Conditionals and Loops

Chapter 5

5TH EDITION

Lewis & Loftus

java

Software Solutions

Foundations of Program Design

Conditionals and Loops

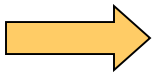
- **Now we will examine programming statements that allow us to:**
  - **make decisions**
  - **repeat processing steps in a loop**

10/3/17
control structures
assignment #4
in class

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

-sequence
-selection : branching
-iteration: looping

Outline



The `if` Statement and Conditions

Other Conditional Statements

Comparing Data

The `while` Statement

Iterators

Other Repetition Statements

Decisions and Graphics

More Components

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.

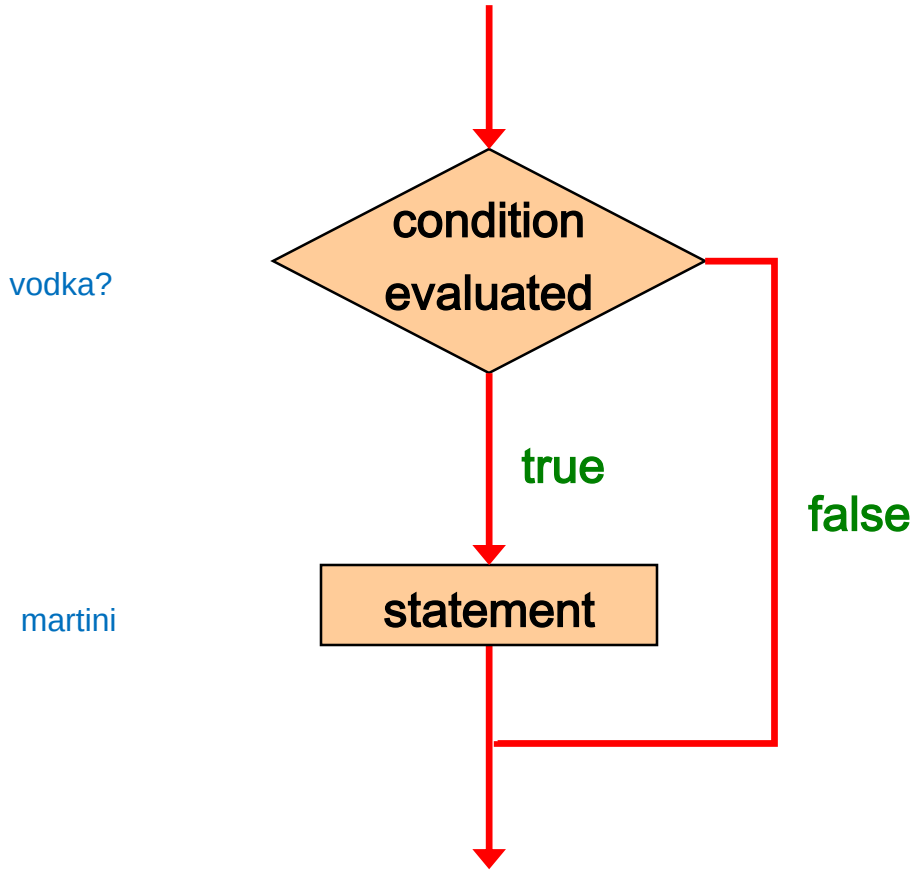
```
if ( condition )
   statement;
```

do not put ; after an if statement - this creates a null statement

algorithm for a party:
1) say "hey"
2) if (vodka)
martini;
3) talk to friends

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:**

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

do this so it can be on a different line - more human readable

- **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;
```

boolean

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*:**

aka boolean 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…");
```

3 2 4 1

- **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`**

went over this table

`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"**

this means once you have enough information, you stop asking
for ex: if it is an and statement, and the first expression is false, then it doesn't have to go to the next statement because it will already be false
for or: if the first statement is true, it doesn't have to go to the next statement because it will already be true

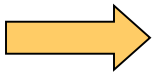
- **If the left operand is sufficient to determine the result, the right operand is not evaluated**

