Introduction to Computer Programming

Lecture #2 – A Look at Designing Algorithms

A Numerical Program

Problem – write a program which can find the average of three numbers.

Let’s list the steps that our program must perform to do this:

• Add up these values
• Divide the sum by the number of values
• Print the result

Each of these steps will be a different statement.
Writing Our Numerical Program

- Add up these values: \( \text{sum} = 2 + 4 + 6; \)
- Divide the sum by the number of values
- Print the result

\( \text{sum} = 2 + 4 + 6; \quad \text{an assignment statement} \)

Assignment Statements

- Assignment statements take the form:
  \[ \text{variable} = \text{expression} \]
  Memory location where the value is stored
  Combination of constants and variables
Expressions

• Expressions combine values using one of several *operations*.
• The operations being used is indicated by the *operator*:
  +   Addition
  -   Subtraction
  *   Multiplication
  /   Division

Expressions – Some Examples

2 + 5
4 * value
x / y
Writing Our Numerical Program

• `sum = 2 + 4 + 6;`
• Divide the sum by the number of values `average = sum / 3;`
• Print the result

Names that describe what the values represent

Writing Our Numerical Program

• `sum = 2 + 4 + 6`
• `average = sum / 3;`
• Print the result

`System.out.println("The average is " + average);`
Writing Our Numerical Program

```java
public class Average3 {
    public static void main(String[] args) {
        int sum, average;
        sum = 2 + 4 + 6;
        average = sum / 3;
        System.out.println("The average is "+ average);
    }
}
```

We still need to add a **declare** our variables. This tells the computer what they are.

* Tells the computer that `sum` and `average` are **integers**
Writing Our Numerical Program

```java
public class Average3a {
    public static void main(String[] args) {
        int sum;
        int average;
        sum = 2 + 4 + 6;
        average = sum / 3;
        System.out.println("The average is \" + average);
    }
}
```

We could also write this as two separate declarations.

Another Version of Average

- Let’s rewrite the average program so it can find the average any 3 numbers we try:
- We now need to:
  1. Find our three values
  2. Add the values
  3. Divide the sum by 3
  4. Print the result
Writing Average3b

This first step becomes:

1.1 Find the first value
1.2 Find the second value
1.3 Find the third value

2. Add the values
3. Divide the sum by 3
4. Print the result

Writing Avg3b (continued)

Since we want the computer to print out some kind of prompt, the first step becomes:

1.1.1 Prompt the user for the first value
1.1.2 Read in the first value
1.2.1 Prompt the user for the second value
1.2.2 Read in the second value
1.3.1 Prompt the user for the third value
1.3.2 Read in the third value

2. Add the values
3. Divide the sum by 3
4. Print the result
Writing Avg3b (continued)

We can prompt the user with:

1.1.1 System.out.println
       ("Enter the first value ?");

1.1.2 Read in the first value

1.2.1 System.out.println
       ("Enter the second value ?");

1.2.2 Read in the second value

1.3.1 System.out.println
       ("Enter the third value ?");

1.3.2 Read in the third value

2. Add the values
3. Divide the sum by 3
4. Print the result

The **Scanner** Class

- Most programs will need some form of input.
- At the beginning, all of our input will come from the keyboard.
- To read in a value, we need to use an object belonging to a class called Scanner:

  Scanner keyb = new Scanner(System.in);
Reading from the keyboard

- Once we declare keyb as Scanner, we can read integer values by writing:

  \[ \text{variable} = \text{keyb.nextInt()} ; \]

Writing the input statements in Average3b

We can read in a value by writing:

```
System.out.println
  ("What is the first value\t?");
int  value1 = keyb.nextInt();
System.out.println
  ("What is the second value\t?");
int  value2 = keyb.nextInt();
System.out.println
  ("What is the third value\t?");
int  value3 = keyb.nextInt();
2. Add the values
3. Divide the sum by 3
4. Print the result
```
Writing the assignments statements in Average3b

```java
System.out.println("What is the first value?\t");
int value1 = keyb.nextInt();
System.out.println("What is the second value?\t");
int value2 = keyb.nextInt();
System.out.println("What is the third value?\t");
int value3 = keyb.nextInt();

sum = value1 + value2 + value3;
```

