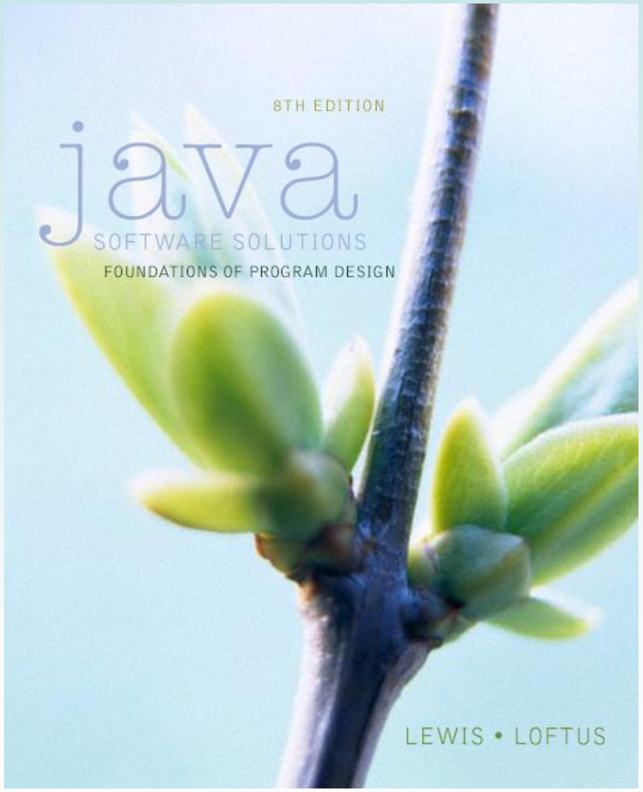
Chapter 5
Conditionals and Loops



Java Software Solutions

Foundations of Program Design

8th Edition

John Lewis
William Loftus

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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
  - the if and if-else statements
  - comparing data
  - while loops
  - iterators
  - ☺ more drawing techniques
  - ☺ more GUI components

Outline

5.1 Flow of Control

- The order of statement execution is called the *flow of control*
- Unless specified otherwise, the order of statement execution through a method is linear: one after another
- Some programming statements make decisions and perform repetitions
- These decisions are based on *boolean expressions* that evaluate to true or false

Boolean Expressions

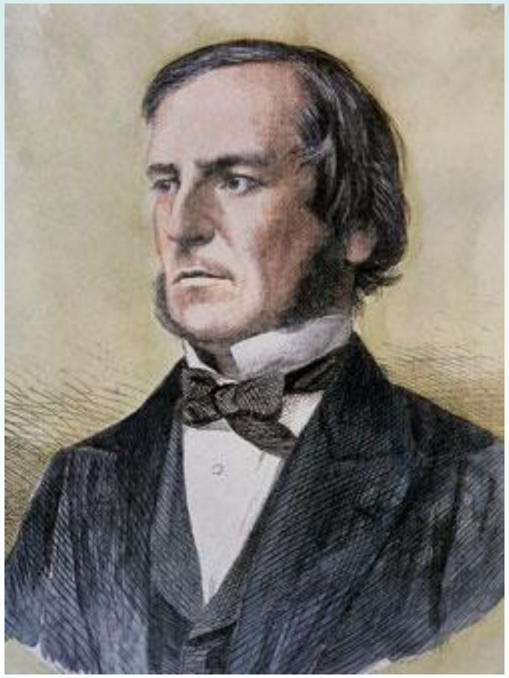
- A condition often uses one of Java's *relational operators*, which return boolean results:

`==`	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

- **George Boole** (1815 – 1864) was an English mathematician, educator, philosopher and logician.
- He is best known as the author of *The Laws of Thought* (1854) which contains Boolean algebra.



Boolean Expressions

- An `if` statement with its boolean condition:

```
if ( sum > MAX )
   delta = sum - MAX;
```

- 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
- See `Age.java`

```java
//********************************************************************
//  Age.java       Author: Lewis/Loftus
//
//  Demonstrates the use of an if statement.
//********************************************************************

import java.util.Scanner;

public class Age
{
   //-----------------------------------------------------------------
   //  Reads the user's age and prints comments accordingly.
   //-----------------------------------------------------------------
   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();
      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

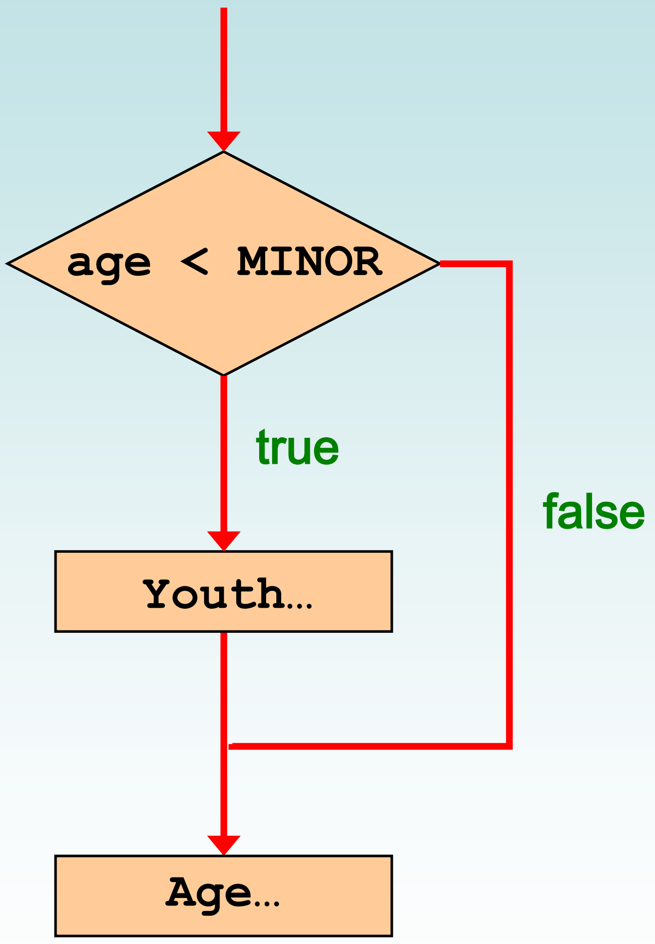
```
Enter your age: 47
You entered: 47
Age is a state of mind.
```

