Chapter 5
Conditionals and Loops

Java Software Solutions
Foundations of Program Design
Seventh Edition

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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

Boolean Expressions
The if Statement
Comparing Data
The while Statement
Iterators
The ArrayList Class
Determining Event Sources
Check Boxes and Radio Buttons
Flow of Control

• Unless specified otherwise, the order of statement execution through a method is linear: one after another

• Some programming statements allow us to make decisions and perform repetitions

• These decisions are based on boolean expressions (also called 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
- They are sometimes called *selection statements*
- Conditional statements give us the power to make basic decisions
- The Java conditional statements are the:
  - *if* and *if-else* statement
  - *switch* statement
- We'll explore the switch statement in Chapter 6
Boolean Expressions

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

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

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

• An if statement with its boolean condition:

```java
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
import java.util.Scanner;

public class Age
{
    // Demonstrates the use of an if statement.
    public static void main (String[] args)
    {
        final int MINOR = 21;
        Scanner scan = new Scanner (System.in);
        System.out.print ("Enter your age: ");
        int age = scan.nextInt();
        continue
    }
}
System.out.println("You entered: "+age);

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

System.out.println("Age is a state of mind.");
}
```java
System.out.println("You entered: "+ age);

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

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

Sample Run

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

Another Sample Run

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

• What is the value of x, a, and b after the execution of the following statements?

```java
int x=1, a=2, b=3;
if (x < 0)
b=5;
a= b*2;
x=4;
```
Quiz

• What is the value of x, a, and b after the execution of the following statements?

```c
int x=1, a=2, b=3;
if (x < 0)
b=5;    // this statement is not executed
a= b*2;
x=4;

x is 4
a is 6
b is 3
```
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 \( \neg a \) is false; if \( a \) is false, then \( \neg a \) is true.

- Logical expressions can be shown using a truth table:

<table>
<thead>
<tr>
<th>( a )</th>
<th>( \neg a )</th>
</tr>
</thead>
<tbody>
<tr>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>false</td>
<td>true</td>
</tr>
</tbody>
</table>
Quiz

What is the value of x, a, and b after the execution of the following statements?

```java
int x=0, a=2, b=3;
if (!(x >1))
b=5;
a= b*2;
x=4;
```
Quiz

What is the value of x, a, and b after the execution of the following statements?

```java
int x=0, a=2, b=3;
if (!(x >1))
b=5; // this statement is executed
a= b*2;
x=4;

x is 4
a is 10
b is 5
```
Logical AND and Logical OR

• The *logical AND* expression
  
  \[ a \land b \]
  
  is true if **both** \( a \) and \( b \) are true, and false otherwise

• The *logical OR* expression
  
  \[ a \lor b \]
  
  is true if \( a \) or \( b \) or **both** are true, and false otherwise
**Logical AND and Logical OR**

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

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

| 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

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

• All logical operators have lower precedence than the relational operators

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

Are the two following Boolean expressions equivalent? Assume that \( a \) and \( b \) are Boolean variables.

1) \( ! (a \land b) \)
2) \( !a \land b \)
Quiz

• Are the two following Boolean expressions equivalent? Assume that a and b are Boolean variables.

1) \(! (a \&\& b)\)
2) \(!a \&\& b\)

NO, the first is always true except when a and b are true. The second is true only when a is false and b is true.
Boolean Expressions

- Specific expressions can be evaluated using truth tables

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

- Assuming that c1 and c2 are boolean variables, create a truth table for the expression:

\[(c1 \&\& !c2) \mid \mid ( !c1 \&\& c2)\]
Quiz

- Assuming that $c_1$ and $c_2$ are boolean variables, create a truth table for the expression:

$$(c_1 && !c_2) || (!c_1 && c_2)$$

| $c_1$ | $c_2$ | $!c_1$ | $!c_2$ | $c_1 && !c_2$ | $!c_1 && c_2$ | $c_1 && !c_2$ || $!c_1 && c_2$ |
|-------|-------|--------|--------|---------------|---------------|-----------------|----------------|
| true  | true  | false  | false  | false         | false         | false           | false          |
| true  | false | false  | true   | true          | false         | false           | true           |
| false | true  | true   | false  | false         | true          | true            | true           |
| false | false | true   | true   | false         | false         | 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**

