Chapter 4 Topics

▶ Flow of control
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▶ Boolean expressions
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▶ if, else and block statements
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▶ Comparing data
  Go to part 3

▶ switch statements
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▶ while, do, and for loops
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▶ Iterators, ArrayLists, Reading/Writing text files
  Go to part 6
Flow of Control

- Statement execution is *linear* unless specified otherwise.
- To make our programs more interesting there are program statements that allow us to:
  - decide whether or not to execute a particular statement *(conditional statements)*
  - execute a statement over and over, repetitively *(loops)*
- These decisions are based on *boolean expressions* *(or conditions)* that evaluate to *true* or *false*
- The order of statement execution is called the *flow of control*
A **conditional statement** lets us choose which statement will be executed next.

Therefore they are sometimes called **selection** statements.

Conditional statements give us the power to make basic decisions.

**Conditional statements in Java:**
- `if` statement
- `if-else` statement
- `switch` statement
The if statement

- The syntax of a basic if statement is:

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

- The condition must be a boolean expression. It must return true or false. Note that the condition must be enclosed in parentheses.
- If the condition is true, then the statement is executed.
- If the condition is false, then the statement is skipped.
Often, conditions are based on equality operators or relational operators.

<table>
<thead>
<tr>
<th>Operator</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>==</td>
<td>equal to</td>
</tr>
<tr>
<td>!=</td>
<td>not equal to</td>
</tr>
<tr>
<td>&lt;</td>
<td>less than</td>
</tr>
<tr>
<td>&lt;=</td>
<td>less than or equal to</td>
</tr>
<tr>
<td>&gt;</td>
<td>greater than</td>
</tr>
<tr>
<td>&gt;=</td>
<td>greater than or equal to</td>
</tr>
</tbody>
</table>

Note that the equality operator `==` is different than the assignment operator `=`.
Examples of **if** statements using equality and relational operators.

```java
if (total == sum)
{
    System.out.println("total equals sum");
}

if (count > 50)
{
    System.out.println("count is more than 50");
}

if (letter != 'x')
{
    System.out.println("letter is not x");
}

if (s.charAt(0) == 'A')
{
    System.out.println("String s starts with an A");
}
```
In-Class Exercise

Write an `if` statement that checks if the length of a `String` variable `str` is greater than zero.
Logical Operators

- Conditions can also use logical operators.

<table>
<thead>
<tr>
<th>Op</th>
<th>Meaning</th>
<th>Example</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>!</td>
<td>logical NOT</td>
<td>!a</td>
<td>true if a is false, false if a is true</td>
</tr>
<tr>
<td>&amp;&amp;</td>
<td>logical AND</td>
<td>a &amp;&amp; b</td>
<td>true if a and b are both true, false otherwise</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>logical OR</td>
</tr>
</tbody>
</table>

- They all take boolean operands and produce boolean results.
- Logical NOT is a unary operator.
- Logical AND and logical OR are binary operators.
A Truth Table represents the values of a Boolean expression for all possible values of its inputs.

- **Logical NOT**

<table>
<thead>
<tr>
<th>$a$</th>
<th>$!a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>false</td>
<td>true</td>
</tr>
<tr>
<td>true</td>
<td>false</td>
</tr>
</tbody>
</table>

- **Logical AND and logical OR**

<table>
<thead>
<tr>
<th>$a$</th>
<th>$b$</th>
<th>$a &amp;&amp; b$</th>
<th>$a \mid\mid b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>false</td>
<td>false</td>
<td>false</td>
<td>false</td>
</tr>
<tr>
<td>false</td>
<td>true</td>
<td>false</td>
<td>true</td>
</tr>
<tr>
<td>true</td>
<td>false</td>
<td>false</td>
<td>true</td>
</tr>
<tr>
<td>true</td>
<td>true</td>
<td>true</td>
<td>true</td>
</tr>
</tbody>
</table>
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.