3. Divide the sum by 3

4. Print the result

Adding up the three values

```
    \[average = \frac{sum}{3};\]
```

4. Print the result

Calculating the average
Writing the output statement in Average3b

```java
import java.util.Scanner;

public class Average3b {
    public static void main(String[] args) {
        int sum, average;
        Scanner keyb = new Scanner(System.in);

            int value1 = keyb.nextInt();
                int value2 = keyb.nextInt();
                    int value3 = keyb.nextInt();
                    sum = value1 + value2 + value3;
                    average = sum / 3;
                    System.out.println("The average is " + average);
    }
}
```
Another example – calculating a payroll

• We are going to write a program which calculates the gross pay for someone earning an hourly wage.

• We need two pieces of information:
  – the hourly rate of pay
  – the number of hours worked.

• We are expected to produce one output: the gross pay, which we can find by calculating:
  – Gross pay = Rate of pay * Hours Worked
Our Design for payroll

1. Get the inputs
2. Calculate the gross pay
3. Print the gross pay

*We can substitute:* 1.1 Get the rate
1.2 Get the hours

Developing The Payroll Program

*We can substitute*:

1.1 Get the rate
1.2 Get the hours

2. Calculate the gross pay
3. Print the gross pay
Coding the payroll program

- Before we code the payroll program, we recognize that the values (rate, hours and gross) may not necessarily be integers.
- We will declare these to be double, which means that they can have (but do not have to have) fractional parts.
- In Java, we usually declare our variables where they first appear in the program.

Developing The Payroll Program (continued)

1.1.1 Prompt the user for the rate
1.1.2 Read the rate
1.2.1 Prompt the user for the hours
1.2.2 Read the hours
2. Calculate the gross pay
3. Print the gross pay

```java
System.out.println("What is your hourly pay rate?");
double rate = keyb.nextDouble();
```
Developing The Payroll Program (continued)

```
System.out.println
    ("What is your hourly pay rate?");
double rate = keyb.nextDouble();

1.2.1 Prompt the user for the hours
1.2.2 Read the hours

2. Calculate the gross pay
3. Print the gross pay

System.out.println("How many hours did you work?");
double hours = keyb.nextDouble();
```

```
System.out.println
    ("What is your hourly pay rate?");
double rate = keyb.nextDouble();
System.out.println
    ("How many hours did you work?");
double hours = keyb.nextDouble();

double gross = rate * hours;
```
Developing The Payroll Program (continued)

```java
import java.util.Scanner;

public class Payroll {

    // This program calculates the gross pay for an
    // hourly worker
    // Inputs - hourly rate and hours worked
    // Output - Gross pay
    public static void main(String[] args) {
        Scanner keyb = new Scanner(System.in);

        // Get the hourly rate
        System.out.println
            ("What is your hourly pay rate?");
        double rate = keyb.nextDouble();

        System.out.println
            ("How many hours did you work?");
        double hours = keyb.nextDouble();

        double gross = rate * hours;

        System.out.println("Your gross pay is $" + gross);
    }
}
```
// Get the hours worked
System.out.println
    ("How many hours did you work?");
double hours = keyb.nextDouble();

// Calculate and display the gross pay
double gross = rate * hours;
System.out.println("Your gross pay is 
    + gross);
}
}

Character Data

- All of our programs so far have used variables to store numbers, not words.
- We can store single characters by writing:
  char x, y;
  - x and y can hold one and only one character
- For now, we use character data for input and output only.
A program that uses a character variable

```java
import java.util.Scanner;

public class Polite {
    // A very polite program that greets you by name
    public static void main(String[] args) {
        String name = new String();
        Scanner keyb = new Scanner(System.in);
        // Ask the user his/her name
        System.out.println("What is your name?");
        name = keyb.next();
        // Greet the user
        System.out.println("Glad to meet you, "+ name);
    }
}
```

Using Stepwise Refinement to Design a Program

- You should notice that when we write a program, we start by describing the steps that our program must perform and we subsequently refine this into a long series of more detailed steps until we are writing individual steps. This is called **stepwise refinement**.
- Stepwise refinement is one of the most basic methods for developing a program.
Example – A program to convert pounds to kilograms

