11

Working with Arrays, Loops, and Dates

Interactive Quizzes

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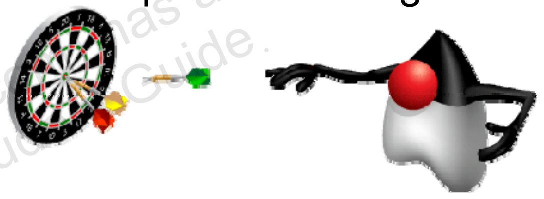
Before you start today's lessons, test your knowledge by answering some quiz questions that relate to yesterday's lessons. Open your quiz file from labs > Quizzes > Java SE 8 Fundamentals Quiz.html. Click the links for the lessons titled "Using Encapsulation" and "More on Conditionals."

Objectives

After completing this lesson, you should be able to:

- Create a `java.time.LocalDateTime` object to show the current date and time
- Parse the `args` array of the `main` method
- Correctly declare and instantiate a two-dimensional array
- Code a nested `while` loop to achieve the desired result
- Use a nested `for` loop to process a two-dimensional array
- Code a `do/while` loop to achieve the desired result
- Use an ArrayList to store and manipulate lists of Objects
- Evaluate and select the best type of loop to use for a given programming requirement



Topics

- Working with dates
- Parsing the `args` array
- Two-dimensional arrays
- Alternate looping constructs
- Nesting loops
- The `ArrayList` class

New SE 8 Feature!

The first topic, "Working with dates," focuses on the new Date Time API. This is a new feature of Java SE 8.

Displaying a Date

```
LocalDate myDate =  LocalDate.now();
System.out.println("Today's date: "+ myDate);
```

Output: 2013-12-20

- `LocalDate` belongs to the package `java.time`.
- The `now` method returns today's date.
- This example uses the default format for the default time zone.

The `now` static method returns an object of type `LocalDate`. Of course, `System.out.println` calls the `toString` method of the `LocalDate` object. Its `String` representation is 2013-12-20 in this example.

Class Names and the Import Statement

- Date classes are in the package `java.time`.
- To refer to one of these classes in your code, you can fully qualify
  `java.time.LocalDate`
  or, add the import statement at the top of the class.

```
import java.time.LocalDate;
public class DateExample {
    public static void main (String[] args) {
        LocalDate myDate;
    }
}
```

Classes in the Java programming language are grouped into packages depending on their functionality. For example, all classes related to the core Java programming language are in the `java.lang` package, which contains classes that are fundamental to the Java programming language, such as `String`, `Math`, and `Integer`. Classes in the `java.lang` package can be referred to in code by just their class names. They do not require full qualification or the use of an import statement.

All classes in other packages (for example, `LocalDate`) require that you fully qualify them in the code or that you use an `import` statement so that they can be referred to directly in the code.

The `import` statement can be:

- For just the class in question
  `java.time.LocalDate;`
- For all classes in the package
  `java.time.*;`

Working with Dates

`java.time`
- Main package for date and time classes

`java.time.format`
- Contains classes with static methods that you can use to format dates and times

Some notable classes:
- `java.time.LocalDate`
- `java.time.LocalDateTime`
- `java.time.LocalTime`
- `java.time.format.DateTimeFormatter`

Formatting example:

```
myDate.format(DateTimeFormatter.ISO_LOCAL_DATE);
```

The Java API has a `java.time` package that offers many options for working with dates and times. A few notable classes are:

- `java.time.LocalDate` is an immutable date-time object that represents a date, often viewed as year-month-day. Other date fields, such as day-of-year, day-of-week, and week-of-year, can also be accessed. For example, the value “2nd October 2007” can be stored in a `LocalDate`.
- `java.time.LocalDateTime` is an immutable date-time object that represents a date-time, often viewed as year-month-day-hour-minute-second. Other date and time fields, such as day-of-year, day-of-week, and week-of-year, can also be accessed. Time is represented to nanosecond precision. For example, the value “2nd October 2007 at 13:45.30.123456789” can be stored in a `LocalDateTime`.
- `java.time.LocalTime` is an immutable date-time object that represents a time, often viewed as hour-minute-second. Time is represented to nanosecond precision. For example, the value “13:45.30.123456789” can be stored in a `LocalTime`. It does not store or represent a date or time-zone. Instead, it is a description of the local time as seen on a wall clock. It cannot represent an instant on the time-line without additional information such as an offset or time zone.

- `java.time.format.DateTimeFormatter` provides static and nonstatic methods to format dates using a specific format style. It also provides static constants (variables) that represent specific formats.
- The example in the slide uses a static constant variable, `ISO_LOCAL_DATE`, from the `DateTimeFormatter` class. It is passed as an argument into the `format` method of Date object:

  ```
  myDate.format(DateTimeFormatter.ISO_LOCAL_DATE)
  ```
- A formatted `String` representing the `LocalDateTime` is returned from the `format` method. For a more complete discussion of date formatting, see “Some Methods of `LocalDate`” later in the lesson.

Working with Different Calendars

- The default calendar is based on the Gregorian calendar.
- If you need non-Gregorian type dates:
  - Use the `java.time.chrono` classes
    - They have conversion methods.
- Example: Convert a `LocalDate` to a Japanese date:

```
LocalDate myDate =  LocalDate.now();
JapaneseDate jDate = JapaneseDate.from(mydate);
System.out.println("Japanese date: "+ jDate);
```

- Output:

  Japanese date: `Japanese Heisei 26-01-16`

In the above example, `JapaneseDate` is a class belonging to the `java.time.chrono` package. `myDate` is passed to the static `from` method, which returns a `JapaneseDate` object (`jDate`). The result of printing the `jDate` object is shown as output.

Some Methods of `LocalDate`

`LocalDate` overview: A few notable methods and fields

- Instance methods:
  - `myDate.minusMonths (15);` `(long monthsToSubtract)`
  - `myDate.plusDays (8);` `(long daysToAdd)`
- Static methods:
  - `of(int year, Month month, int dayOfMonth)`
  - `parse(CharSequence text, DateTimeFormatter formatter)`
  - `now()`

`LocalDate` has many methods and fields. Here are just a few of the instance and static methods that you might use:

- `minusMonths` returns a copy of this `LocalDate` with the specified period in months subtracted.
- `plusDays` returns a copy of this `LocalDate` with the specified number of days added.
- `of(int year, Month month, int dayOfMonth)` obtains an instance of `LocalDate` from a year, month, and day.
- `parse(CharSequence text, DateTimeFormatter formatter)` obtains an instance of `LocalDate` from a text string using a specific formatter.