```
      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.");
   }
}
```

Another Sample Run

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

Logic of an if statement



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 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`

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

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
- The `!` operator has higher precedence than `&&` and `||`

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 `&&` and `||` 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 should be used carefully
  - Beware of side effects in skipped sub-expressions

Outline

5.2 The if Statement

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

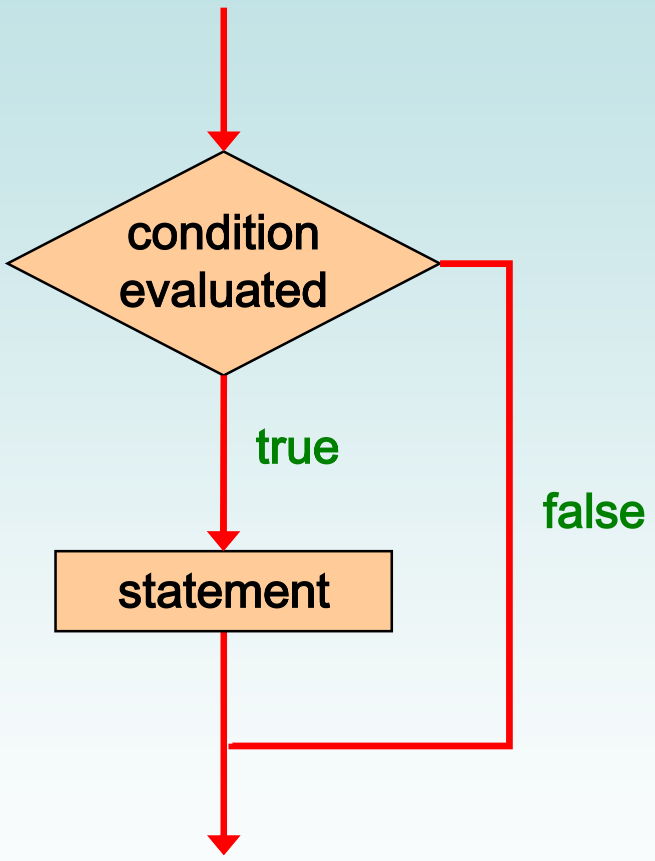
The ***`condition`*** must be a boolean expression. It must evaluate to either true or false.

`if` is a Java reserved word

```
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



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, which can lead to errors if the indentation is not correct

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

— Martin Golding

Quick Check

What do the following statements do?

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

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

Quick Check

What do the following statements do?

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

Sets the boolean variable to true if the value of `total` is not equal to the sum of `stock` and `warehouse`.

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

Prints "Ok" if `found` is true or `done` is false.

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`

```
//********************************************************************
//  Wages.java       Author: Lewis/Loftus
//
//  Demonstrates the use of an if-else statement.
//********************************************************************

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

public class Wages
{
   //-----------------------------------------------------------------
   //  Reads the number of hours worked and calculates 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;
```

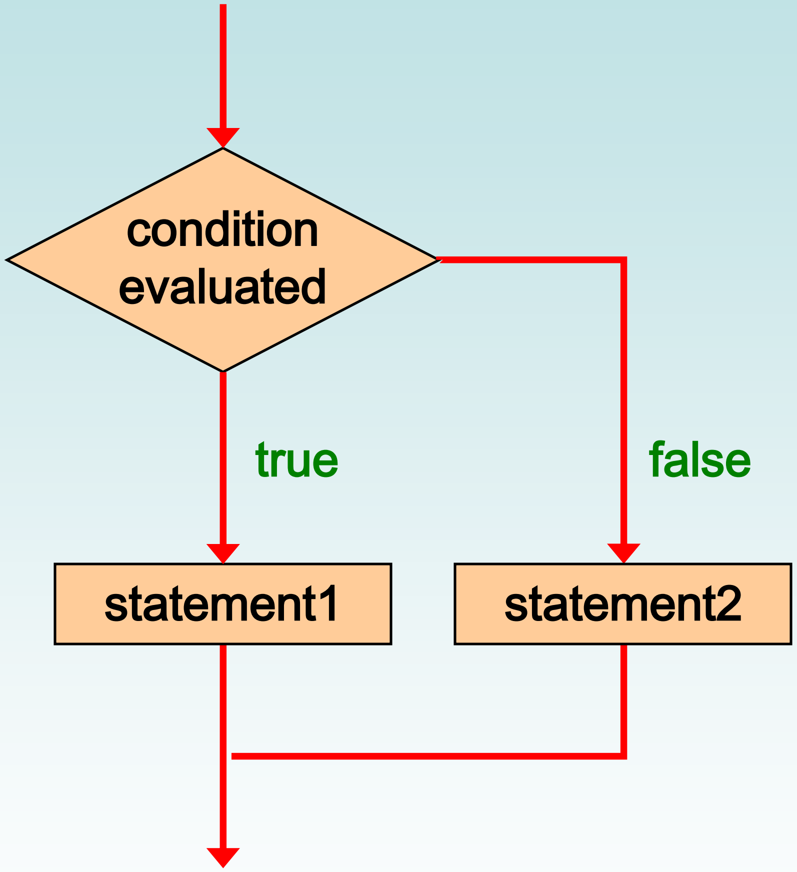
continue

```
      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));
   }
}
```

Sample Run

```
Enter the number of hours worked: 46

Gross earnings: $404.25
```

Logic of an if-else statement



The Coin Class

- Let's look at an example that uses 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`
- See `Coin.java`

```java
//********************************************************************
//  CoinFlip.java       Author: Lewis/Loftus
//
//  Demonstrates the use of an if-else statement.
//********************************************************************

public class CoinFlip
{
   //-----------------------------------------------------------------
   //  Creates a Coin object, flips it, and prints the results.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      Coin myCoin = new Coin();

      myCoin.flip();

      System.out.println(myCoin);

      if (myCoin.isHeads())
         System.out.println("You win.");
      else
         System.out.println("Better luck next time.");
   }
}
```

```
//*****************                              **********************
//  CoinFlip.java
//
//  Demonstrates the                              .
//*****************                              **********************

public class CoinFlip
{
   //-----------------------------------------------------------------
   //  Creates a Coin object, flips it, and prints the results.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      Coin myCoin = new Coin();

      myCoin.flip();

      System.out.println(myCoin);

      if (myCoin.isHeads())
         System.out.println("You win.");
      else
         System.out.println("Better luck next time.");
   }
}
```

