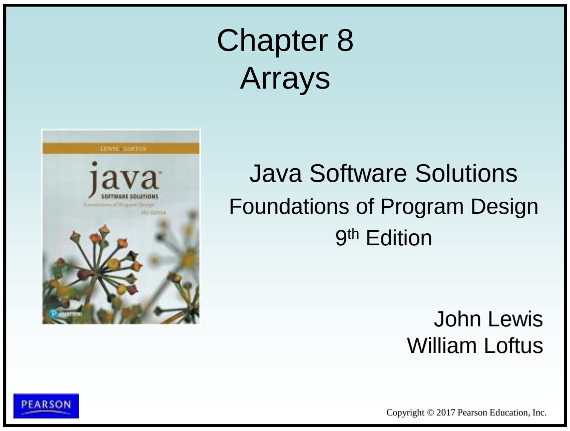
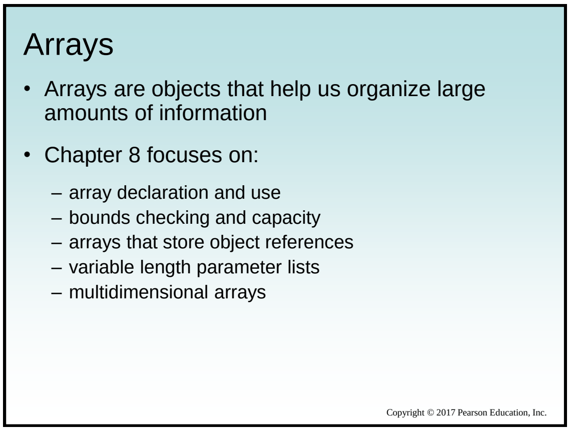


Chapter 8
Arrays

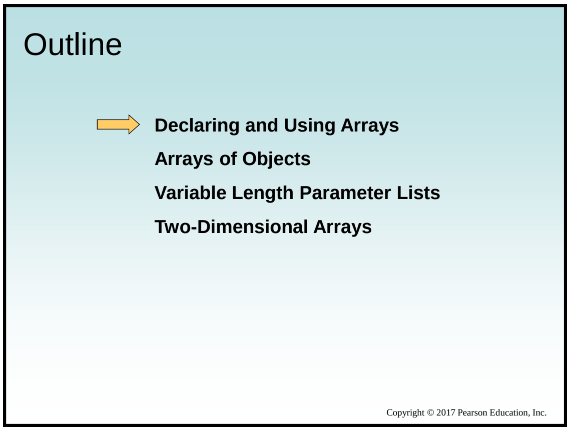
Java Software Solutions
Foundations of Program Design
9th Edition

John Lewis
William Loftus



Arrays

- Arrays are objects that help us organize large amounts of information
- Chapter 8 focuses on:
  - array declaration and use
  - bounds checking and capacity
  - arrays that store object references
  - variable length parameter lists
  - multidimensional arrays



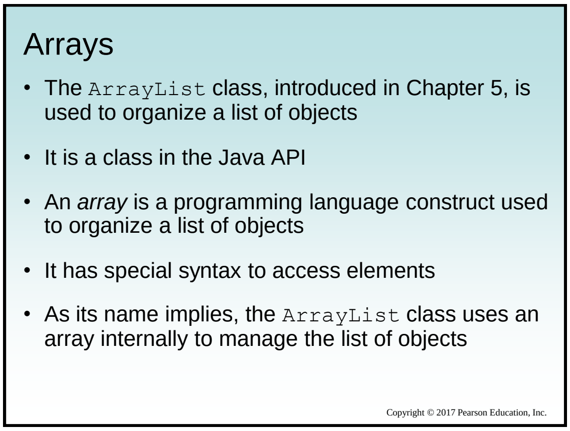
Outline

➡ **Declaring and Using Arrays**

Arrays of Objects

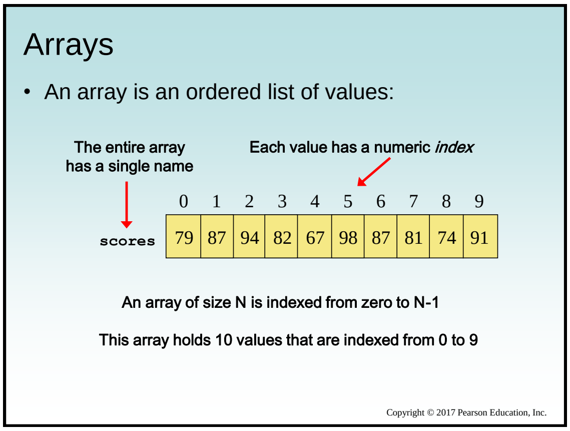
Variable Length Parameter Lists

Two-Dimensional Arrays



Arrays

- The `ArrayList` class, introduced in Chapter 5, is used to organize a list of objects
- It is a class in the Java API
- An *array* is a programming language construct used to organize a list of objects
- It has special syntax to access elements
- As its name implies, the `ArrayList` class uses an array internally to manage the list of objects



Arrays

- An array is an ordered list of values:

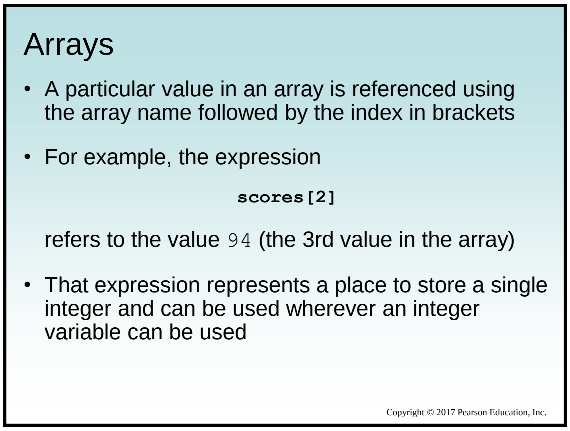
The entire array has a single name

Each value has a numeric *index*

	0	1	2	3	4	5	6	7	8	9
`scores`	79	87	94	82	67	98	87	81	74	91

An array of size N is indexed from zero to N-1

This array holds 10 values that are indexed from 0 to 9



Arrays

- A particular value in an array is referenced using the array name followed by the index in brackets
- For example, the expression

```
scores[2]
```

refers to the value `94` (the 3rd value in the array)

- That expression represents a place to store a single integer and can be used wherever an integer variable can be used

Arrays

- For example, an array element can be assigned a value, printed, or used in a calculation:

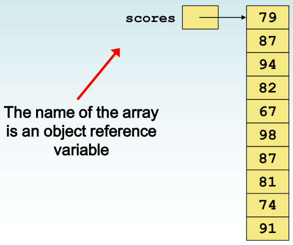
```
scores[2] = 89;
scores[first] = scores[first] + 2;
mean = (scores[0] + scores[1])/2;
System.out.println("Top = " + scores[5]);
pick = scores[rand.nextInt(11)];
```

Arrays

- The values held in an array are called *array elements*
- An array stores multiple values of the same type – the *element type*
- The element type can be a primitive type or an object reference
- Therefore, we can create an array of integers, an array of characters, an array of `String` objects, an array of `Coin` objects, etc.

Arrays

- In Java, the array itself is an object that must be instantiated
- Another way to depict the `scores` array:



Declaring Arrays

- The `scores` array could be declared as follows:

```
int[] scores = new int[10];
```

- The type of the variable `scores` is `int[]` (an array of integers)
- Note that the array type does not specify its size, but each object of that type has a specific size
- The reference variable `scores` is set to a new array object that can hold 10 integers

Declaring Arrays

- Some other examples of array declarations:

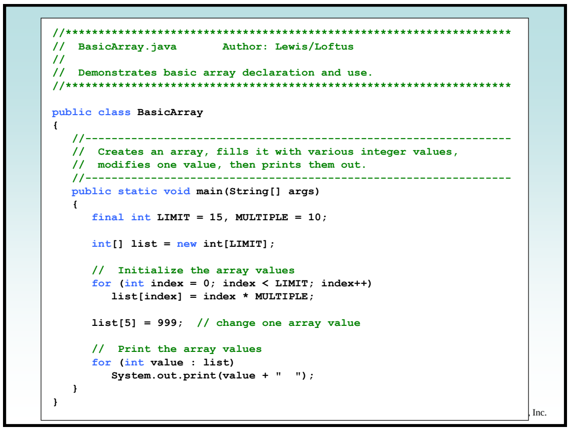
```
int[] weights = new int[2000];

double[] prices = new double[500];

boolean[] flags;
flags = new boolean[20];

char[] codes = new char[1750];
```

Using Arrays

- The for-each version of the `for` loop can be used when processing array elements:

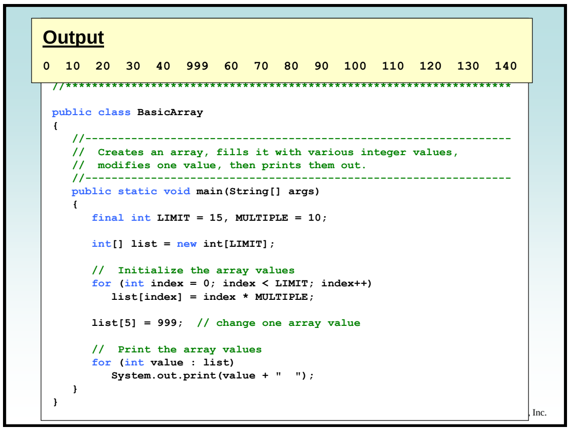
```
for (int score : scores)
   System.out.println(score);
```

- This is only appropriate when processing all array elements starting at index 0
- It can't be used to set the array values
- See `BasicArray.java`



```
//********************************************************************
//  BasicArray.java       Author: Lewis/Loftus
//
//  Demonstrates basic array declaration and use.
//********************************************************************

public class BasicArray
{
   //-----------------------------------------------------------------
   //  Creates an array, fills it with various integer values,
   //  modifies one value, then prints them out.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      final int LIMIT = 15, MULTIPLE = 10;

      int[] list = new int[LIMIT];

      //  Initialize the array values
      for (int index = 0; index < LIMIT; index++)
         list[index] = index * MULTIPLE;

      list[5] = 999;  // change one array value

      //  Print the array values
      for (int value : list)
         System.out.print(value + "  ");
   }
}
```

, Inc.