Read the LocalDate API reference for more details.

Formatting Dates

```
 1 LocalDateTime today = LocalDateTime.now();
 2 System.out.println("Today's date time (no formatting): "
 3          + today);
 4
 5
 6  String sdate =
 7     today.format(DateTimeFormatter.ISO_DATE_TIME);
 8  System.out.println("Date in ISO_DATE_TIME format: "
 9          + sdate);
10
11 String fdate =
12    today.format(DateTimeFormatter.ofLocalizedDateTime
14         (FormatStyle.MEDIUM));
15  System.out.println("Formatted with MEDIUM FormatStyle: "
16          + fdate);
```

Format the date in standard ISO format.

Localized date time in Medium format

```
Output:
Today's date time (no formatting):        2013-12-23T16:51:49.458
Date in ISO_DATE_TIME format:             2013-12-23T16:51:49.458
Formatted with MEDIUM FormatStyle:        Dec 23, 2013 4:51:49 PM
```

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The code example in the slide shows you some options for formatting the output of your dates.

- **Line 1:** Get a `LocalDateTime` object that reflects today's date.
- **Lines 6 - 7:** Get a `String` that shows the date object formatted in standard `ISO_DATE_TIME` format. As you see in the output, the default format when you just print the `LocalDateTime` object uses the same format.
- **Lines 11 - 12:** Call the `ofLocalizedDateTime` method of the `DateTimeFormatter` to get a `String` representing the date in a medium localized date-time format. The third line of the output shows this shorter version of the date.

Exercise 11-1: Declare a `LocalDateTime` Object

1. Declare and initialize a `LocalDateTime` object.
2. Print and format the `OrderDate`.
3. Run the code.

- Open the Java Code Console and access 11-ArraysLoopsDates > Exercise1.
- Follow the instructions below the code editor.
- If you need help, click the Solution link. To go back to your code, click the Exercise link again. Any changes that you have made will have been saved.

Topics

- Working with dates
- Parsing the `args` array
- Two-dimensional arrays
- Alternate looping constructs
- Nesting loops
- The `ArrayList` class

Using the `args` Array in the `main` Method

- Parameters can be typed on the command line:

```
> java ArgsTest Hello World!
args[0] is Hello
args[1] is World!
```

Goes into args[1]

Goes into args[0]

- Code for retrieving the parameters:

```
public class ArgsTest {
    public static void main (String[] args) {
        System.out.println("args[0] is " + args[0]);
        System.out.println("args[1] is " + args[1]);
    }
}
```

When you pass strings to your program on the command line, the strings are put in the `args` array. To use these strings, you must extract them from the `args` array and, optionally, convert them to their proper type (because the `args` array is of type `String`).

The `ArgsTest` class shown in the slide extracts two `String` arguments passed on the command line and displays them.

To add parameters on the command line, you must leave one or more spaces after the class name (in this case, `ArgsTest`) and one or more spaces between each parameter added.

NetBeans does not allow you a way to run a Java class from the command line, but you can set command-line arguments as a property of the NetBeans project.

Converting `String` Arguments to Other Types

- Numbers can be typed as parameters:

```
> java ArgsTest 2 3
Total is: 23     Concatenation, not addition!
Total is: 5
```

- Conversion of `String` to `int`:

```
public class ArgsTest {                                    Strings
   public static void main (String[] args) {
      System.out.println("Total is:"+(args[0]+args[1]));
         int arg1 = Integer.parseInt(args[0]);
         int arg2 = Integer.parseInt(args[1]);
         System.out.println("Total is: " + (arg1+arg2));
   }
}                                          Note the parentheses.
```

The `main` method treats everything you type as a literal string. If you want to use the string representation of a number in an expression, you must convert the string to its numerical equivalent.

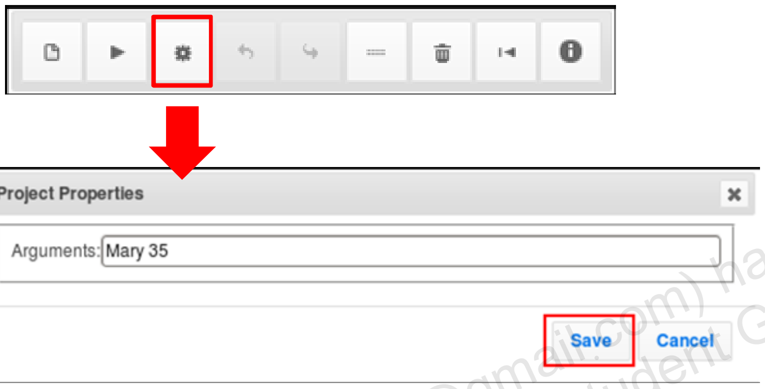
The `parseInt` static method of the Integer class is used to convert the `String` representation of each number to an `int` so they can be added.

Note that the parentheses around `arg1 + arg2` are required so that the `+` sign indicates addition rather than concatenation. The `System.out.println` method converts any argument passed to it to a `String`. We want it to add the numbers first, and *then* convert the total to a `String`.

Exercise 11-2: Parsing the `args` Array

In this exercise, you parse the `args` array in the `main` method to get the command-line arguments and assign them to local variables.

- To enter command-line arguments, click the Configure button and enter the values, separated by a space.



Arguments: Mary 35

- In the Java Code Console, access Lessons > 11-ArraysLoopsDates > Exercise2.
- Follow the instructions below the code editor to parse the `args` array in the `main` method, saving the arguments to local variables and then printing them.
- Enter command arguments as described in the slide above.
- Run the file to test your code.
- If you need help, click the Solution link. To go back to your code, click the Exercise link again. Any changes that you have made will have been saved.

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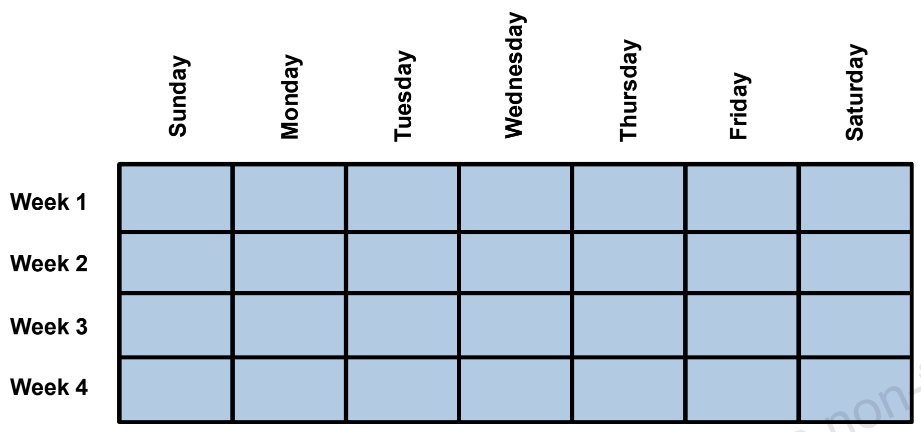
Describing Two-Dimensional Arrays



You can store matrices of data by using multidimensional arrays (arrays of arrays, of arrays, and so on). A two-dimensional array (an array of arrays) is similar to a spreadsheet with multiple columns (each column represents one array or list of items) and multiple rows.

