Multiple Dimensions

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WHAT'S COVERED

In this lesson, you will learn to recognize that arrays have more than one dimension as you explore the difference between one, two, and three dimensional arrays. Specifically, this lesson covers:

1. Multidimensional Arrays

A **dimension** of an array is an axis along which the elements are organized. The data in an array can be organized along one, two, or more axes or dimensions.

KEY CONCEPT

Java multidimensional arrays are arranged as an array of arrays.

The elements of multidimensional arrays are seen in rows and columns. Before discussing multiple dimensions in Java arrays, it is important to explore what multiple dimensions look like.

TERM TO KNOW

Dimension
A dimension of an array is an axis along which the elements are organized.

1a. One-Dimensional Arrays

Recall what you learned about one-dimensional arrays in a previous tutorial. A one-dimensional array resembles a list data collection type.

It appears as a straight line on a flat plane, as demonstrated in this diagram:

A one-dimensional listing would look like this on paper:

element value	“sun”	“fun”	“run”	“bun”	“nun”	“pun”
Index	0	1	2	3	4	5

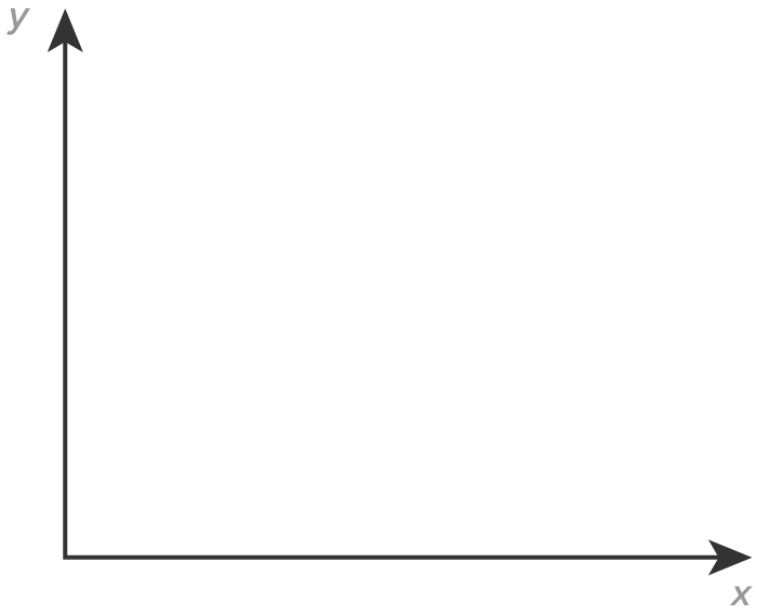
The index position is one integer. To locate “run” from this listing, you can use the single index position. Remember that list elements start at 0.

EXAMPLE The element “run” is at index value 2.

1b. Two-Dimensional Arrays

When nesting an array within an array, you are, in a sense, adding a second dimension. A nested list is a **two-dimensional** list, or 2D, for short.

Here is what it looks like graphically:



You have likely seen this previously in an X/Y chart. It has two dimensions. One dimension is running diagonally and the other vertically, though they are still on a flat plane.

A two-dimensional listing would look like this on paper:

X/Y indexes	X →		
	0	1	2

Y ⬇	0	fun	sun	run
	1	bun	nun	pun
	2	fan	van	man
	3	can	tan	ran

There are two index positions for each element. To locate “fan” from this two-dimensional listing, identify both index positions, starting with the row, then column.

↪ EXAMPLE The element “fan” is at position 2, 0 (Y, X or Row/Column)

There can be more than one dimension when it comes to an array in Java. Consider how teachers store their grades for a class in a grade book. They have a list of students and within the list of students, they have a list of assignments. For each of those assignments, they will have a grade assigned.

The scores in Row 0 represent the scores for one student. This person's scores, for the different assignments, are seen in Column 0, Column 1, Column 2, and Column 3. The scores in Row 1 and Row 2 represent scores for other students. Since all of the values in an array have to be of the same data type, you cannot mix names or letter grades in with the integer scores. The following table demonstrates four inner lists within an outer list, making this a 2D list:

	Column 0	Column 1	Column 2	Column3
Row 0	100	92	99	85
Row 1	100	95	88	91
Row 2	99	100	100	100

Let’s see this 2D array in Java code. To print out a two-dimensional array, use the **Arrays.deepToString()** method. This method has to "go deep" because it needs to work down through both dimensions in the array to display the values, not just one.