Sample Run

```
Tails
Better luck next time.
```

```
//********************************************************************
//  Coin.java       Author: Lewis/Loftus
//
//  Represents a coin with two sides that can be flipped.
//********************************************************************

public class Coin
{
   private final int HEADS = 0;
   private final int TAILS = 1;

   private int face;

   //-----------------------------------------------------------------
   //  Sets up the coin by flipping it initially.
   //-----------------------------------------------------------------
   public Coin()
   {
      flip();
   }
```

```
//-----------------------------------------------------------------
//  Flips the coin by randomly choosing a face value.
//-----------------------------------------------------------------
public void flip()
{
   face = (int) (Math.random() * 2);
}

//-----------------------------------------------------------------
//  Returns true if the current face of the coin is heads.
//-----------------------------------------------------------------
public boolean isHeads()
{
   return (face == HEADS);
}
```

```
   //-----------------------------------------------------------------
   //  Returns the current face of the coin as a string.
   //-----------------------------------------------------------------
   public String toString()
   {
      String faceName;

      if (face == HEADS)
         faceName = "Heads";
      else
         faceName = "Tails";

      return faceName;
   }
}
```

Indentation Revisited

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

```
if (depth >= UPPER_LIMIT)
    delta = 100;
else
    System.out.println("Reseting Delta");
    delta = 0;
```

- Despite what the indentation implies, `delta` will be set to 0 no matter what

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

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

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

- See `Guessing.java`

```
//********************************************************************
//  Guessing.java       Author: Lewis/Loftus
//
//  Demonstrates the use of a block statement in an if-else.
//********************************************************************

import java.util.*;

public class Guessing
{
   //-----------------------------------------------------------------
   //  Plays a simple guessing game with the user.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      final int MAX = 10;
      int answer, guess;

      Scanner scan = new Scanner(System.in);
      Random generator = new Random();

      answer = generator.nextInt(MAX) + 1;
```

continue

```
      System.out.print ("I'm thinking of a number between 1 and "
                        + MAX + ". Guess what it is: ");

      guess = scan.nextInt();

      if (guess == answer)
         System.out.println("You got it! Good guessing!");
      else
      {
         System.out.println("That is not correct, sorry.");
         System.out.println("The number was " + answer);
      }
   }
}
```

Sample Run

```
I'm thinking of a number between 1 and 10. Guess what it is: 6
That is not correct, sorry.
The number was 9
```

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`

```java
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);
   }
}
```

Sample Run

```
Enter three integers:
84  69  90
Minimum value: 69
```

Outline

5.3 Comparing Data

- Some 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 from what is arithmetically correct
- Often, two floating point numbers are "close enough" even if they aren't exactly equal

Comparing Float Values

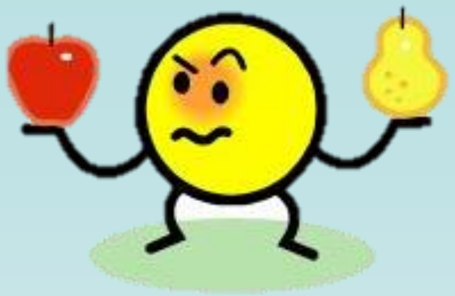
- Use this technique:

```
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



- 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

- In Java a character string is an object
- The **`equals`** method determines 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

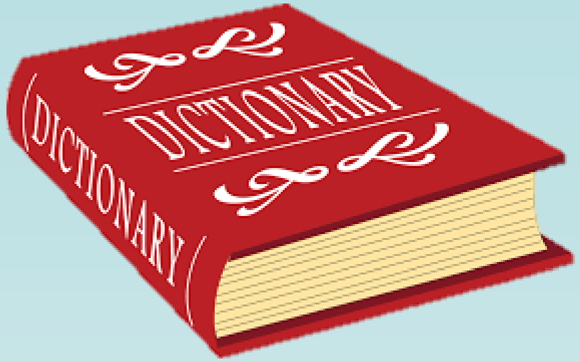
- We <u>cannot</u> use the relational operators to compare strings
- The `String` class contains the **`compareTo`** method for determining if one string comes before another
- A call to `name1.compareTo(name2)`
  - returns zero if `name1` and `name2` are equal (contain the same characters)
  - returns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

Comparing Strings

- Called *lexicographic ordering*

```
int result = name1.comareTo(name2);

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

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 used with object references.
  - 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 meaning 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

5.4 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: `while`, `do`, and `for` loops
- The `do` and `for` loops are discussed in Chapter 6