The diagram in the slide shows a two-dimensional array. Note that the descriptive names Week 1, Week 2, Monday, Tuesday, and so on would not be used to access the elements of the array. Instead, Week 1 would be index 0 and Week 4 would be index 3 along that dimension, whereas Sunday would be index 0 and Saturday would be index 6 along the other dimension.

Declaring a Two-Dimensional Array

Example:

```
    int [][] yearlySales;
```

Syntax:

```
    type [][] array_identifier;
```

Two-dimensional arrays require an additional set of brackets. The process of creating and using two-dimensional arrays is otherwise the same as with one-dimensional arrays. The syntax for declaring a two-dimensional array is:

```
        type [][] array_identifier;
```

where:

- `type` represents the primitive data type or object type for the values stored in the array
- `[][]` informs the compiler that you are declaring a two-dimensional array
- `array_identifier` is the name you have assigned the array during declaration

The example shown declares a two-dimensional array (an array of arrays) called `yearlySales`.

Instantiating a Two-Dimensional Array

Example:

```
// Instantiates a 2D array: 5 arrays of 4 elements each
yearlySales = new int[5][4];
```

Syntax:

```
array_identifier = new type [number_of_arrays] [length];
```

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Year 1				
Year 2				
Year 3				
Year 4				
Year 5				

The syntax for instantiating a two-dimensional array is:

```
array_identifier = new type [number_of_arrays] [length];
```

where:

- `array_identifier` is the name that you have assigned the array during declaration
- `number_of_arrays` is the number of arrays within the array
- `length` is the length of each array within the array

The example shown in the slide instantiates an array of arrays for quarterly sales amounts over five years. The `yearlySales` array contains five elements of the type `int` array (five subarrays). Each subarray is four elements in size and tracks the sales for one year over four quarters.

Initializing a Two-Dimensional Array

Example:

```
int[][] yearlySales = new int[5][4];
yearlySales[0][0] = 1000;
yearlySales[0][1] = 1500;
yearlySales[0][2] = 1800;
yearlySales[1][0] = 1000;
yearlySales[3][3] = 2000;
```

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Year 1	1000	1500	1800	
Year 2	1000			
Year 3				
Year 4				2000
Year 5				

When setting (or getting) values in a two-dimensional array, indicate the index number in the array by using a number to represent the row, followed by a number to represent the column. The example in the slide shows five assignments of values to elements of the `yearlySales` array.

Note: When you choose to draw a chart based on a 2D array, they way you orient the chart is arbitrary. That is, you have the option to decide if you would like to draw a chart corresponding to `array2DName[x][y]` or `array2DName[y][x]`.

Quiz

A two-dimensional array is similar to a _______.

a. Shopping list
b. List of chores
c. Matrix
d. Bar chart containing the dimensions for several boxes

Answer: c

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Some New Types of Loops

Loops are frequently used in programs to repeat blocks of code while some condition is true.

There are three main types of loops:

- A `while` loop repeats *while* an expression is true.
- A `for` loop simply repeats a *set number* of times.
  - * A variation of this is the **enhanced** `for` loop. This loops through the elements of an array.
- A `do/while` loop executes once and then continues to repeat *while* an expression is true.

**You have already learned this one!*

Up to this point, you have been using the enhanced for loop, which repeats a block of code for each element of an array.

Now you can learn about the other types of loops as described above.

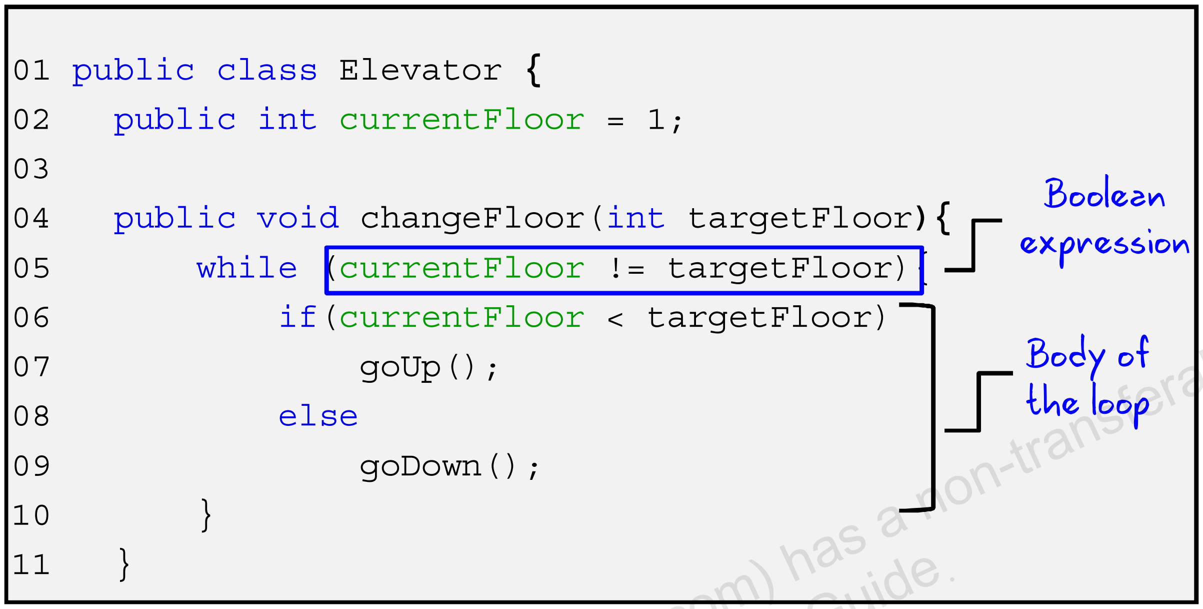
Repeating Behavior

```
while (!areWeThereYet) {

  read book;
  argue with sibling;
  ask, "Are we there yet?";

}

Woohoo!;
Get out of car;
```

A common requirement in a program is to repeat a number of statements. Typically, the code continues to repeat the statements until something changes. Then the code breaks out of the loop and continues with the next statement.