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

• This type of processing should be used carefully
Quiz

• What is the value of count and base after the execution of the following statements?

```c
int count=2, base=0;
if (count > 1 || ++base > count)
    count--;
```
Quiz

• What is the value of count and base after the execution of the following statements?

```c
int count=2, base=0;
if (count > 1 || ++base > count)
    count--;
```

count is 1
base is 0
What is the value of count and base after the execution of the following statements?

```c
int count=2, base=0;
if (++base > count || count > 1)
    count--;  
```
Quiz

• What is the value of count and base after the execution of the following statements

```c
int count=2, base=0;
if (++base > count || count > 1)
    count--;

count is 1
base is 1
```
Outline

- Boolean Expressions
  - The \texttt{if} Statement
  - Comparing Data
- The \texttt{while} Statement
- Iterators
- The \texttt{ArrayList} Class
- Determining Event Sources
- Check Boxes and Radio Buttons
The if Statement

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

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

*if* is a Java reserved word

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

If the *condition* is true, the *statement* is executed.
If it is false, the *statement* is skipped.
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 you to make (logical) 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?

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

```java
if (found || !done)
    System.out.println("Ok");
```
What do the following statements do?

```java
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`.

```java
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
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
continue

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

System.out.println();

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

NumberFormat fmt = NumberFormat.getCurrencyInstance();
System.out.println("Gross earnings: "+fmt.format(pay));
}
System.out.print("Enter the number of hours worked: ");
int hours = scan.nextInt();
System.out.println();
// Pay overtime at "time and a half"
if (hours > STANDARD)
    pay = STANDARD * RATE + (hours-STANDARD) * (RATE * 1.5);
else
    pay = hours * RATE;

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

- **condition evaluated**

  - **true** → **statement1**
  - **false** → **statement2**
Quiz

What is printing the program described in this flowchart?
Syntax Diagram

If Statement

```
if (Expression) Statement
```

```
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
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.");
    }
}
public class CoinFlip
{
    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.");
    }
}
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();
    }
}
continue
public void flip ()
{
    face = (int) (Math.random() * 2);
}

public boolean isHeads ()
{
    return (face == HEADS);
}
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

```java
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
Quiz

Consider the following code that will assign a letter grade of 'A', 'B', 'C', 'D', or 'F' depending on a student's test score.

```java
if (score >= 90) grade = 'A';
if (score >= 80) grade = 'B';
if (score >= 70) grade = 'C';
if (score >= 60) grade = 'D';
else grade = 'F';
```

A) This code will work correctly in all cases
B) This code will work correctly only if grade >= 60
C) This code will work correctly only if grade < 60
D) This code will work correctly only if grade < 70
E) This code will not work correctly under any circumstances
Quiz

Consider the following code that will assign a letter grade of 'A', 'B', 'C', 'D', or 'F' depending on a student's test score.

```java
if (score >= 90) grade = 'A';
if (score >= 80) grade = 'B';
if (score >= 70) grade = 'C';
if (score >= 60) grade = 'D';
else grade = 'F';
```

A) This code will work correctly in all cases
B) This code will work correctly only if grade >= 60
C) This code will work correctly only if grade < 60
D) This code will work correctly only if grade < 70
E) This code will not work correctly under any circumstances
Block Statements

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

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

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

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

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

- See Guessing.java
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

```java
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);
}
```
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

• Example:

```java
if (age < 21)
    if (age > 2)
        System.out.println("age is larger than" + " 2 and smaller than 21");
```
Nested if Statements

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

```java
if (age < 21)
    if (age > 2)
        System.out.println("age is larger than" +
                           " 2 and smaller than 21");
    else
        System.out.println("age is " +
                           "smaller than 21");
```

- Braces can be used to specify the if statement to which an else clause belongs.
Quiz

• What is printing the algorithm described in the flowchart below, given 3 numbers (A, B and C) as input:

START

READ A, B, C

IS B>C?

IS A>B?

IS A>C?

