Chapter 3: Program Statements

Presentation slides for

Java Software Solutions

Foundations of Program Design
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Program Statements

- We will now examine some other program statements
- Chapter 3 focuses on:
  - the flow of control through a method
  - decision-making statements
  - operators for making complex decisions
  - repetition statements
  - software development stages
  - more drawing techniques

Flow of Control

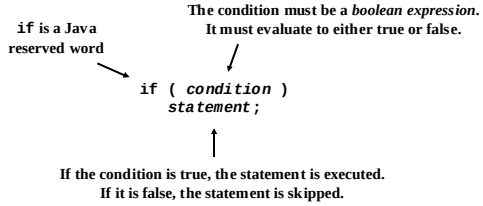
- Unless indicated otherwise, the order of statement execution through a method is linear: one after the other in the order they are written
- Some programming statements modify that order, allowing us to:
  - decide whether or not to execute a particular statement, or
  - perform a statement over and over repetitively
- 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
- Java's conditional statements are the *if statement*, the *if-else statement*, and the *switch statement*

The if Statement

- The *if statement* has the following syntax:



The if Statement

- An example of an if statement:

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

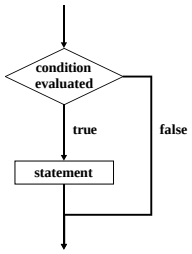
First, the condition is evaluated. The value of `sum` is either greater than the value of `MAX`, or it is not.

If the condition is true, the assignment statement is executed. If it is not, the assignment statement is skipped.

Either way, the call to println is executed next.

- See Age.java (page 112)

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 (=)

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The if-else Statement

- An *else clause* can be added to an if statement to make it 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 116)

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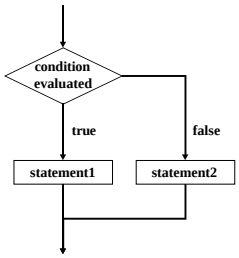
Logic of an if-else statement



Block Statements

- Several statements can be grouped together into a *block statement*
- A block is delimited by braces ({ … })
- A block statement can be used wherever a statement is called for in the Java syntax
- For example, in an if-else statement, the if portion, or the else portion, or both, could be block statements
- See Guessing.java (page 117)

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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 118)
- An else clause is matched to the last unmatched if (no matter what the indentation implies)

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Comparing Characters

- We can use the relational operators on character data
- The results are based on the Unicode character set
- The following condition is true because the character '+' comes before the character 'J' in Unicode:

```
if ('+' < 'J')
   System.out.println ("+ is less than J");
```

- The uppercase alphabet (A-Z) and the lowercase alphabet (a-z) both appear in alphabetical order in Unicode

Comparing Strings

- Remember that a character string in Java is an object
- We cannot use the relational operators to compare strings
- The `equals` method can be called on a string to determine if two strings contain exactly the same characters in the same order
- The String class also contains a method called `compareTo` to determine if one string comes before another alphabetically (as determined by the Unicode character set)

Comparing Floating Point Values

- We also have to be careful when comparing two floating point values (`float` or `double`) for equality
- You should rarely use the equality operator (==) when comparing two floats
- In many situations, you might consider two floating point numbers to be "close enough" even if they aren't exactly equal
- Therefore, to determine the equality of two floats, you may want to use the following technique:

```
if (Math.abs (f1 - f2) < 0.00001)
   System.out.println ("Essentially equal.");
```

The switch Statement

- The *switch statement* provides another means 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 list associated with the first value that matches

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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 can be helpful, but usually we only want to execute the statements associated with one case

The switch Statement

- A switch statement can have an optional *default case* as the last case in the statement
- 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 data type*, like an integer or character; it cannot be a floating point value
- Note that the implicit boolean condition in a switch statement is equality - it tries to match the expression with a value
- You cannot perform relational checks with a switch statement
- See GradeReport.java (page 121)

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 has one operand), but logical AND and logical OR are binary operators (they each have two operands)

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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 *truth tables*

a	!a
true	false
false	true

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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