The pseudocode example above, shows a `while` loop that loops until the `areWeThereYet` `boolean` is `true`.

A `while` Loop Example



```
public class Elevator {
  public int currentFloor = 1;

  public void changeFloor(int targetFloor){
      while (currentFloor != targetFloor){
          if(currentFloor < targetFloor)
              goUp();
          else
              goDown();
      }
  }
```

The code in the slide shows a very simple `while` loop in an `Elevator` class. The elevator accepts commands for going up or down only one floor at a time. So to move a number of floors, the `goUp` or `goDown` method needs to be called a number of times.

- The `goUp` and `goDown` methods increment or decrement the `currentFloor` variable.
- The boolean expression returns `true` if `currentFloor` is not equal to `targetFloor`. When these two variables are equal, this expression returns `false` (because the elevator is now at the desired floor), and the body of the `while` loop is not executed.

Coding a `while` Loop

Syntax:

```
   while (boolean_expression) {
        code_block;
   }
```

The `while` loop first evaluates a boolean expression and, while that value is true, it repeats the code block. To avoid an infinite loop, you need to be sure that something will cause the boolean expression to return false eventually. This is frequently handled by some logic in the code block itself.

`while` Loop with Counter

```java
System.out.println("/*");
int counter = 0;
while (counter < 3){
     System.out.println(" *");
     counter++;
}
System.out.println("*/");
```

Output:

```
/*
 *
 *
 *
*/
```

Loops are often used to repeat a set of commands a specific number of times. You can easily do this by declaring and initializing a counter (usually of type `int`), incrementing that variable inside the loop, and checking whether the counter has reached a specific value in the `while` boolean expression.

Although this works, the standard `for` loop is ideal for this purpose.

Coding a Standard `for` Loop

The standard `for` loop repeats its code block for a set number of times using a counter.

Example:

```
01 for(int i = 1; i < 5; i++){
02     System.out.print("i = " +i +"; ");
03 }
```

Output: i = 1; i = 2; i = 3; i = 4;

Syntax:

```
01 for  (<type> counter = n;
02        <boolean_expression>;
03        <counter_increment>){
04           code_block;
05 }
```

The three essential elements of a standard `for` loop are the counter, the boolean expression, and the increment. All of these are expressed within parentheses following the keyword `for`.

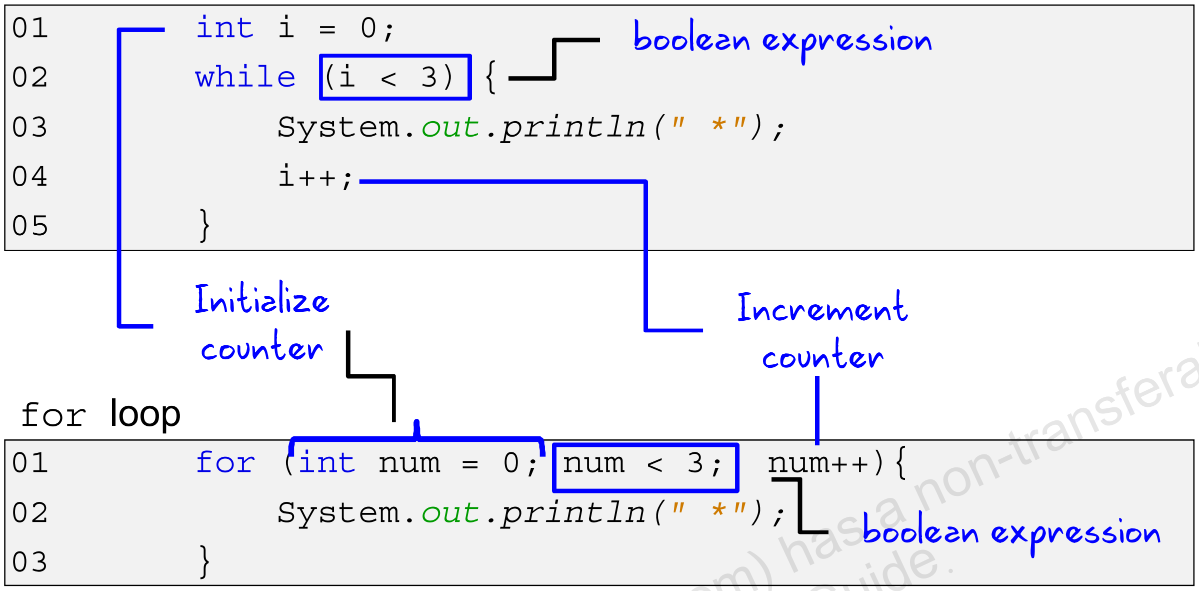
1. A `counter` is declared and initialized as the first parameter of the `for` loop. (`int i = 1`)
2. A boolean expression is the second parameter. It determines the number of loop iterations. (`i < 5`)
3. The `counter` increment is defined as the third parameter. (`i++`)

The code block (shown on line 2) is executed in each iteration of the loop. At the end of the code block, the counter is incremented by the amount indicated in the third parameter.

As you can see, in the output shown above, the loop iterates four times.

Standard `for` Loop Compared to a `while` loop

`while` loop



```
01        int i = 0;
02        while (i < 3) {
03            System.out.println(" *");
04            i++;
05        }
```