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

this code make sure that it doesn't divide by zero

- **This type of processing must be used carefully**

Outline



The `if` Statement and Conditions

Other Conditional Statements

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Decisions and Graphics

More Components

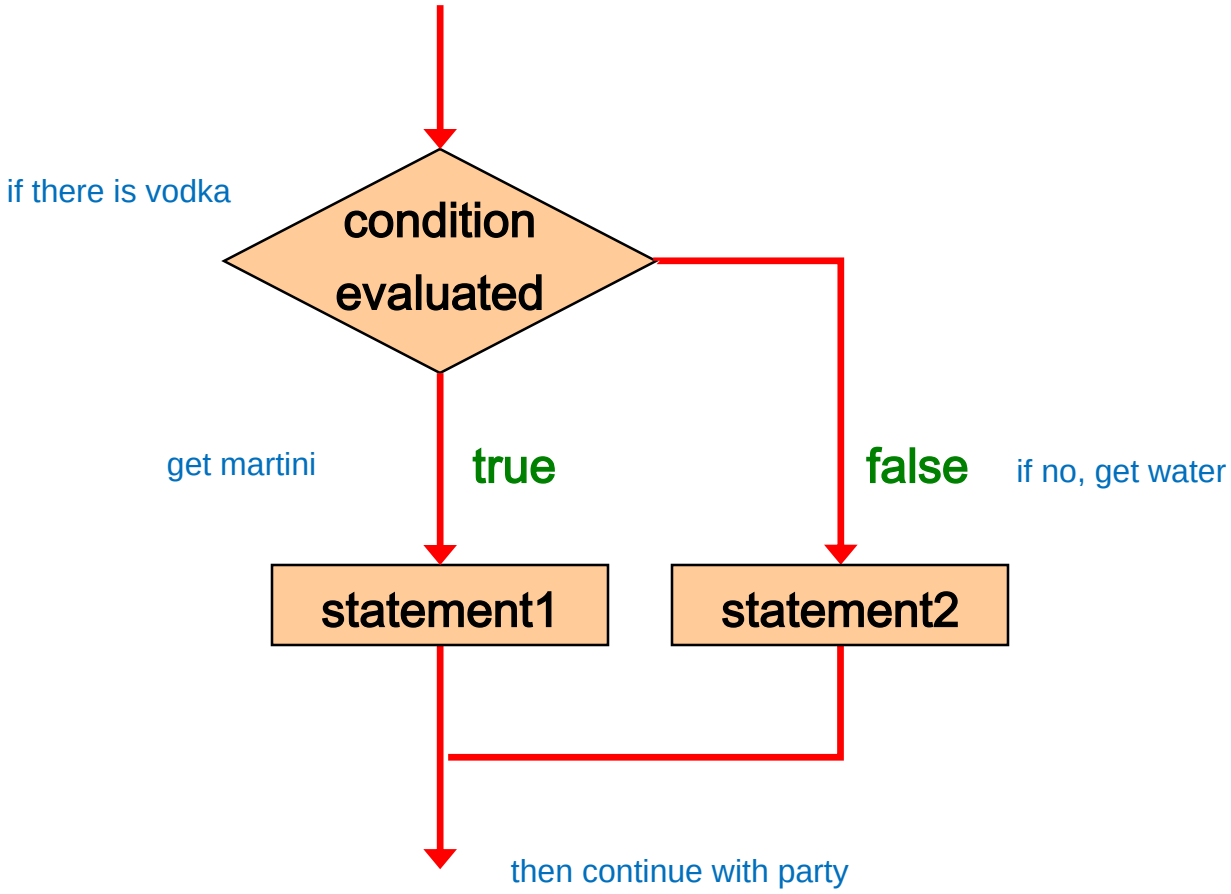
The if-else Statement

- **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

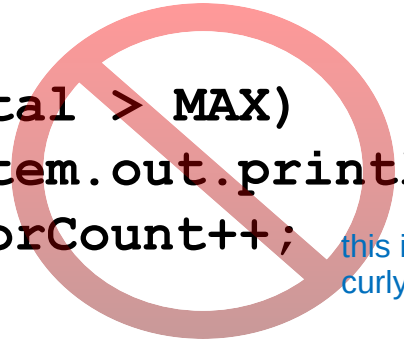


The Coin Class

- **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**



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

this is a new statement outside of the if because it is not within curly braces

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**

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

- **See Guessing.java (page 223)**

The Conditional Operator

- **Java has a *conditional operator* that uses a boolean condition to determine which of two expressions is evaluated**
- **Its syntax is:**

A B C

```
condition ? expression1 : expression2
```

If A is true, then B happens, else, C happens

- **If the `condition` is true, `expression1` is evaluated; if it is false, `expression2` is evaluated**
- **The value of the entire conditional operator is the value of the selected expression**

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 than `num2`, then `num1` is assigned to `larger`; otherwise, `num2` is assigned to `larger`**
- **The conditional operator is *ternary* because it requires three operands**

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**

wont have to write something like this, but be able to reconize

Nested if Statements

```
import java.util.Scanner;
public class MinOfThree
{
  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();
    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);
  }
}
```

- 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**

break here

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)**

scalar

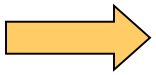
break takes you to the end of the curly brace - it is needed to stop the checking
switch without break falls through, it will go through all the rest of the code after the switch selection. look at GradeReport without breaks. Enter 70. the only reason to use this to fall through is if using 'or', so either 10 or 9 - goes to "Above average. Excelent"