Logical NOT has higher precedence than logical AND and logical OR.
Specific expressions can be evaluated using truth tables.

```java
if (total < MAX+5 && !found)
{
    System.out.println("processing..."seud);
}
```

Truth table:

<table>
<thead>
<tr>
<th>total &lt; MAX+5</th>
<th>found</th>
<th>!found</th>
<th>total &lt; MAX+5 &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>
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</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>
Short-Circuited Operators

- The processing of logical AND and logical OR 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");
}
```

- If count is equal to 0, then we won’t check the rest of the condition.
- This type of processing should be used carefully.
The if statement

- Consider the following if statement:

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

- First the condition is evaluated – the value of sum is either greater than the value of MAX, or it is not.
- If the condition is true, the assignment statement is executed – if it isn’t, it is skipped.
- Either way, the call to println is executed at the end.
- Example: Age.java
The statement controlled by the if statement is indented to indicate that relationship.

The use of a consistent indentation style makes a program easier to read and understand.

Although it makes no difference to the compiler, proper indentation is crucial for readability and maintainability.

Remember, indentation is for the human reader, and is ignored by the computer. E.g., this is BAD:

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

Despite what is implied by the indentation, the increment will occur whether the condition is true or not.
Several statements can be grouped together into a block statement delimited by curly 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 ++;
}
```

To avoid confusion, it is best to always use block statements.
The \textit{if-else} statement

- An \texttt{else clause} can be added to an \texttt{if} statement to make an \texttt{if-else} statement.

```java
if ( condition )
    statement1;
else
    statement2;
```

- If the \texttt{condition} is \texttt{true}, \texttt{statement1} is executed.
- If the condition is \texttt{false}, \texttt{statement2} is executed.
- One or the other will be executed, but never both.
- Examples: \texttt{Wages.java}, \texttt{Guessing.java}
Java has a **conditional operator** that uses a boolean condition to determine which of two expressions is evaluated.

The syntax is

```
condition ? expression1 : expression2;
```

- If the `condition` is `true`, `expression1` is evaluated.
- If the `condition` is `false`, `expression2` is evaluated.
- The resulting value of the entire conditional operator is the value of the selected expression.
The conditional operator is similar to an if-else statement, except that it is an expression that returns a value.

For example:

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

If `num1` is greater than `num2`, then `num1` is assigned to `larger`. If `num1` is less than or equal to `num2`, then `num2` is assigned to `larger`.

Here is another example:

```java
System.out.println("Your change is " + count + 
                   ((count == 1) ? "dime" : "dimes"));
```
Nested if Statements

- The statement executed as a result of an if statement or else clause could be another if statement.
- These are called nested if statements.
- An else clause is matched to the last unmatched if (no matter what the indentation implies).
- Braces should be used to specify the if statement to which an else clause belongs.
- Examples: MinOfThree.java
- In-class exercise: Write a code snippet to find the minimum of four numbers.
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 objects vs. comparing object references.
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 (e.g. 3.14 vs. 3.141592).

In many situations, you might consider two floating point numbers to be “close enough” even if they aren’t exactly equal.
To determine the equality of two floating point values, we can 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. For example, 10E-7 for `float` and 10E-15 for `double`.
- Example: `TestDoubleCompare.java`
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.
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>

We can also add and subtract characters. For example:

```java
System.out.println('b' - 'a');
System.out.println('9' - '0');
System.out.println('A' - 'a');
```
Comparing Strings (1)

- Recall 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");
}
```
We cannot use the relational operators to compare Strings.

The String class contains a method called `compareTo` to determine if one string comes before another.

Using the method would look something like:

```java
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 (3)

```java
if (name1.compareTo(name2) < 0)
{
    System.out.println(name1 + " comes first");
}
else if (name1.compareTo(name2) == 0)
{
    System.out.println("Same name");
}
else
{
    System.out.println(name2 + " comes first");
}
```
Because comparing characters and strings is based on a character set, it is called a lexicographic ordering.

Lexicographic ordering 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".
The `==` operator can be applied to objects, but it returns `true` if the two references are *aliases* of each other. It doesn't compare the values of the objects.

The `equals` method is defined for all objects, unless we redefine it when we write a class.

By default, it will be the same as the `==` operator.

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

When writing classes, we can/should redefine the `equals` method to return `true` under the appropriate conditions.