`for` loop

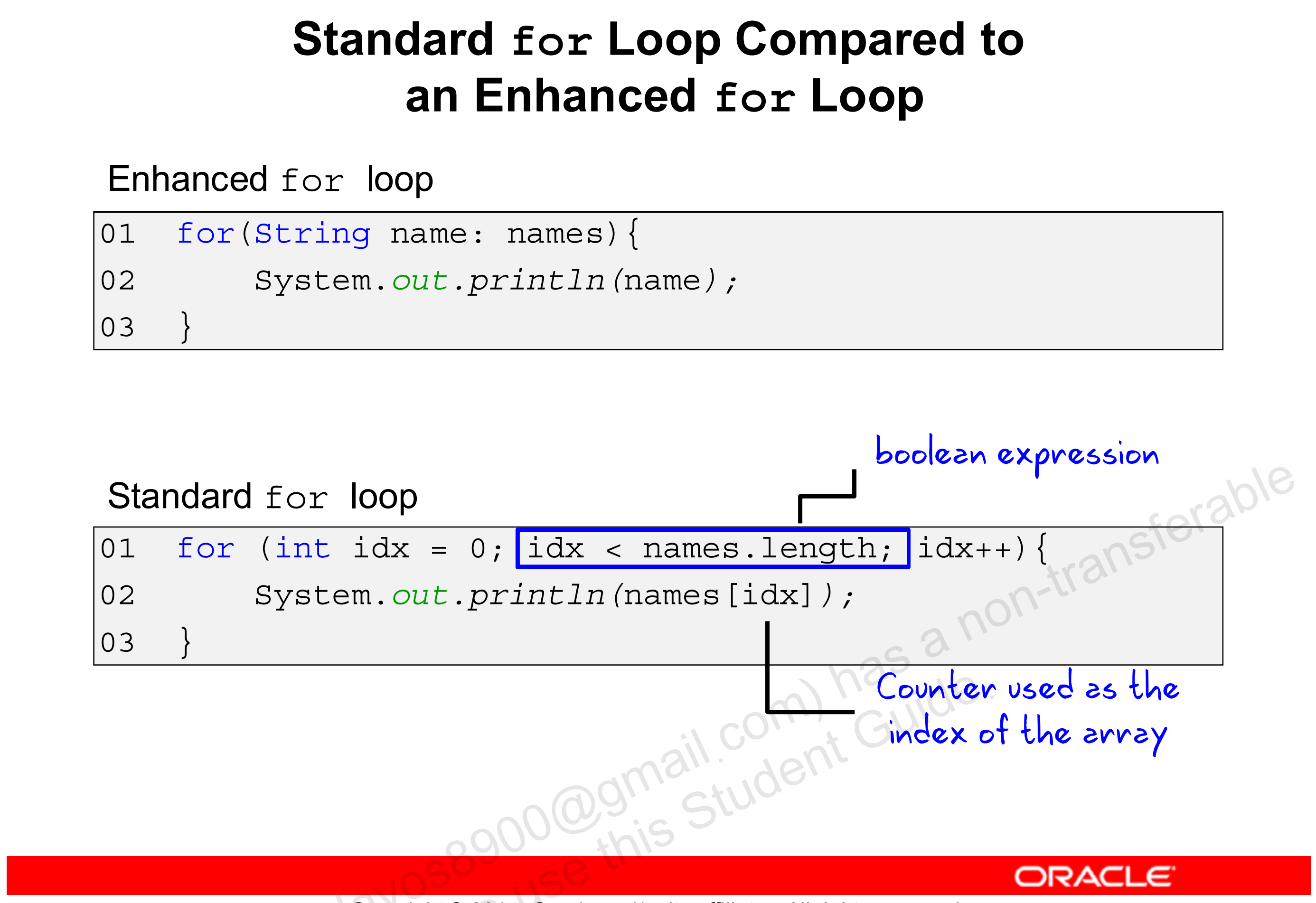
```
01        for (int num = 0; num < 3; num++){
02            System.out.println(" *");
03        }
```

In this slide, you see a `while` loop example at the top of the slide. At the bottom, you see the same logic implemented using a standard `for` loop.

The three essential elements of a `while` loop are also present in the `for` loop, but in different places.

1. The counter `(i)` is declared and initialized outside the `while` loop on line 1.
2. The counter is incremented in the `while` loop on line 4.
3. The boolean expression that determines the number of loop iterations is within the parentheses for the `while` loop on line 2.
4. In the `for` loop, all three elements occur within the parentheses as indicated in the slide.

The output for each statement is the same.



Standard `for` Loop Compared to an Enhanced `for` Loop

Enhanced `for` loop

```
for(String name: names){
    System.out.println(name);
}
```

Standard `for` loop

```
for (int idx = 0; idx < names.length; idx++){
    System.out.println(names[idx]);
}
```

boolean expression
Counter used as the index of the array

This slide compares the standard `for` loop to the enhanced `for` loop that you learned about in the lesson titled "Managing Multiple Items." The examples here show each type of `for` loop used to iterate through an array. Enhanced `for` loops are used only to process arrays, but standard `for` loops can be used in many ways.

- **The enhanced `for` loop example:** A `String` variable, `name`, is declared to hold each element of the array. Following the colon, the `names` variable is a reference to the array to be processed. The code block is executed as many times as there are elements in the array.
- **The standard `for` loop example:** A counter, `idx`, is declared and initialized to 0. A boolean expression compares `idx` with the `length` of the `names` array. If `idx < names.length`, the code block is executed. `idx` is incremented by one at the end of each code block.
- Within the code block, `idx` is used as the array index.

The output for each statement is the same.

`do/while` Loop to Find the Factorial Value of a Number

```
// Finds the product of a number and all integers below it
static void factorial(int target){
    int save = target;
    int fact = 1;
    do {
        fact *= target--;
    }while(target > 0);
    System.out.println("Factorial for "+save+": "+ fact);
}
```

Executed once before evaluating the condition

Outputs for two different targets:

```
Factorial value for 5: 120

Factorial value for 6: 720
```

The `do/while` loop is a slight variation on the `while` loop.

The example above shows a `do/while` loop that determines the factorial value of a number, called `target`. The factorial value is the product of an integer, multiplied by each positive integer smaller than itself. For example if the `target` parameter is `5`, this method multiplies 1 * `5 * 4 *3 * 2 * 1` resulting in a factorial value of `120`.

`do/while` loops are not used as often as `while` loops. The code above could be rewritten as a `while` loop like this:

```
while (target > 0) {
     fact *= target--;
}
```

The decision to use a `do/while` loop instead of a `while` loop usually relates to code readability.

Coding a `do/while` Loop

Syntax:

```
do {
    code_block;
}
while (boolean_expression);  // Semicolon is mandatory.
```

This block executes at least once.

In a `do/while` loop, the condition (shown at the bottom of the loop) is evaluated *after* the code block has already been executed once. If the condition evaluates to true, the code block is repeated continually until the condition returns false.

The *body of the loop* is, therefore, processed at least once. If you want the statement or statements in the body to be processed at least once, use a `do/while` loop instead of a `while` or `for` loop.

Comparing Loop Constructs

- Use the `while` loop to iterate indefinitely through statements and to perform the statements zero or more times.
- Use the standard `for` loop to step through statements a predefined number of times.
- Use the `enhanced for` loop to iterate through the elements of an Array or ArrayList (discussed later).
- Use the `do/while` loop to iterate indefinitely through statements and to perform the statements *one* or more times.