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Truth Tables

- A truth table shows the possible true/false combinations of the terms
- Since `&&` and `||` each have two operands, there are four possible combinations of true and false

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

Logical Operators

- Conditions in selection statements and loops can use logical operators to form complex expressions

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

- Logical operators have precedence relationships between themselves and other operators

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Truth Tables

- 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

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More Operators

- To round out our knowledge of Java operators, let's examine a few more
- In particular, we will examine the:
  - increment and decrement operators
  - assignment operators
  - conditional operator

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Increment and Decrement Operators

- The increment and decrement operators are arithmetic and operate on one operand
- The *increment operator* (++) adds one to its operand
- The *decrement operator* (--) subtracts one from its operand
- The statement

```
count++;
```

is essentially equivalent to

```
count = count + 1;
```

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Increment and Decrement Operators

- The increment and decrement operators can be applied in *prefix form* (before the variable) or *postfix form* (after the variable)
- When used alone in a statement, the prefix and postfix forms are basically equivalent. That is,

```
count++;
```

is equivalent to

```
++count;
```

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Increment and Decrement Operators

- When used in a larger expression, the prefix and postfix forms have a different effect
- In both cases the variable is incremented (decremented)
- But the value used in the larger expression depends on the form:

Expression	Operation	Value of Expression
count++	add 1	old value
++count	add 1	new value
count--	subtract 1	old value
--count	subtract 1	new value

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Increment and Decrement Operators

- If `count` currently contains 45, then

```
total = count++;
```

  assigns 45 to `total` and 46 to `count`

- If `count` currently contains 45, then

```
total = ++count;
```

  assigns the value 46 to both `total` and `count`

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Assignment Operators

- Often we perform an operation on a variable, then store the result back into that variable
- Java provides *assignment operators* to simplify that process
- For example, the statement

```
num += count;
```

  is equivalent to

```
num = num + count;
```

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Assignment Operators

- There are many assignment operators, including the following:

Operator	Example	Equivalent To
`+=`	`x += y`	`x = x + y`
`-=`	`x -= y`	`x = x - y`
`*=`	`x *= y`	`x = x * y`
`/=`	`x /= y`	`x = x / y`
`%=`	`x %= y`	`x = x % y`

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Assignment Operators

- The right hand side of an assignment operator can be a complete expression
- The entire right-hand expression is evaluated first, then the result is combined with the original variable
- Therefore

```
result /= (total-MIN) % num;
```

  is equivalent to

```
result = result / ((total-MIN) % num);
```

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The Conditional Operator

- Java has a *conditional operator* that evaluates a boolean condition that determines which of two other expressions is evaluated
- The result of the chosen expression is the result of the entire conditional operator
- Its syntax is:

```
condition ? expression1 : expression2
```

- If the *condition* is true, *expression1* is evaluated; if it is false, *expression2* is evaluated

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The Conditional Operator

- The conditional operator is similar to an if-else statement, except that it is an expression that returns a value
- For example:

```
larger = (num1 > num2) ? num1 : num2;
```

- If `num1` is greater that `num2`, then `num1` is assigned to `larger`; otherwise, `num2` is assigned to `larger`
- The conditional operator is *ternary*, meaning that it requires three operands

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The Conditional Operator

- Another example:

```
System.out.println ("Your change is " + count +
   (count == 1) ? "Dime" : "Dimes");
```

- If `count` equals 1, then `"Dime"` is printed
- If `count` is anything other than 1, then `"Dimes"` is printed

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Repetition Statements

- *Repetition statements* allow us to execute a statement multiple times repetitively
- They are often simply 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*, and the *for loop*
- The programmer must choose the right kind of loop for the situation

The while Statement

- The *while statement* has the following syntax:

`while` is a reserved word

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

If the condition is true, the statement is executed. Then the condition is evaluated again.

The statement is executed repetitively until the condition becomes false.

