Pointer to an Array | Array Pointer

Difficulty Level : Medium • Last Updated : 21 Sep, 2021

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Prerequisite: Pointers Introduction

Pointer to Array

Consider the following program:

C++

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

int main()
{
int arr[5] = { 1, 2, 3, 4, 5 };
int *ptr = arr;

cout <<"\n"<< ptr;
return 0;
}

// thus code is contributed by shivanisinghss2110
```

C

```c
#include<stdio.h>
```

```
  printf("%p\n", ptr);
  return 0;
}
```

In this program, we have a pointer *ptr* that points to the 0^{th} element of the array. Similarly, we can also declare a pointer that can point to whole array instead of only one element of the array. This pointer is useful when talking about multidimensional arrays.

Syntax:

```
data_type (*var_name)[size_of_array];
```

Example:

```
int (*ptr)[10];
```

Here *ptr* is pointer that can point to an array of 10 integers. Since subscript have higher precedence than indirection, it is necessary to enclose the indirection operator and pointer name inside parentheses. Here the type of ptr is ‘pointer to an array of 10 integers’.

Note : The pointer that points to the 0^{th} element of array and the pointer that points to the whole array are totally different. The following program shows this:

```
// C++ program to understand difference between
// pointer to an integer and pointer to an
// array of integers.
#include <iostream>
using namespace std;
int main()
{
    // Pointer to an integer
    int *p;

    // Pointer to an array of 5 integers
    int (*ptr)[5];
    int arr[5];

    // Points to 0th element of the arr.
    p = arr;

    // Points to the whole array arr.
    ptr = &arr;

    cout << "p =" << p <<", ptr = "<< ptr<< endl;
    p++;
    ptr++;
    cout << "p =" << p <<", ptr = "<< ptr<< endl;

    return 0;
}

// This code is contributed by SHUBHAMSINGH10
```

C

```
// C program to understand difference between
// pointer to an integer and pointer to an
// array of integers.
#include<stdio.h>

int main()
{
    // Pointer to an integer
    int *p;
    // Points to the whole array arr.
    ptr = &arr;

    printf("p = %p, ptr = %p\n", p, ptr);

    p++;
    ptr++;

    printf("p = %p, ptr = %p\n", p, ptr);

    return 0;
}
```

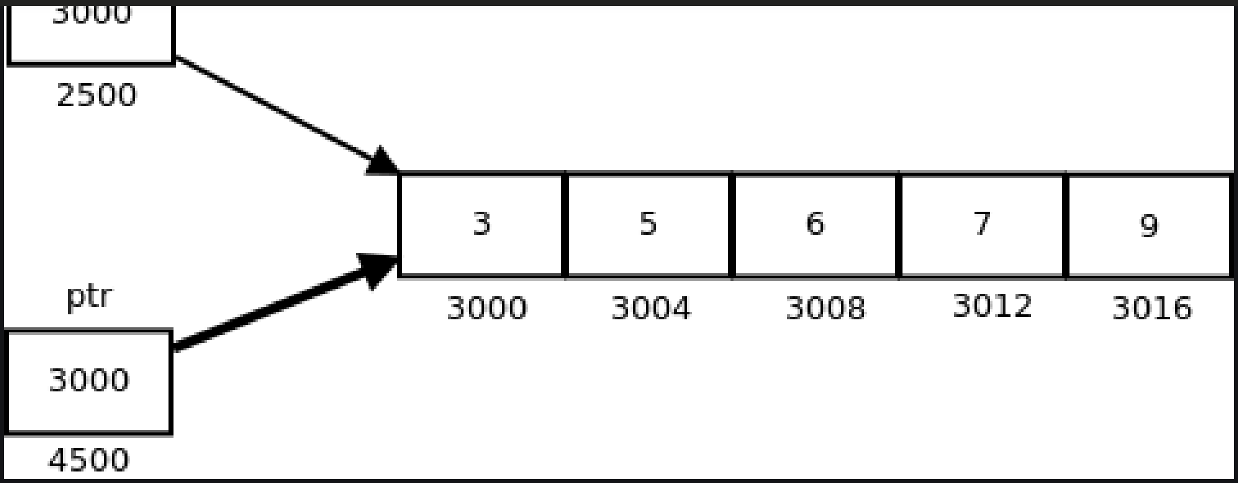
Output:

```
p = 0x7fff4f32fd50, ptr = 0x7fff4f32fd50
p = 0x7fff4f32fd54, ptr = 0x7fff4f32fd64
```

p: is pointer to 0th element of the array *arr*, while ***ptr*** is a pointer that points to the whole array *arr*.

- The base type of *p* is int while base type of *ptr* is 'an array of 5 integers'.
- We know that the pointer arithmetic is performed relative to the base size, so if we write ptr++, then the pointer *ptr* will be shifted forward by 20 bytes.

The following figure shows the pointer p and ptr. Darker arrow denotes pointer to an array.



On dereferencing a pointer expression we get a value pointed to by that pointer expression. Pointer to an array points to an array, so on dereferencing it, we should get the array, and the name of array denotes the base address. So whenever a pointer to an array is dereferenced, we get the base address of the array to which it points.

C++

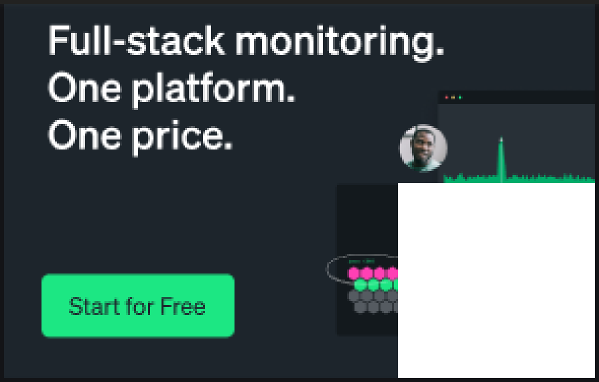
```
// C++ program to illustrate sizes of
// pointer of array
#include <bits/stdc++.h>
using namespace std;

int main()
{
    int arr[] = { 3, 5, 6, 7, 9 };
    int *p = arr;
    int (*ptr)[5] = &arr;

    cout << "p = "<< p <<", ptr = " << ptr << endl;
    cout << "*p = "<< *p <<", *ptr = " << *ptr << endl;

    cout << "sizeof(p) = "<< sizeof(p) <<
            ", sizeof(*p) = " << sizeof(*p) << endl;
    cout << "sizeof(ptr) = "<< sizeof(ptr) <<
        ", sizeof(*ptr) = " << sizeof(*ptr) << endl;
    return 0;
```

```c
// C program to illustrate sizes of
// pointer of array
#include<stdio.h>

int main()
{
    int arr[] = { 3, 5, 6, 7, 9 };
    int *p = arr;
    int (*ptr)[5] = &arr;

    printf("p = %p, ptr = %p\n", p, ptr);
    printf("*p = %d, *ptr = %p\n", *p, *ptr);