The `continue` Keyword

There are two keywords that enable you to interrupt the iterations in a loop of any type:

- `break` causes the loop to exit. *
- `continue` causes the loop to skip the current iteration and go to the next.

```
for (int idx = 0; idx < names.length; idx++){
      if (names[idx].equalsIgnoreCase("Unavailable"))
         continue;
      System.out.println(names[idx]);
}
```

** Or any block of code to exit*

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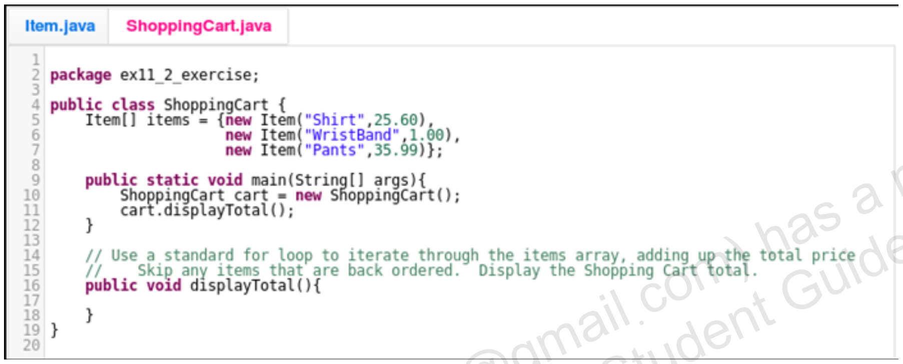
- `break` allows you to terminate an execution of a loop or switch and skip to the first line of code following the end of the relevant loop or switch block.
- `continue` is used only within a loop. It causes the loop to skip the current iteration and move on to the next. This is shown in the code example above. The `for` loop iterates through the elements of the `names` array. If it encounters an element value of "Unavailable", it does not print out that value, but skips to the next array element.

Exercise 11-3: Processing an Array of Items

In this exercise you:

- Process an array of items to calculate the Shopping Cart total
- Skip any items that are back ordered
- Display the total


Item.java | ShoppingCart.java

```java

package ex11_2_exercise;

public class ShoppingCart {
    Item[] items = {new Item("Shirt",25.60),
                    new Item("WristBand",1.00),
                    new Item("Pants",35.99)};

    public static void main(String[] args){
        ShoppingCart cart = new ShoppingCart();
        cart.displayTotal();
    }

    // Use a standard for loop to iterate through the items array, adding up the total price
    //    Skip any items that are back ordered.  Display the Shopping Cart total.
    public void displayTotal(){

    }
}

```

- In the Java Code Console, access Lessons > 11-ArraysLoopsDates > Exercise3.
- Follow the instructions below the code editor. Code the `displayTotal` method of the `ShoppingCart` class so that it will iterate through the items array and print out the total for the Shopping Cart.
- Skip any items that are back ordered. (You might want to examine the Item class to see how this setting is determined.)
- If you need help, click the Solution link. To go back to your code, click the Exercise link again. Any changes that you have made will have been saved.

Topics

- Working with dates
- Parsing the `args` array
- Two-dimensional arrays
- Alternate looping constructs
- Nesting loops
- The `ArrayList` class

Nesting Loops

All types of loops can be nested within the body of another loop. This is a powerful construct used to:

- Process multidimensional arrays
- Sort or manipulate large amounts of data

How it works:

1st iteration of outer loop triggers:
Inner loop
2nd iteration of outer loop triggers:
Inner loop
3rd iteration of outer loop triggers:
Inner loop
and so on…

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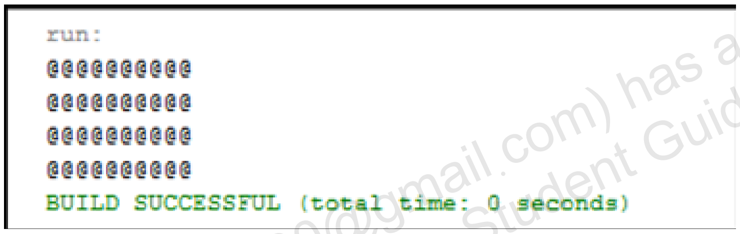
Nested `for` Loop

Example: Print a table with 4 rows and 10 columns:

```java
int height = 4, width = 10;

for(int row = 0; row < height; row++){
    for (int col = 0; col < width; col++){
        System.out.print("@");
    }
    System.out.println();
}
```

Output:



```
run:
@@@@@@@@@@
@@@@@@@@@@
@@@@@@@@@@
@@@@@@@@@@
BUILD SUCCESSFUL (total time: 0 seconds)
```

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The code in the slide shows a simple nested loop to output a block of `@` symbols with height and width given in the initial local variables.

- The outer `for` loop produces the rows. It loops four times.
- The inner `for` loop prints the columns for a given row. It loops ten times.
- Notice how the outer loop prints a new line to start a new row, whereas the inner loop uses the `print` method of `System.out` to print an `@` symbol for every column. (Remember that, unlike `println`, `print` does not generate a new line.)
- The output is shown at the bottom: a table containing four rows of ten columns.

Nested `while` Loop

Example:

```java
String name = "Lenny";
String guess = "";
int attempts = 0;
while (!guess.equalsIgnoreCase(name)) {
    guess = "";
    while (guess.length() < name.length()) {
        char asciiChar = (char) (Math.random() * 26 + 97);
        guess += asciiChar;
    }
    attempts++;
}
System.out.println(name+" found after "+attempts+" tries!");
```

Output:

```
Lenny found after 20852023 tries!
```

The nested `while` loop in the above example is a little more complex than the previous `for` example. The nested loop tries to guess a name by building a String of the same length completely at random.

- Looking at the inner loop first, the code initializes `char asciiChar` to a lowercase letter randomly. These `chars` are then added to `String guess`, until that String is as long as the String that it is being matched against. Notice the convenience of the concatenation operator here, allowing concatenation of a String and a `char`.
- The outer loop tests to see whether `guess` is the same as a lowercase version of the original name.
  If it is not, `guess` is reset to an empty String and the inner loop runs again, usually millions of times for a five-letter name. (Note that names longer than five letters will take a very long time.)

