C++ Multidimensional Arrays

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In this tutorial, we'll learn about multi-dimensional arrays in C++. More specifically, how to declare them, access them, and use them efficiently in our program.

In C++, we can create an array of an array, known as a multidimensional array. For example:

```
int x[3][4];
```

Here, *x* is a two-dimensional array. It can hold a maximum of 12 elements.

We can think of this array as a table with 3 rows and each row has 4 columns as shown below.

	Col 1	Col 2	Col 3	Col 4
Row 1	x[0][0]	x[0][1]	x[0][2]	x[0][3]
Row 2	x[1][0]	x[1][1]	x[1][2]	x[1][3]
Row 3	x[2][0]	x[2][1]	x[2][2]	x[2][3]

Elements in two-dimensional array in C++ Programming

Three-dimensional arrays also work in a similar way. For example:

```
float x[2][4][3];
```

This array *x* can hold a maximum of 24 elements.

We can find out the total number of elements in the array simply by multiplying its dimensions:

```
2 x 4 x 3 = 24
```

Multidimensional Array Initialization

Like a normal array, we can initialize a multidimensional array in more than one way.

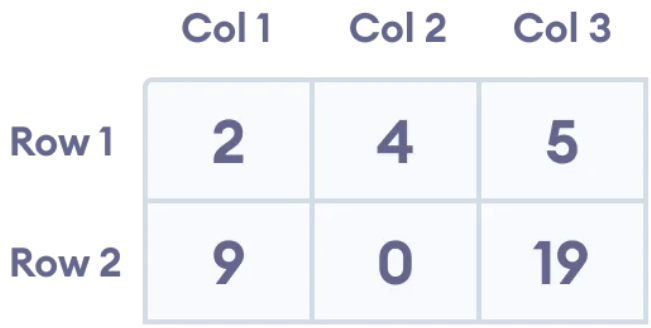
1. Initialization of two-dimensional array

```
int test[2][3] = {2, 4, 5, 9, 0, 19};
```

The above method is not preferred. A better way to initialize this array with the same array elements is given below:

```
int  test[2][3] = { {2, 4, 5}, {9, 0, 19}};
```

This array has 2 rows and 3 columns, which is why we have two rows of elements with 3 elements each.



Initializing a two-dimensional array in C++

2. Initialization of three-dimensional array

```
int test[2][3][4] = {3, 4, 2, 3, 0, -3, 9, 11, 23, 12, 23,
                2, 13, 4, 56, 3, 5, 9, 3, 5, 5, 1, 4, 9};
```

This is not a good way of initializing a three-dimensional array. A better way to initialize this array is:

```
int test[2][3][4] = {
                    { {3, 4, 2, 3}, {0, -3, 9, 11}, {23, 12, 23, 2} },
                    { {13, 4, 56, 3}, {5, 9, 3, 5}, {5, 1, 4, 9} }
                };
```

Notice the dimensions of this three-dimensional array.

The first dimension has the value `2`. So, the two elements comprising the first dimension are:

```
Element 1 = { {3, 4, 2, 3}, {0, -3, 9, 11}, {23, 12, 23, 2} }
Element 2 = { {13, 4, 56, 3}, {5, 9, 3, 5}, {5, 1, 4, 9} }
```

The second dimension has the value `3`. Notice that each of the elements of the first dimension has three elements each:

```
{3, 4, 2, 3}, {0, -3, 9, 11} and {23, 12, 23, 2} for Element 1.
{13, 4, 56, 3}, {5, 9, 3, 5} and {5, 1, 4, 9} for Element 2.
```

Finally, there are four `int` numbers inside each of the elements of the second dimension:

```
{3, 4, 2, 3}
{0, -3, 9, 11}
... .. ...
... .. ...
```

Example 1: Two Dimensional Array

```
// C++ Program to display all elements
// of an initialised two dimensional array

#include <iostream>
using namespace std;

int main() {
    int test[3][2] = {{2, -5},
                      {4, 0},
                      {9, 1}};

    // use of nested for loop
    // access rows of the array
    for (int i = 0; i < 3; ++i) {

        // access columns of the array
        for (int j = 0; j < 2; ++j) {
            cout << "test[" << i << "][" << j << "] = " << test[i][j] << endl;
        }
    }

    return 0;
}
```

Output

```
test[0][0] = 2
test[0][1] = -5
test[1][0] = 4
test[1][1] = 0
test[2][0] = 9
test[2][1] = 1
```

In the above example, we have initialized a two-dimensional `int` array named *test* that has 3 "rows" and 2 "columns".

Here, we have used the nested `for` loop to display the array elements.

- the outer loop from `i == 0` to `i == 2` access the rows of the array
- the inner loop from `j == 0` to `j == 1` access the columns of the array

Finally, we print the array elements in each iteration.

Example 2: Taking Input for Two Dimensional Array

```
#include <iostream>
using namespace std;

int main() {
    int numbers[2][3];

    cout << "Enter 6 numbers: " << endl;

    // Storing user input in the array
    for (int i = 0; i < 2; ++i) {
        for (int j = 0; j < 3; ++j) {
            cin >> numbers[i][j];
        }
    }

    cout << "The numbers are: " << endl;

    //  Printing array elements
    for (int i = 0; i < 2; ++i) {
        for (int j = 0; j < 3; ++j) {
            cout << "numbers[" << i << "][" << j << "]: " << numbers[i][j] <<
endl;
        }
    }

    return 0;
}
```

Output

```
Enter 6 numbers:
1
2
3
4
5
6
The numbers are:
numbers[0][0]: 1
numbers[0][1]: 2
numbers[0][2]: 3
numbers[1][0]: 4
numbers[1][1]: 5
numbers[1][2]: 6
```

Here, we have used a nested `for` loop to take the input of the 2d array. Once all the input has been taken, we have used another nested `for` loop to print the array members.

Example 3: Three Dimensional Array

```
// C++ Program to Store value entered by user in
// three dimensional array and display it.

#include <iostream>
using namespace std;

int main() {
    // This array can store upto 12 elements (2x3x2)
    int test[2][3][2] = {
                                {
                                    {1, 2},
                                    {3, 4},
                                    {5, 6}
                                },
                                {
                                    {7, 8},
                                    {9, 10},
                                    {11, 12}
                                }
                            };

    // Displaying the values with proper index.
    for (int i = 0; i < 2; ++i) {
        for (int j = 0; j < 3; ++j) {
            for (int k = 0; k < 2; ++k) {
                cout << "test[" << i << "][" << j << "][" << k << "] = " <<
test[i][j][k] << endl;
            }
        }
    }

    return 0;
}
```

Output

```
test[0][0][0] = 1
test[0][0][1] = 2
test[0][1][0] = 3
test[0][1][1] = 4
test[0][2][0] = 5
test[0][2][1] = 6
test[1][0][0] = 7
test[1][0][1] = 8
test[1][1][0] = 9
test[1][1][1] = 10
test[1][2][0] = 11
test[1][2][1] = 12
```

The basic concept of printing elements of a 3d array is similar to that of a 2d array.

However, since we are manipulating 3 dimensions, we use a nested for loop with 3 total loops instead of just 2:

- the outer loop from `i == 0` to `i == 1` accesses the first dimension of the array
- the middle loop from `j == 0` to `j == 2` accesses the second dimension of the array

- the innermost loop from `k == 0` to `k == 1` accesses the third dimension of the array

As we can see, the complexity of the array increases exponentially with the increase in dimensions.