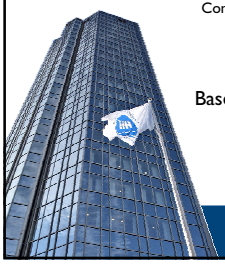
5

Conditionals and Loops



Based on template from Lewis & Loftus

Conditionals and Loops

- Now we will examine programming statements that allow us to:
  - make decisions
  - repeat processing steps in a loop
- Chapter 5 focuses on:
  - boolean expressions
  - conditional statements
  - comparing data
  - repetition statements
  - iterators
  - more drawing techniques
  - more GUI components

Outline

Flow of Control

- Unless specified otherwise, the order of statement execution through a method is linear: one statement after another in sequence
- Some programming statements allow us to:
  - decide whether or not to execute a particular statement
  - execute a statement over and over, repetitively
- These decisions are based on *boolean expressions* (or *conditions*) that evaluate to true or false
- The order of statement execution is called the *flow of control*

Conditional Statements

- A *conditional statement* lets us choose which statement will be executed next
- Therefore they are sometimes called *selection statements*
- Conditional statements give us the power to make basic decisions
- The Java conditional statements are the:
  - *if statement*
  - *if-else statement*
  - *switch statement*

The if Statement

- The *if statement* has the following syntax:

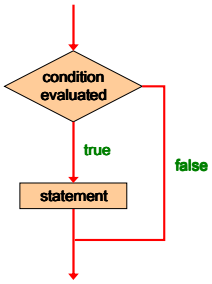
`if` is a Java reserved word

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

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

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

Logic of an if statement



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 (=)

The if Statement

- An example of an `if` statement:

```
if (sum > MAX)
   delta = sum - MAX;
System.out.println ("The sum is " + sum);
```

  - First the condition is evaluated -- the value of `sum` is either greater than the value of `MAX`, or it is not
  - If the condition is true, the assignment statement is executed -- if it isn't, it is skipped.
  - Either way, the call to `println` is executed next
  - See Age.java (page 216)

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
- Although it makes no difference to the compiler, proper indentation is crucial

"Always code as if the person who ends up maintaining your code will be a violent psychopath who knows where you live."

-- Martin Golding

The if Statement

- What do the following statements do?

```
if (top >= MAXIMUM)
   top = 0;
```

Sets `top` to zero if the current value of `top` is greater than or equal to the value of `MAXIMUM`

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

Sets a flag to true if the value of `total` is not equal to the sum of `stock` and `warehouse`

- The precedence of the arithmetic operators is higher than the precedence of the equality and relational operators

Logical Operators

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

!	Logical NOT
&&	Logical AND
||	Logical OR

- 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*

a	!a
true	false
false	true

Logical AND and Logical OR

- The *logical AND* expression

  a && b

  is true if both a and b are true, and false otherwise
- The *logical OR* expression

  a || b

  is true if a or b or both are true, and false otherwise

Logical Operators

- Expressions that use logical operators can form complex conditions

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

  - All logical operators have lower precedence than the relational operators
  - Logical NOT has higher precedence than logical AND and logical OR

Logical Operators

- 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

a	b	a && b	a || b
true	true	true	true
true	false	false	true
false	true	false	true
false	false	false	false

Boolean Expressions

- Specific expressions can be evaluated using truth tables

total < MAX	found	!found	total < MAX && !found
false	false	true	false
false	true	false	false
true	false	true	true
true	true	false	false

Short-Circuited Operators

- The processing of logical AND and logical OR is "short-circuited"
- If the left operand is sufficient to determine the result, the right operand is not evaluated

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

- This type of processing must be used carefully

Outline

- The `if` Statement and Conditions
- Other Conditional Statements
- Comparing Data
- The `while` Statement
- Iterators
- Other Repetition Statements
- Decisions and Graphics
- More Components