- Our program will convert a weight expressed in pounds into kilograms.
  - Our input is the weight in pounds.
  - Our output is the weight in kilograms
  - We also know that
    Kilograms = Pounds / 2.2

Pounds to Kilograms Program (continued)

- Our program must:
  1. Get the weight in pounds
  2. Calculate the weight in kilograms
  3. Print the weight in kilograms
Pounds to Kilograms Program (continued)

• Our program must:

1. Get the weight in pounds
2. Calculate the weight in kilograms
3. Print the weight in kilograms

   1.1 Prompt the user for the weight in pounds
   1.2 Read the pounds

Pounds to Kilograms Program (continued)

• Our program must:

   1.1 Prompt the user for the weight in pounds
   1.2 Read the pounds
   2. Calculate the weight in kilograms
   3. Print the weight in kilograms

```java
System.out.println
    ("What is the weight in pounds?");
double lbs = keyb.nextInt();
```
Pounds to Kilograms Program (continued)

```java
System.out.println
("What is the weight in pounds?");
double lbs = keyb.nextInt();
2. Calculate the weight in kilograms
3. Print the weight in kilograms
double kg = lbs / 2.2;
```

Pounds to Kilograms Program (continued)

```java
System.out.println
("What is the weight in pounds?");
double lbs = keyb.nextInt();
double kg = lbs / 2.2;
3. Print the weight in kilograms
System.out.println("The weight is " + kg + " kilograms");
```
import java.util.Scanner;

public class ConvertPounds {

    // Convert pounds to kilograms
    // Input - weight in pounds
    // Output - weight in kilograms
    public static void main(String[] args) {
        Scanner keyb = new Scanner(System.in);

        // Get the weight in pounds
        System.out.println("What is the weight in pounds?");
        double lbs = keyb.nextInt();

        // Calculate and display the weight in kilograms
        double kg = lbs / 2.2;
        System.out.println("The weight is " + kg + " kilograms");
    }
}

Another Example – The Area of A Rectangle

• Our program will calculate the area of a rectangle.
  – Our input is the length and width.
  – Our output is the area.
  – We also know that
    \[
    \text{Area} = \text{Length} \times \text{Width}
    \]
Our Program’s Steps

1. Find the length and width
2. Calculate the area
3. Print the area

Our Program’s Steps (continued)

1. Find the length and width
2. Calculate the area
3. Print the area

1.1 Find the length
1.2 Find the width
Our Program’s Steps (continued)

1. Find the length
   1.1 Prompt the user for the length
   1.2 Read the length
2. Calculate the area
3. Print the area
   1.1.1 Prompt the user for the length
   1.1.2 Read the length
   1.2.1 Prompt the user for the width
   1.1.2 Read the width

```java
System.out.println("Enter the length?");
double length = keyb.nextDouble();

System.out.println("Enter the width?");
double width = keyb.nextDouble();
```
Our Program’s Steps (continued)

```java
System.out.println("Enter the length?");
double length = keyb.nextDouble();

System.out.println("Enter the width?");
double width = keyb.nextDouble();

2. Calculate the area
3. Print the area
   double area = length * width;
```

Our Program’s Steps (continued)

```java
System.out.println("Enter the length?");
double length = keyb.nextDouble();

System.out.println("Enter the width?");
double width = keyb.nextDouble();
   double area = length * width;
3. Print the area
   System.out.println("The area is " + area);
```
import java.util.Scanner;

public class CalculateArea {
    // Calculates the area of a rectangle
    // Inputs - The length and width of the rectangle
    // Output - The area of the rectangle
    public static void main(String[] args) {
        Scanner keyb = new Scanner(System.in);

        // Print an explanatory message for the user
        System.out.println("Given the width and length of a rectangle");
        System.out.println("this program calculates its area. ");

        // Get the inputs
        System.out.println("Enter the length?");
        double length = keyb.nextDouble();

        System.out.println("Enter the width?");
        double width = keyb.nextDouble();

        // Calculate and display the area
        double area = length * width;
        System.out.println("The area is " + area);
    }
}