Here is what a 2D array in Java code would look like:

```
import java.util.Arrays;

class Scores2DArray {
  public static void main(String[] args) {
    // Array of 3 rows & 4 columns
    // 2 pairs of square brackets declare 2D array of int
    int[][] scores = {
      {100, 92, 99, 85},
      {100, 95, 88, 91},
      {99, 100, 100, 100}
```

```
    };
    System.out.println(Arrays.deepToString(scores));
  }
}
```

The output should look like this:

```
[[100, 92, 99, 85], [100, 95, 88, 91], [99, 100, 100, 100]]
```

As demonstrated above, this 2D list is a long row of elements separated by the square brackets. Keep in mind that a two-dimensional array in Java can be thought of as an array of arrays.

The array scores could have been declared like this:

```
import java.util.Arrays;

class Scores2DArray {
  public static void main(String[] args) {
    // Array of 3 rows & 4 columns
    // 2 pairs of square brackets declare 2D array of int
    int[][] scores = new int[3][4];
    // Assign a 1D array to each row in the 2D array
    scores[0] = new int[] {100, 92, 99, 85};
    scores[1] = new int[] {100, 95, 88, 91};
    scores[2] = new int[] {99, 100, 100, 100};
    // Print out just the first row as a 1-dimensional array
    System.out.println(Arrays.toString(scores[0]));
  }
}
```

Either way, the first list can be accessed by using the index for the first row (index 0):

```
import java.util.Arrays;

class Scores2DArray {
  public static void main(String[] args) {
    // Array of 3 rows & 4 columns
    // 2 pairs of square brackets declare 2D array of int
    int[][] scores = {
      {100, 92, 99, 85},
      {100, 95, 88, 91},
      {99, 100, 100, 100}
    };
    // Print out just the first row as a 1-dimensional array
```

```
    System.out.println(Arrays.toString(scores[0]));
  }
}
```

The output is just the first row from the 2D array as a 1D array, as seen below:

```
[100, 92, 99, 85]
```

To access a specific element within that first row, use an index in a second pair of square brackets after the first set. To select the third element from the first row, use the 2 as the column index. Each row in the 2D array represents the grades for one student.

The following code shows how to access the 3rd score for the 1st student, since each column (the 2nd dimension or index) represents a different assignment score:

```
class Scores2DArray {
  public static void main(String[] args) {
    // Array of 3 rows & 4 column
    // 2 pairs of square brackets declare 2D array of int
    int[][] scores = new int[3][4];
    // Assign a 1D array to each row in the 2D array
    scores[0] = new int[] {100, 92, 99, 85};
    scores[1] = new int[] {100, 95, 88, 91};
    scores[2] = new int[] {99, 100, 100, 100};
    // Print out just the element in the first row,
    // third column as int. No toString() needed.
    System.out.println("1st student, 3rd score: " + scores[0][2]);
  }
}
```

The output should look like this:

```
1st student, 3rd score: 99
```

TERMS TO KNOW

Two-Dimensional (or 2D) Array
A two-dimensional array is an array of arrays with data laid out in a grid-like pattern of rows and columns.

Arrays.deepToString()
A Java method that converts data in a two-dimensional array to a format that can be displayed on the screen.

1c. Three-Dimensional Arrays

Using **three-dimensional arrays** can be complicated. Here, you will consider X, Y, and Z index positions. At this point, it becomes difficult to see a representation of it on “paper” or a flat plane. Utilizing three-dimensional

collections of data is rarely done unless it is for 3D object modeling or mapping.

When defining a 3D array representing some sort of values in points in three-dimensional space, the declaration would look like this:

EXAMPLE

```
int[][][] temperatures3D = new int[100][100][100];
```

The values in the elements of this array could be assigned and accessed using three indices. The first index is the "layer" in the three-dimensional structure. The second index is the row within that layer, and the third index is the column within that row.

TERM TO KNOW

Three-Dimensional (or 3D) Array
A three-dimensional array adds a 3rd index or axis to the organization of the array elements.

SUMMARY

In this lesson, you learned about using arrays with **multiple dimensions**. You learned about the difference between **one, two, and three dimensions**. Finally, you learned that three-dimensional arrays are complex and not often used in basic programming in Java.

Source: This content and supplemental material has been adapted from Java, Java, Java: Object-Oriented Problem Solving. Source cs.trincoll.edu/~ram/jjj/jjj-os-20170625.pdf

It has also been adapted from “Python for Everybody” By Dr. Charles R. Severance. Source py4e.com/html3/

TERMS TO KNOW

Arrays.deepToString()
A Java method that converts data in a two-dimensional array to a format that can be displayed on the screen.

Dimension
A dimension of an array is an axis along which the elements are organized.

Three-Dimensional (or 3D) Array
A three-dimensional array adds a 3rd index or axis to the organization of the array elements.

Two-Dimensional (or 2D) Array

A two-dimensional array is an array of arrays with data laid out in a grid-like pattern of rows and columns.