Algorithms and Java basics: pseudocode, variables, assignment, and interactive programs

CSC 1051 – Algorithms and Data Structures I
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Algorithms

An algorithm is a specific set of instructions for carrying out a procedure or solving a problem, usually with the requirement that the procedure terminate at some point. Specific algorithms sometimes also go by the name method, procedure, or technique. The word “algorithm” is a distortion of al-Khwārizmī [named after Muhammad ibn al-Khwārizmī], a Persian mathematician who wrote an influential treatise about algebraic methods.

Algorithm Example:
Input-Compute-Output pattern

GPA problem: Write a program that computes and outputs the GPA, given the credits and quality points earned.

Variables: qp, credits, gpa

Algorithm:
1. qp = input from user
2. credits = input from user
3. gpa = qp / credits
4. Print gpa

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Source: http://xkcd.com/627/

Source: http://mathworld.wolfram.com/Algorithm.html
and Wikipedia (http://en.wikipedia.org/wiki/Muhammad_ibn_Maswareh)
Java Program

Algorithm

<table>
<thead>
<tr>
<th>Variables</th>
<th>qp, credits, gpa</th>
</tr>
</thead>
</table>

Algorithm:
1. qp = input from user
2. credits = input from user
3. gpa = qp / credits
4. Print gpa

Interactive Programs – Input/Output

- In Java, you first need to create a Scanner object

```java
int age;
String name;
Scanner scan = new Scanner(System.in);
System.out.print("Enter your name");
name = scan.next();
System.out.print("Enter your age");
age = scan.nextInt();
```

Interactive Programs – Input/Output

- The Scanner class is part of the java.util class library, and must be imported into a program in order to be used
- The import statement goes at beginning of your program (above class definition)

```java
import java.util.Scanner;
public class GPA {
    public static void main (String[] args) {
        // Inputs quality points and credits and calculates GPA.
        double qp, credits, gpa;
        Scanner scan = new Scanner(System.in);
        // Input qp
        System.out.print("Enter Quality Points > ");
        qp = scan.nextInt();
        // Input credits
        System.out.print("Enter Credits > ");
        credits = scan.nextInt();
        // Calculate GPA
        gpa = qp / credits;
        // Print GPA
        System.out.println("tGPA : "+ gpa);
    }
}
```
Interactive Programs – Input/Output

Summary:
1. import the Scanner class, i.e., add this before the class definition of your program:
   ```java
   import java.util.Scanner;
   ```
2. In your main method, before doing any input, declare and initialize the Scanner object
   ```java
   Scanner scan = new Scanner(System.in);
   ```
3. Input away!
   ```java
   System.out.print("Enter your name");
   name = scan.next();
   System.out.print("Enter your age");
   age = scan.nextInt();
   System.out.println("Pleased to meet you, " + name + "!");
   System.out.println("Your age in dog years: " + age*10.5);
   ```

Interactive Programs – Input/Output

Example

```java
import java.util.Scanner;
public class TellMeAboutYou {
    public static void main(String[] args) {
        int age;
        String name;
        Scanner scan = new Scanner(System.in);
        System.out.print("Enter your name");
        name = scan.next();
        System.out.print("Enter your age");
        age = scan.nextInt();
        System.out.println("Pleased to meet you, " + name + "!");
        System.out.println("Your age in dog years: " + age*10.5);
    }
}
```

Enter your name: Fiona
Enter your age: 17
Pleased to meet you, Fiona!
Your age in dog years: 178.5

Inspired by: http://www.onlineconversion.com/dogyears.htm

Scanner methods

- `nextInt()` → input an `int`
- `nextDouble()` → input a `double`
- `nextLine()` → input a `String` (until end of line)
- `next()` → input a `String` token (one word or other delimited “chunk” of text)
  
  - White space (space, tab, new line) are used to separate input tokens

Variables & Assignment

- **Variable**. A name that refers to a value of declared type.
- **Literal**. Programming language representation of a value.
- **Assignment statement**. Associates a value with a variable.

<table>
<thead>
<tr>
<th>type</th>
<th>variable</th>
<th>declaration statement</th>
<th>assignment statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>int</td>
<td>age = 18;</td>
<td>declaration statement</td>
<td>literal</td>
</tr>
<tr>
<td>double</td>
<td>x = 3.2, y = -0.80;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **constant declaration** (always initializes value)
- **final**

```
final int INCHES_PER_FOOT = 12;
String name = scan.nextLine();
```
Variable Declaration

- A variable is a name for a location of data in memory.
- A variable must be declared by specifying the variable's name and the type of information that it will hold.

```
int age;
double x, y;
String name;
```

Assignment Statement

- **Changes the value of a variable**
- The assignment operator is the `=` sign.

```
total = 55 - discount;
```