PRINT B

PRINT C

PRINT A

END
import java.util.Scanner;

public class MinOfThree
{
    public static void main (String[] args)
    {
        Scanner scan = new Scanner (System.in);
        System.out.println ("Enter three integers: ");
        num1 = scan.nextInt();
        num2 = scan.nextInt();
        num3 = scan.nextInt();
        continue
    }
}
continue

    if (num1 < num2)
        if (num1 < num3)
            min = num1;
        else //matches the last unmatched if
            min = num3;
    else
        if (num2 < num3)
            min = num2;
        else
            min = num3;

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

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

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

• What happens in the MinOfThree program if two or more of the values are equal? If exactly two of the values are equal, does it matter whether the equal values are lower or higher than the third?
Quiz

• What happens in the MinOfThree program if two or more of the values are equal? If exactly two of the values are equal, does it matter whether the equal values are lower or higher than the third?

If two or more values are equal, the program still prints the lowest value.
Quiz

• What output is produced by the following code fragment given the assumptions below

```java
if (num1 < num2)
    System.out.println("red ");
if ((num1 + 5) < num2)
    System.out.println("white ");
else
    System.out.println("blue ");
System.out.println("yellow ");
```

a) num1=2, num2=10
b) num1=10, num2=2
c) num1=2, num2=2
Quiz

• What output is produced by the following code fragment given the assumptions below

```java
if (num1 < num2)
    System.out.println("red ");
if ((num1 + 5) < num2)
    System.out.println("white ");
else
    System.out.println("blue ");
System.out.println("yellow ");
```

a) num1=2, num2=10 → red white yellow
b) num1=10, num2=2 → blue yellow
c) num1=2, num2=2 → blue yellow
Outline

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

• When comparing data using boolean expressions, it's important to understand the nuances of certain data types

• Let's examine some key situations:
  – Comparing floating point values for equality
  – Comparing characters
  – Comparing strings (alphabetical order)
  – Comparing object vs. comparing object references
Comparing Float Values

• You should rarely use the equality operator (==) when comparing two floating point values (float or double)

• Two floating point values are equal only if their underlying binary representations match exactly

• Computations often result in slight differences that may be irrelevant

• In many situations, you might consider two floating point numbers to be "close enough" even if they aren't exactly equal
Comparing Float Values

- To determine the equality of two floats, use the following technique:

  ```java
  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

<table>
<thead>
<tr>
<th>Characters</th>
<th>Unicode Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 9</td>
<td>48 through 57</td>
</tr>
<tr>
<td>A – Z</td>
<td>65 through 90</td>
</tr>
<tr>
<td>a – z</td>
<td>97 through 122</td>
</tr>
</tbody>
</table>
Quiz

Is this snippet syntactically correct? If yes, what is going to be printed?

```java
if ('a' > 'b')
    System.out.println(true);
else
    System.out.println(false);
```
Quiz

Is this snippet syntactically correct? If yes, what is going to be printed?

```java
if ('a' > 'b')
    System.out.println(true);
else
    System.out.println(false);
```

YES it is correct and will print:
false
Comparing Objects

• The == operator can be applied to objects – it returns true if the two references are aliases of each other

• The equals method is defined for all objects, but unless we redefine it when we write a class, it has the same semantics as the == operator

• It has been redefined in the String class to compare the characters in the two strings

• When you write a class, you can redefine the equals method to return true under whatever conditions are appropriate
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

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

• We cannot use the relational operators to compare strings (‘<’ or ‘>’)

• The String class contains the compareTo method for determining if one string comes before another – but it returns an integer!

• 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

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

```java
int result = name1.compareTo(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".
Quiz

• Write an `compareTo` method for the `Die` class of section 4.2

• A call to `die1.compareTo(die2)`
  – returns zero if `die1` and `die2` are equal (show the same face)
  – returns a negative value if the `faceValue` of `die1` is smaller than the `faceValue` of `die2`
  – returns a positive value in the other cases
Quiz

• Write an `compareTo` method for the `Die` class of section 4.2

• A call to `die1.compareTo(die2)`
  – returns zero if `die1` and `die2` are equal (show the same face)
  – returns a negative value if the `faceValue` of `die1` is smaller than the `faceValue` of `die2`
  – returns a positive value in the other cases

```java
public int compareTo(Die die) {
    return faceValue - die.faceValue;
}
```
Quiz

- Write an equals method for the Die class of section 4.2
Quiz

- Write an `equals` method for the `Die` class of section 4.2

```java
public boolean equals(Die die) {
    if (faceValue == die.faceValue)
        return true;
    return false;
}
```

```java
public boolean equals(Die die) {
    return (faceValue == die.faceValue);
}
```
Quiz

• Write an equals method for the Die class of section 4.2

• Actually the previous solutions are not OK because the parameter of equals must be of type Object

```java
public boolean equals(Object die) {
    if (die.getClass() == getClass())
        return faceValue == (((Die) die).faceValue);
    return false;
}
```
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

condition evaluated

statement

true

false
The while Statement

• An example of a while statement:

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

• If the condition of a while loop is false initially, the statement is never executed.

