Arrays

The array is a group of consecutive, adjacent memory locations (i.e. elements) that all have the same data type. Arrays may have from one to several dimensions. We will study the one-dimensional (1D) and two-dimensional (2D) arrays.

1D Array

Definition:

data type arrayName[Size];

The *Size* must be an integer constant greater than zero.

For example:

```
int    a[10];
char   name[20];
float  temperature[6];
```

Accessing array elements:

arrayName[index]

- All arrays have 0 as the index of their first element and *Size-1* as the index of their last element.
- The *arrayName* represents the address of the first element in the array.

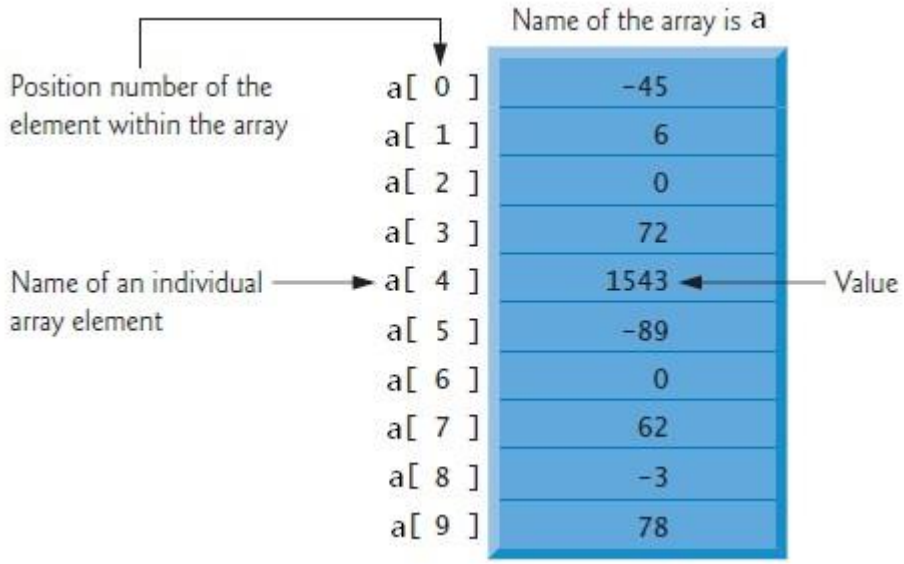
For example:

```
int   a[10];
```

The first element is `a[0]`

The last element is `a[9]`

The array is a[0] , a[1] , a[2] , . . . , a[9]



For example:

- `a[3] = 60;  // assign 60 to the fourth element`
- `cin >> mark[3];  // read the value of the 4th mark`
- ```
  for(int i=0; i<10; i++)
      cin >> a[i];  // input values to the array
  ```
- ```
  for(int j=0; j<10; j++)
      cout << a[j]; // print values of the array
  ```

Example: Write a C++ program that loads an integer array with the numbers 0 through 9 and prints the array values.

```
#include <iostream>
using namespace std;
int main()
{
  int a[10];
  for(int i=0 ; i<10 ; i++)
     a[i] = i;
  cout << "Array is " << endl;
  for(int i=0; i<10 ; i++)
     cout << a[i] << " ";
  return 0;

}
```

Array initialization:

C++ allows the initialization of arrays at the time of their declaration. For example:

```
int a[5] = { 8 , 5 , 13 , 2 , 9};
int a[ ] = { 8 , 5 , 13 , 2 , 9};
```

Example: Write a C++ program that calculates the sum and average of an initialized integer array.

```
#include <iostream>
using namespace std;
int main()
{
  int b[5] = { 9 , 3 , 11 , 7 , 1 };
  int sum  = 0;
  for(int i=0 ; i<5 ; i++)
       sum += b[i];
  cout<<"Sum is " << sum << endl
      <<"Average is " <<sum/5.0;
  return 0;
}
```

Example: Write a C++ program that inputs ten integer values into an array and finds the maximum number in the array.

```
#include <iostream>
using namespace std;
int main()
{
  const int size = 10;
  int c[size] , max;
  cout<<"Enter ten integer values: ";
  for(int i=0 ; i<10 ; i++)
      cin >> c[i];
  max = c[0];
  for(int i=1 ; i < 10 ; i++)
  if(c[i] > max)
     max = c[i];
  cout<<"The maximum number is " << max;
  return 0;

}
```

Example: Write a C++ program that computes the number of even integer numbers in an array entered by the user.

```
#include <iostream>
using namespace std;
int main()
{
  const int size = 10;
  int a[size] , count = 0;
  cout<<"Enter ten integer numbers: ";
  for(int i=0 ; i<10 ; i++)
    {
     cin >> a[i];
     if(a[i] % 2 == 0)
       count++;
    }
  cout<<"The number of even numbers is " << count;
  return 0; }
```

Note

Only constants can be used to declare the size of arrays. Not using a constant for this purpose will generate a compilation error.