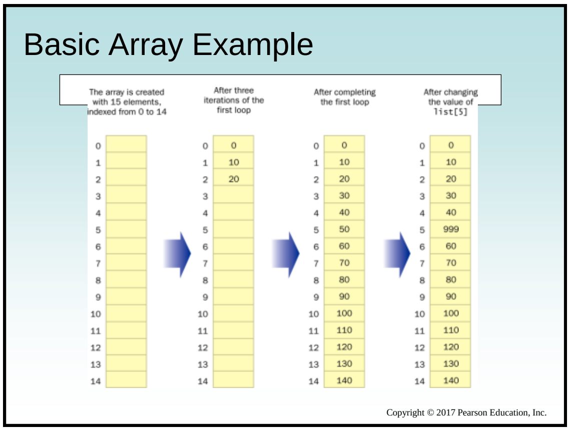


Output

```
0   10   20   30   40   999   60   70   80   90   100   110   120   130   140
```

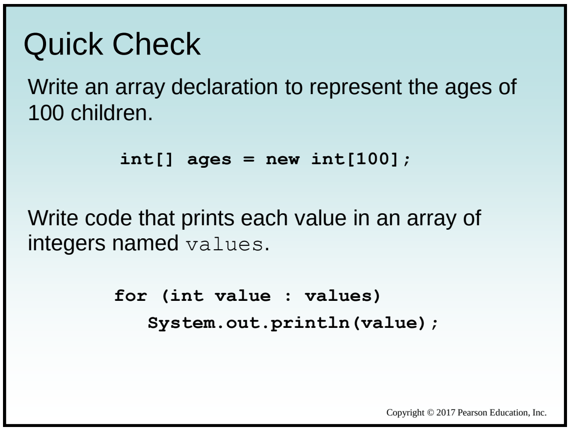
```
//********************************************************************

public class BasicArray
{
   //-----------------------------------------------------------------
   //  Creates an array, fills it with various integer values,
   //  modifies one value, then prints them out.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      final int LIMIT = 15, MULTIPLE = 10;

      int[] list = new int[LIMIT];

      //  Initialize the array values
      for (int index = 0; index < LIMIT; index++)
         list[index] = index * MULTIPLE;

      list[5] = 999;  // change one array value

      //  Print the array values
      for (int value : list)
         System.out.print(value + "  ");
   }
}
```

, Inc.



Basic Array Example

	The array is created with 15 elements, indexed from 0 to 14	After three iterations of the first loop	After completing the first loop	After changing the value of `list[5]`
0		0	0	0
1		10	10	10
2		20	20	20
3			30	30
4			40	40
5			50	999
6			60	60
7			70	70
8			80	80
9			90	90
10			100	100
11			110	110
12			120	120
13			130	130
14			140	140



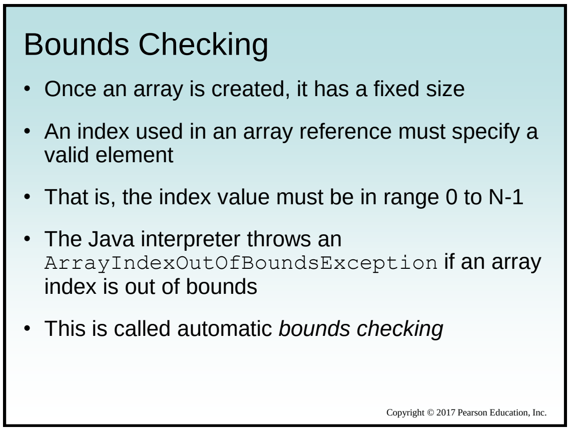
Quick Check

Write an array declaration to represent the ages of 100 children.

```
int[] ages = new int[100];
```

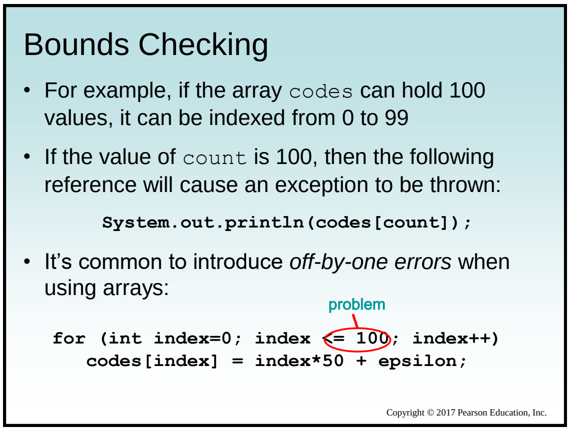
Write code that prints each value in an array of integers named `values`.

```
for (int value : values)
   System.out.println(value);
```



Bounds Checking

- Once an array is created, it has a fixed size
- An index used in an array reference must specify a valid element
- That is, the index value must be in range 0 to N-1
- The Java interpreter throws an `ArrayIndexOutOfBoundsException` if an array index is out of bounds
- This is called automatic *bounds checking*



Bounds Checking

- For example, if the array `codes` can hold 100 values, it can be indexed from 0 to 99
- If the value of `count` is 100, then the following reference will cause an exception to be thrown:

```
System.out.println(codes[count]);
```

- It's common to introduce *off-by-one errors* when using arrays:

problem

```
for (int index=0; index <= 100; index++)
   codes[index] = index*50 + epsilon;
```

Bounds Checking

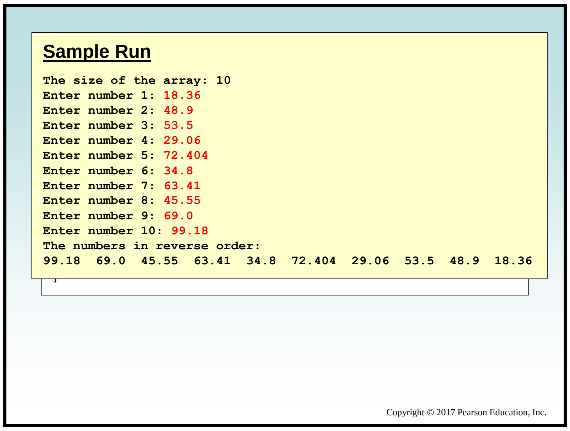
- Each array object has a public constant called `length` that stores the size of the array
- It is referenced using the array name:

  `scores.length`

- Note that `length` holds the number of elements, not the largest index
- See `ReverseOrder.java`
- See `LetterCount.java`

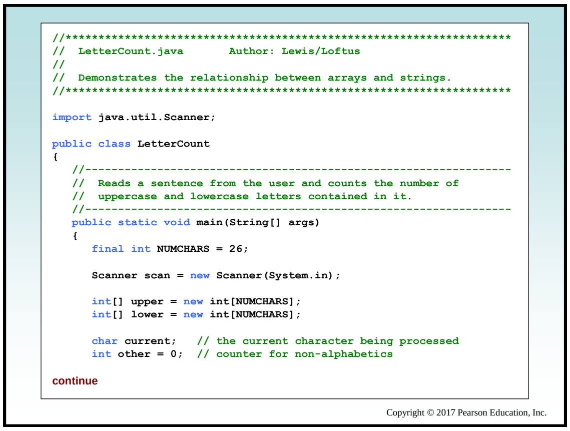
```
//********************************************************************
//  ReverseOrder.java       Author: Lewis/Loftus
//
//  Demonstrates array index processing.
//********************************************************************

import java.util.Scanner;

public class ReverseOrder
{
   //-----------------------------------------------------------------
   //  Reads a list of numbers from the user, storing them in an
   //  array, then prints them in the opposite order.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      Scanner scan = new Scanner(System.in);

      double[] numbers = new double[10];

      System.out.println("The size of the array: " + numbers.length);

continue
```

```
continue

      for (int index = 0; index < numbers.length; index++)
      {
         System.out.print("Enter number " + (index+1) + ": ");
         numbers[index] = scan.nextDouble();
      }

      System.out.println("The numbers in reverse order:");

      for (int index = numbers.length-1; index >= 0; index--)
         System.out.print(numbers[index] + "  ");
   }
}
```

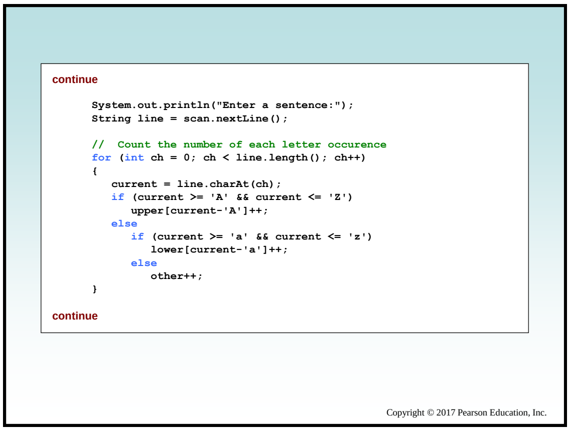


Sample Run

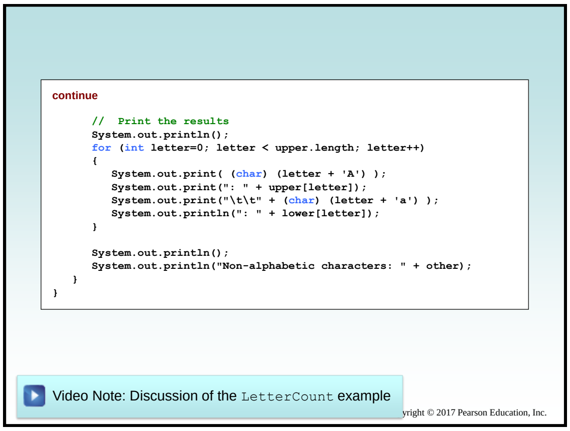
```
The size of the array: 10
Enter number 1: 18.36
Enter number 2: 48.9
Enter number 3: 53.5
Enter number 4: 29.06
Enter number 5: 72.404
Enter number 6: 34.8
Enter number 7: 63.41
Enter number 8: 45.55
Enter number 9: 69.0
Enter number 10: 99.18
The numbers in reverse order:
99.18  69.0  45.55  63.41  34.8  72.404  29.06  53.5  48.9  18.36
```



```
//********************************************************************
//  LetterCount.java       Author: Lewis/Loftus
//
//  Demonstrates the relationship between arrays and strings.
//********************************************************************

import java.util.Scanner;

public class LetterCount
{
   //-----------------------------------------------------------------
   //  Reads a sentence from the user and counts the number of
   //  uppercase and lowercase letters contained in it.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      final int NUMCHARS = 26;

      Scanner scan = new Scanner(System.in);

      int[] upper = new int[NUMCHARS];
      int[] lower = new int[NUMCHARS];

      char current;   // the current character being processed
      int other = 0;  // counter for non-alphabetics

continue
```