• Therefore, the body of a while loop will execute zero or more times.
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();

        continue
```java
continue

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();
}
continue
```
continue

    System.out.println ()

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

        DecimalFormat fmt = new DecimalFormat ("0.###");
        System.out.println ("The average is " + fmt.format(average));
    }
}
```java
System.out.println();
if (count == 0)
    System.out.println("No values were entered.");
else {
    average = (double)sum / count;
    DecimalFormat fmt = new DecimalFormat("0.###");
    System.out.println("The average is " + fmt.format(average));
}
}
```
Quiz

• Modify the code of the previous example so that 0 can be entered as any other integer, i.e., will not stop the input

• Hint: use another non numeric "sentinel" and use hasNextInt() method of Scanner (it returns true if the input is an integer)
Solution

System.out.print("Enter an integer (\"q\" to quit): ");
while (scan.hasNextInt())
{
    value = scan.nextInt();
    count++;
    sum += value;
    System.out.println("The sum so far is "+sum);
    System.out.print("Enter an integer (\"q\" to quit): ");
}
Input Validation

• A loop can also be used for *input validation*, making a program more *robust*

• It's generally a good idea to verify that input is valid (in whatever sense) when possible

• See `WinPercentage.java`
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();

        continue
continue

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

ratio = (double)won / NUM_GAMES;

NumberFormat fmt = NumberFormat.getPercentInstance();

System.out.println();
System.out.println("Winning percentage: " + fmt.format(ratio));

}
continue

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

ratio = (double)won / NUM_GAMES;

NumberFormat fmt = NumberFormat.getPercentInstance();

System.out.println();
System.out.println ("Winning percentage: " + fmt.format(ratio));
What is going on here?

• An example of an "strange" loop:

```java
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.
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
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`
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;

            continue
        }
    }
}
```
continue

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 (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();
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
Quick Check

If \( x \) is an int where \( x = 1 \), what will \( x \) be after the following loop terminates?

\[
\text{while } (x < 100) \\
\quad x *= 2;
\]
Quick Check

If \( x \) is an int where \( x = 1 \), what will \( x \) be after the following loop terminates?

\[
\text{while } (x < 100) \\
\quad x *= 2;
\]

\( x = 128 \)
Outline

Boolean Expressions
The if Statement
Comparing Data
The while Statement
Iterators
The ArrayList Class
Determining Event Sources
Check Boxes and Radio Buttons
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 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 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](#)
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"));

        continue
// 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("/");

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

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

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

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The ArrayList Class

• An ArrayList object stores a list of objects, and is often processed using a loop

• The ArrayList class is part of the java.util package

• You can reference each object in the list using 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   "Bashful"
  1   "Sleepy"
  2   "Happy"
  3   "Dopey"
  4   "Doc"

• Elements can be inserted and removed

• The indexes of the elements adjust accordingly
ArrayList Methods

• Some **ArrayList** methods:

  ```java
  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 stored in the list is established when the ArrayList object is created:

```java
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, but that's what wrapper classes are for

• See Beatles.java
import java.util.ArrayList;

public class Beatles {
    public static void main (String[] args) {
        ArrayList<String> band = new ArrayList<String>();
        band.add("Paul");
        band.add("Pete");
        band.add("John");
        band.add("George");
    }
}

continue
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++;
}
}
```java
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

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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`
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);
    }
}
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);
    }
}
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
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);
}
private class ButtonListener implements ActionListener {
    public void actionPerformed (ActionEvent event) {
        if (event.getSource() == left)
            label.setText("Left");
        else
            label.setText("Right");
    }
}
Outline

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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 *ItemEvent* 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`
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);
    }
}
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);
    }
}
import javax.swing.*;
import java.awt.*;
import java.awt.event.*;

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

    continue
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
private class StyleListener implements ItemListener {
    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
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);
    }
}
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);
    }
}
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;

    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
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