Example: Write a C++ program that inputs an integer array a[10] and arranges it in an ascending order.

```
#include <iostream>
using namespace std;
int main()
{ const int size = 10; int a[size];
  cout<<"Enter ten integer array values: ";
  for (int i=0; i<size; i++)
     cin>>a[i];
  for (int i=0; i<size-1; i++)
   for(int j=i+1; j<size; j++)
    if(a[i] > a[j])
     {
       int temp = a[i];
       a[i] = a[j];
       a[j] = temp;
     }
  cout << "Array in ascending order: " <<endl;
  for(int i=0; i<size ;i++)
    cout<<a[i]<<" ";
  return 0;
}
```

2D Array (Matrix)

Two-dimensional arrays consist of values arranged in rows and columns.

Definition:

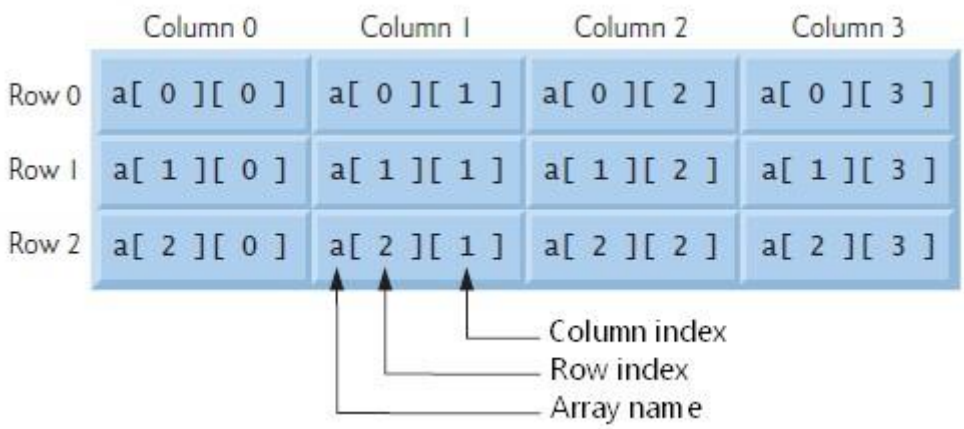
data type arrayName [RowSize][ColumnSize];

For example:

```
int   a[3][4];
float b[10][20];
```

Accessing 2D array elements:

arrayName[RowIndex] [ColumnIndex]



For example:

- `a[3][4] = 60;`
- `cin >> mark[3][1];`
- ```
  for(int i=0; i<10; i++)
   for(int j=0; j<10; j++)
      cin >> a[i][j]; // input values to the 2D array
  ```

- ```
  for(int m=0; m<10; m++)
  {
   for(int n=0; n<10; n++)
     cout<< a[m][n]<<"\t"; //print values of 2D array
   cout<<endl;
  }
  ```

2D Array initialization:

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

Example: Write a C++ program that adds two initialized 3×4 matrices A and B and then stores the result in a matrix C.

```
#include <iostream>
using namespace std;
int main()
{
  int A[3][4] = { {1, 4, 3, 2},
                  {5, 6, 7, 8},
                  {9, 10, 11, 12} };
  int B[3][4] = { {3, 4, 3, 1},
                  {8, 7, 5, 6},
                  {12, 9, 11, 8} };
  int C[3][4];
  for (int i=0; i<3; i++)
   {
    for (int j=0; j<4; j++)
     {
      C[i][j] = A[i][j] + B[i][j];
      cout << C[i][j] << "\t";
     }
  cout << endl;
 }
   return 0;
}
```

Example: Write a C++ program that finds the average of each row of a 3× 4 matrix input by the user.

```
#include <iostream>
using namespace std;
int main()
{
  int a[3][4];
  int sum;
  cout<<"Enter 3x4 integer matrix: ";
  for (int i=0; i<3; i++)
   for (int j=0; j<4; j++)
     cin>>a[i][j];
  cout<<"Average of each row: "<<endl;
```

```
  for (i=0; i<3; i++)
   {
    sum = 0;
    for(j=0; j<4; j++)
       sum += a[i][j];
    cout<<sum/4.0<<endl;
   }
  return 0;
}
```