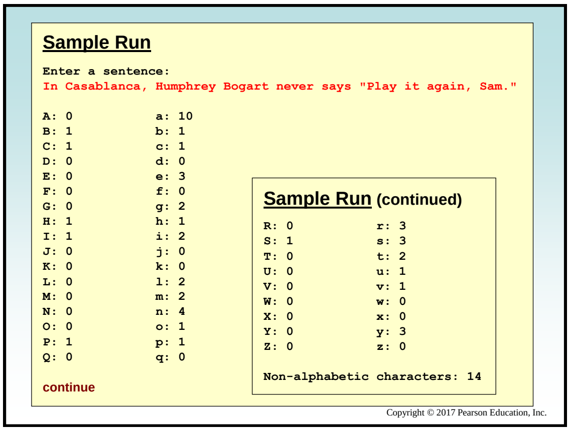
```
continue

      System.out.println("Enter a sentence:");
      String line = scan.nextLine();

      //  Count the number of each letter occurence
      for (int ch = 0; ch < line.length(); ch++)
      {
         current = line.charAt(ch);
         if (current >= 'A' && current <= 'Z')
            upper[current-'A']++;
         else
            if (current >= 'a' && current <= 'z')
               lower[current-'a']++;
            else
               other++;
      }

continue
```



continue

```
      //  Print the results
      System.out.println();
      for (int letter=0; letter < upper.length; letter++)
      {
         System.out.print( (char) (letter + 'A') );
         System.out.print(": " + upper[letter]);
         System.out.print("\t\t" + (char) (letter + 'a') );
         System.out.println(": " + lower[letter]);
      }

      System.out.println();
      System.out.println("Non-alphabetic characters: " + other);
   }
}
```

▶ Video Note: Discussion of the `LetterCount` example



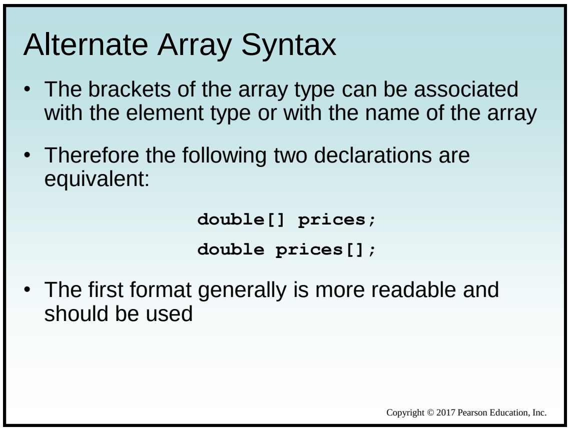
Sample Run

```
Enter a sentence:
In Casablanca, Humphrey Bogart never says "Play it again, Sam."

A: 0            a: 10
B: 1            b: 1
C: 1            c: 1
D: 0            d: 0
E: 0            e: 3
F: 0            f: 0
G: 0            g: 2
H: 1            h: 1
I: 1            i: 2
J: 0            j: 0
K: 0            k: 0
L: 0            l: 2
M: 0            m: 2
N: 0            n: 4
O: 0            o: 1
P: 1            p: 1
Q: 0            q: 0
```

continue

Sample Run (continued)

```
R: 0            r: 3
S: 1            s: 3
T: 0            t: 2
U: 0            u: 1
V: 0            v: 1
W: 0            w: 0
X: 0            x: 0
Y: 0            y: 3
Z: 0            z: 0

Non-alphabetic characters: 14
```

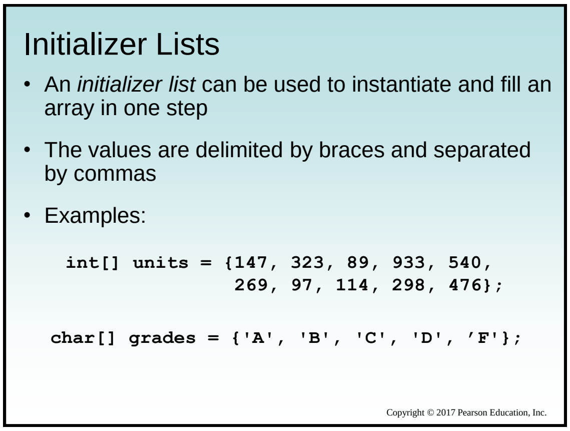


Alternate Array Syntax

- The brackets of the array type can be associated with the element type or with the name of the array
- Therefore the following two declarations are equivalent:

```
double[] prices;
double prices[];
```

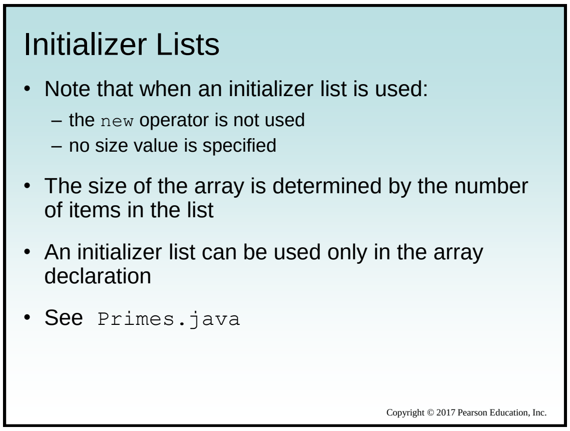
- The first format generally is more readable and should be used



Initializer Lists

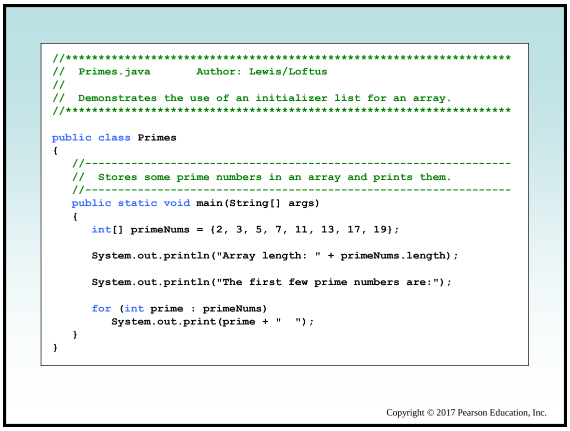
- An *initializer list* can be used to instantiate and fill an array in one step
- The values are delimited by braces and separated by commas
- Examples:

```
   int[] units = {147, 323, 89, 933, 540,
                  269, 97, 114, 298, 476};

char[] grades = {'A', 'B', 'C', 'D', 'F'};
```

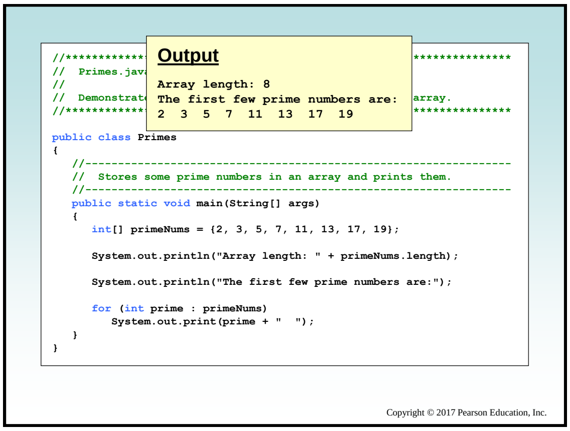


Initializer Lists

- Note that when an initializer list is used:
  - the `new` operator is not used
  - no size value is specified
- The size of the array is determined by the number of items in the list
- An initializer list can be used only in the array declaration
- See `Primes.java`



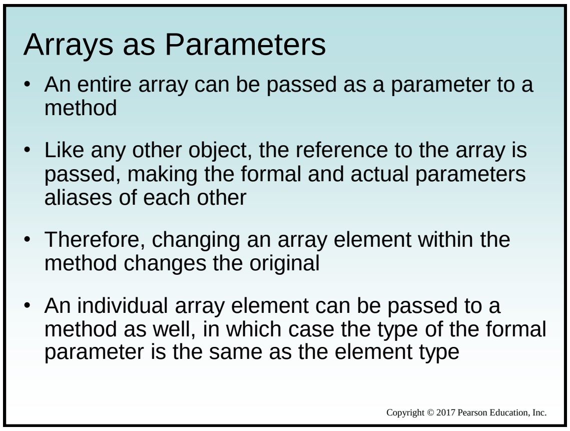
```
//********************************************************************
//  Primes.java       Author: Lewis/Loftus
//
//  Demonstrates the use of an initializer list for an array.
//********************************************************************

public class Primes
{
   //-----------------------------------------------------------------
   //  Stores some prime numbers in an array and prints them.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      int[] primeNums = {2, 3, 5, 7, 11, 13, 17, 19};

      System.out.println("Array length: " + primeNums.length);

      System.out.println("The first few prime numbers are:");

      for (int prime : primeNums)
         System.out.print(prime + "  ");
   }
}
```



```
//*************                                 ***************
//  Primes.jav
//
//  Demonstrat                                  array.
//*************                                 ***************

public class Primes
{
   //-----------------------------------------------------------------
   //  Stores some prime numbers in an array and prints them.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      int[] primeNums = {2, 3, 5, 7, 11, 13, 17, 19};

      System.out.println("Array length: " + primeNums.length);

      System.out.println("The first few prime numbers are:");

      for (int prime : primeNums)
         System.out.print(prime + "  ");
   }
}
```

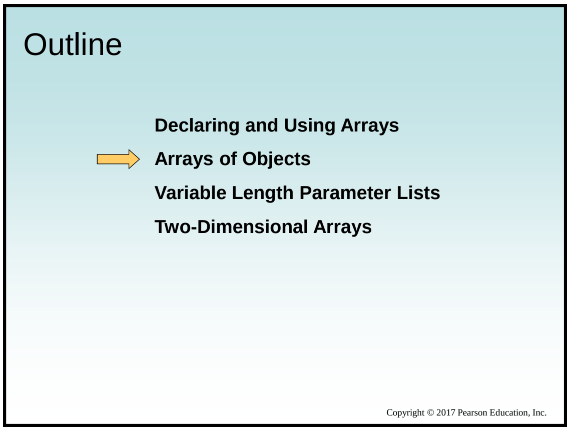
Output

```
Array length: 8
The first few prime numbers are:
2  3  5  7  11  13  17  19
```



Arrays as Parameters

- An entire array can be passed as a parameter to a method
- Like any other object, the reference to the array is passed, making the formal and actual parameters aliases of each other
- Therefore, changing an array element within the method changes the original
- An individual array element can be passed to a method as well, in which case the type of the formal parameter is the same as the element type



Outline

Declaring and Using Arrays

➡ **Arrays of Objects**

Variable Length Parameter Lists

Two-Dimensional Arrays

Arrays of Objects

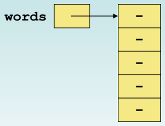
- The elements of an array can be object references
- The following declaration reserves space to store 5 references to `String` objects

```
String[] words = new String[5];
```

- It does NOT create the `String` objects themselves
- Initially an array of objects holds `null` references
- Each object stored in an array must be instantiated separately

Arrays of Objects

- The `words` array when initially declared:

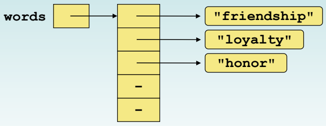


- At this point, the following line of code would throw a `NullPointerException`:

```
System.out.println(words[0]);
```

Arrays of Objects

- After some `String` objects are created and stored in the array:



Arrays of Objects

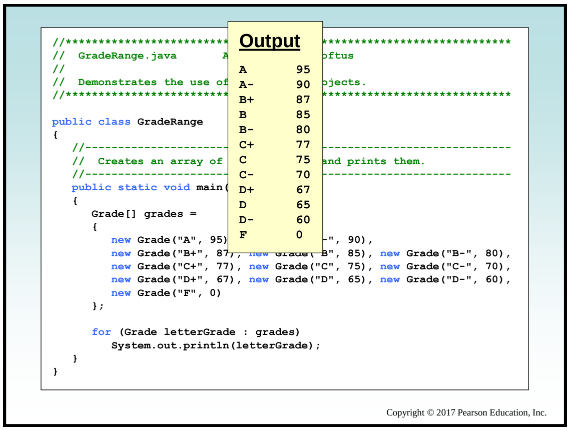
- Keep in mind that `String` objects can be created using literals
- The following declaration creates an array object called `verbs` and fills it with four `String` objects created using string literals

```
String[] verbs = {"play", "work", "eat",
                  "sleep", "run"};
```

Arrays of Objects

- The following example creates an array of `Grade` objects, each with a string representation and a numeric lower bound
- The letter grades include plus and minus designations, so must be stored as strings instead of `char`
- See `GradeRange.java`
- See `Grade.java`

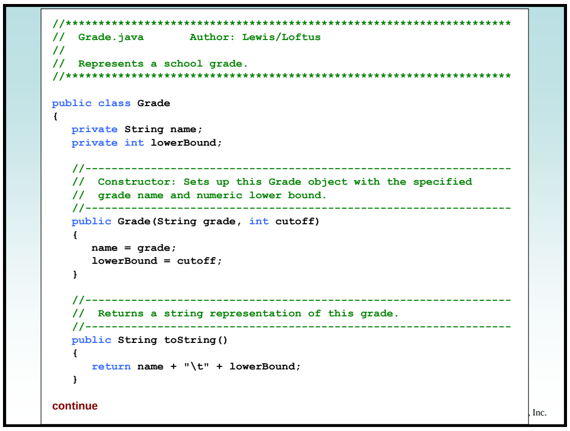
```
//********************************************************************
//  GradeRange.java       Author: Lewis/Loftus
//
//  Demonstrates the use of an array of objects.
//********************************************************************

public class GradeRange
{
   //-----------------------------------------------------------------
   //  Creates an array of Grade objects and prints them.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      Grade[] grades =
      {
         new Grade("A", 95), new Grade("A-", 90),
         new Grade("B+", 87), new Grade("B", 85), new Grade("B-", 80),
         new Grade("C+", 77), new Grade("C", 75), new Grade("C-", 70),
         new Grade("D+", 67), new Grade("D", 65), new Grade("D-", 60),
         new Grade("F", 0)
      };

      for (Grade letterGrade : grades)
         System.out.println(letterGrade);
   }
}
```



```
//**************************                ******************************
//  GradeRange.java       A                 oftus
//
//  Demonstrates the use of                 ojects.
//**************************                ******************************

public class GradeRange
{
   //--------------------------             ------------------------------
   //  Creates an array of                  and prints them.
   //--------------------------             ------------------------------
   public static void main(
   {
      Grade[] grades =
      {
         new Grade("A", 95)                 -", 90),
         new Grade("B+", 87               B", 85), new Grade("B-", 80),
         new Grade("C+", 77), new Grade("C", 75), new Grade("C-", 70),
         new Grade("D+", 67), new Grade("D", 65), new Grade("D-", 60),
         new Grade("F", 0)
      };

      for (Grade letterGrade : grades)
         System.out.println(letterGrade);
   }
}
```

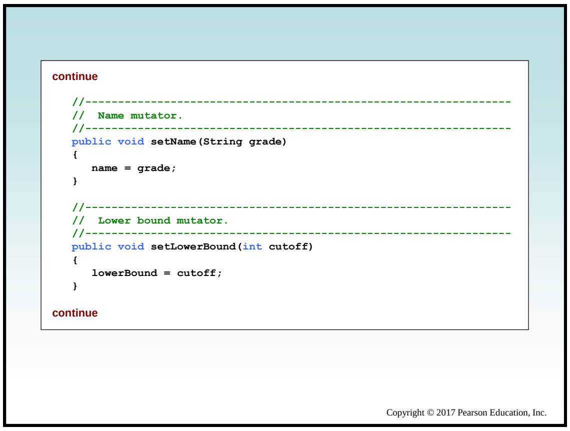
Output

```
A        95
A-       90
B+       87
B        85
B-       80
C+       77
C        75
C-       70
D+       67
D        65
D-       60
F        0
```



```
//********************************************************************
//  Grade.java       Author: Lewis/Loftus
//
//  Represents a school grade.
//********************************************************************

public class Grade
{
   private String name;
   private int lowerBound;

   //-----------------------------------------------------------------
   //  Constructor: Sets up this Grade object with the specified
   //  grade name and numeric lower bound.
   //-----------------------------------------------------------------
   public Grade(String grade, int cutoff)
   {
      name = grade;
      lowerBound = cutoff;
   }

   //-----------------------------------------------------------------
   //  Returns a string representation of this grade.
   //-----------------------------------------------------------------
   public String toString()
   {
      return name + "\t" + lowerBound;
   }
```

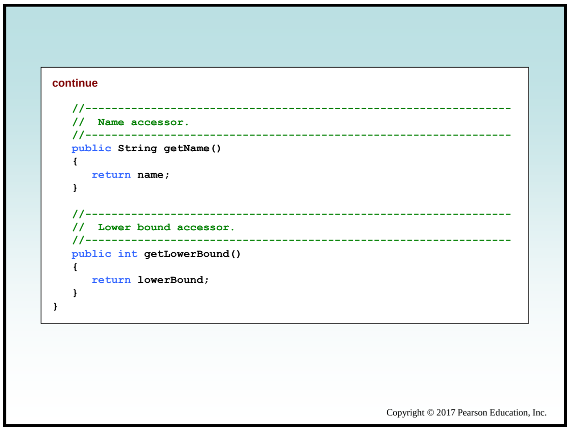
continue



continue

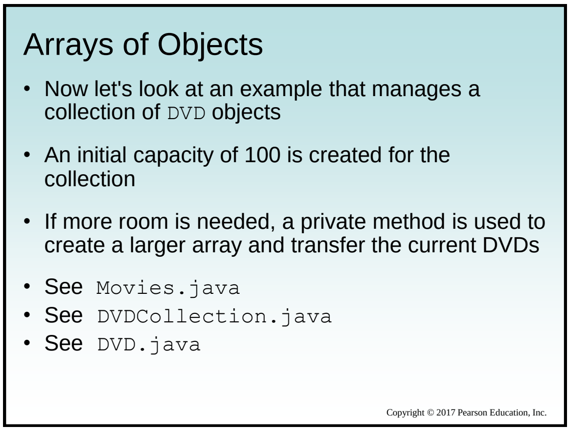
```
   //-----------------------------------------------------------------
   //  Name mutator.
   //-----------------------------------------------------------------
   public void setName(String grade)
   {
      name = grade;
   }

   //-----------------------------------------------------------------
   //  Lower bound mutator.
   //-----------------------------------------------------------------
   public void setLowerBound(int cutoff)
   {
      lowerBound = cutoff;
   }
```

continue



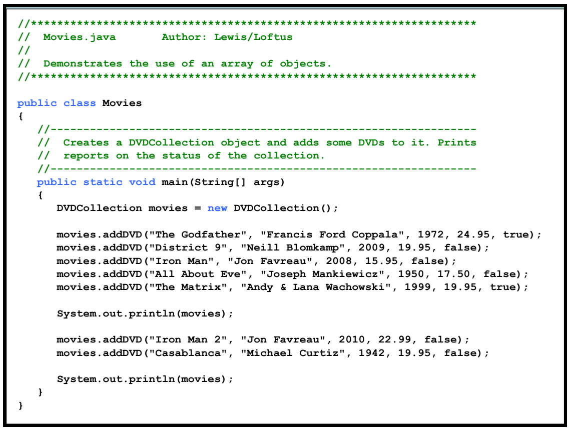
continue

```
   //-----------------------------------------------------------------
   //  Name accessor.
   //-----------------------------------------------------------------
   public String getName()
   {
      return name;
   }

   //-----------------------------------------------------------------
   //  Lower bound accessor.
   //-----------------------------------------------------------------
   public int getLowerBound()
   {
      return lowerBound;
   }
}
```

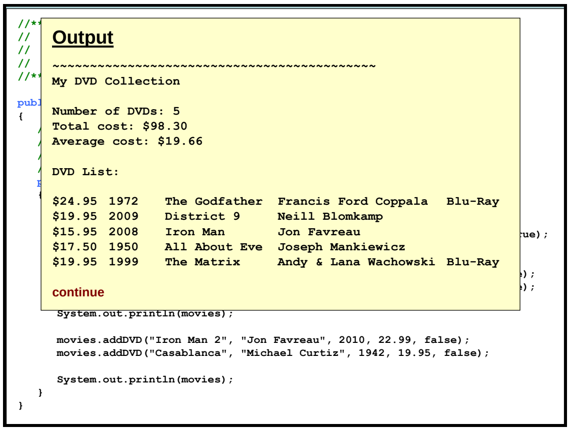


Arrays of Objects

- Now let's look at an example that manages a collection of `DVD` objects
- An initial capacity of 100 is created for the collection
- If more room is needed, a private method is used to create a larger array and transfer the current DVDs
- See `Movies.java`
- See `DVDCollection.java`
- See `DVD.java`



```
//********************************************************************
//  Movies.java       Author: Lewis/Loftus
//
//  Demonstrates the use of an array of objects.
//********************************************************************

public class Movies
{
   //-----------------------------------------------------------------
   //  Creates a DVDCollection object and adds some DVDs to it. Prints
   //  reports on the status of the collection.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      DVDCollection movies = new DVDCollection();

      movies.addDVD("The Godfather", "Francis Ford Coppala", 1972, 24.95, true);
      movies.addDVD("District 9", "Neill Blomkamp", 2009, 19.95, false);
      movies.addDVD("Iron Man", "Jon Favreau", 2008, 15.95, false);
      movies.addDVD("All About Eve", "Joseph Mankiewicz", 1950, 17.50, false);
      movies.addDVD("The Matrix", "Andy & Lana Wachowski", 1999, 19.95, true);

      System.out.println(movies);

      movies.addDVD("Iron Man 2", "Jon Favreau", 2010, 22.99, false);
      movies.addDVD("Casablanca", "Michael Curtiz", 1942, 19.95, false);

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

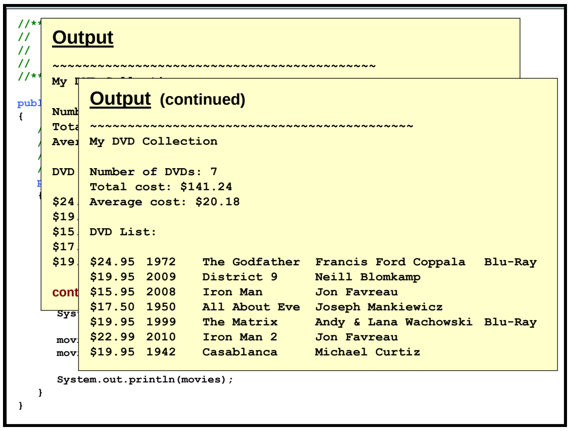


Output

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
My DVD Collection

Number of DVDs: 5
Total cost: $98.30
Average cost: $19.66

DVD List:

$24.95  1972   The Godfather  Francis Ford Coppala  Blu-Ray
$19.95  2009   District 9     Neill Blomkamp
$15.95  2008   Iron Man       Jon Favreau
$17.50  1950   All About Eve  Joseph Mankiewicz
$19.95  1999   The Matrix     Andy & Lana Wachowski  Blu-Ray
```