Some types of data in Java

<table>
<thead>
<tr>
<th>Type</th>
<th>Set of Values</th>
<th>Literal Values</th>
<th>Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>char</td>
<td>characters</td>
<td><code>'A'</code>, <code>'b'</code></td>
<td>compare</td>
</tr>
<tr>
<td>String</td>
<td>sequences of characters</td>
<td>&quot;Hello World&quot;, &quot;jacket123&quot;</td>
<td>concatenate</td>
</tr>
<tr>
<td>int</td>
<td>integers</td>
<td>17, 12345</td>
<td>add, subtract, multiply, divide</td>
</tr>
<tr>
<td>double</td>
<td>floating-point numbers</td>
<td>3.1415, 6.022e23</td>
<td>add, subtract, multiply, divide</td>
</tr>
<tr>
<td>boolean</td>
<td>truth values</td>
<td><code>true</code>, <code>false</code></td>
<td>and, or, not</td>
</tr>
</tbody>
</table>

Combined declaration and assignment

A variable can be given an initial value in the declaration.

```java
int age = 18;
double x = 3.2, y = -0.80;
String name = scan.nextLine();
```
Combined declaration and assignment

A variable can be given an initial value in the declaration - a new value can be assigned later:

```java
int age = 18;
double x = 3.2, y = -0.80;
String name = scan.nextLine();
age = 19;
x = x + 0.5;
name = scan.nextLine();
```

Trace: TRY THIS:

```java
int a, b;
a = 3;
b = 4;
int c = a;
a = b;
b = 5;
b = c;
```

Final values:
- a
- b
- c
Assignment operator

- Assignment (=) copies the value of the right side into the memory location associated with the left side
- It does not set up an ongoing equivalence

```java
int davesAge = 21;
int suesAge = davesAge;
davesAge = 22;
System.out.println (davesAge); // prints 22
System.out.println (suesAge); // prints 21
```

CONSTANTS: like variables, but value cannot change – declare using final modifier:

```java
final int INCHES_PER_FOOT = 12;
final double LBS_PER_KG = 2.2;
```

Conventions: Use UPPER_CASE identifiers

Variables & Assignment

- **Variable.** A name that refers to a value of declared type.
- **Literal.** Programming language representation of a value.
- **Assignment statement.** Associates a value with a variable.

```
type variable declaration statement
age = 18; assignment statement
int age;
double x = 3.2, y = -0.80;
final int INCHES_PER_FOOT = 12;
String name = scan.nextLine();
```

Arithmetic Operators

- **Addition** +
- **Subtraction** -
- **Multiplication** *
- **Division** /
- **Remainder** %

- If either or both operands used by an arithmetic operator are floating point (e.g., type double), then the result is a floating point
Example

```c
int feet = 25;
int inches = feet * INCHES_PER_FOOT;

int seconds = 143;
int minutes = seconds / 60;
int remainingSeconds = seconds % 60;
```

Division and Remainder

- If both operands are integers (e.g., type `int`), the division result is an integer (the fractional part is discarded):

<table>
<thead>
<tr>
<th>Integer Division</th>
<th>Remainder</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 / 3</td>
<td>14 % 3</td>
</tr>
<tr>
<td>143 / 60</td>
<td>143 % 60</td>
</tr>
<tr>
<td>20 / 16</td>
<td>20 % 16</td>
</tr>
<tr>
<td>8 / 12</td>
<td>8 % 12</td>
</tr>
</tbody>
</table>

Operator Precedence

**What is the order of evaluation of sub-expressions?**

1. Multiplication, division, remainder
2. Addition, subtraction, string concatenation
   - Operators with the same precedence: **left to right**
   - Use **parentheses** to override default order

**More examples:**

- `a + b + c + d + e`
- `a / (b + c) - d % e`
- `a - b / c + d * e`
- `a / (b * (c + (d - e)))`

Increment and Decrement

- The **increment operator** (`++`) adds one to its operand
- The **decrement operator** (`--`) subtracts one from its operand
- The statement `count++;`
  - is functionally equivalent to `count = count + 1;`
```java
import java.util.Scanner;

public class GPA {
    public static void main(String[] args) {
        double qp, credits, gpa;
        Scanner scan = new Scanner(System.in);
        // input qp
        System.out.print("Enter Quality Points > ");
        qp = scan.nextInt();
        // input credits
        System.out.print("Enter Credits > ");
        credits = scan.nextInt();
        // calculate GPA
        gpa = qp / credits;
        // print GPA
        System.out.println("GPA: "+ gpa);
    }
}
```

**Writing an algorithm in pseudocode**

- List the variables used.
- List the steps for solving the problem, in order.
- Try to be brief and unambiguous; use Java expressions only when it is simpler to specify a step in Java than in English.

**Example**

Write an algorithm to solve the following problem:

> Input values representing a time duration in hours, minutes, and seconds and then calculate and output the equivalent total number of seconds.

**Example**

Write an algorithm to solve the following problem:

> Input a value representing a number of seconds, then calculate and output the equivalent amount of time as a combination of hours, minutes, and seconds.