Example: `StringEquals.java`

Example: `PoetryPlay.java`
In-class exercise

```java
if (age < 18)
{
    if (status == "happy")
        System.out.println("Hi, I'm a minor and I'm happy!");
    else if (status == "sad")
        System.out.println("Hi, I'm a minor and I'm sad :(");
    else
        System.out.println("Hi, I'm a minor and I don't know my status");
}
else if (age >= 18 && age < 21)
{
    System.out.println("Hey, I'm over 18, but still not 21.");
}
else
{
    if (status == "happy")
        System.out.println("I love getting older!");
    else if (status == "sad")
        System.out.println("Man, I'm getting old...");
}
System.out.println("Goodbye!");
```

- What is the output if age = 17 and status = "happy"?
- What is the output if age = 25 and status = "excited"?
- What is the output if age = 21 and status = "sad"?
The switch Statement (1)

- The `switch` statement provides another way to decide which statement to execute next.
- The general syntax of the `switch` statement is

```java
switch (expression) {
    case value1:
        statement-list1
    case value2:
        statement-list2
    case value3:
        statement-list3
    case ...
}
```
The `switch` Statement (1)

- A `switch` statement evaluates an expression, then attempts to match the result to one of several possible cases.
- Each `case` contains a value and a list of statements.
- The flow of control transfers to the statement associated with the first case value that matches.
The `switch` Statement (2)

- Often a `break` statement is used as the last statement in each case’s statement list.
- A `break` statement causes control to transfer to the end of the `switch` statement.
- If a `break` statement is not used, the flow of control will continue into the next case. Sometimes this may be appropriate, but often we want to execute only the statements associated with one case.
The *switch* Statement (3)

- An example *switch* statement:

```java
cchar option = 'A';

switch (option) {
    case 'A':
        aCount ++;
        break;
    case 'B':
        bCount ++;
        break;
    case 'C':
        cCount ++;
        break;
}
```

- In-class Exercise. Rewrite the above *switch* statement using *if-else* statements.
The `switch` Statement (4)

- A `switch` statement can have an optional `default` case.
- The default case has no associated value and simply uses the reserved word `default`.
- If the default case is present, control will transfer to it if no other case value matches.
- If there is no default case, and no other value matches, control falls through to the statement after the switch.
Another example switch statement:

```java
public enum MyColors {BLUE, GREEN, PURPLE, ORANGE};

int countBlue = 0, countGreen = 0;
int countPurple = 0, countOrange = 0;
MyColors color = MyColors.BLUE;

switch (color)
{
    case BLUE:
        countBlue ++;
        break;
    case GREEN:
        countGreen ++;
        break;
    case PURPLE:
        countPurple ++;
        break;
    case ORANGE:
        countOrange ++;
        break;
    default:
        System.out.println("Not in my top four!");
        break;
}
```
The `switch` Statement (6)

- The expression of a switch statement must result in an integral type, meaning an integer (`byte`, `short`, `int`, `long`), `char` or an `enum`.
- Switch statements can also use `String` type from Java 7 onward.
- It cannot be a boolean value or a floating point value (`float` or `double`).
- The implicit boolean condition in a switch statement is equality.
- You cannot perform relational checks with a switch statement.
- Example: GradeReport.java, Days.java and SwitchDays.java, FavoriteColors.java and FavoriteColorsByOrdinal.java
Loops allow us to execute a statement multiple times.
Like conditional statements, they are controlled by boolean expressions.
Java has three kinds of loops:
  - the while loop
  - the do loop
  - the for loop
The **while** loop (1)

- A **while** loop has the following syntax:

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

- If the **condition** is true, the **statement** is executed.
- The **statement** is executed repeatedly until the condition becomes false.
- If the condition of a while loop is false initially, the statement is never executed.
- Therefore, the body of a while loop will execute zero or more times.
The **while** loop (2)

- *While count is less than or equal to 5, print the value of count and increment the value of count by one.*

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

- What is the output from the above code snippet?
The while loop (3)

Write a loop that counts the number of times the letter 'z' occurs in a given String s.

String s = "I am a zizzer zazzer zuzz";

int count = 0;
int index = 0;
while (index < s.length())
{
    if (s.charAt(index) == 'z')
        count++;
    index++;
}
System.out.println("#z: " + count);
In-class exercise

Write a `while` loop that prints the letters in a string variable `s`, one per line.

```java
String s = "watch me go!";  
```
The **while** loop (4)

- Let’s look at some more examples of loop processing.
- A loop can be used to maintain a *running sum*. Or compute the average or min or max value from a series of values.
- A **sentinel value** is a special input value that represents the end of input.
  - Example: `Average.java`
- A loop can be used to validate input from a user.
  - Example: `WinPercentage.java`
Infinite Loops

- **Infinite loops** are loops that keep running forever. Usually, they are not good!
- Example of an infinite loop.

```java
int count = 1;
while (count <= 25)
{
    System.out.println(count);
    count--;
}
```

- To stop an infinite loop, interrupt your program execution with the cancel command (ctrl-c). In Eclipse, click on the red stop button.
- Infinite loops can be useful in certain circumstances.

```java
while (true)
{
    //wait for interaction from user
}
```

- For example, the operating system runs in an infinite loop on your desktop, laptop or phone (unless you power it off or it crashes!)
- Example: InfiniteLoop.java
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.