Example: Write a C++ program that exchanges row3 with row1 in a 4× 4 integer matrix input by the user.

```
#include <iostream>
using namespace std;
int main()
{
  int a[4][4];
  cout<<"Enter 4x4 integer matrix: ";
  for (int i=0; i<4; i++)
   for (int j=0; j<4; j++)
     cin>>a[i][j];
  for (i=0; i<4; i++)
   {
    int temp = a[0][i];
    a[0][i] = a[2][i];
    a[2][i] = temp;
   }
  cout<<"Matrix after exchanging row3 with row1:"
      <<endl;
  for (i=0; i<4; i++)
   {
    for (j=0; j<4; j++)
      cout<<a[i][j]<<" ";
    cout<<endl;
   }
  return 0;
}
```

Example: Write a C++ program that inputs a 4×4 integer matrix and finds the maximum value in the primary diagonal and the minimum value in the secondary diagonal.

```
#include <iostream>
using namespace std;
int main()
{
  int b[4][4] , max , min;
  cout<<"Enter 4x4 integer matrix: ";
```

```
  for (int i=0; i<4; i++)
   for (int j=0; j<4; j++)
     cin>>b[i][j];
  max = b[0][0];
  min = b[0][3];
  for (int i=1; i<4; i++)
    {
     if(b[i][i] > max)
        max = b[i][i];
     if(b[i][3-i] < min)
        min = b[i][3-i];
    }
cout << "Max value is " << max <<endl
     << "Min value is " << min;
   return 0;
}
```

Example: Write a C++ program that multiplies 3×4 matrix by 4×3 matrix both are entered by the user. Then the program should store the result in a third matrix.

```
#include <iostream>
using namespace std;
int main()
{
  const int row_a=3 , col_a=4 ,
            row_b=4 , col_b=3;
  int a[row_a][col_a];
  int b[row_b][col_b];
  int c[row_a][col_b];

  cout<<"Enter "<<row_a<<"x"<<col_a
      <<" integer matrix: " << endl;
  for (int i=0; i<row_a; i++)
   for (int j=0; j<col_a; j++)
     cin>>a[i][j];

  cout<<"Enter "<<row_b<<"x"<<col_b
      <<" integer matrix: " << endl;
  for (i=0; i<row_b; i++)
   for (j=0; j<col_b; j++)
     cin>>b[i][j];
```

```
  for(i=0; i<row_a; i++)
   for(j=0; j<col_b ; j++)
    {
      c[i][j] = 0;
      for(int k=0; k<col_a ; k++)
        c[i][j] += a[i][k] * b[k][j];
      }

  cout<<"Resulted Matrix is " << endl;
  for (i=0; i<row_a; i++)
   {
    for (j=0; j<col_b; j++)
      cout<<c[i][j]<<" ";
    cout<<endl;
   }
  return 0;
}
```

Homework:

1. Write a C++ program that inputs an integer array of 10 elements and prints only the prime numbers in the array.

2. Write a C++ program that reads an integer array a[10] and finds the max value with its position and the min value with its position.

3. Write a C++ program that inputs an integer array b[10] and then reverse it and print the reversed array.

4. Write a C++ program that exchanges the primary and secondary diagonals of 4×4 matrix.

5. Write a C++ program that converts a two dimensional array into one dimensional array. Then print the 1D array.

6. Write a C++ program that creates the following matrix:

$$A = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

7. Write a C++ program that creates the following matrix:

$$A = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 2 & 2 & 2 \\ 1 & 2 & 3 & 3 \\ 1 & 2 & 3 & 4 \end{bmatrix}$$

8. Write a C++ program that finds the transpose of the following matrix:

$$A = \begin{bmatrix} 1 & 2 & 3 & 4 \\ 1 & 2 & 3 & 4 \\ 1 & 2 & 3 & 4 \\ 1 & 2 & 3 & 4 \end{bmatrix} \longrightarrow A^T = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 2 & 2 & 2 & 2 \\ 3 & 3 & 3 & 3 \\ 4 & 4 & 4 & 4 \end{bmatrix}$$

9. Write a C++ program that computes the sum of the secondary diagonal elements in a square integer matrix.

10. Write a C++ program that inputs a 4×4 matrix and then exchanges the upper triangle above the main diagonal with the respect lower triangle.