continue

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

      movies.addDVD("Iron Man 2", "Jon Favreau", 2010, 22.99, false);
      movies.addDVD("Casablanca", "Michael Curtiz", 1942, 19.95, false);

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



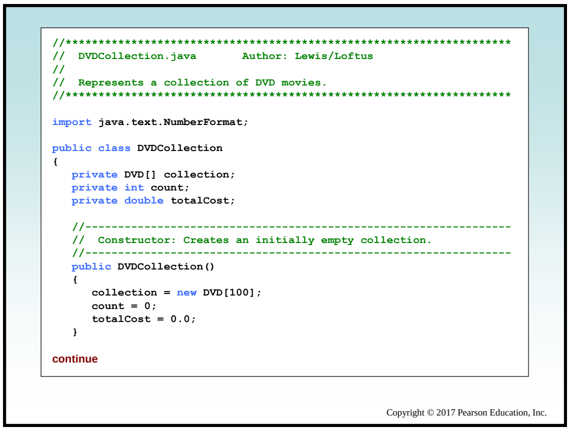
Output

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

Output (continued)

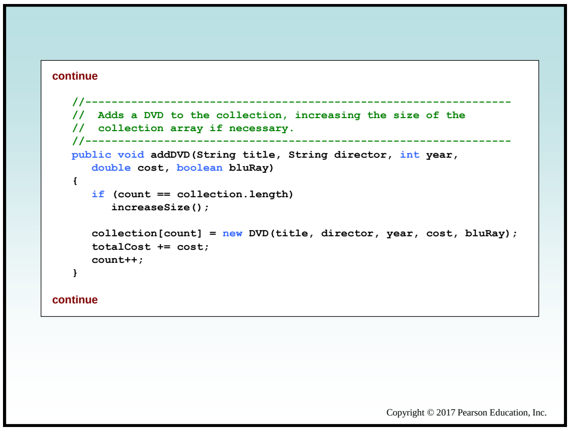
```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
My DVD Collection

Number of DVDs: 7
Total cost: $141.24
Average cost: $20.18

DVD List:

$24.95  1972   The Godfather  Francis Ford Coppala  Blu-Ray
$19.95  2009   District 9     Neill Blomkamp
$15.95  2008   Iron Man       Jon Favreau
$17.50  1950   All About Eve  Joseph Mankiewicz
$19.95  1999   The Matrix     Andy & Lana Wachowski  Blu-Ray
$22.99  2010   Iron Man 2     Jon Favreau
$19.95  1942   Casablanca     Michael Curtiz
```

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



```
//********************************************************************
//  DVDCollection.java       Author: Lewis/Loftus
//
//  Represents a collection of DVD movies.
//********************************************************************

import java.text.NumberFormat;

public class DVDCollection
{
   private DVD[] collection;
   private int count;
   private double totalCost;

   //-----------------------------------------------------------------
   //  Constructor: Creates an initially empty collection.
   //-----------------------------------------------------------------
   public DVDCollection()
   {
      collection = new DVD[100];
      count = 0;
      totalCost = 0.0;
   }
```

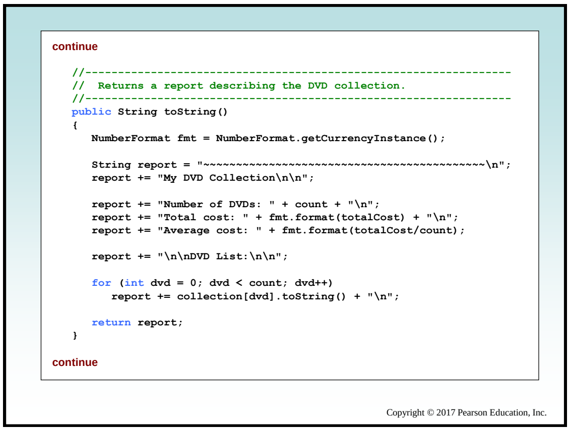
continue



continue

```
   //-----------------------------------------------------------------
   //  Adds a DVD to the collection, increasing the size of the
   //  collection array if necessary.
   //-----------------------------------------------------------------
   public void addDVD(String title, String director, int year,
      double cost, boolean bluRay)
   {
      if (count == collection.length)
         increaseSize();

      collection[count] = new DVD(title, director, year, cost, bluRay);
      totalCost += cost;
      count++;
   }
```

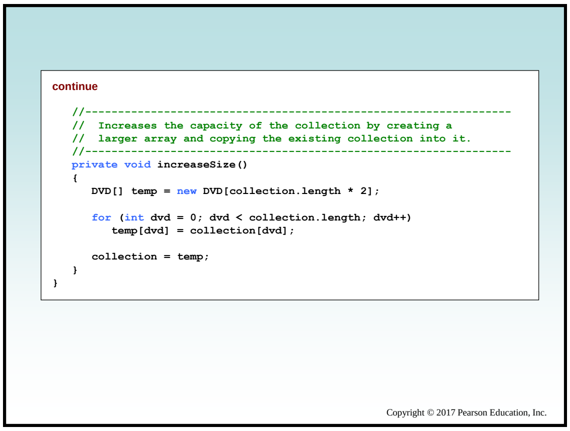
continue



continue

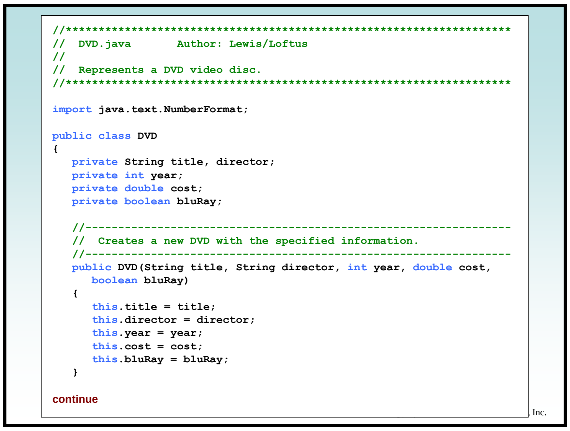
```
   //-----------------------------------------------------------------
   //  Returns a report describing the DVD collection.
   //-----------------------------------------------------------------
   public String toString()
   {
      NumberFormat fmt = NumberFormat.getCurrencyInstance();

      String report = "~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~\n";
      report += "My DVD Collection\n\n";

      report += "Number of DVDs: " + count + "\n";
      report += "Total cost: " + fmt.format(totalCost) + "\n";
      report += "Average cost: " + fmt.format(totalCost/count);

      report += "\n\nDVD List:\n\n";

      for (int dvd = 0; dvd < count; dvd++)
         report += collection[dvd].toString() + "\n";

      return report;
   }
```

continue



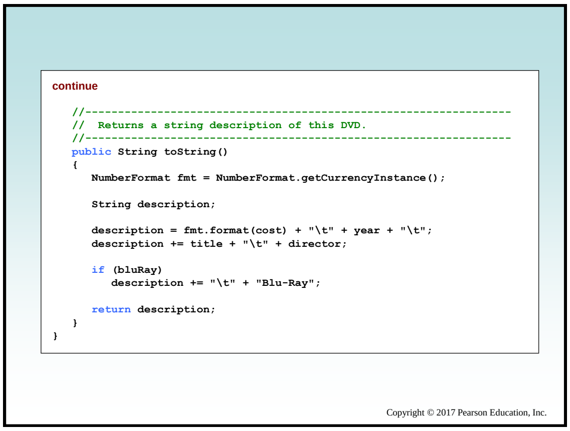
continue

```
   //-----------------------------------------------------------------
   //  Increases the capacity of the collection by creating a
   //  larger array and copying the existing collection into it.
   //-----------------------------------------------------------------
   private void increaseSize()
   {
      DVD[] temp = new DVD[collection.length * 2];

      for (int dvd = 0; dvd < collection.length; dvd++)
         temp[dvd] = collection[dvd];

      collection = temp;
   }
}
```



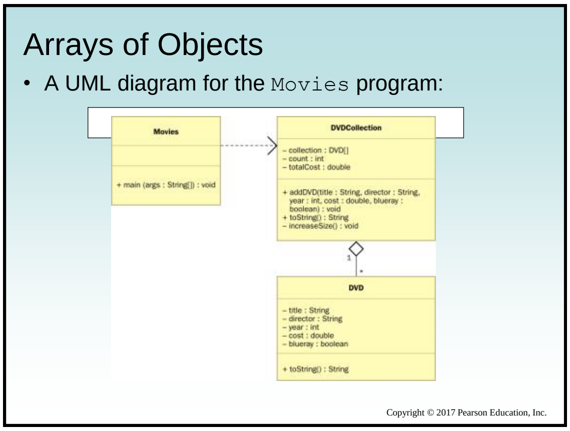
```
//********************************************************************
//  DVD.java       Author: Lewis/Loftus
//
//  Represents a DVD video disc.
//********************************************************************

import java.text.NumberFormat;

public class DVD
{
   private String title, director;
   private int year;
   private double cost;
   private boolean bluRay;

   //-----------------------------------------------------------------
   //  Creates a new DVD with the specified information.
   //-----------------------------------------------------------------
   public DVD(String title, String director, int year, double cost,
      boolean bluRay)
   {
      this.title = title;
      this.director = director;
      this.year = year;
      this.cost = cost;
      this.bluRay = bluRay;
   }
```

continue



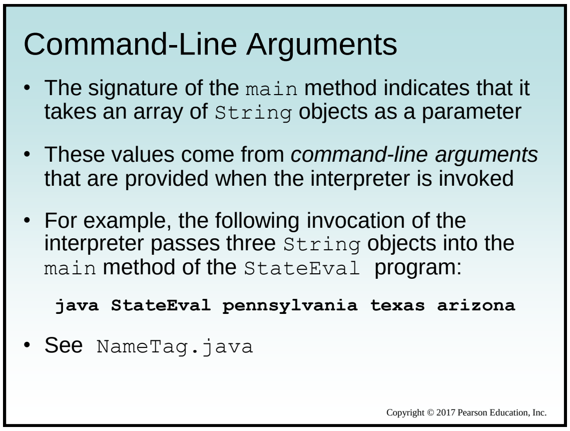
continue

```
   //-----------------------------------------------------------------
   //  Returns a string description of this DVD.
   //-----------------------------------------------------------------
   public String toString()
   {
      NumberFormat fmt = NumberFormat.getCurrencyInstance();

      String description;

      description = fmt.format(cost) + "\t" + year + "\t";
      description += title + "\t" + director;

      if (bluRay)
         description += "\t" + "Blu-Ray";

      return description;
   }
}
```



