Algorithms and Conditionals

CSC 1051 – Data Structures and Algorithms I

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Course website:
www.csc.villanova.edu/~map/1051/
Statement of GPA problem:
Write a program that reads the credits and quality points earned and outputs the gpa.

Algorithm:
variables: qp, credits, gpa
1. Input qp
2. Input credits
3. gpa = qp / credits
4. Print gpa
Algorithm:
variables: qp, credits, gpa
1. Input qp
2. Input credits
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4. Print gpa
Pseudocode: a way to describe what an algorithm does without writing a program.

Algorithm:
variables: qp, credits, gpa
1. Input qp
2. Input credits
3. gpa = qp / credits
4. Print 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.

**Algorithm:**
variables: qp, credits, gpa

1. Input qp
2. Input credits
3. gpa = qp / credits
4. Print 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.

Algorithm:
variables: qp, credits, gpa (use floating point)

1. Input qp
2. Input credits
3. gpa = qp / credits  
   (Note: use floating point division)
4. Print gpa

When the type is not obvious you can add a note.
Another example (from Lab 2):

PP 2.8 Write an application that reads values representing a time duration in hours, minutes, and seconds and then prints the equivalent total number of seconds. (For example, 1 hour, 28 minutes, and 42 seconds is equivalent to 5322 seconds.)
Can we reverse this calculation?

PP 2.9 Create a version of the previous project that reverses the computation. That is, read a value representing a number of seconds, then print the equivalent amount of time as a combination of hours, minutes, and seconds. (For example, 99999 seconds is equivalent to 2 hours, 46 minutes, and 39 seconds.)

The next 3 slides will help us visualize this problem.
Algorithm for PP 2.9
How many of each can you pack in the black box?
How many of each can you pack in the black box?
How many of each can you pack in the black box?
Topic Thread

- 2.1 Character Strings
- 2.2 Variables, Assignment
- 2.3 Data Types, in particular int, double
- 2.4 Expressions (simple)
- 2.5 Data Conversion
- 2.6 Interactive Programs
- 5.1 Boolean Expressions
- 5.2 The if Statement
- 5.5 The while Statement
Order of statement execution

• Unless specified otherwise, the flow of control through a method is *linear*

• ie, *statements are executed in the order they appear*

• We can modify this using *conditional* and *repetition* statements
Algorithm:
variables: qp, credits, gpa
1. Input qp
2. Input credits
3. gpa = qp / credits
4. Print gpa

What if credits = 0  ????
**Algorithm:**
variables: qp, credits, gpa

1. Input qp
2. Input credits
3. if credits = 0
   • Print “No gpa yet”
else
   • gpa = qp / credits
   • Print gpa
4. Print goodbye message

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**Algorithm:**
variables: qp, credits, gpa

1. Input qp
2. Input credits
3. if credits = 0
   • Print "No gpa yet"
else
   • gpa = qp / credits
   • Print gpa
4. Print goodbye message

```java
if (credits == 0)
    System.out.println("\n\tGPA:     None");
else
{
    gpa = qp / credits;
    System.out.println("\n\tGPA:  " + gpa);
}
```
Algorithm:
variables: qp, credits, gpa

1. Input qp
2. Input credits
3. gpa = \( \frac{qp}{\text{credits}} \)
4. Print gpa

```java
import java.util.Scanner;

public class GPA_updated
{
    public static void main (String[] args)
    {
        Scanner scan = new Scanner(System.in);

        // get input
        System.out.print ("Enter Quality Points > ");
        qp = scan.nextInt();
        System.out.print ("Enter Credits > ");
        credits = scan.nextInt();

        // output information entered
        System.out.println ("\n\nQuality Points:   " + qp);
        System.out.println ("Credits:        " + credits);

        // calculate and output GPA, if possible
        if (credits == 0)
        {
            System.out.println ("\n\tGPA:     None\n" + gpa);
        }
        else
        {
            gpa = qp / credits;
            System.out.println ("\n\tGPA:  " + gpa);
        }
    }
}
```

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Conditional statements

- Conditional statements depart from linear flow of control:
- Example:

```java
if (credits == 0)
    System.out.println ("GPA: None");
```

A *boolean expression*
Topic Thread

• 2.1 Character Strings
• 2.2 Variables, Assignment
• 2.3 Data Types, in particular int, double
• 2.4 Expressions (simple)
• 2.5 Data Conversion
• 2.6 Interactive Programs
• 5.1 Boolean Expressions
• 5.2 The if Statement
• 5.5 The while Statement
5.1 Boolean Expressions

• A condition often uses one of Java's *equality operators* or *relational operators*, which all return boolean results:

  ```
  ==       equal to
  !=       not equal to
  <        less than
  >        greater than
  <=       less than or equal to
  >=       greater than or equal to
  ```