```
switch (category)
{
   case 10:
     System.out.println ("a perfect score. Well done.");
     break;
   case 9:
     System.out.println ("well above average. Excellent.");
     break;
   case 8:
     System.out.println ("above average. Nice job.");
     break;
   case 7:
     System.out.println ("average.");
     break;
   case 6:
     System.out.println ("below average. You should see the");
     System.out.println ("instructor to clarify the material "
                         + "presented in class.");
     break;
   default:
     System.out.println ("not passing.");
}
```

Outline

10/5/17
loops
assignment 4
in class assignment

for assignment 3, needed 2 separate listeners to not cause error



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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`)** do not use == with floats!!!!!!!!!!
- **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

every character is mapped

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**

only primitives can use '='
everything else needs to use equals

calling object method argument

```
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**

strings do ascii ordering

- **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**

auto mem dynamic
s1(L411) L411: DOG
s2(L200) L200: DOG

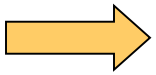
s1 == s2 -> L411 ==L200 false

== compares what is in automatic memory - the addresses

S1.equals(S2) --> DOG.equals DOG true

- **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



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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**

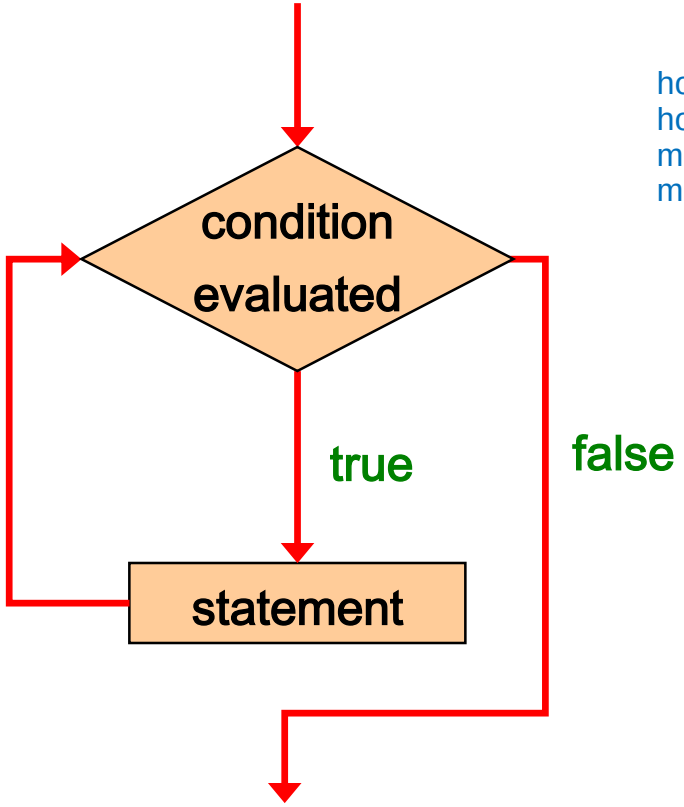
The while Statement

- **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



how many times does the loop iterate?
how many times it enters the body
min: 0
max: infinite

The while Statement

- **An example of a while statement:**

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

3

if using <=3:

step	count	expression
I	1	
II		T
A		
B	2	
II		T
A		
B	3	
II		T
A		
B	4	
II		F

- **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** sentinel: enter -1 when done entering grades (which would never be -1)
- **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++;
}
```