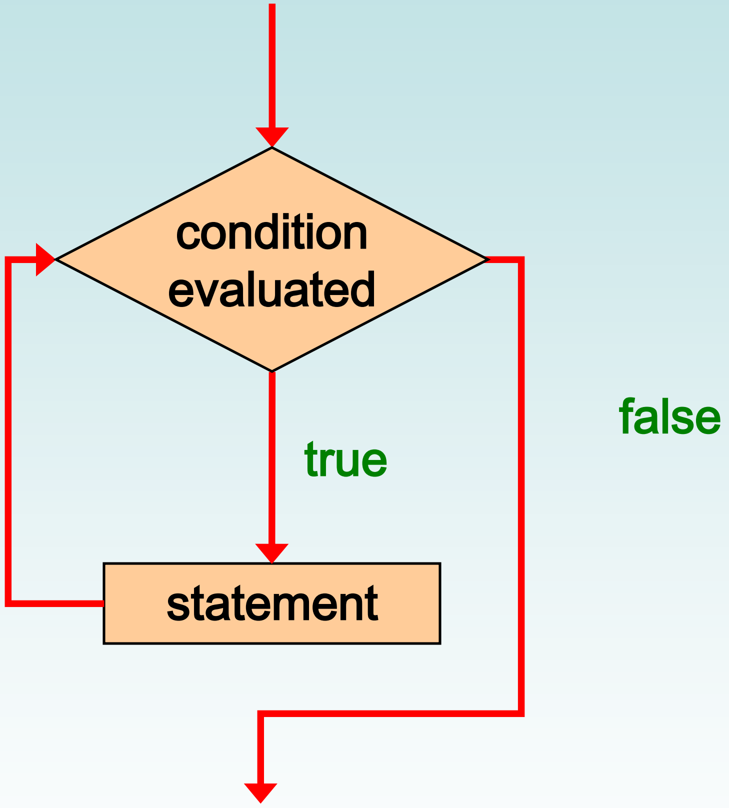
The while Statement

- 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

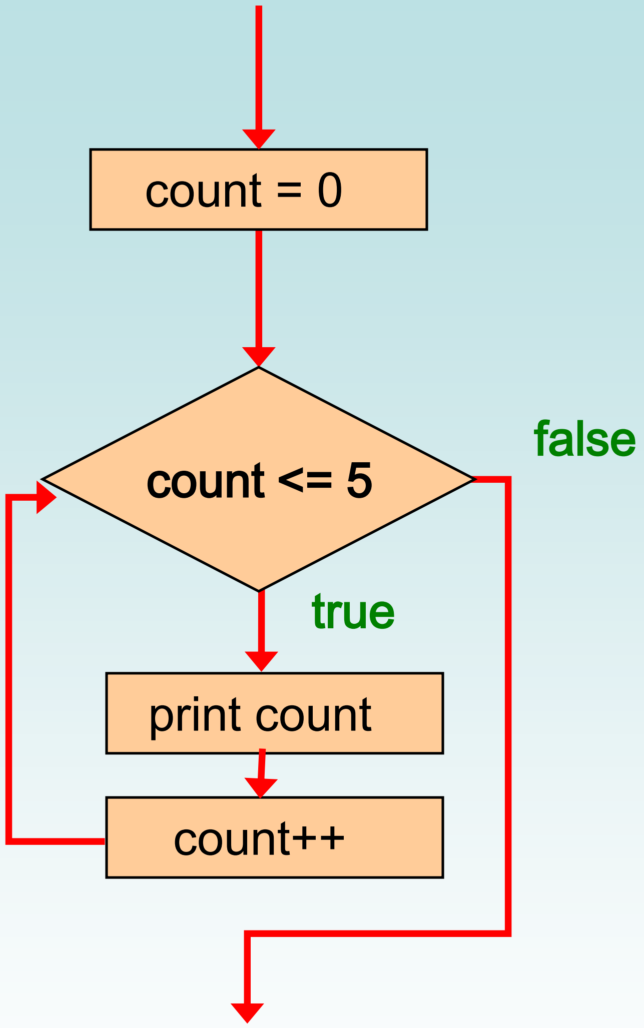


The while Statement

- An example of a while statement:

```
int count = 0;
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


count = 0
count <= 5
false
true
print count
count++

Sentinel Values

- 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`

```
//********************************************************************
//  Average.java       Author: Lewis/Loftus
//
//  Demonstrates the use of a while loop, a sentinel value, and a
//  running sum.
//********************************************************************

import java.text.DecimalFormat;
import java.util.Scanner;

public class Average
{
   //-----------------------------------------------------------------
   //  Computes the average of a set of values entered by the user.
   //  The running sum is printed as the numbers are entered.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      int sum = 0, value, count = 0;
      double average;

      Scanner scan = new Scanner(System.in);

      System.out.print("Enter an integer (0 to quit): ");
      value = scan.nextInt();
```

```
while (value != 0)  // sentinel value of 0 to terminate loop
{
   count++;

   sum += value;
   System.out.println("The sum so far is " + sum);

   System.out.print("Enter an integer (0 to quit): ");
   value = scan.nextInt();
}
```

```
        System.out.println();

        if (count == 0)
           System.out.println("No values were entered.");
        else
        {
           average = (double)sum / count;  // notice the type cast

           DecimalFormat fmt = new DecimalFormat("0.###");
           System.out.println("The average is " + fmt.format(average));
        }
     }
  }
```

```
      System.ou

      if (count
         System
      else
      {
         average

         Decima
         System                                       at(average));
      }
   }
}
```

Sample Run

```
Enter an integer (0 to quit): 25
The sum so far is 25
Enter an integer (0 to quit): 164
The sum so far is 189
Enter an integer (0 to quit): -14
The sum so far is 175
Enter an integer (0 to quit): 84
The sum so far is 259
Enter an integer (0 to quit): 12
The sum so far is 271
Enter an integer (0 to quit): -35
The sum so far is 236
Enter an integer (0 to quit): 0

The average is 39.333
```

Input Validation

- A loop can also be used for *input validation*, making a program more *robust*
- It's a good idea to verify that input is valid
- See `WinPercentage.java`

```
//********************************************************************
//  WinPercentage.java       Author: Lewis/Loftus
//
//  Demonstrates the use of a while loop for input validation.
//********************************************************************

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

public class WinPercentage
{
   //-----------------------------------------------------------------
   //  Computes the percentage of games won by a team.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      final int NUM_GAMES = 12;
      int won;
      double ratio;

      Scanner scan = new Scanner(System.in);

      System.out.print("Enter the number of games won (0 to "
                       + NUM_GAMES + "): ");
      won = scan.nextInt();
```

Sample Run

```
Enter the number of games won (0 to 12): -5
Invalid input. Please reenter: 13
Invalid input. Please reenter: 7

Winning percentage: 58%
```

```
      while (won < 0 || won > NUM_GAMES)
      {
         System.out.print ("Invalid input. Please reenter: ");
         won = scan.nextInt();
      }

      ratio = (double)won / NUM_GAMES;

