

Topic Notes: Two Dimensional Arrays

We can create arrays to hold objects of any type, either basic data types like `int` and `double`, or instances of objects such as `Image` and `FilledOval` or `TShirt`.

Nothing stops us from defining arrays of arrays. To declare an array, each of whose elements is an array of `int`:

```
int[][] twoDArray;
```

While it is normally written without parentheses, we can think of the above declaration as defining `twoDArray` as having type `(int []) []`. Thus each element of `twoDArray` is an array of `ints`.

Despite the fact that Java will treat this as an array of arrays, we usually think about this as a two-dimensional array, with the elements arranged in a two-dimensional table so that `twoDArray[i][j]` can be seen as the element in the *i*th row and *j*th column. For example here is the layout for a two-dimensional array `a` with 6 rows (numbered 0 to 5) and 4 columns:

	0	1	2	3
0	<code>a[0][0]</code>	<code>a[0][1]</code>	<code>a[0][2]</code>	<code>a[0][3]</code>
1	<code>a[1][0]</code>	<code>a[1][1]</code>	<code>a[1][2]</code>	<code>a[1][3]</code>
2	<code>a[2][0]</code>	<code>a[2][1]</code>	<code>a[2][2]</code>	<code>a[2][3]</code>
3	<code>a[3][0]</code>	<code>a[3][1]</code>	<code>a[3][2]</code>	<code>a[3][3]</code>
4	<code>a[4][0]</code>	<code>a[4][1]</code>	<code>a[4][2]</code>	<code>a[4][3]</code>
5	<code>a[5][0]</code>	<code>a[5][1]</code>	<code>a[5][2]</code>	<code>a[5][3]</code>

Viewed in this way, our two-dimensional array is a grid, much like a map or a spreadsheet. This is a natural way to store things like tables of data or matrices.

We access elements of two-dimensional arrays in a manner similar to that used for one dimensional arrays, except that we must provide both the row and column to access an element, giving the row number first.

We create a two-dimensional array by providing the number of rows and columns. Thus we can create the two-dimensional array above by writing:

```
int[][] a = new int[6][4];
```

(Though as good programmers, you would define constants for the number of rows and the number of columns.)

A nested `for` loop is the most common way to access or update the elements of a two-dimensional array. One loop walks through the rows and the other walks through the columns. For example, if we wanted to assign a unique number to each cell of our two-dimensional array, we could do the following:

```
for (int row = 0; row < 6; row++) {
    for (int col = 0; col < 4; col++) {
        a[row][col] = 4*row + col + 1;
    }
}
```

This assigns the numbers 1 through 24 to the elements of array `a`. The array is filled by assigning values to the elements in the first row, then the second row, etc. and results in:

```
1  2  3  4
5  6  7  8
9 10 11 12
13 14 15 16
17 18 19 20
21 22 23 24
```

You could modify the above to be slightly more interesting by computing a multiplication table.

We could just as well process all the elements of column 0 first, then all of column 1, etc., by swapping the order of our loops:

```
for (int col = 0; col < 4; col++)
    for (int row = 0; row < 6; row++)
        ...
```

For the most part, it doesn't matter which order you choose, though for large arrays it is generally a good idea to traverse the array in the same order that your programming language will store the values in memory. For Java (and C, C++), the data is stored by rows, known as *row major* order. However, a two-dimensional array in FORTRAN is stored in *column major* order. You will almost certainly see this again if you go on and take courses like Computer Organization or Operating Systems.

A Tic-Tac-Toe Game

Let's look at an example that makes use of a small (3×3) two-dimensional array: a tic-tac-toe game.

See Example: TicTacToe

Most of the program is pretty straightforward, so we'll focus on the use of the two-dimensional arrays and discuss some of the private helper methods that make the code simpler, especially when checking for winning boards.

The array that represents the board is a two-dimensional array of `int` called `marks`. Each entry will contain one of three values that will indicate if the cell is empty (0), contains an X (1) or contains an O (2). Named constants make the code involving these numbers easier to understand.

Several private helper methods are provided to draw the board and the X's and O's. We will look at a bit at the `onMouseClicked` method where the game is played. When the mouse is clicked and it is determined which (if any) of the 9 spaces contain the click point, we check to see if the space is occupied. If not, the array entry is set and the appropriate mark is drawn on the screen.

From there, the `checkGameWon` method is called to see if this last move led to a win. If not, we call the `checkAllFilled` method to see if all squares are now occupied, meaning the game ends in a tie.

Breakout

A hopefully more interesting use of two-dimensional arrays is to manage the bricks in a breakout game.

See Example: Breakout

This is a greatly-enhanced version of our last pong game, where there are now a series of bricks that get removed as the ball bounces off one of them.

The most relevant to the current discussion is the two-dimensional array in the `BrickCollection` class.