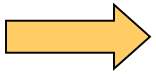
this will run 10 times

tis will run 20 times

so it runs 20 times every time

10 * 20 = 200

Outline



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

Iterators

- **An *iterator* is an object that allows you to process a collection of items one at a time**
- **It lets you step through each item in turn and process it as needed**
- **An iterator object has a `hasNext` method that returns true if there is at least one more item to process**
- **The `next` method returns the next item**
- **Iterator objects are defined using the `Iterator` interface, which is discussed further in Chapter 6**

Iterators

- **Several classes in the Java standard class library are iterators**
- **The `Scanner` class is an iterator**
  - **the `hasNext` method returns true if there is more data to be scanned**
  - **the `next` method returns the next scanned token as a string**
- **The `Scanner` class also has variations on the `hasNext` method for specific data types (such as `hasNextInt`)**

Iterators

- **The fact that a `Scanner` is an iterator is particularly helpful when reading input from a file**
- **Suppose we wanted to read and process a list of URLs stored in a file**
- **One scanner can be set up to read each line of the input until the end of the file is encountered**
- **Another scanner can be set up for each URL to process each part of the path**
- **See URLDissector.java (page 247)**

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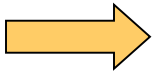

Other Repetition Statements

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More Components

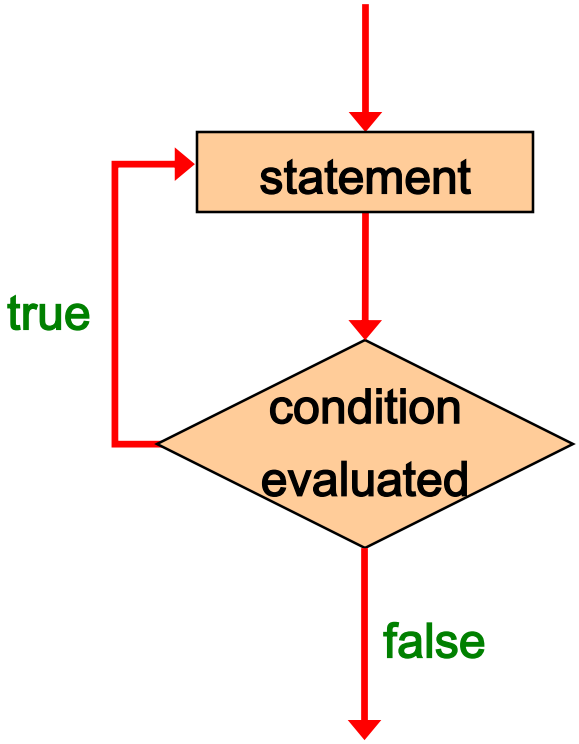
The do Statement

- **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

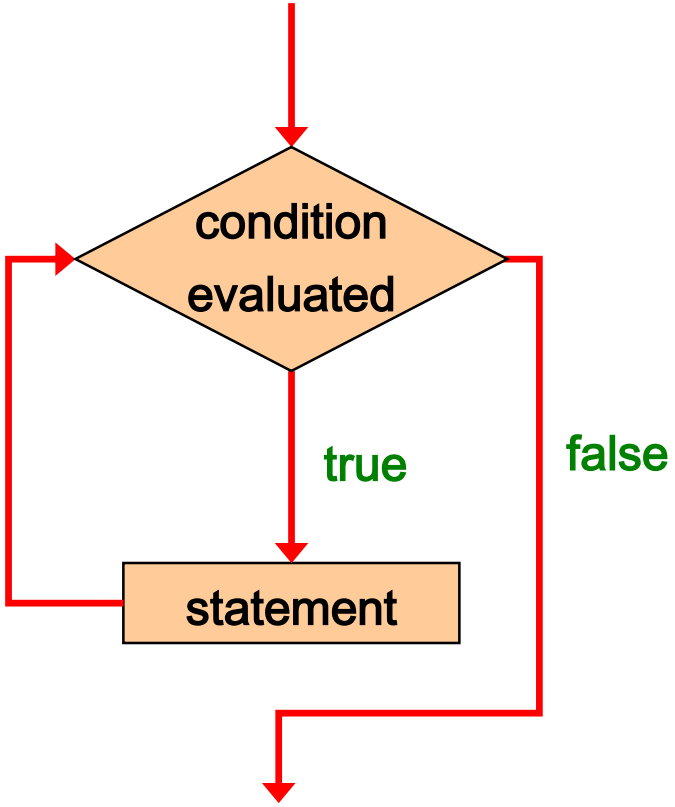
- **An example of a `do` loop:**

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

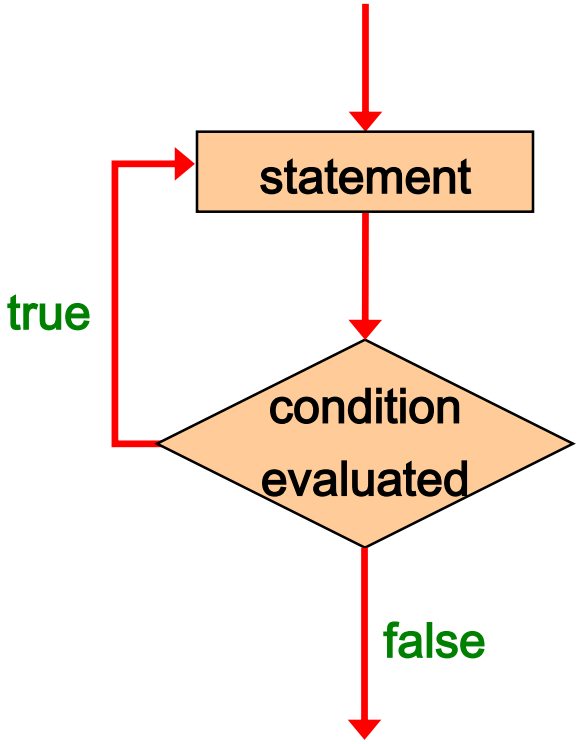
- **The body of a `do` loop executes at least once**
- **See ReverseNumber.java (page 251)**