      System.out.println();
      System.out.println("Winning percentage: " +  ratio  );
   }
}
```

Infinite Loops

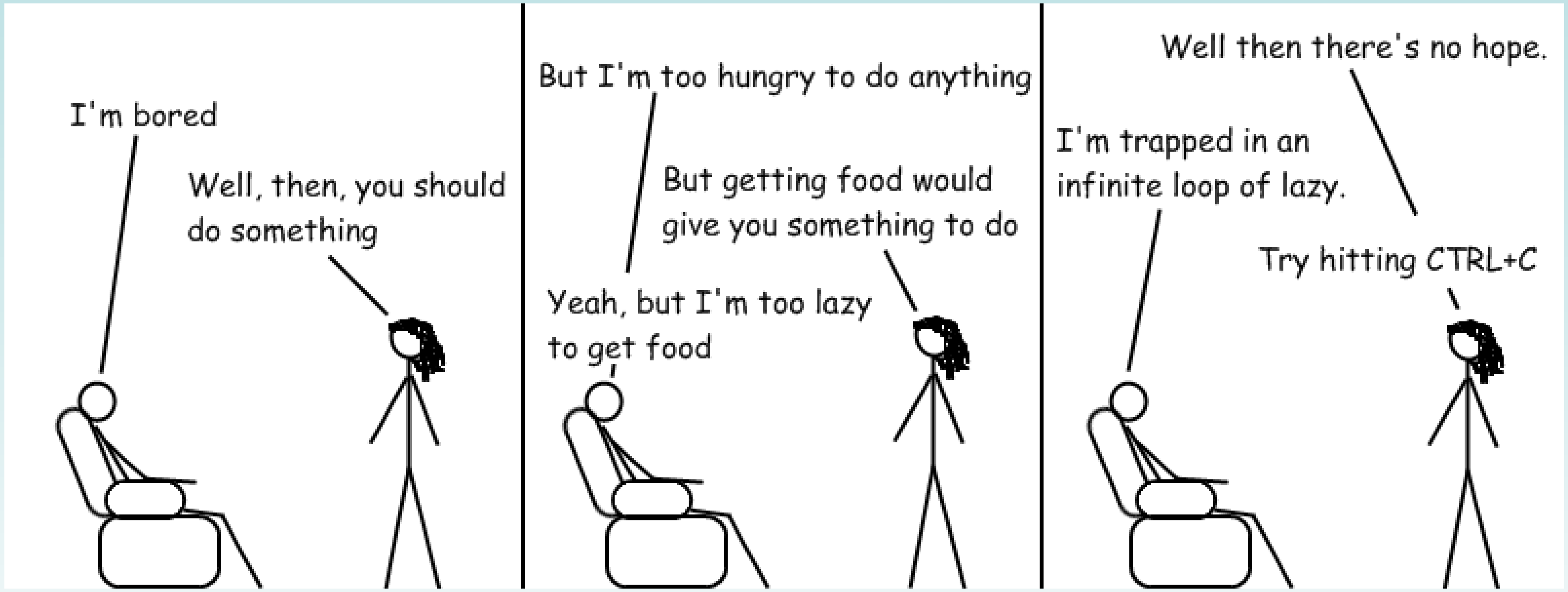
- The body of a `while` loop eventually must make the condition false
- If not, it is called an *infinite loop*, which will execute until the user interrupts the program
- This is a common logical error

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 integer overflow produces a bogus positive


I'm bored
Well, then, you should do something
But I'm too hungry to do anything
But getting food would give you something to do
Yeah, but I'm too lazy to get food
I'm trapped in an infinite loop of lazy.
Well then there's no hope.
Try hitting CTRL+C

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`

```java
//********************************************************************
//  PalindromeTester.java       Author: Lewis/Loftus
//
//  Demonstrates the use of nested while loops.
//********************************************************************

import java.util.Scanner;

public class PalindromeTester
{
   //-----------------------------------------------------------------
   //  Tests strings to see if they are palindromes.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      String str, another = "y";
      int left, right;

      Scanner scan = new Scanner(System.in);

      while (another.equalsIgnoreCase("y"))  // allows y or Y
      {
         System.out.println("Enter a potential palindrome:");
         str = scan.nextLine();

         left = 0;
         right = str.length() - 1;
         while (str.charAt(left) == str.charAt(right) && left < right)
         {
            left++;
            right--;
         }

         System.out.println();

         if (left < right)
            System.out.println("That string is NOT a palindrome.");
         else
            System.out.println("That string IS a palindrome.");

         System.out.println();
         System.out.print("Test another palindrome (y/n)? ");
         another = scan.nextLine();
      }
   }
}
```

```
          while                                   & left < right)
          {
             lef
             rig
          }

          Systen

          if (le
             Sys                                    alindrome.");
          else
             Sys                                    drome.");

          Systen
          Systen                                    n)? ");
          anothe
       }
    }
 }
```

Sample Run

```
Enter a potential palindrome:
radar

That string IS a palindrome.

Test another palindrome (y/n)? y
Enter a potential palindrome:
able was I ere I saw elba

That string IS a palindrome.

Test another palindrome (y/n)? y
Enter a potential palindrome:
abracadabra

That string is NOT a palindrome.

Test another palindrome (y/n)? n
```

Quick Check

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++;
}
```

Quick Check

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 * 19 = 190

Outline

5.5 Iterators

- An *iterator* is a type of object which can access a collection of items one at a time
- It steps through each item in turn
- An iterator 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 7

Iterators

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

Iterators

- A `Scanner` can read 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`

Say that the file `urls.inp` contains:

```
www.google.com
www.linux.org/info/gnu.html
thelyric.com/calendar/
www.cs.vt.edu/undergraduate/about
youtube.com/watch?v=EHCRimwRGLs
```

```java
import java.util.Scanner;
import java.io.*;

public class URLDissector
{
   public static void main(String[] args) throws IOException
   {
      String url;
      Scanner fileScan, urlScan;
      fileScan = new Scanner(new File("urls.inp"));

      // Read and process each line of the file
      while ( fileScan.hasNext() )
      {
         url = fileScan.nextLine();
         System.out.println("URL:  " + url);

         urlScan = new Scanner(url);
         urlScan.useDelimiter("/");     // tokens are separated by /

         //  Print each part of the url
         while ( urlScan.hasNext() )
            System.out.println ( "   " + urlScan.next() );

         System.out.println();
      }
   }
}
```

```
        // Rea
        while
        {
            url
            Sys

            url
            url

            //
            whi


            Sys
        }
    }
}
```

Sample Run

```
URL: www.google.com
   www.google.com

URL: www.linux.org/info/gnu.html
   www.linux.org
   info
   gnu.html

URL: thelyric.com/calendar/
   thelyric.com
   calendar

URL: www.cs.vt.edu/undergraduate/about
   www.cs.vt.edu
   undergraduate
   about

URL: youtube.com/watch?v=EHCRimwRGLs
   youtube.com
   watch?v=EHCRimwRGLs
```