• Note the difference between the equality operator (==) and the assignment operator (=)
Boolean Expressions

• The reserved words `true` and `false` are the only valid values for a `boolean` type

• Example `boolean` declaration:

  ```java
  boolean aboveAgeLimit = false;
  ```

• Another example:

  ```java
  boolean usePlural = quarters > 1;
  ```

A boolean expression using a relational operator
Example

• An `if` statement with its boolean condition:

```java
if (miles > 1)
    System.out.print("s");
```

• Another way, using a boolean variable:

```java
boolean usePlural = miles > 1;
if (usePlural)
    System.out.print("s");
```

• See also `Age.java`
import java.util.Scanner;

public class Age
{
    public static void main (String[] args)
    {
        final int MINOR = 21;

        Scanner scan = new Scanner (System.in);

        System.out.print ("Enter your age: ");
        int age = scan.nextInt();

        continue
System.out.println("You entered: " + age);

if (age < MINOR)
    System.out.println("Youth is a wonderful thing. Enjoy.");

    System.out.println("Age is a state of mind.");

}
```java
System.out.println("You entered: "+ age);
if (age < MINOR)
    System.out.println("Youth is a wonderful thing. Enjoy.");
System.out.println("Age is a state of mind.");
```

**Sample Run**

Enter your age: 47
You entered: 47
Age is a state of mind.

**Another Sample Run**

Enter your age: 12
You entered: 12
Youth is a wonderful thing. Enjoy.
Age is a state of mind.
The if Statement

- Let's now look at the `if` statement in more detail
- The *if statement* has the following syntax:

```java
if (condition)
    statement;
```

*The condition* must be a boolean expression. It must evaluate to either true or false.

If the *condition* is true, the *statement* is executed. If it is false, the *statement* is skipped.

*If* is a Java reserved word.
Logic of an if statement

- Condition evaluated
  - If true, execute the statement
  - If false, do nothing

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Indentation

• The statement controlled by the $if$ statement is indented to indicate that relationship

• The use of a consistent indentation style makes a program easier to read and understand

• The compiler ignores indentation
The if-else Statement

• An *else clause* can be added to an `if` statement to make an *if-else statement*

```java
if ( condition )
    statement1;
else
    statement2;
```

• If the *condition* is true, *statement1* is executed; if the condition is false, *statement2* is executed

• One or the other will be executed, but not both

• See _Wages.java_
Example: Calculating wages with overtime

Variables:
- hours, pay

Algorithm:
import java.text.NumberFormat;
import java.util.Scanner;

public class Wages {
    public static void main(String[] args) {
        final double RATE = 8.25; // regular pay rate
        final int STANDARD = 40; // standard hours in a work week

        Scanner scan = new Scanner(System.in);

        double pay = 0.0;
        continue
System.out.print ("Enter the number of hours worked: ");
int hours = scan.nextInt();

System.out.println ();

// Pay overtime at "time and a half"
if (hours > STANDARD)
    pay = STANDARD * RATE + (hours-STANDARD) * (RATE * 1.5);
else
    pay = hours * RATE;

NumberFormat fmt = NumberFormat.getCurrencyInstance();
System.out.println ("Gross earnings: " + fmt.format(pay));
System.out.print("Enter the number of hours worked: ");
int hours = scan.nextInt();
System.out.println();

// Pay overtime at "time and a half"
if (hours > STANDARD)
    pay = STANDARD * RATE + (hours-STANDARD) * (RATE * 1.5);
else
    pay = hours * RATE;

NumberFormat fmt = NumberFormat.getCurrencyInstance();
System.out.println("Gross earnings: "+fmt.format(pay));
}
Logic of an if-else statement

- **condition evaluated**
  - **true** → **statement1**
  - **false** → **statement2**
Block Statements

• Several statements can be grouped together into a block statement delimited by braces

• A block statement can be used wherever a statement is called for in the Java syntax rules

```java
if (total > MAX) {
    System.out.println ("Error!!");
    errorCount++;
}
```
Block Statements

- The if clause, or the else clause, or both, could govern block statements

```java
if (total > MAX)
{
    System.out.println("Error!!");
    errorCount++;
}
else
{
    System.out.println("Total: " + total);
    current = total*2;
}
```
Indentation Revisited

- Remember that indentation is for the human reader, and is ignored by the computer.

```java
if (total > MAX)
    System.out.println("Error!!");
    errorCount = errorcount + 1;
```

Despite what is implied by the indentation, the increment will occur whether the condition is true or not.
Logical Operators

• Boolean expressions can also use the following *logical operators*:

\[ \begin{align*}
! & \quad \text{Logical NOT} \\
&& \quad \text{Logical AND} \\
\| \| & \quad \text{Logical OR}
\end{align*} \]

• They all take boolean operands and produce boolean results

• Logical NOT is a unary operator (it operates on one operand)

• Logical AND and logical OR are binary operators (each operates on two operands)
Logical NOT

- The *logical NOT* operation is also called *logical negation* or *logical complement*.