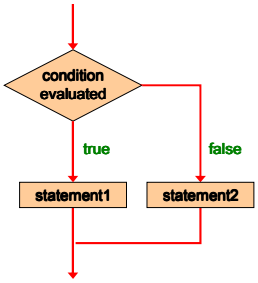
The if-else Statement

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

```
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 (page 219)

Logic of an if-else statement



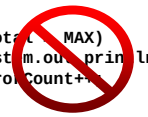
The Coin Class

- Let's examine a class that represents a coin that can be flipped
- Instance data is used to indicate which face (heads or tails) is currently showing
- See CoinFlip.java (page 220)
- See Coin.java (page 221)

Indentation Revisited

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

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



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

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

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

Block Statements

- In an `if-else` statement, the `if` portion, or the `else` portion, or both, could be block statements

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

- See Guessing.java (page 223)

Nested if Statements

- The statement executed as a result of an `if` statement or `else` clause could be another `if` statement
- These are called *nested if statements*
- See MinOfThree.java (page 227)
- 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

The switch Statement

- The *switch statement* provides another way to decide which statement to execute next
- The `switch` statement evaluates an expression, then attempts to match the result to one of several possible *cases*
- Each case contains a value and a list of statements
- The flow of control transfers to statement associated with the first case value that matches

The switch Statement

- The general syntax of a `switch` statement is:

switch and case are reserved words

```
switch ( expression )
{
   case value1 :
      statement-list1
   case value2 :
      statement-list2
   case value3 :
      statement-list3
   case  ...

}
```

If *expression* matches *value2*, control jumps to here

The switch Statement

- Often a *break statement* is used as the last statement in each case's statement list
- A `break` statement causes control to transfer to the end of the `switch` statement
- If a `break` statement is not used, the flow of control will continue into the next case
- Sometimes this may be appropriate, but often we want to execute only the statements associated with one case

The switch Statement

- An example of a switch statement:

```
switch (option)
{
   case 'A':
      aCount++;
      break;
   case 'B':
      bCount++;
      break;
   case 'C':
      cCount++;
      break;
}
```

The switch Statement

- A `switch` statement can have an optional *default case*
- The default case has no associated value and simply uses the reserved word `default`
- If the default case is present, control will transfer to it if no other case value matches
- If there is no default case, and no other value matches, control falls through to the statement after the switch

The switch Statement

- The expression of a `switch` statement must result in an *integral type*, meaning an integer (`byte`, `short`, `int`, `long`) or a `char`
- It cannot be a `boolean` value or a floating point value (`float` or `double`)
- The implicit boolean condition in a `switch` statement is equality
- You cannot perform relational checks with a `switch` statement
- See GradeReport.java (page 233)

Outline

Comparing Data

- When comparing data using boolean expressions, it's important to understand the nuances of certain data types
- Let's examine some key situations:
  - Comparing floating point values for equality
  - Comparing characters
  - Comparing strings (alphabetical order)
  - Comparing object vs. comparing object references

Comparing Float Values

- You should rarely use the equality operator (==) when comparing two floating point values (`float` or `double`)
- Two floating point values are equal only if their underlying binary representations match exactly
- Computations often result in slight differences that may be irrelevant
- In many situations, you might consider two floating point numbers to be "close enough" even if they aren't exactly equal

Comparing Float Values

- To determine the equality of two floats, you may want to use the following technique:

```
if (Math.abs(f1 - f2) < TOLERANCE)
   System.out.println ("Essentially equal");
```

  - If the difference between the two floating point values is less than the tolerance, they are considered to be equal
  - The tolerance could be set to any appropriate level, such as 0.000001

Comparing Characters

- As we've discussed, Java character data is based on the Unicode character set
- Unicode establishes a particular numeric value for each character, and therefore an ordering
- We can use relational operators on character data based on this ordering
- For example, the character `'+'` is less than the character `'J'` because it comes before it in the Unicode character set
- Appendix C provides an overview of Unicode

Comparing Characters

- In Unicode, the digit characters (0-9) are contiguous and in order
- Likewise, the uppercase letters (A-Z) and lowercase letters (a-z) are contiguous and in order

Characters	Unicode Values
0 – 9	48 through 57
A – Z	65 through 90
a – z	97 through 122

Comparing Strings

- Remember that in Java a character string is an object
- The `equals` method can be called with strings to determine if two strings contain exactly the same characters in the same order
- The `equals` method returns a boolean result