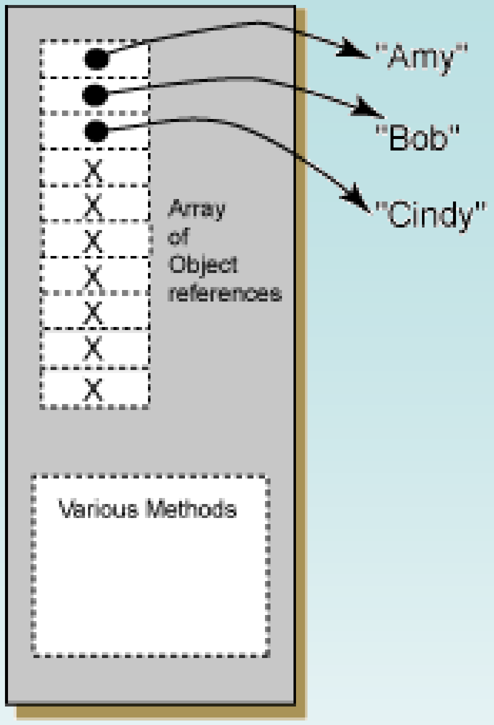
Outline

☺ 5.6 The ArrayList Class

- An `ArrayList` object stores a list of object references and is often processed using a loop

- Each object reference in the list is called an *element*

- The `ArrayList` class is part of the `java.util` package



After three add()

☺ The ArrayList Class

- Each object reference in the list has a numeric index
- An `ArrayList` object grows and shrinks as needed, adjusting its capacity as necessary

☺ The ArrayList Class

- Index values of an `ArrayList` begin at 0 (not 1):

0	“Amy"
1	“Bob"
2	“Cindy"
3	"Dopey"
4	"Doc"

- Elements can be inserted and removed
- The indexes of the elements are adjusted accordingly

☺ ArrayList Methods

- Some `ArrayList` methods:

```
boolean add(E obj)

void add(int index, E obj)

Object remove(int index)

Object get(int index)

boolean isEmpty()

int size()
```

☺ The ArrayList Class

- The type of object reference stored in the list is established when the `ArrayList` object is created:

```
    ArrayList<String> names = new ArrayList<String>();

    ArrayList<Book> list = new ArrayList<Book>();
```

- This makes use of Java *generics*, which provide additional type checking at compile time
- An `ArrayList` object cannot store primitive types
- Use wrapper classes for this

```
//********************************************************************
//  Beatles.java       Author: Lewis/Loftus
//
//  Demonstrates the use of a ArrayList object.
//********************************************************************

import java.util.ArrayList;

public class Beatles
{
   //-----------------------------------------------------------------
   //  Stores and modifies a list of band members.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      ArrayList<String> band = new ArrayList<String>();

      band.add("Paul");
      band.add("Pete");
      band.add("John");
      band.add("George");
      System.out.println (band);
      int location = band.indexOf ("Pete");
      band.remove (location);

      System.out.println (band);
      System.out.println ("At index 1: " + band.get(1));
      band.add (2, "Ringo");

      System.out.println ("Size of the band: " + band.size());
      int index = 0;
      while (index < band.size())
      {
         System.out.println(band.get(index));
         index++;
      }
   }
}
```

Output

```
[Paul, Pete, John, George]
[Paul, John, George]
At index 1: John
Size of the band: 4
Paul
John
Ringo
George
```

Outline

- Boolean Expressions
- The `if` Statement
- Comparing Data
- The `while` Statement
- Iterators
- ☺ The `ArrayList` Class
- ⇨ ☺ Determining Event Sources
- ☺ Check Boxes and Radio Buttons

☺ Determining Event Sources

- Recall that interactive GUIs require establishing a relationship between components and the listeners that respond to component events

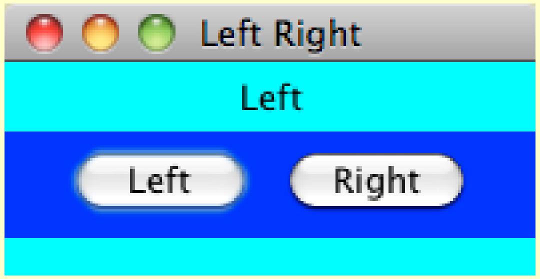
- One listener object can be used to listen to two different components

- The source of the event can be determined by using the `getSource` method of the event passed to the listener

- See `LeftRight.java`
- See `LeftRightPanel.java`

```
//********************************************************************
//  LeftRight.java       Authors: Lewis/Loftus
//
//  Demonstrates the use of one listener for multiple buttons.
//********************************************************************

import javax.swing.JFrame;

public class LeftRight
{
   //-----------------------------------------------------------------
   //  Creates the main program frame.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      JFrame frame = new JFrame("Left Right");
      frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

      frame.getContentPane().add(new LeftRightPanel());

      frame.pack();
      frame.setVisible(true);
   }
}
```

```
//*********************                            *********************
//  LeftRight.java
//
//  Demonstrates the u                              ple buttons.
//*********************                            *********************

import javax.swing.JFr

public class LeftRight
{
   //-----------------------------------------------------------------
   //  Creates the main program frame.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      JFrame frame = new JFrame("Left Right");
      frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

      frame.getContentPane().add(new LeftRightPanel());

      frame.pack();
      frame.setVisible(true);
   }
}
```



```java
//********************************************************************
//  LeftRightPanel.java       Authors: Lewis/Loftus
//
//  Demonstrates the use of one listener for multiple buttons.
//********************************************************************

import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

public class LeftRightPanel extends JPanel
{
   private JButton left, right;
   private JLabel label;
   private JPanel buttonPanel;
```

continue

continue

```
   //-----------------------------------------------------------------
   //  Constructor: Sets up the GUI.
   //-----------------------------------------------------------------
   public LeftRightPanel()
   {
      left = new JButton("Left");
      right = new JButton("Right");

      ButtonListener listener = new ButtonListener();
      left.addActionListener(listener);
      right.addActionListener(listener);

      label = new JLabel("Push a button");

      buttonPanel = new JPanel();
      buttonPanel.setPreferredSize(new Dimension(200, 40));
      buttonPanel.setBackground(Color.blue);
      buttonPanel.add(left);
      buttonPanel.add(right);

      setPreferredSize(new Dimension(200, 80));
      setBackground(Color.cyan);
      add(label);
      add(buttonPanel);
   }
```

continue

continue

```
   //*****************************************************************
   //  Represents a listener for both buttons.
   //*****************************************************************
   private class ButtonListener implements ActionListener
   {
      //--------------------------------------------------------------
      //  Determines which button was pressed and sets the label
      //  text accordingly.
      //--------------------------------------------------------------
      public void actionPerformed(ActionEvent event)
      {
         if (event.getSource() == left)
            label.setText("Left");
         else
            label.setText("Right");
      }
   }
}
```