Comparing while and do

The while Loop



The do Loop



The for Statement

- **A *for statement* has the following syntax:**

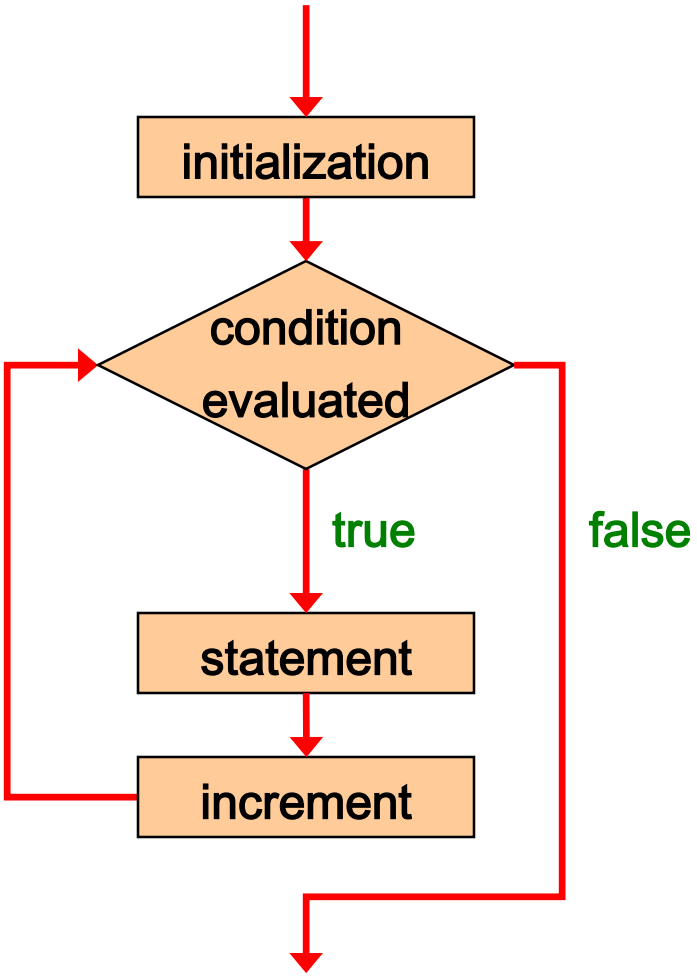
The *initialization* is executed once before the loop begins

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

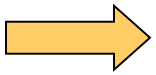
Other Conditional Statements

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)**

Outline

The `if` Statement and Conditions

Other Conditional Statements

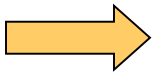
Comparing Data

The `while` Statement

Iterators

Other Repetition Statements

Decisions and Graphics



More Components

Dialog Boxes

- **A *dialog box* is a window that appears on top of any currently active window**
- **It may be used to:**
  - **convey information**
  - **confirm an action**
  - **allow the user to enter data**
  - **pick a color**
  - **choose a file**
- **A dialog box usually has a specific, solitary purpose, and the user interaction with it is brief**

Dialog Boxes

- **The `JOptionPane` class provides methods that simplify the creation of some types of dialog boxes**
- **See EvenOdd.java (page 268)**
- **We examine dialog boxes for choosing colors and files in Chapter 9**

Check Boxes

- A *check box* is a button that can be toggled on or off
- It is represented by the `JCheckBox` class
- Unlike a push button, which generates an action event, a check box generates an *item event* whenever it changes state (is checked on or off)
- The `ItemListener` interface is used to define item event listeners
- The check box calls the `itemStateChanged` method of the listener when it is toggled

Check Boxes

- **Let's examine a program that uses check boxes to determine the style of a label's text string**
- **It uses the `Font` class, which represents a character font's:**
  - **family name (such as Times or Courier)**
  - **style (bold, italic, or both)**
  - **font size**
- **See StyleOptions.java (page 271)**
- **See StyleOptionsPanel.java (page 272)**

Radio Buttons

- **A group of *radio buttons* represents a set of mutually exclusive options – only one can be selected at any given time**
- **When a radio button from a group is selected, the button that is currently "on" in the group is automatically toggled off**
- **To define the group of radio buttons that will work together, each radio button is added to a `ButtonGroup` object**
- **A radio button generates an action event**

Radio Buttons

- **Let's look at a program that uses radio buttons to determine which line of text to display**
- **See `QuoteOptions.java` (page 275)**
- **See `QuoteOptionsPanel.java` (page 276)**
- **Compare and contrast check boxes and radio buttons**
  - **Check boxes work independently to provide a boolean option**
  - **Radio buttons work as a group to provide a set of mutually exclusive options**

Summary

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