```
if (name1.equals(name2))
   System.out.println ("Same name");
```


Comparing Strings

- We cannot use the relational operators to compare strings
- The `String` class contains a method called `compareTo` to determine if one string comes before another
- A call to `name1.compareTo(name2)`
  - returns zero if `name1` and `name2` are equal (contain the same characters)
  - returns a negative value if `name1` is less than `name2`
  - returns a positive value if `name1` is greater than `name2`

Comparing Strings

```
if (name1.compareTo(name2) < 0)
   System.out.println (name1 + "comes first");
else
   if (name1.compareTo(name2) == 0)
      System.out.println ("Same name");
   else
      System.out.println (name2 + "comes first");
```

- Because comparing characters and strings is based on a character set, it is called a *lexicographic ordering*

Lexicographic Ordering

- Lexicographic ordering is not strictly alphabetical when uppercase and lowercase characters are mixed
- For example, the string `"Great"` comes before the string `"fantastic"` because all of the uppercase letters come before all of the lowercase letters in Unicode
- Also, short strings come before longer strings with the same prefix (lexicographically)
- Therefore `"book"` comes before `"bookcase"`

Comparing Objects

- The == operator can be applied to objects – it returns true if the two references are aliases of each other
- The `equals` method is defined for all objects, but unless we redefine it when we write a class, it has the same semantics as the == operator
- It has been redefined in the `String` class to compare the characters in the two strings
- When you write a class, you can redefine the `equals` method to return true under whatever conditions are appropriate

Outline

Repetition Statements

- *Repetition statements* allow us to execute a statement multiple times
- Often they are referred to as *loops*
- Like conditional statements, they are controlled by boolean expressions
- Java has three kinds of repetition statements:
  - the *while loop*
  - the *do loop*
  - the *for loop*
- The programmer should choose the right kind of loop for the situation

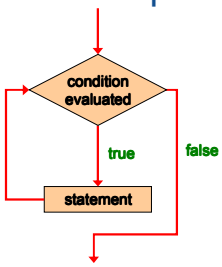
The while Statement

- A *while statement* has the following syntax:

```
while ( condition )
   statement;
```

  - If the `condition` is true, the `statement` is executed
  - Then the condition is evaluated again, and if it is still true, the statement is executed again
  - The statement is executed repeatedly until the condition becomes false

Logic of a while Loop



The while Statement

- An example of a while statement:

```
int count = 1;
while (count <= 5)
{
   System.out.println (count);
   count++;
}
```

  - If the condition of a `while` loop is false initially, the statement is never executed
  - Therefore, the body of a `while` loop will execute zero or more times

The while Statement

- Let's look at some examples of loop processing
- A loop can be used to maintain a *running sum*
- A *sentinel value* is a special input value that represents the end of input
- See Average.java (page 237)
- A loop can also be used for *input validation*, making a program more *robust*
- See WinPercentage.java (page 239)

Infinite Loops

- The body of a `while` loop eventually must make the condition false
- If not, it is called an *infinite loop*, which will execute until the user interrupts the program
- This is a common logical error
- You should always double check the logic of a program to ensure that your loops will terminate normally

Infinite Loops

- An example of an infinite loop:

```
int count = 1;
while (count <= 25)
{
   System.out.println (count);
   count = count - 1;
}
```

  - This loop will continue executing until interrupted (Control-C) or until an underflow error occurs

Nested Loops

- Similar to nested `if` statements, loops can be nested as well
- That is, the body of a loop can contain another loop
- For each iteration of the outer loop, the inner loop iterates completely
- See PalindromeTester.java (page 243)

Nested Loops

- How many times will the string "Here" be printed?