Processing a Two-Dimensional Array

Example: Quarterly Sales per Year

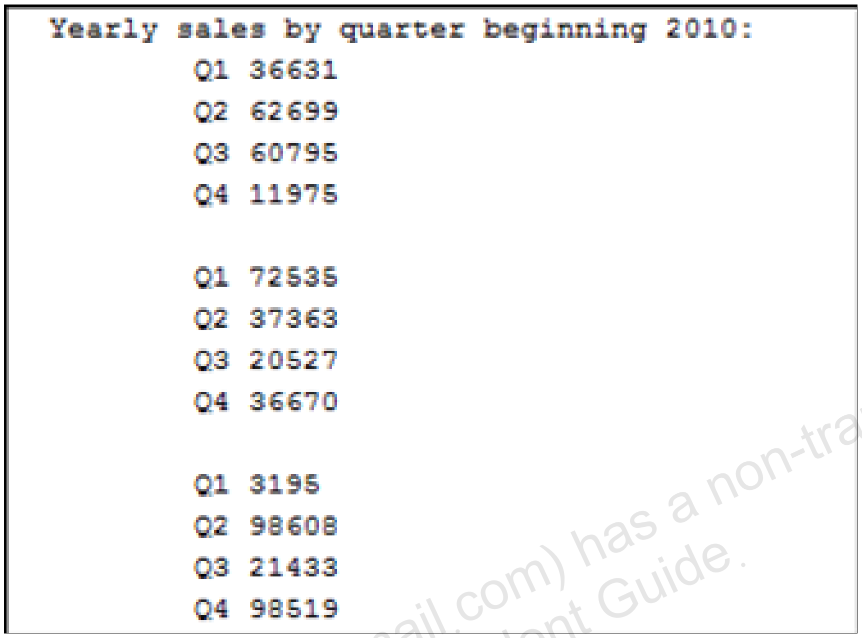
```
01  int sales[][] = new int[3][4];
02  initArray(sales);  //initialize the array
03  System.out.println
04      ("Yearly sales by quarter beginning 2010:");
05  for(int i=0; i < sales.length; i++){
06      for(int j=0; j < sales[i].length; j++){
07         System.out.println("\tQ"+(j+1)+" "+sales[i][j]);
08      }
09      System.out.println();
10  }
```

This example illustrates the process of a two-dimensional array called `sales`. The `sales` array has three rows of four columns. The rows represent years and the columns represent the quarters of the year.

- The `initArray` method is called on line 2 to initialize the array with values.
- An opening message is printed on lines 3 and 4.
- On line 5, you see the outer `for` loop defined. The outer loop iterates through the three years. Notice that `i` is used as the counter for the outer loop.
- On line 6, you see the inner `for` loop defined. The inner loop iterates through each quarter of the year. It uses `j` as a counter. For each quarter of the year, it prints the quarter number (Q1, Q2, …) plus the quarterly sales value in the element of the array indicated by the row number (`i`) and the column number (`j`).

  Note: The "\t" character combination creates a tab indent.
- Notice that the quarter number is calculated as `j+1`. Because array elements start with 0, the index number of the first element will be 0, the second element index will be 1, and so on. To translate this into a quarter number, you add 1 to it.
- The output can be seen in the next slide.

Output from Previous Example



```
Yearly sales by quarter beginning 2010:
          Q1  36631
          Q2  62699
          Q3  60795
          Q4  11975

          Q1  72535
          Q2  37363
          Q3  20527
          Q4  36670

          Q1  3195
          Q2  98608
          Q3  21433
          Q4  98519
```

Quiz

_________________ enable you to check and recheck a decision to execute and re-execute a block of code.

a. Classes
b. Objects
c. Loops
d. Methods

Answer: c

Quiz

Which of the following loops always executes at least once?

a. The `while` loop
b. The nested `while` loop
c. The `do/while` loop
d. The `for` loop

Answer: c

Topics

- Working with dates
- Parsing the `args` array
- Two-dimensional arrays
- Alternate looping constructs
- Nesting loops
- The `ArrayList` class

`ArrayList` Class

Arrays are not the only way to store lists of related data.

- `ArrayList` is one of several list management classes.
- It has a set of useful methods for managing its elements:
  - `add`, `get`, `remove`, `indexOf`, and many others
- It can store *only objects*, not primitives.
  - Example: an ArrayList of Shirt objects:
    - `shirts.add(shirt04);`
  - Example: an ArrayList of String objects:
    - `names.remove ("James");`
  - Example: an ArrayList of ages:
    - `ages.add(5)   //NOT ALLOWED!`
    - `ages.add(new Integer(5))  // OK`

The `ArrayList` is one of several list management classes included in the `java.util` package. The other classes of this package (often referred to as the “collections framework”) are covered in greater depth in the *Java SE 8 Programming* course.

- `ArrayList` is based on the Array object and has many useful methods for managing the elements. Some of these are listed above, and you will see examples of how to use them in an upcoming slide.
- An important thing to remember about `ArrayList` variables is that you cannot store primitive types (`int`, `double`, `boolean`, `char`, and so on) in them—only object types. If you need to store a list of primitives, use an Array, or store the primitive values in the corresponding object type as shown in the final example above.

Benefits of the `ArrayList` Class

- Dynamically resizes:
  - An `ArrayList` grows as you add elements.
  - An `ArrayList` shrinks as you remove elements.
  - You can specify an initial capacity, but it is not mandatory.
- Option to designate the object type it contains:

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

Contains only String objects

- Call methods on an `ArrayList` or its elements:

```
states.size();              //Size of list
```

```
states.get(49).length(); //Length of 49th element
```

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For lists that are very dynamic, the `ArrayList` offers significant benefits such as:

- `ArrayList` objects dynamically allocate space as needed. This can free you from having to write code to:
  - Keep track of the index of the last piece of data added
  - Keep track of how full the array is and determine whether it needs to be resized
  - Increase the size of the array by creating a new one and copying the elements from the current one into it
- When you declare an `ArrayList`, you have the option of specifying the object type that will be stored in it using the diamond operator (`<>`). This technique is called "generics." This means that when accessing an element, the compiler already knows what type it is. Many of the classes included in the collections framework support the use of generics.
- You may call methods on either the `ArrayList` or its individual elements.
  - Assume that all 50 US states have already been added to the list.
  - The examples show how to get the size of the list, or call a method on an individual element (such as the length of a `String` object).

Importing and Declaring an `ArrayList`

- You must `import java.util.ArrayList` to use an `ArrayList`.
- An `ArrayList` may contain any object type, including a type that you have created by writing a class.