Outline

Boolean Expressions

The `if` Statement

Comparing Data

The `while` Statement

Iterators

The `ArrayList` Class

☺ Determining Event Sources

➡ ☺ Check Boxes and Radio Buttons

☺ 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
- The `ItemListener` interface is used to define item event listeners
- A check box calls the `itemStateChanged` method of the listener when it is toggled

☺ Check Boxes

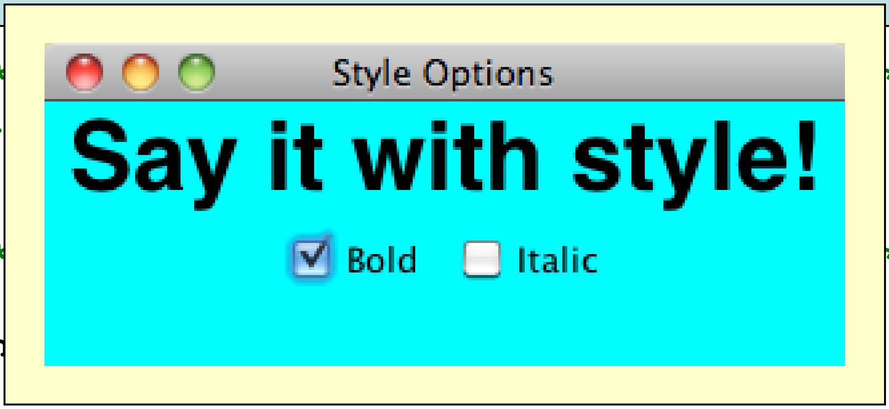
- Let's examine a program that uses check boxes to determine the style of a label's text string

- It uses the `Font` class, which embodies a character font's:
  - family name (such as Times or Courier)
  - style (bold, italic, or both)
  - font size

- See `StyleOptions.java`
- See `StyleOptionsPanel.java`

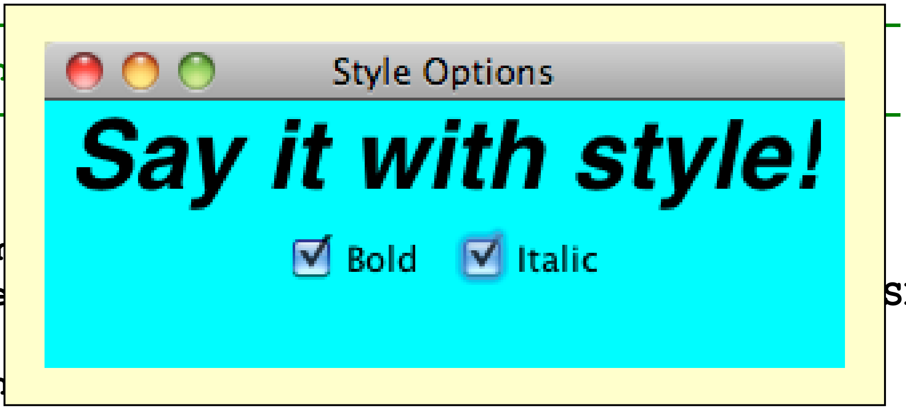
```
//********************************************************************
//  StyleOptions.java       Author: Lewis/Loftus
//
//  Demonstrates the use of check boxes.
//********************************************************************

import javax.swing.JFrame;

public class StyleOptions
{
   //-----------------------------------------------------------------
   //  Creates and presents the program frame.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      JFrame frame = new JFrame("Style Options");
      frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

      StyleOptionsPanel panel = new StyleOptionsPanel();
      frame.getContentPane().add(panel);

      frame.pack();
      frame.setVisible(true);
   }
}
```

```
//**************                                              **************
//   StyleOptions.
//
//   Demonstrates
//**************                                              **************

import javax.swin

public class StyleOptions
{
   //-----------                                              --------------
   //   Creates an
   //-----------                                              --------------
   public static
   {
      JFrame fram
      frame.setDe                                             SE);

      StyleOption
      frame.getContentPane().add(panel);

      frame.pack();
      frame.setVisible(true);
   }
}
```



Say it with style!

✓ Bold ☐ Italic



Say it with style!

✓ Bold ✓ Italic

```
//********************************************************************
//  StyleOptionsPanel.java       Author: Lewis/Loftus
//
//  Demonstrates the use of check boxes.
//********************************************************************

import javax.swing.*;
import java.awt.*;
import java.awt.event.*;

public class StyleOptionsPanel extends JPanel
{
   private JLabel saying;
   private JCheckBox bold, italic;
```

continue

continue

```
   //-----------------------------------------------------------------
   //  Sets up a panel with a label and some check boxes that
   //  control the style of the label's font.
   //-----------------------------------------------------------------
   public StyleOptionsPanel()
   {
      saying = new JLabel("Say it with style!");
      saying.setFont(new Font("Helvetica", Font.PLAIN, 36));

      bold = new JCheckBox("Bold");
      bold.setBackground(Color.cyan);
      italic = new JCheckBox("Italic");
      italic.setBackground(Color.cyan);

      StyleListener listener = new StyleListener();
      bold.addItemListener(listener);
      italic.addItemListener(listener);

      add(saying);
      add(bold);
      add(italic);

      setBackground(Color.cyan);
      setPreferredSize(new Dimension(300, 100));
   }
```

continue

continue

```
   //*****************************************************************
   //  Represents the listener for both check boxes.
   //*****************************************************************
   private class StyleListener implements ItemListener
   {
      //--------------------------------------------------------------
      //  Updates the style of the label font style.
      //--------------------------------------------------------------
      public void itemStateChanged(ItemEvent event)
      {
         int style = Font.PLAIN;

         if (bold.isSelected())
            style = Font.BOLD;

         if (italic.isSelected())
            style += Font.ITALIC;

         saying.setFont(new Font("Helvetica", style, 36));
      }
   }
}
```