Arrays of Objects

- A UML diagram for the `Movies` program:

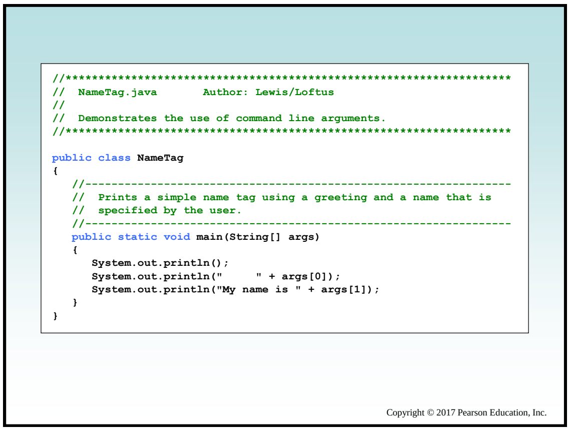


Command-Line Arguments

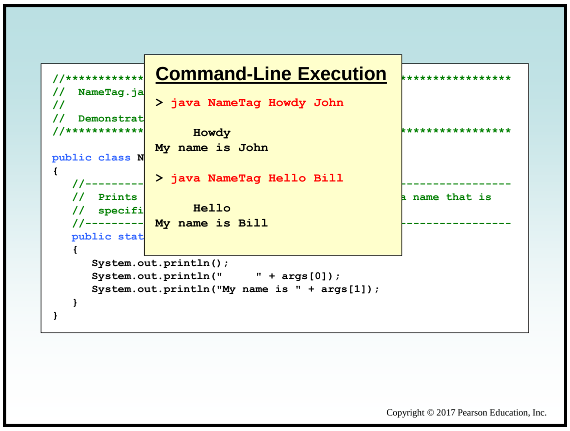
- The signature of the `main` method indicates that it takes an array of `String` objects as a parameter
- These values come from *command-line arguments* that are provided when the interpreter is invoked
- For example, the following invocation of the interpreter passes three `String` objects into the `main` method of the `StateEval` program:

```
java StateEval pennsylvania texas arizona
```

- See `NameTag.java`



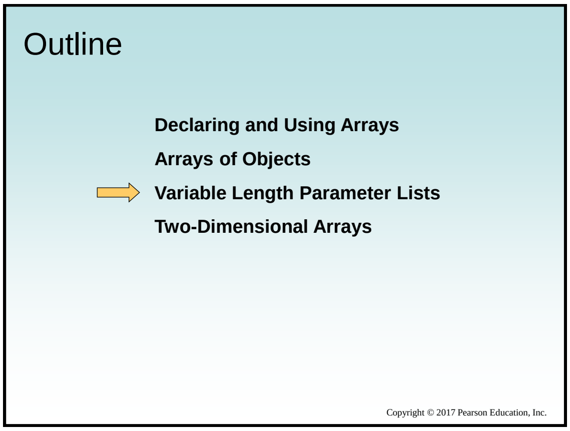
```
//********************************************************************
//  NameTag.java       Author: Lewis/Loftus
//
//  Demonstrates the use of command line arguments.
//********************************************************************

public class NameTag
{
   //-----------------------------------------------------------------
   //  Prints a simple name tag using a greeting and a name that is
   //  specified by the user.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      System.out.println();
      System.out.println("     " + args[0]);
      System.out.println("My name is " + args[1]);
   }
}
```



```
//************                          *****************
//  NameTag.ja
//
//  Demonstrat
//************                          *****************

public class N
{
   //---------                          ----------------
   //  Prints                           a name that is
   //  specifi
   //---------                          ----------------
   public stat
   {
      System.out.println();
      System.out.println("     " + args[0]);
      System.out.println("My name is " + args[1]);
   }
}
```

Command-Line Execution

```
> java NameTag Howdy John

     Howdy
My name is John

> java NameTag Hello Bill

     Hello
My name is Bill
```



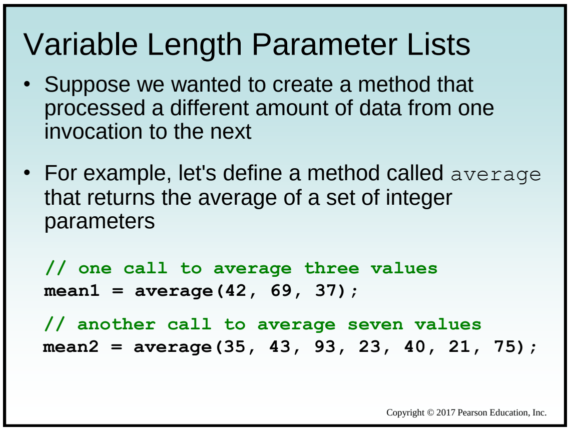
Outline

Declaring and Using Arrays

Arrays of Objects

➡ Variable Length Parameter Lists

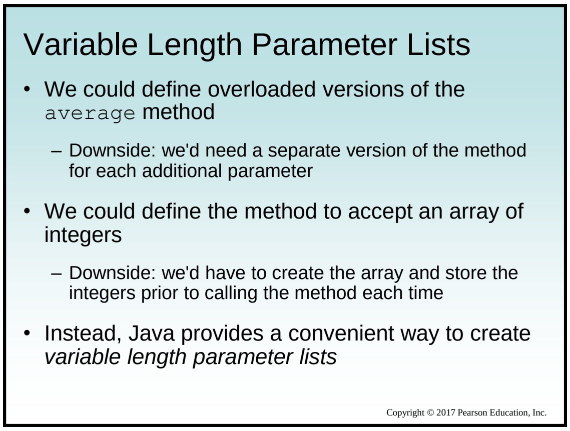
Two-Dimensional Arrays



Variable Length Parameter Lists

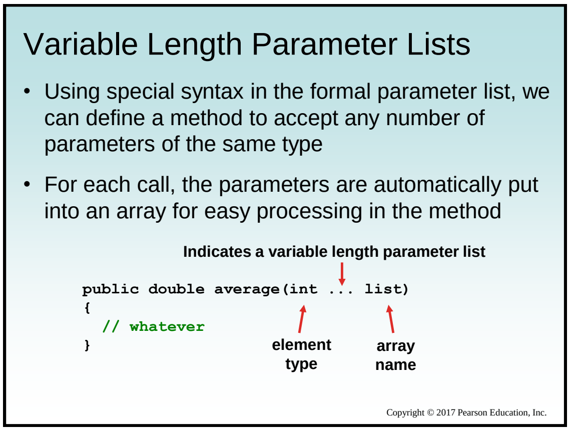
- Suppose we wanted to create a method that processed a different amount of data from one invocation to the next
- For example, let's define a method called `average` that returns the average of a set of integer parameters

```
// one call to average three values
mean1 = average(42, 69, 37);

// another call to average seven values
mean2 = average(35, 43, 93, 23, 40, 21, 75);
```



Variable Length Parameter Lists

- We could define overloaded versions of the `average` method
  - Downside: we'd need a separate version of the method for each additional parameter
- We could define the method to accept an array of integers
  - Downside: we'd have to create the array and store the integers prior to calling the method each time
- Instead, Java provides a convenient way to create *variable length parameter lists*



Variable Length Parameter Lists

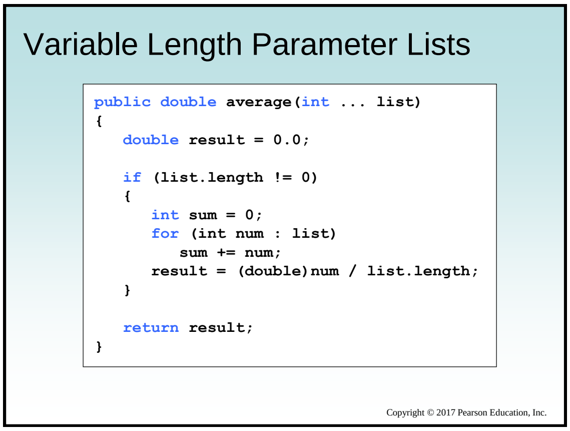
- Using special syntax in the formal parameter list, we can define a method to accept any number of parameters of the same type
- For each call, the parameters are automatically put into an array for easy processing in the method

Indicates a variable length parameter list

```
public double average(int ... list)
{
  // whatever
}
```

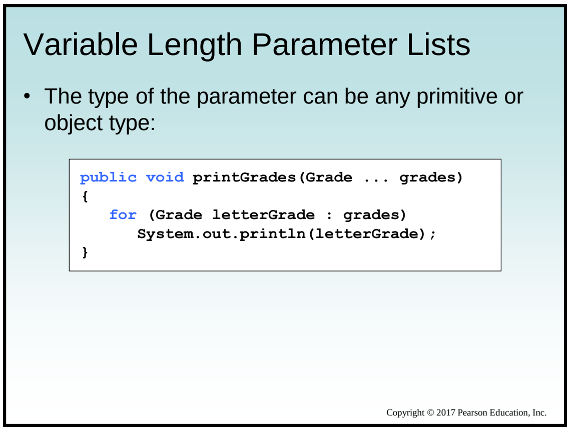
element type

array name



Variable Length Parameter Lists

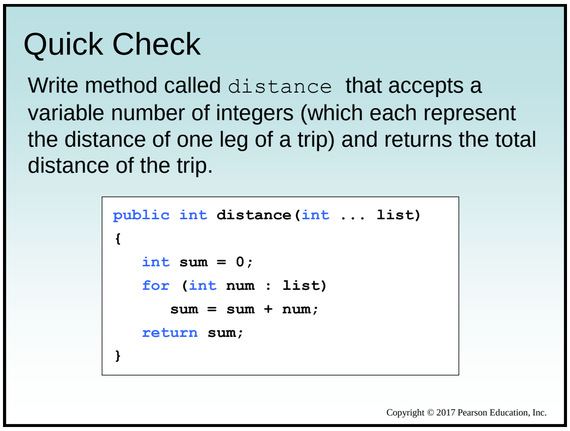
```
public double average(int ... list)
{
   double result = 0.0;

   if (list.length != 0)
   {
      int sum = 0;
      for (int num : list)
         sum += num;
      result = (double)num / list.length;
   }

   return result;
}
```