How many times will the output be printed?

```java
int count1 = 1;
while (count1 <= 10)
{
    int count2 = 1;
    while (count2 <= 50)
    {
        System.out.println("Here again");
        count2++;
    }
    count1++;
}
```

What if the condition on outer loop was (count1 < 10)?
What if the variable count2 was initialized to 10 instead of 1 before the inner loop?
A **Palindrome** is a string of characters that reads the same both forward and backward. Are the following palindromes?

- radar
- kayak
- Radar
- A man, a plan, a canal, Panama.

**Example:** `PalindromeTester.java`

Generalize to skip spaces, punctuation and changes in case for letters.
The do Loop (1)

- The do loop has the following syntax:

```java
do
{
    statements;
}
while (condition);
```

- The statement is executed once initially, and then the condition is evaluated.
- The statement is executed repeatedly until the condition becomes false.
- The body of a do loop is executed at least once.
The do Loop (2)

- An example of a do loop:

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

- Example: ReverseNumber.java
while vs. do-while

- Check for understanding...what is the difference?
The **for** Loop (1)

- The **for** loop has the following syntax:

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

- The **initialization** is executed *once* before the loop begins.
- If the **condition** is true, the **statement** is executed, then the **increment** is executed.
- The **condition** is evaluated again, and if it is still true, the **statement** and **increment** are executed again.
- The **statement** and **increment** are executed repeatedly until the condition becomes false.
The **for** loop (2)

The **for** loop is functionally equivalent to the following **while** loop structure:

```plaintext
initialization;
while (condition) {
    statement;
    increment;
}
```
An example of a for loop:

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

- The initialization section can be used to declare a variable.
- Like a `while` loop, the condition of a `for` loop is tested prior to executing the loop body.
- Therefore, the body of a `for` loop will execute zero or more times.
- A `for` loop is well suited for executing statements a specific number of times that can be calculated or determined in advance.
The **for** Loop (4)

- The increment section can perform any calculation.

```java
for (int num = 100; num > 0; num = num - 5)
    System.out.println(num);
```

- Write a **for** loop to print the multiples of 3 from 3 to 300.

```java
for (int i = 1; i <= 100; i++)
    System.out.println(3*i);
```

- Write a **for** loop to print the multiples of 3 from 300 down to 3.

```java
for (int i = 100; i >= 1; i--)
    System.out.println(3*i);
```
The **for** Loop (5)

- Write a **for** loop that computes the sum of integers from 20 to 70, inclusive, and then prints the result.

```java
int sum = 0; int low = 20; int high = 70;
for (int i = low; i <= high; i++)
{
    sum += i;
}
System.out.println(sum = " + sum);
```

- Write a **for** loop that creates a new string composed of every other character from the **String** object called **name**

```java
String s = "";
for (int i = 0; i < name.length(); i += 2)
{
    s += name.charAt(i);
}
System.out.println(s);
```
Example: Multiples.java.

- Shows how to print fixed number of values per line using the mod % operator inside a for loop.

- Nested for loops are similar to other nested loops. What does the following loop print?

```java
//PP 4.6
int n = 12;
for (int i = 1; i <= n; i++)
{
    for (int j = 1; j <= n; j++)
    {
        System.out.print(i*j + " ");
    }
    System.out.println();
}
```
In-class Exercise

What does the following for loop print?

```java
final int MAX_ROWS = 10;

for (int row = MAX_ROWS; row > 0; row--)
{
    for (int star = 0; star < row; star++)
        System.out.print("*");
    System.out.println();
}
```
The `for` Loop (7)

▶ Each expression in the header of a `for` loop is optional.
▶ If the initialization is left out, no initialization is performed.
▶ If the condition is left out, it is always considered to be true, and therefore creates an infinite loop.
▶ If the increment is left out, no increment operation is performed.
▶ The following is a valid, infinite `for` loop!

```java
for (;;) {}
```
More for Loop Examples

- More examples using for loops.
  - Example: RandomBoxes.java
  - Example: BullsEye.java
In-class Exercise