☺ Radio Buttons

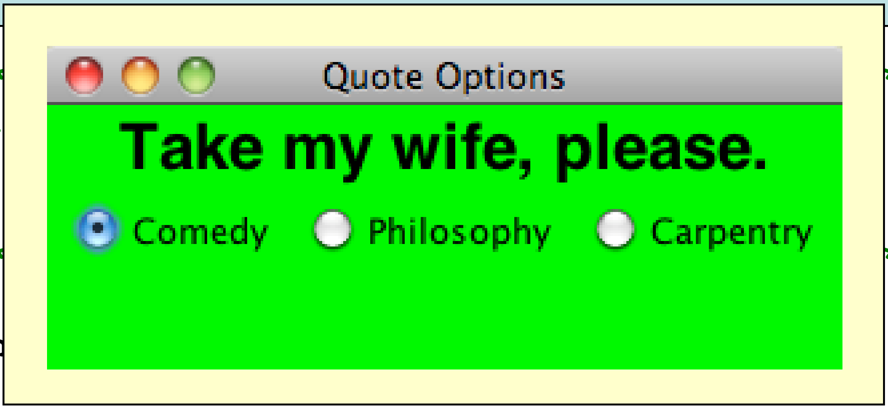
- A group of *radio buttons* represents a set of mutually exclusive options – only one can be selected at any given time
- When a radio button from a group is selected, the button that is currently "on" in the group is automatically toggled off
- To define the group of radio buttons that will work together,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

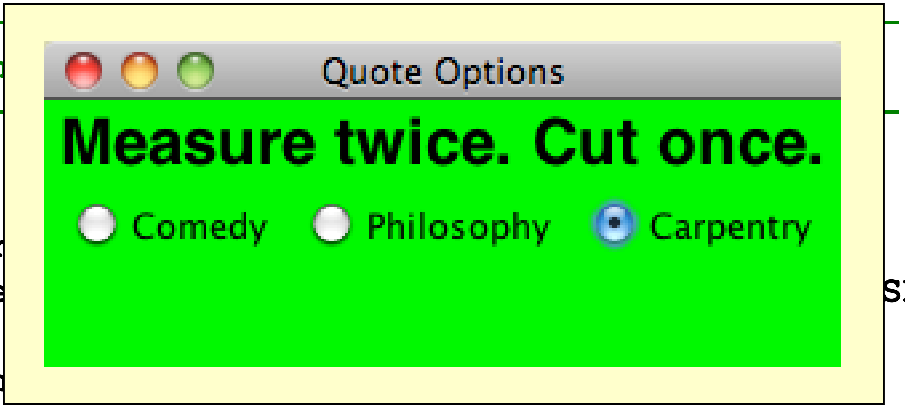
☺ Radio Buttons

- Let's look at a program that uses radio buttons to determine which line of text to display
- See `QuoteOptions.java`
- See `QuoteOptionsPanel.java`

```java
//********************************************************************
//  QuoteOptions.java       Author: Lewis/Loftus
//
//  Demonstrates the use of radio buttons.
//********************************************************************

import javax.swing.JFrame;

public class QuoteOptions
{
   //-----------------------------------------------------------------
   //  Creates and presents the program frame.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      JFrame frame = new JFrame("Quote Options");
      frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

      QuoteOptionsPanel panel = new QuoteOptionsPanel();
      frame.getContentPane().add(panel);

      frame.pack();
      frame.setVisible(true);
   }
}
```

```
//*************                                  **************
//  QuoteOptions.
//
//  Demonstrates
//*************                                  **************

import javax.swin

public class QuoteOptions
{
   //-----------                                  --------------
   //  Creates an
   //-----------                                  --------------
   public static
   {
      JFrame fram
      frame.setDe                                  SE);

      QuoteOption
      frame.getContentPane().add(panel);

      frame.pack();
      frame.setVisible(true);
   }
}
```





```java
//********************************************************************
//  QuoteOptionsPanel.java       Author: Lewis/Loftus
//
//  Demonstrates the use of radio buttons.
//********************************************************************

import javax.swing.*;
import java.awt.*;
import java.awt.event.*;

public class QuoteOptionsPanel extends JPanel
{
   private JLabel quote;
   private JRadioButton comedy, philosophy, carpentry;
   private String comedyQuote, philosophyQuote, carpentryQuote;

   //-----------------------------------------------------------------
   //  Sets up a panel with a label and a set of radio buttons
   //  that control its text.
   //-----------------------------------------------------------------
   public QuoteOptionsPanel()
   {
      comedyQuote = "Take my wife, please.";
      philosophyQuote = "I think, therefore I am.";
      carpentryQuote = "Measure twice. Cut once.";

      quote = new JLabel(comedyQuote);
      quote.setFont(new Font("Helvetica", Font.BOLD, 24));
```

continue

continue

```
      comedy = new JRadioButton("Comedy", true);
      comedy.setBackground(Color.green);
      philosophy = new JRadioButton("Philosophy");
      philosophy.setBackground(Color.green);
      carpentry = new JRadioButton("Carpentry");
      carpentry.setBackground(Color.green);

      ButtonGroup group = new ButtonGroup();
      group.add(comedy);
      group.add(philosophy);
      group.add(carpentry);

      QuoteListener listener = new QuoteListener();
      comedy.addActionListener(listener);
      philosophy.addActionListener(listener);
      carpentry.addActionListener(listener);

      add(quote);
      add(comedy);
      add(philosophy);
      add(carpentry);

      setBackground(Color.green);
      setPreferredSize(new Dimension(300, 100));
   }
```

continue

continue

```
   //*****************************************************************
   //  Represents the listener for all radio buttons
   //*****************************************************************
   private class QuoteListener implements ActionListener
   {
      //--------------------------------------------------------------
      //  Sets the text of the label depending on which radio
      //  button was pressed.
      //--------------------------------------------------------------
      public void actionPerformed(ActionEvent event)
      {
         Object source = event.getSource();

         if (source == comedy)
            quote.setText(comedyQuote);
         else
            if (source == philosophy)
               quote.setText(philosophyQuote);
            else
               quote.setText(carpentryQuote);
      }
   }
}
```

Summary

- Chapter 5 focused on:
  - boolean expressions
  - the if and if-else statements
  - comparing data
  - while loops
  - iterators
  - ☺ more drawing techniques
  - ☺ more GUI components