```
count1 = 1;
while (count1 <= 10)
{
   count2 = 1;
   while (count2 <= 20)
   {
      System.out.println ("Here");
      count2++;
   }
   count1++;
}
```

10 * 20 = 200

Outline

- The `if` Statement and Conditions
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- Iterators
- ⇨ Other Repetition Statements
- Decisions and Graphics
- More Components

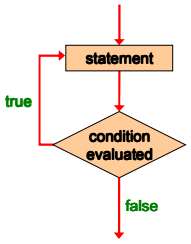
The do Statement

- A *do statement* has the following syntax:

```
do
{
   statement;
}
while ( condition )
```

  - The `statement` is executed once initially, and then the `condition` is evaluated
  - The statement is executed repeatedly until the condition becomes false

Logic of a do Loop



The do Statement

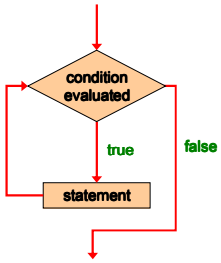
- An example of a do loop:

```
int count = 0;
do
{
   count++;
   System.out.println (count);
} while (count < 5);
```

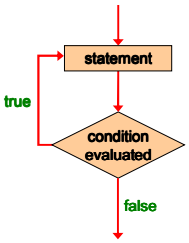
  - The body of a do loop executes at least once
  - See ReverseNumber.java (page 251)

Comparing while and do

The while Loop



The do Loop



The for Statement

- A *for statement* has the following syntax:

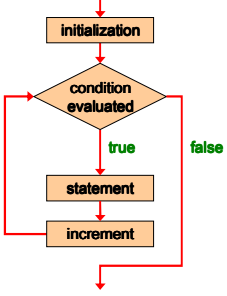
The *initialization* is executed once before the loop begins

The *statement* is executed until the *condition* becomes false

```
for ( initialization ; condition ; increment )
   statement;
```

The *increment* portion is executed at the end of each iteration

Logic of a for loop



The for Statement

- A `for` loop is functionally equivalent to the following `while` loop structure:

```
initialization;
while ( condition )
{
   statement;
   increment;
}
```


The for Statement

- An example of a `for` loop:

```
for (int count=1; count <= 5; count++)
   System.out.println (count);
```

  - The initialization section can be used to declare a variable
  - Like a `while` loop, the condition of a `for` loop is tested prior to executing the loop body
  - Therefore, the body of a `for` loop will execute zero or more times

The for Statement

- The increment section can perform any calculation

```
for (int num=100; num > 0; num -= 5)
   System.out.println (num);
```

  - A `for` loop is well suited for executing statements a specific number of times that can be calculated or determined in advance
  - See Multiples.java (page 255)
  - See Stars.java (page 257)

The for Statement

- Each expression in the header of a `for` loop is optional
- If the initialization is left out, no initialization is performed
- If the condition is left out, it is always considered to be true, and therefore creates an infinite loop
- If the increment is left out, no increment operation is performed

Iterators and for Loops

- Recall that an iterator is an object that allows you to process each item in a collection
- A variant of the `for` loop simplifies the repetitive processing the items
- For example, if `BookList` is an iterator that manages `Book` objects, the following loop will print each book:

```
for (Book myBook : BookList)
   System.out.println (myBook);
```


Iterators and for Loops

- This style of `for` loop can be read "for each `Book` in `BookList`, …"
- Therefore the iterator version of the `for` loop is sometimes referred to as the *foreach* loop
- It eliminates the need to call the `hasNext` and `next` methods explicitly
- It also will be helpful when processing arrays, which are discussed in Chapter 7

Outline

- The `if` Statement and Conditions
- Other Conditional Statements
- Comparing Data
- The `while` Statement
- Iterators
- Other Repetition Statements
- Decisions and Graphics
- More Components

Drawing Techniques

- Conditionals and loops enhance our ability to generate interesting graphics
- See Bullseye.java (page 259)
- See BullseyePanel.java (page 290)
- See Boxes.java (page 262)
- See BoxesPanel.java (page 263)

Determining Event Sources

- Recall that interactive GUIs require establishing a relationship between components and the listeners that respond to component events
- One listener object can be used to listen to two different components
- The source of the event can be determined by using the `getSource` method of the event passed to the listener
- See LeftRight.java (page 265)
- See LeftRightPanel.java (page 266)

Summary

- Chapter 5 focused on:
  - boolean expressions
  - conditional statements
  - comparing data
  - repetition statements
  - iterators
  - more drawing techniques
  - more GUI components