codes in Java
// *****

import javax.swing.JApplet;
import java.awt.*;

public class Colors extends JApplet
{
    public void paint (Graphics page)
    {
        // Declare size constants
        final int PAGE_WIDTH = 600;
        final int PAGE_HEIGHT = 400;

        // Declare variables
        int x, y;    // x and y coordinates of upper left-corner of each shape
        int width, height; // width and height of each shape

        Color myColor = new Color (200, 100, 255);

        // Set the background color and paint the screen with a white rectangle
        setBackground (Color.white);
        page.setColor(Color.white);
        page.fillRect(0, 0, PAGE_WIDTH, PAGE_HEIGHT);

        // Set the color for the rectangle
        page.setColor (myColor);

        // Assign the corner point and width and height then draw
        x = 200;
        y = 125;
        width = 200;
        height = 150;

        page.fillRect(x, y, width, height);
    }
}

```

Colors.html

```

<html>
<applet code="Colors.class" width=600 height=400>
</applet>
</html>

```