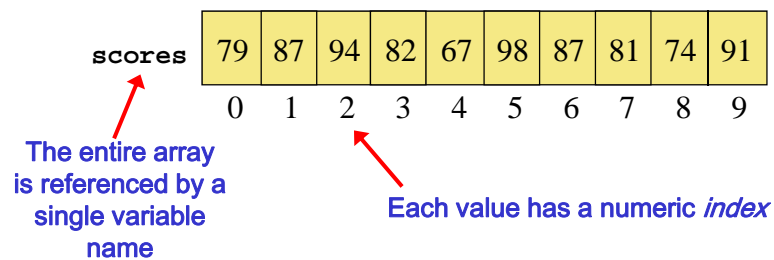


8. Arrays

- Objectives - when we have completed this set of notes, you should be familiar with:
 - array declaration and use
 - bounds checking and capacity
 - arrays that store object references
 - variable length parameter lists
 - multidimensional arrays

Arrays

- An *array* is an ordered list of values (similar to an ArrayList)



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

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

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 int or an **int array**)
- An array is an object rather than a primitive type, thus the use of the **new** operator
- The reference variable scores is set to a new array object that holds 10 integers

Alternate Array Syntax

- The brackets of the array type can be associated with the element type or with the name of the array:

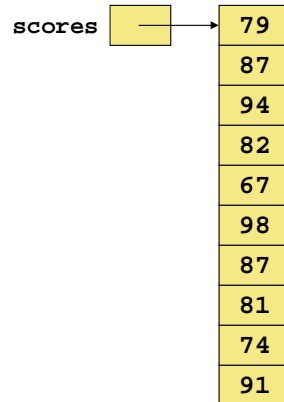
```
float[] prices;
```

```
float prices[];
```

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

Arrays

- Another way to depict the `scores` array:



Arrays

- The values held in an array are called array *elements*
 - The *element type* can be a primitive or a reference type
- When an array is declared only, the array object does not yet exist in memory
`char[] letters;`
- When it is instantiated, the array is created with the specified number of elements
`letters = new char[5];`

Arrays

- When an array is created, the initial value of each array element depends on the type.

- Numerical elements (including char) are initialized to 0 or 0.0

```
double[] grades = new double[4];
```

0.0	0.0	0.0	0.0
0	1	2	3

- boolean values are initialized to false

```
boolean[] statuses = new boolean[3];
```

false	false	false
0	1	2

- Any type of object element is initialized to null

```
String[] names = new String[2];
```

```
Coin[] change = new Coin[4];
```

```
CableAccount accounts = new CableAccount[3];
```

[ArrayExamples.java](#)

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Accessing Array Elements

- Elements are accessed using the array name followed by the index in brackets
- The expression `scores[2]` evaluates to the value 94

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

Examples:

```
int singleScore = scores[2];
```

```
System.out.println("3rd score: " + scores[2]);
```

```
double avg = ((double) scores[0] + scores[1]) / 2;
```

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Setting Array Elements

- Individual array elements are also assigned using the array name followed by the index in brackets
- Example: declare a double array and assign elements

```
double[] gradeBook = new double[4];
```

0.0	0.0	0.0	0.0
0	1	2	3

```
gradeBook[0] = 94.2;
```

94.2	0.0	0.0	0.0
0	1	2	3

```
gradeBook[3] = 98.1;
```

94.2	0.0	0.0	98.1
0	1	2	3

Initializer Lists

- An *initializer list* can be used to instantiate and fill an array in one step
 - The size of the array is determined by the number of items in the initializer list
 - It can only be used when declaring the array.
- Examples:

```
int[] units = {147, 323, 89, 933};
```

147	323	89	933
0	1	2	3

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

A	B	C	D	F
0	1	2	3	4

[InitializerListExample.java](#)

Using Arrays

- The length variable can be accessed to get the length of the array.

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

- The for loop can be used when processing array elements

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

- The for each loop can also be used with arrays:

```
for (int currentScore : scores) {  
    System.out.println (currentScore);  
}
```

Bounds Checking

- Once an array is created, it has a fixed size
 - An index used in an array reference must specify a valid element from 0 to length - 1
- The Java interpreter throws an `ArrayIndexOutOfBoundsException` if an array index is out of bounds
- This is called automatic *bounds checking*
- Common in *off by one* errors:

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

More on Arrays of Objects

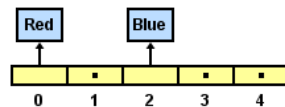
- When the elements of an array are object references, they are initialized to null (i.e., no objects are created). For example, below no String objects are created:

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



- Each object element stored in an array must be instantiated separately

```
colors[2] = new String("Blue");  
colors[0] = "Red"; // String objects only
```



Arrays as Parameters

- An entire array can be passed as a parameter to a method or returned to the client program.

```
public Polygon(double[] sidesIn)
```

```
public void setSides(double[] sidesIn)
```

```
public double[] getSides()
```

- See [Polygon.java](#)

“Aliases”

- Recall that reference variables can refer to the same object. This was not as important with Strings (they are immutable), but it can cause unexpected errors with arrays.
- For example, try the following code in interactions:

```
double[] sides1 = {5.4, 2.3, 5.7, 4.5};  
Polygon shape = new Polygon(sides1);  
double[] sides2 = shape.getSides();  
sides2[0] = -1;  
double[] sides3 = shape.getSides();  
sides3[0]  
-1.0
```

“Aliases”

- Recall that encapsulation is achieved by objects “protecting and managing their own information.”
- If you return a reference to an array object (or any object) in a method and it is modified by a client program, does it support encapsulation?
- Lesson: be very careful with reference variables.

Array vs. ArrayList

- Recall that the size of an array object cannot be changed. Thus, you would have to create a whole new array and copy all of the elements over.
- Similarly, if you want to insert an element into the middle of the array, you'll have to move (copy) the elements to the left to make room
- The ArrayList class holds an array and performs the above operations for you if needed.
- ArrayList is provided in the java class library, and so it is unique to the Java language. Arrays are not.

Command-Line Arguments

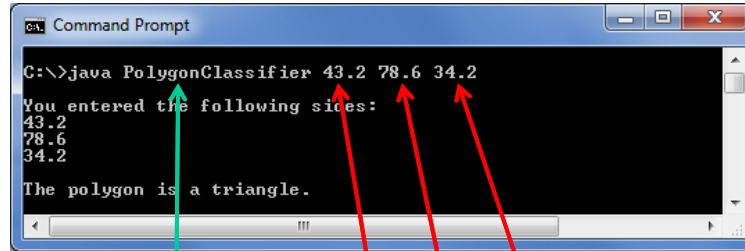
- The signature of the main method indicates that it takes an array of String objects as a parameter

```
public static void main(String[] args)
```

- The args array comes from *command-line arguments* that are provided when the Java interpreter is invoked (for example, in the command prompt or terminal)

Command-Line Arguments

- Consider running the PolygonClassifier program:



```
C:\>java PolygonClassifier 43.2 78.6 34.2
You entered the following sides:
43.2
78.6
34.2
The polygon is a triangle.
```

Name of class args[0] args[1] args[2]

- For ease of testing your program, command line arguments can also be passed in via jGRASP. See [PolygonClassifier.java](#).

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 multiple versions of the average method (each taking a different number of parameter inputs)
 - Downside: we'd need a separate version of the method for each parameter count
- 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*

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Variable Length Parameter Lists

- We can define a method to accept any number of parameters of the same type
- The parameters are automatically put into an array with a specified variable name

Indicates a variable length parameter list

```
public double average (int ... list)
```

↑
element
type

↑
array
name

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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) sum / list.length;
    }

    return result;
}
```

Variable Length Parameter Lists

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

```
public String allPolygons(Polygon ... polygonSet) {
    String output = "";
    for (Polygon shape : polygonSet) {
        output += shape + " ";
    }
    return output;
}
```

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`

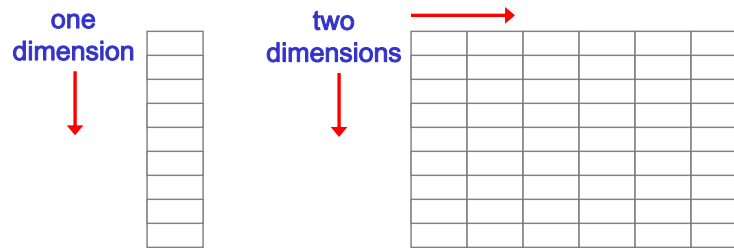
```
public void test(int count, String name, double ... nums)
```

Variable Length Parameter Lists

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

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

- A two-dimensional array is an “array of arrays”
- A two-dimensional array is declared by specifying the size of each dimension separately:

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

- A single element is referenced using two index values:

```
int value = scores[3][6];
```

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

```
int[] valueSet = scores[3];
```

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 [TwoDArraySums.java](#)

Multidimensional Arrays

- An array can have many dimensions – if it has more than one dimension, it is called a *multidimensional array*
- 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*

```
int[][] raggedExample = { {1,2,3,4},  
                          {5,6},  
                          {7,8,9} };
```