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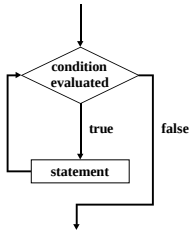
Logic of a while loop



The while Statement

- Note that if the condition of a while statement is false initially, the statement is never executed
- Therefore, the body of a while loop will execute zero or more times
- See Counter.java (page 133)
- See Average.java (page 134)
- See WinPercentage.java (page 136)

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Infinite Loops

- The body of a while loop must eventually make the condition false
- If not, it is an *infinite loop*, which will execute until the user interrupts the program
- See Forever.java (page 138)
- This is a common type of logical error
- You should always double check to ensure that your loops will terminate normally

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Nested Loops

- Similar to nested if statements, loops can be nested as well
- That is, the body of a loop could contain another loop
- Each time through the outer loop, the inner loop will go through its entire set of iterations
- See PalindromeTester.java (page 137)

The do Statement

- The *do statement* has the following syntax:

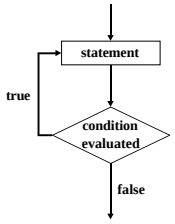
Uses both the `do` and `while` reserved words

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

The statement is executed once initially, then the condition is evaluated

The statement is repetitively executed until the condition becomes false

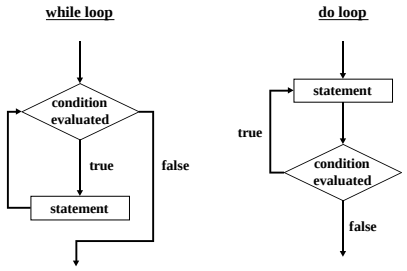
Logic of a do loop



The do Statement

- A do loop is similar to a while loop, except that the condition is evaluated after the body of the loop is executed
- Therefore the body of a do loop will execute at least one time
- See Counter2.java (page 143)
- See ReverseNumber.java (page 144)

Comparing the while and do loops



The for Statement

- The *for statement* has the following syntax:

Reserved word

The *initialization* portion is executed once before the loop begins

The statement is executed until the *condition* becomes false

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

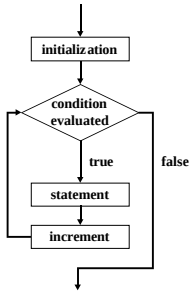
The *increment* portion is executed at the end of each iteration

The for Statement

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

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

Logic of a for loop



The for Statement

- Like a while loop, the condition of a for statement is tested prior to executing the loop body
- Therefore, the body of a for loop will execute zero or more times
- It is well suited for executing a specific number of times that can be determined in advance
- See Counter3.java (page 146)
- See Multiples.java (page 147)
- See Stars.java (page 150)

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
- Both semi-colons are always required in the for loop header

Program Development

- The creation of software involves four basic activities:
  - establishing the requirements
  - creating a design
  - implementing the code
  - testing the implementation
- The development process is much more involved than this, but these basic steps are a good starting point

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Requirements

- *Requirements* specify the tasks a program must accomplish (what to do, not how to do it)
- They often include a description of the user interface
- An initial set of requirements are often provided, but usually must be critiqued, modified, and expanded
- It is often difficult to establish detailed, unambiguous, complete requirements
- Careful attention to the requirements can save significant time and money in the overall project

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Design

- An *algorithm* is a step-by-step process for solving a problem
- A program follows one or more algorithms to accomplish its goal
- The *design* of a program specifies the algorithms and data needed
- In object-oriented development, the design establishes the classes, objects, and methods that are required
- The details of a method may be expressed in *pseudocode*, which is code-like, but does not necessarily follow any specific syntax

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Implementation

- *Implementation* is the process of translating a design into source code
- Most novice programmers think that writing code is the heart of software development, but it actually should be the least creative step
- Almost all important decisions are made during requirements analysis and design
- Implementation should focus on coding details, including style guidelines and documentation
- See ExamGrades.java (page 155)

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Testing

- A program should be executed multiple times with various input in an attempt to find errors
- *Debugging* is the process of discovering the cause of a problem and fixing it
- Programmers often erroneously think that there is "only one more bug" to fix
- Tests should focus on design details as well as overall requirements

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More Drawing Techniques

- Conditionals and loops can greatly enhance our ability to control graphics
- See Bullseye.java (page 157)
- See Boxes.java (page 159)
- See BarHeights.java (page 162)