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
{
    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
```java
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
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.
```
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;
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*:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( a )</td>
<td>( \neg a )</td>
</tr>
<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?

```c
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 |
|---|---|--------|--------|
| 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 `||`
Quiz

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

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

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

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

$$(c_1 \land \neg c_2) \lor (\neg c_1 \land c_2)$$

<table>
<thead>
<tr>
<th>$c_1$</th>
<th>$c_2$</th>
<th>$\neg c_1$</th>
<th>$\neg c_2$</th>
<th>$c_1 \land \neg c_2$</th>
<th>$\neg c_1 \land c_2$</th>
<th>$c_1 \land \neg c_2 \lor \neg c_1 \land c_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>true</td>
<td>true</td>
<td>false</td>
<td>false</td>
<td>false</td>
<td>false</td>
<td>false</td>
</tr>
<tr>
<td>true</td>
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<td>false</td>
<td>false</td>
<td>true</td>
<td>true</td>
<td>false</td>
<td>false</td>
<td>false</td>
</tr>
</tbody>
</table>
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?

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

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Quiz

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

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

count is 1
base is 0
```
Quiz

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

```java
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

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

count is 1
base is 1
```
Outline

Boolean Expressions
The if Statement
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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:

```
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.
Logic of an if statement

Flowchart

condition evaluated

true

false

statement

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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;

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

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*

```java
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
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));
```java
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

- Condition evaluated
- If true, execute statement1
- If false, execute statement2
What is printing the program described in this flowchart?
Syntax Diagram

If Statement

```java
if (Expression) Statement
else Statement
```

Switch Statement

```java
switch (Expression) {
    Switch Case: Block Statement
    default: Block Statement
}
```

While Statement

```java
while (Expression) Statement
```

For Statement

```java
for (For Init; Expression; For Update) (Statement)
```

Do Statement

```java
do (Statement) while (Expression);
```

Local Variable Declaration

```java
Statement Expression, Statement Expression, Statement Expression
```
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
// 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.");
    }
}
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

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

• Despite what the indentation implies, \texttt{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.

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

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

    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
```
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);
    }
```

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 );
}
}
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?

NO

IS A>B?

YES

IS A>C?

NO

YES

PRINT B

PRINT C

PRINT A

END
import java.util.Scanner;

public class MinOfThree
{
    //-----------------------------------------------
    //  Reads three integers from the user and determines the smallest
    //  value.
    //-----------------------------------------------
    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();

        continue
    }
}
continue

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

    System.out.println ("Minimum value: " + min);
}
```java
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
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Check Boxes and Radio Buttons

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Comparing Data

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

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

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

• 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 '☻' 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;
}

public boolean equals(Die die) {
    return (this.faceValue == die.faceValue);
}
```
Outline

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

true

statement

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
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
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));
}
}
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));
}

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
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
{
    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();
}

total = (double)won / NUM_GAMES;

NumberFormat fmt = NumberFormat.getPercentInstance();

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

}
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
{
    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
        }
    }
}
```java
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();
} 
} 
} 
} 

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++;
}

$10 \times 19 = 190$
Quick Check

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

```java
while (x < 100)
    x *= 2;
```
Quick Check

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

```
while (x < 100)
    x *= 2;
```

x=128
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
{
    //----------------------------------------------------------------------------
    // Reads urls from a file and prints their path components.
    //----------------------------------------------------------------------------
    public static void main (String[] args) throws IOException
    {
        String url;
        Scanner fileScan, urlScan;

        fileScan = new Scanner (new File("urls.inp"));

        continue
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();
}
```java
// 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=EHCRemwRGLs
youtube.com
watch?v=EHCRemwRGLs
Outline

- Boolean Expressions
- The if Statement
- Comparing Data
- The while Statement
- Iterators
- The ArrayList Class
- Determining Event Sources
- Check Boxes and Radio Buttons
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):**
  
<table>
<thead>
<tr>
<th>Index</th>
<th>String</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&quot;Bashful&quot;</td>
</tr>
<tr>
<td>1</td>
<td>&quot;Sleepy&quot;</td>
</tr>
<tr>
<td>2</td>
<td>&quot;Happy&quot;</td>
</tr>
<tr>
<td>3</td>
<td>&quot;Dopey&quot;</td>
</tr>
<tr>
<td>4</td>
<td>&quot;Doc&quot;</td>
</tr>
</tbody>
</table>

- Elements can be inserted and removed

- **The indexes of the elements adjust 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 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 {
    // 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");
        continue
    }
}

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++;
    }
    
}
System.out.println(band);
int location = band.indexOf("Pete");
bond.remove(location);
System.out.println(bond);
System.out.println("At index 1: " + bond.get(1));
bond.add(2, "Ringo");
System.out.println("Size of the band: " + bond.size());
int index = 0;
while (index < bond.size()) {
    System.out.println(bond.get(index));
    index++;
}
}
Outline

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

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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);
    }
}
//**********************************************************
// 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
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 {

    // 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
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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 `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 {
    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.*;

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
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 {
    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 {
    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;

    // 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

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