Variable Length Parameter Lists

- The type of the parameter can be any primitive or object type:

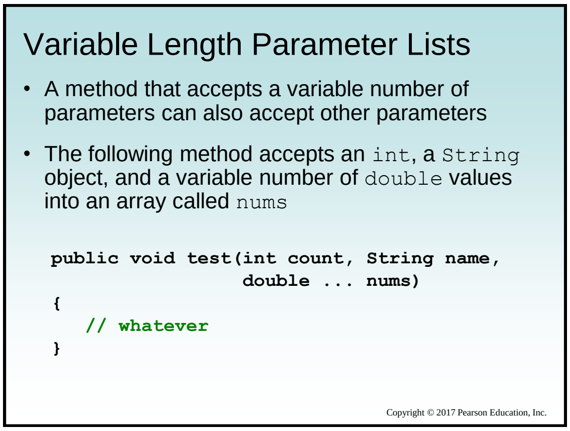
```
public void printGrades(Grade ... grades)
{
   for (Grade letterGrade : grades)
      System.out.println(letterGrade);
}
```



Quick Check

Write method called `distance` that accepts a variable number of integers (which each represent the distance of one leg of a trip) and returns the total distance of the trip.

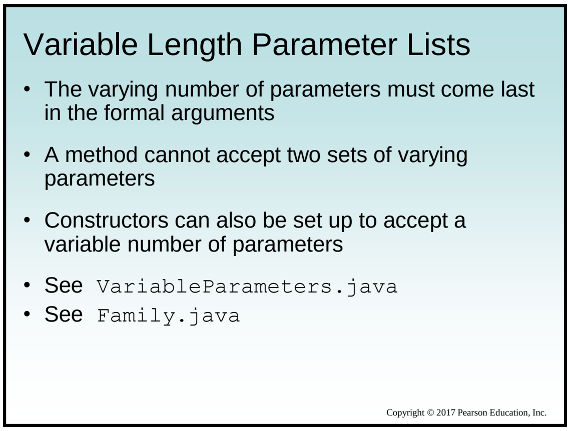
```
public int distance(int ... list)
{
   int sum = 0;
   for (int num : list)
      sum = sum + num;
   return sum;
}
```



Variable Length Parameter Lists

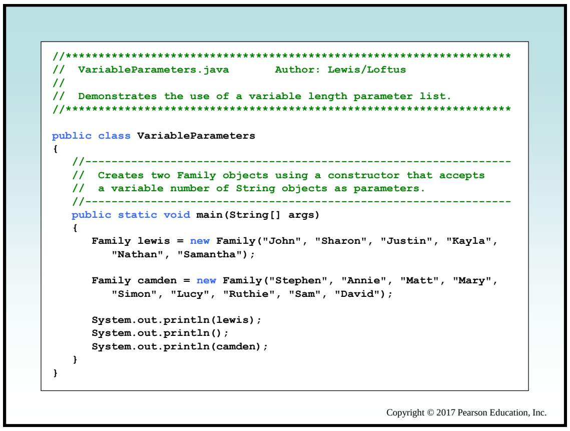
- A method that accepts a variable number of parameters can also accept other parameters
- The following method accepts an `int`, a `String` object, and a variable number of `double` values into an array called `nums`

```
public void test(int count, String name,
                 double ... nums)
{
   // whatever
}
```

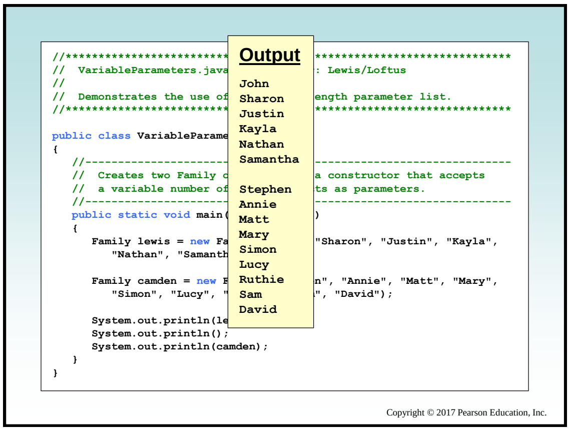


Variable Length Parameter Lists

- The varying number of parameters must come last in the formal arguments
- A method cannot accept two sets of varying parameters
- Constructors can also be set up to accept a variable number of parameters
- See `VariableParameters.java`
- See `Family.java`



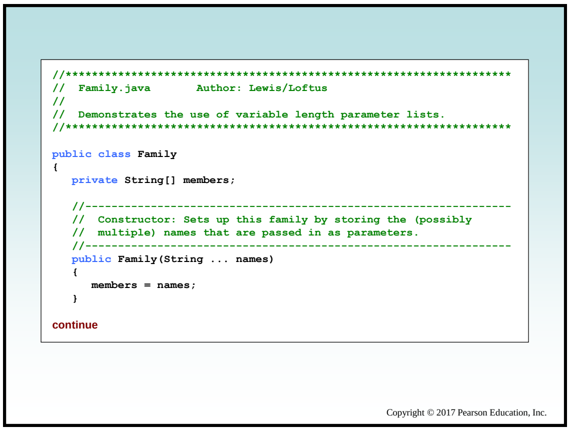
```
//********************************************************************
//  VariableParameters.java       Author: Lewis/Loftus
//
//  Demonstrates the use of a variable length parameter list.
//********************************************************************

public class VariableParameters
{
   //-----------------------------------------------------------------
   //  Creates two Family objects using a constructor that accepts
   //  a variable number of String objects as parameters.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      Family lewis = new Family("John", "Sharon", "Justin", "Kayla",
         "Nathan", "Samantha");

      Family camden = new Family("Stephen", "Annie", "Matt", "Mary",
         "Simon", "Lucy", "Ruthie", "Sam", "David");

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



```
//****************************            ******************************
//  VariableParameters.java               : Lewis/Loftus
//
//  Demonstrates the use of               ength parameter list.
//****************************            ******************************

public class VariableParame
{
   //-----------------------              -----------------------------
   //  Creates two Family o               a constructor that accepts
   //  a variable number of               ts as parameters.
   //-----------------------              -----------------------------
   public static void main(                )
   {
      Family lewis = new Fa               "Sharon", "Justin", "Kayla",
         "Nathan", "Samanth

      Family camden = new F               n", "Annie", "Matt", "Mary",
         "Simon", "Lucy", "               ", "David");

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

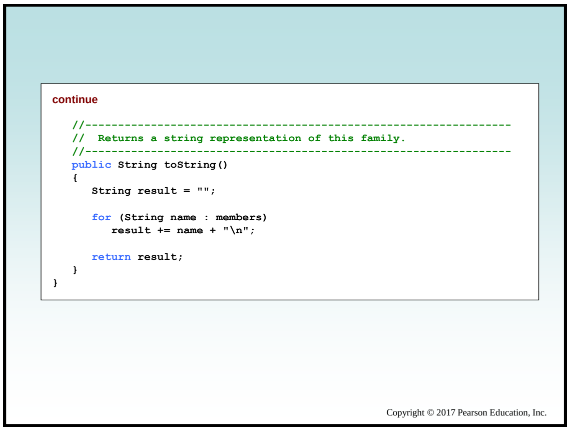
Output

```
John
Sharon
Justin
Kayla
Nathan
Samantha

Stephen
Annie
Matt
Mary
Simon
Lucy
Ruthie
Sam
David
```



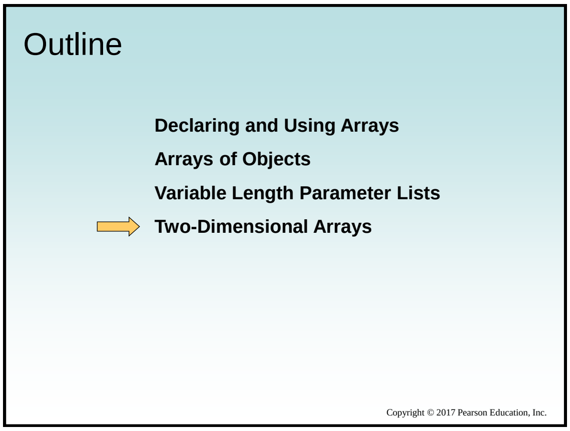
```
//********************************************************************
//  Family.java       Author: Lewis/Loftus
//
//  Demonstrates the use of variable length parameter lists.
//********************************************************************

public class Family
{
   private String[] members;

   //-----------------------------------------------------------------
   //  Constructor: Sets up this family by storing the (possibly
   //  multiple) names that are passed in as parameters.
   //-----------------------------------------------------------------
   public Family(String ... names)
   {
      members = names;
   }
```

continue



continue

```
   //-----------------------------------------------------------------
   //  Returns a string representation of this family.
   //-----------------------------------------------------------------
   public String toString()
   {
      String result = "";

      for (String name : members)
         result += name + "\n";

      return result;
   }
}
```



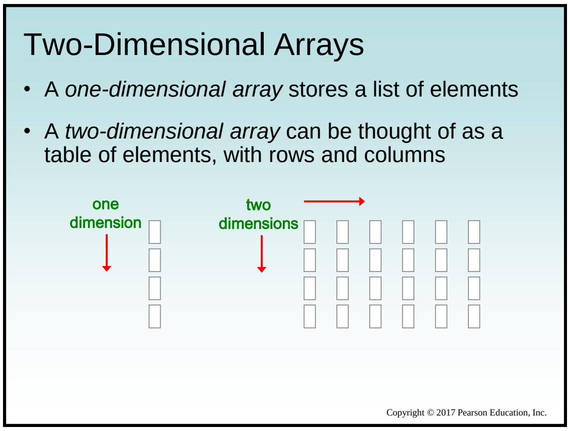
Outline

Declaring and Using Arrays

Arrays of Objects

Variable Length Parameter Lists

⇨ **Two-Dimensional Arrays**



Two-Dimensional Arrays

- A *one-dimensional array* stores a list of elements
- A *two-dimensional array* can be thought of as a table of elements, with rows and columns

Two-Dimensional Arrays

- To be precise, in Java a two-dimensional array is an array of arrays
- A two-dimensional array is declared by specifying the size of each dimension separately:

```
int[][] table = new int[12][50];
```