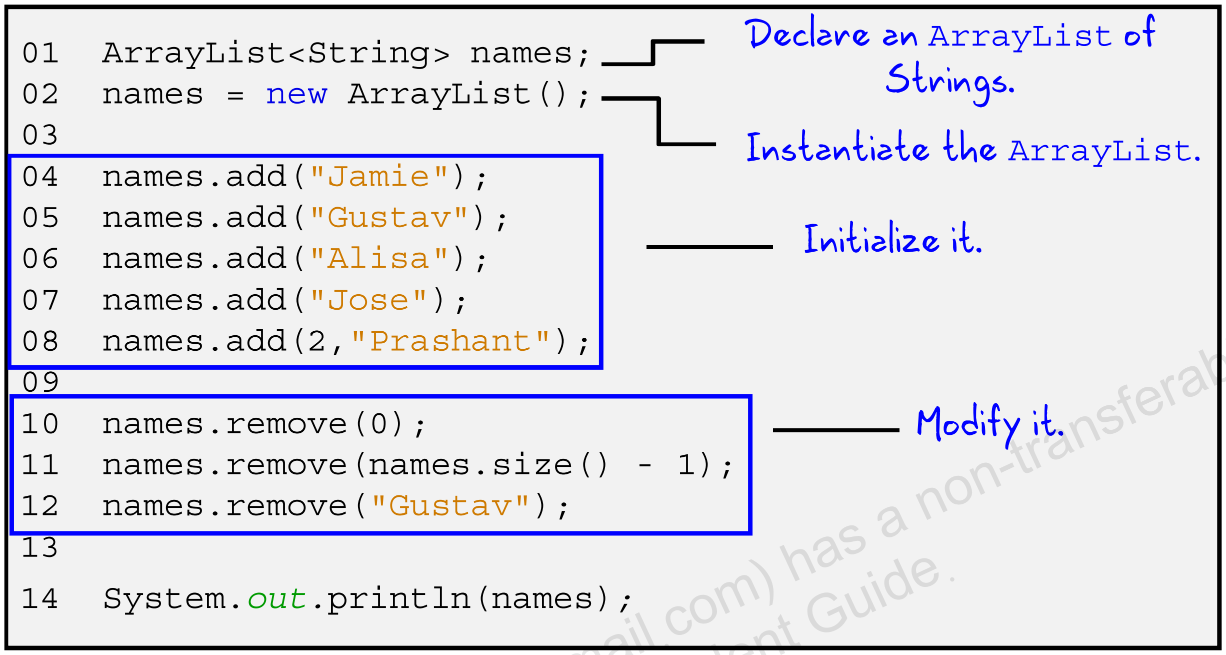
```
import java.util.ArrayList;

 public class ArrayListExample {
     public static void main (String[] args) {
          ArrayList<Shirt> myList;
     }
}
```

You may specify any object type.

- If you forget to import `java.util.ArrayList`, NetBeans will complain but also correctly suggest that you add the `import` statement.
- In the example above, the `myList` ArrayList will contain `Shirt` objects. You may declare that an array list contains any type of object.

Working with an `ArrayList`



```
01  ArrayList<String> names;
02  names = new ArrayList();
03
04  names.add("Jamie");
05  names.add("Gustav");
06  names.add("Alisa");
07  names.add("Jose");
08  names.add(2,"Prashant");
09
10  names.remove(0);
11  names.remove(names.size() - 1);
12  names.remove("Gustav");
13
14  System.out.println(names);
```

Declare an ArrayList of Strings.
Instantiate the ArrayList.
Initialize it.
Modify it.

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Declaring an `ArrayList`, you use the diamond operator `(<>)` to indicate the object type. In the example above:

- Declaration of the `names ArrayList` occurs on line 1.
- Instantiation occurs on line 2.

There are a number of methods to add data to the `ArrayList`. This example uses the `add` method, to add several `String` objects to the list. In line 8, it uses an overloaded `add` method that inserts an element at a specific location:

`add(int index, E element).`

There are also many methods available for manipulating the data. The example here shows just one method, but it is very powerful.

- `remove(0)` removes the first element (in this case, `"Jamie"`).
- `remove(names.size() - 1)` removes the last element, which would be “Jose”.
- `remove("Gustav")` removes an element that matches a specific value.
- You can pass the `ArrayList` to `System.out.println`. The resulting output is: `[Prashant, Alisa]`

Exercise 11-4: Working with an `ArrayList`

In this exercise, you:

- Declare, instantiate, and initialize an `ArrayList` of `Strings`
- Use two different `add` methods
  - `add(E element)`
  - `add(int index, E element)`
- Use the following methods to find and remove a specific element if it exists
  - `contains (Object element)`
  - `remove (Object element)`

- In the Java Code Console, access Lessons > 11-ArraysLoopsDates > Exercise4.
- Follow the instructions below the code editor. Initialize and manipulate an `ArrayList`, using various methods of the `ArrayList` class.
- Note that, in this case, the `ArrayList` contains `String` objects, so the Object reference in the above method signatures can be a `String` literal.
- If you need help, click the Solution link. To go back to your code, click the Exercise link again. Any changes that you have made will have been saved.

Summary

In this lesson, you should have learned how to:

- Create a `java.time.LocalDateTime` object to show the current date and time
- Parse the `args` array of the `main` method
- Nest a `while` loop
- Develop and nest a `for` loop
- Code and nest a `do/while` loop
- Use an `ArrayList` to store and manipulate objects

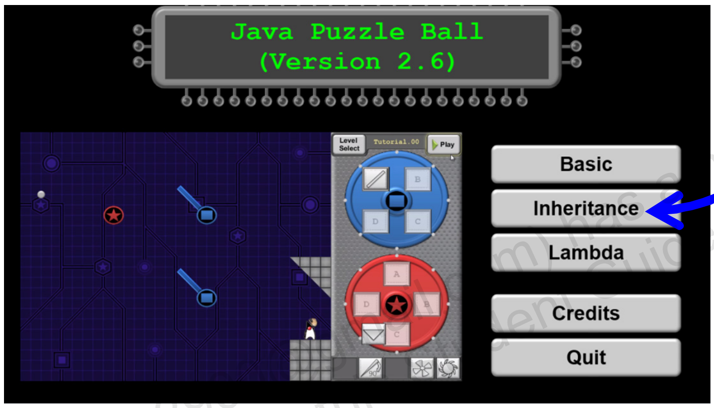
Play Time!

Play **Inheritance Puzzles 1, 2, and 3** before the next lesson titled “Using Inheritance.”

Consider the following:

What is inheritance?

Why are these considered “Inheritance” puzzles?



You will be asked this question in the lesson titled “Using Inheritance.”

Practice 11-1 Overview: Iterating Through Data

This practice covers the following topics:

- Converting a comma-separated list of names to an array of names
- Processing the array using a `for` loop
- Using a nested loop to populate an `ArrayList` of games

Practice 11-2 Overview: Working with `LocalDateTime`

This practice covers working with a few classes and methods from the `java.time` package in order to show date information for games played.