- If some boolean condition $a$ is true, then $!a$ is false; if $a$ is false, then $!a$ is true.

- Logical expressions can be shown using a *truth table*:

<table>
<thead>
<tr>
<th>$a$</th>
<th>$!a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>false</td>
<td>true</td>
</tr>
</tbody>
</table>
Logical AND and Logical OR

• The *logical AND* expression

\[ a \land b \]

is true if both \( a \) and \( b \) are true, and false otherwise

• The *logical OR* expression

\[ a \lor b \]

is true if \( a \) or \( b \) or both are true, and false otherwise
Logical AND and Logical OR

- A truth table shows all possible true-false combinations of the terms

- Since `&&` and `||` each have two operands, there are four possible combinations of conditions `a` and `b`

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>b</td>
<td>a &amp;&amp; b</td>
<td>a</td>
</tr>
<tr>
<td>true</td>
<td>true</td>
<td>true</td>
<td>true</td>
</tr>
<tr>
<td>true</td>
<td>false</td>
<td>false</td>
<td>true</td>
</tr>
<tr>
<td>false</td>
<td>true</td>
<td>false</td>
<td>true</td>
</tr>
<tr>
<td>false</td>
<td>false</td>
<td>false</td>
<td>false</td>
</tr>
</tbody>
</table>
Logical Operators

• Expressions that use logical operators can form complex conditions

```java
if (total < MAX+5 && !found)
    System.out.println("Processing..."******
```

• All logical operators have lower precedence than the relational operators

• The `!` operator has higher precedence than `&&` and `||`
Boolean Expressions

- Specific expressions can be evaluated using truth tables – let’s try this one:

<table>
<thead>
<tr>
<th>total &lt; MAX</th>
<th>found</th>
<th>!found</th>
<th>total &lt; MAX &amp;&amp; !found</th>
</tr>
</thead>
<tbody>
<tr>
<td>false</td>
<td>false</td>
<td></td>
<td></td>
</tr>
<tr>
<td>false</td>
<td>true</td>
<td></td>
<td></td>
</tr>
<tr>
<td>true</td>
<td>false</td>
<td></td>
<td></td>
</tr>
<tr>
<td>true</td>
<td>true</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Quick Check

What do the following statements do?

```java
if (total != stock + warehouse)
    inventoryError = true;

if (found || !done)
    System.out.println("Ok");
```
Boolean Expressions

- using truth tables – let’s try this one:

| found | done | !done | found || !done |
|-------|------|-------|-------|--------|
| false | false|       |       |        |
| false | true |       |       |        |
| true  | false|       |       |        |
| true  | true |       |       |        |
How much of a boolean expression do we need to evaluate before determining its value?

*** Short-Circuited Operators

- The processing of `&&` and `||` is “short-circuited” in cases where the left operand is sufficient to determine the result (the right operand is not evaluated at all)

- This can be both useful and dangerous!

```java
if (count != 0 && total/count > MAX)
    System.out.println ("Testing.");
```
Nested if Statements

- The statement executed as a result of an `if` or `else` clause could be another `if` statement.
- These are called *nested if statements*.
- An `else` clause is matched to the last unmatched `if` (no matter what the indentation implies).
- Braces can be used to specify the `if` statement to which an `else` clause belongs.
- See `MinOfThree.java`
import java.util.Scanner;

public class MinOfThree
{
    //--
    //  Reads three integers from the user and determines the smallest
    //  value.
    //--
    public static void main (String[] args)
    {
        int num1, num2, num3, min = 0;

        Scanner scan = new Scanner (System.in);

        System.out.println ("Enter three integers: ");
        num1 = scan.nextInt();
        num2 = scan.nextInt();
        num3 = scan.nextInt();

        continue
continue

    if (num1 < num2)
        if (num1 < num3)
            min = num1;
        else
            min = num3;
    else
        if (num2 < num3)
            min = num2;
        else
            min = num3;

    System.out.println("Minimum value: "+min);
}
}
continue

```java
if (num1 < num2)
    if (num1 < num3)
        min = num1;
    else
        min = num3;
else
    if (num2 < num3)
        min = num2;
    else
        min = num3;

System.out.println("Minimum value: " + min);
```
```
Homework

• Read Sections 5.1, 5.2
  – pages 208-218 and 221-226 (skip coin example in listings 5.3, 5.4)

  – **Always** do all self-review exercises when you review material

• Do Exercises EX 5.1 – 5.5