- A array element is referenced using two index values:

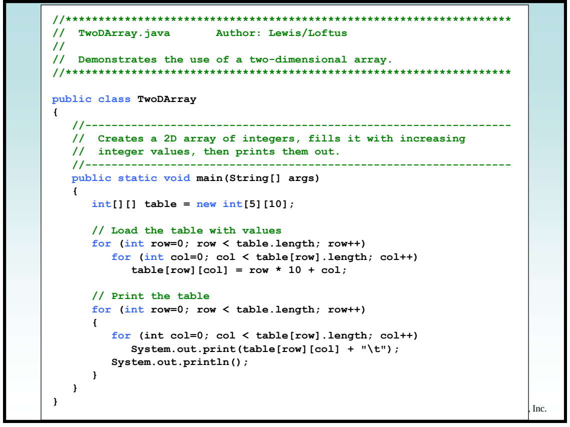
```
value = table[3][6]
```

- The array stored in one row can be specified using one index

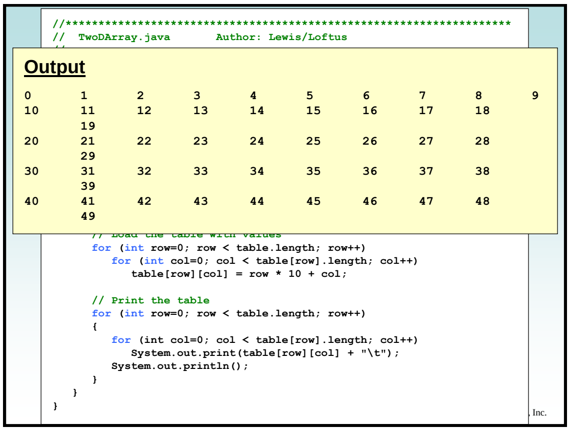
Two-Dimensional Arrays

Expression	Type	Description
`table`	`int[][]`	2D array of integers, or array of integer arrays
`table[5]`	`int[]`	array of integers
`table[5][12]`	`int`	integer

- See `TwoDArray.java`
- See `SodaSurvey.java`



```
//********************************************************************
//  TwoDArray.java       Author: Lewis/Loftus
//
//  Demonstrates the use of a two-dimensional array.
//********************************************************************

public class TwoDArray
{
   //-----------------------------------------------------------------
   //  Creates a 2D array of integers, fills it with increasing
   //  integer values, then prints them out.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      int[][] table = new int[5][10];

      // Load the table with values
      for (int row=0; row < table.length; row++)
         for (int col=0; col < table[row].length; col++)
            table[row][col] = row * 10 + col;

      // Print the table
      for (int row=0; row < table.length; row++)
      {
         for (int col=0; col < table[row].length; col++)
            System.out.print(table[row][col] + "\t");
         System.out.println();
      }
   }
}
```

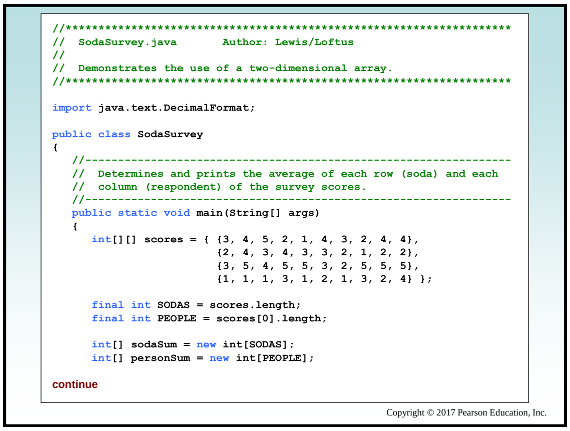


```
//********************************************************************
//  TwoDArray.java       Author: Lewis/Loftus
//
```

Output

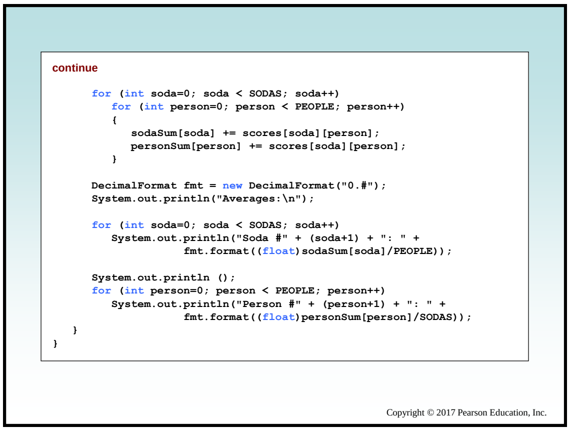
```
0       1       2       3       4       5       6       7       8       9
10      11      12      13      14      15      16      17      18
        19
20      21      22      23      24      25      26      27      28
        29
30      31      32      33      34      35      36      37      38
        39
40      41      42      43      44      45      46      47      48
        49
```

```
      // Load the table with values
      for (int row=0; row < table.length; row++)
         for (int col=0; col < table[row].length; col++)
            table[row][col] = row * 10 + col;

      // Print the table
      for (int row=0; row < table.length; row++)
      {
         for (int col=0; col < table[row].length; col++)
            System.out.print(table[row][col] + "\t");
         System.out.println();
      }
   }
}
```



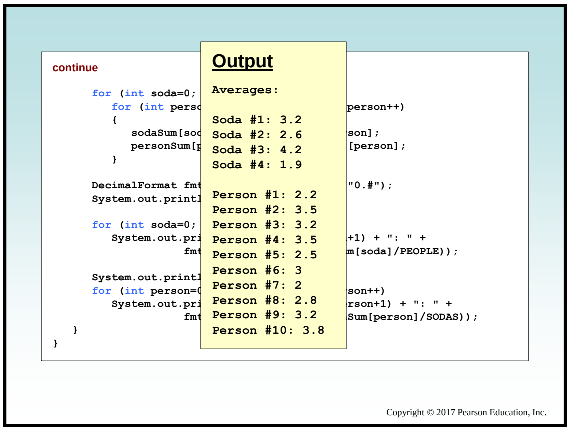
```
//********************************************************************
//  SodaSurvey.java       Author: Lewis/Loftus
//
//  Demonstrates the use of a two-dimensional array.
//********************************************************************

import java.text.DecimalFormat;

public class SodaSurvey
{
   //-----------------------------------------------------------------
   //  Determines and prints the average of each row (soda) and each
   //  column (respondent) of the survey scores.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      int[][] scores = { {3, 4, 5, 2, 1, 4, 3, 2, 4, 4},
                         {2, 4, 3, 4, 3, 3, 2, 1, 2, 2},
                         {3, 5, 4, 5, 5, 3, 2, 5, 5, 5},
                         {1, 1, 1, 3, 1, 2, 1, 3, 2, 4} };

      final int SODAS = scores.length;
      final int PEOPLE = scores[0].length;

      int[] sodaSum = new int[SODAS];
      int[] personSum = new int[PEOPLE];
```

continue



continue

```
      for (int soda=0; soda < SODAS; soda++)
         for (int person=0; person < PEOPLE; person++)
         {
            sodaSum[soda] += scores[soda][person];
            personSum[person] += scores[soda][person];
         }

      DecimalFormat fmt = new DecimalFormat("0.#");
      System.out.println("Averages:\n");

      for (int soda=0; soda < SODAS; soda++)
         System.out.println("Soda #" + (soda+1) + ": " +
                    fmt.format((float)sodaSum[soda]/PEOPLE));

      System.out.println ();
      for (int person=0; person < PEOPLE; person++)
         System.out.println("Person #" + (person+1) + ": " +
                    fmt.format((float)personSum[person]/SODAS));
   }
}
```

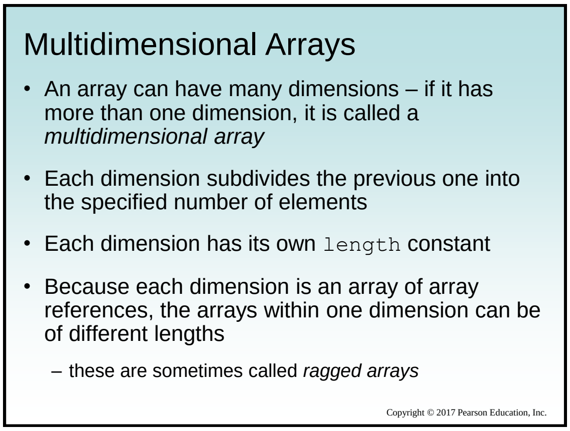


continue

```
      for (int soda=0;                      person++)
         for (int perso
         {
            sodaSum[soc                     son];
            personSum[p                     [person];
         }

      DecimalFormat fmt                     "0.#");
      System.out.printl

      for (int soda=0;
         System.out.pri                     +1) + ": " +
                    fmt                     m[soda]/PEOPLE));

      System.out.printl
      for (int person=(                     son++)
         System.out.pri                     rson+1) + ": " +
                    fmt                     Sum[person]/SODAS));
   }
}
```

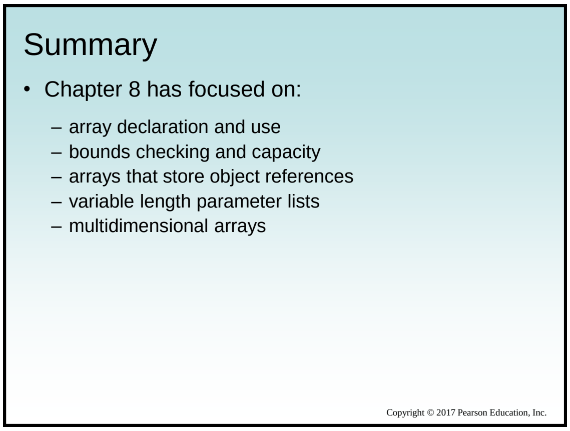
Output

```
Averages:

Soda #1: 3.2
Soda #2: 2.6
Soda #3: 4.2
Soda #4: 1.9

Person #1: 2.2
Person #2: 3.5
Person #3: 3.2
Person #4: 3.5
Person #5: 2.5
Person #6: 3
Person #7: 2
Person #8: 2.8
Person #9: 3.2
Person #10: 3.8
```



Multidimensional Arrays

- An array can have many dimensions – if it has more than one dimension, it is called a *multidimensional array*
- Each dimension subdivides the previous one into the specified number of elements
- Each dimension has its own `length` constant
- Because each dimension is an array of array references, the arrays within one dimension can be of different lengths
  - these are sometimes called *ragged arrays*



Summary

- Chapter 8 has focused on:
  - array declaration and use
  - bounds checking and capacity
  - arrays that store object references
  - variable length parameter lists
  - multidimensional arrays