What does the `for` loop in following `paintComponent` method draw?

```java
private final int SIZE = 30;
private final int GAP = 10;
private final int WIDTH = 800;

public void paintComponent(Graphics page) {
    super.paintComponent(page);
    int n = WIDTH / 40;
    for (int i = 0; i < n; i++)
        for (int j = 0; j < n; j++) {
            page.setColor(Color.blue);
            page.fillRect((SIZE + GAP)*i, (SIZE + GAP)*j, SIZE, SIZE);
        }
}
```

A two-dimensional lattice of blue squares!
Iterators (1)

- An **iterator** is an object that allows you to process a collection of items one at a time.
- It lets you step through each item in turn and process it as needed.
- An iterator object has a **hasNext** method that returns true if there is at least one more item to process.
- The **next** method returns the next item.
- Iterator objects are defined using the **Iterator** interface.
Some classes in the Java API are iterators. For example, the \texttt{Scanner} class is an iterator.
\begin{itemize}
\item the \texttt{hasNext} method returns true if there is more data to be scanned.
\item the \texttt{next} method returns the next scanned token as a string.
\end{itemize}

The \texttt{Scanner} class also has variations on the \texttt{hasNext} method for specific data types (such as \texttt{hasNextInt}).
Reading Text Files (1)

- The File from the java.io allows us to interact with files on the system.

```java
File image = new File("photo.jpg");
if (image.exists())
    System.out.println("Image size: " + image.length() + " bytes");
```

- Example: FileTest.java
- A File object can be passed to the Scanner constructor, which allows to read from a file by iterating through it.
- Scanner can be used to read a file line by line or token by token. Here is a code snippet for reading a file line by line:

```java
Scanner fileScan = new Scanner(new File("input.txt"));
while (fileScan.hasNextLine()) {
    String line = fileScan.nextLine();
    // do something with the line
}
fileScan.close();
```

- Example: FileReading.java
- Example: ListFileWords.java
- Also, check out example on writing text files: FileWriting.java
When we use a `Scanner` to open a file, it is possible to get an exception thrown because the file wasn’t found.

We have two choices for an `Exception`:

- **try and catch**: Use a try-catch statement to handle the exception in the method.

  ```java
  try {
      ...
  } catch (FileNotFoundException e) {
      // print or handle appropriate error
  }
  ``

- **throw**: The other option is for the method to pass on the exception to the calling method using the `throws` clause

  ```java
  public static void readFile(File file) throws FileNotFoundException {
      ...
  }
  ```
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 file until the end of the file is encountered.

Another scanner can be set up for each URL to process each part of the path.

Example URLDissector.java
Iterators and the for-each Loop

- A variant of the for loop simplifies the repetitive processing for any object that implements the Iterable interface.
- This style of for loop is referred to as the for-each loop.
- An Iterable interface provides an iterator.
- For example, the values() associated with an enum gives us an Iterable list that we can use with a for-each loop.

```java
public enum Day { SUNDAY, MONDAY, TUESDAY, WEDNESDAY, THURSDAY, FRIDAY, SATURDAY; }

for (Day today : Day.values())
    System.out.println(today);
```

- It will be helpful when processing arrays (Chapter 7).
The **ArrayList** Class

- The **ArrayList** class stores a list of objects. It is part of the `java.util` package.
- It grows and shrinks as needed. Each object in it has a numeric index, starting from zero. Objects can be inserted or removed and the indices adjust accordingly.
- The declaration establishes the type of objects that a given **ArrayList** class can store. This is an example of **generics**.

```java
ArrayList<String> band = new ArrayList<String>();
band.add("Paul");
band.add("Pete");
band.add("John");
band.add("George");
System.out.println("Size of the band: " + band.size());
// Iterate over the band members using a for-each loop
for (String member : band) {
    System.out.print(member + " ");
}
```

- Example: **Beatles.java**
- The **ArrayList** class cannot store primitive types. We can use wrapper objects if we want to store primitive types in an **ArrayList**.
Review

- while, do-while, and for loops
- Which loop should we use to
  - Print numbers 1 - 100.
  - Keep asking the user to enter input until they enter a specific sentinel value.
  - Ask the user for 3 items.
  - Read a number from the user and store each digit of the number in a separate int.
  - Reverse a String.
Exercises

▶ Read Chapter 4.

▶ **Recommended Homework:**
  ▶ Exercises: EX 4.2–4.4, 4.6, 4.8, 4.11–4.14, 4.17, 4.21, 4.22.

▶ Browse: Sections 5.1–5.4.