    printf("sizeof(p) = %lu, sizeof(*p) = %lu\n",
                          sizeof(p), sizeof(*p));
    printf("sizeof(ptr) = %lu, sizeof(*ptr) = %lu\n",
                        sizeof(ptr), sizeof(*ptr));
    return 0;
}
```

Output:

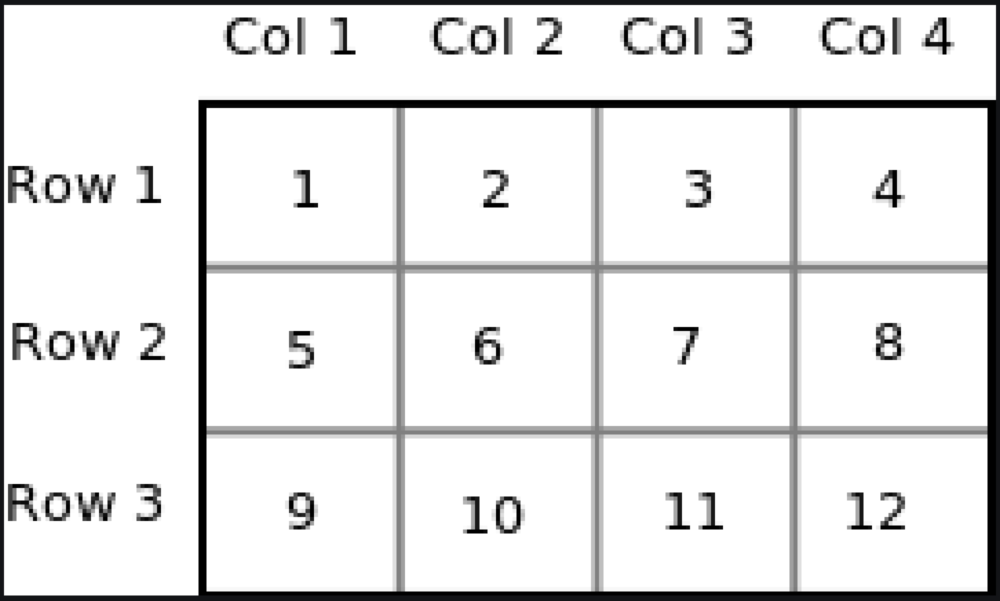
```
p = 0x7ffde1ee5010, ptr = 0x7ffde1ee5010
*p = 3, *ptr = 0x7ffde1ee5010
sizeof(p) = 8, sizeof(*p) = 4
sizeof(ptr) = 8, sizeof(*ptr) = 20
```

Pointer to Multidimensional Arrays:



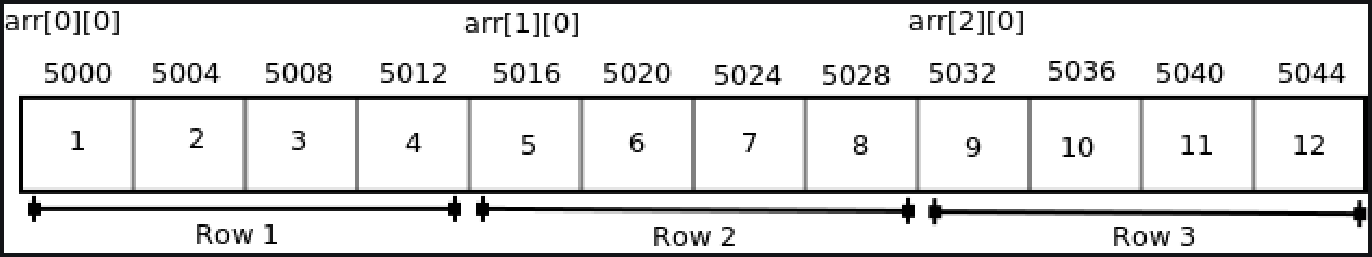
- **Pointers and two dimensional Arrays:** In a two dimensional array, we can access each element by using two subscripts, where first subscript represents the row number and second subscript represents the column number. The elements of 2-D array can be accessed with the help of pointer notation also. Suppose arr is a 2-D array, we can access any element *arr[i][j]* of the array using the pointer expression ***(*(arr + i) + j)**. Now we'll see how this expression can be derived.
  Let us take a two dimensional array *arr[3][4]*:

```
int arr[3][4] = { {1, 2, 3, 4}, {5, 6, 7, 8}, {9, 10, 11, 12} };
```

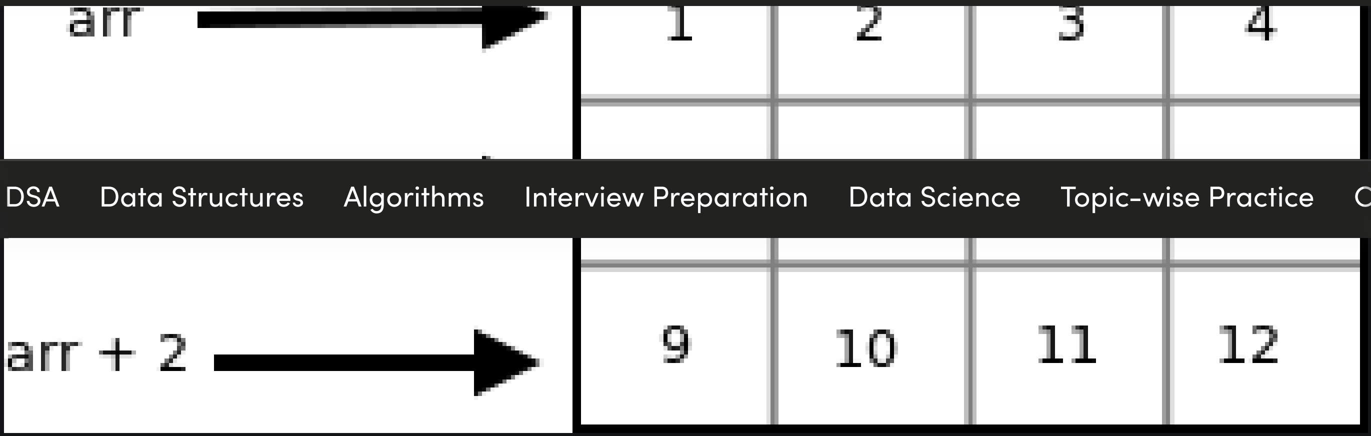


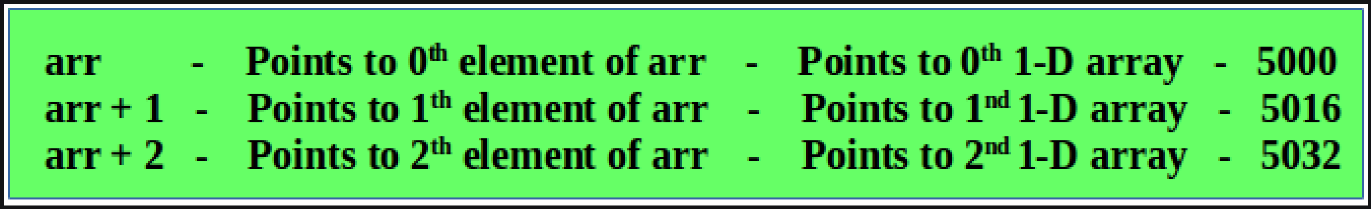
	Col 1	Col 2	Col 3	Col 4
Row 1	1	2	3	4
Row 2	5	6	7	8
Row 3	9	10	11	12

Since memory in a computer is organized linearly it is not possible to store the 2-D array



Each row can be considered as a 1-D array, so a two-dimensional array can be considered as a collection of one-dimensional arrays that are placed one after another. In other words, we can say that 2-D dimensional arrays that are placed one after another. So here *arr* is an array of 3 elements where each element is a 1-D array of 4 integers.
We know that the name of an array is a constant pointer that points to 0^{th} 1-D array and contains address 5000. Since *arr* is a 'pointer to an array of 4 integers', according to pointer arithmetic the expression arr + 1 will represent the address 5016 and expression arr + 2 will represent address 5032.
So we can say that *arr* points to the 0^{th} 1-D array, *arr + 1* points to the 1^{st} 1-D array and *arr + 2* points to the 2^{nd} 1-D array.





arr	-	Points to 0th element of arr	-	Points to 0th 1-D array	-	5000
arr + 1	-	Points to 1th element of arr	-	Points to 1nd 1-D array	-	5016
arr + 2	-	Points to 2th element of arr	-	Points to 2nd 1-D array	-	5032

In general we can write:

```
arr + i  Points to ith element of arr ->
Points to ith 1-D array
```

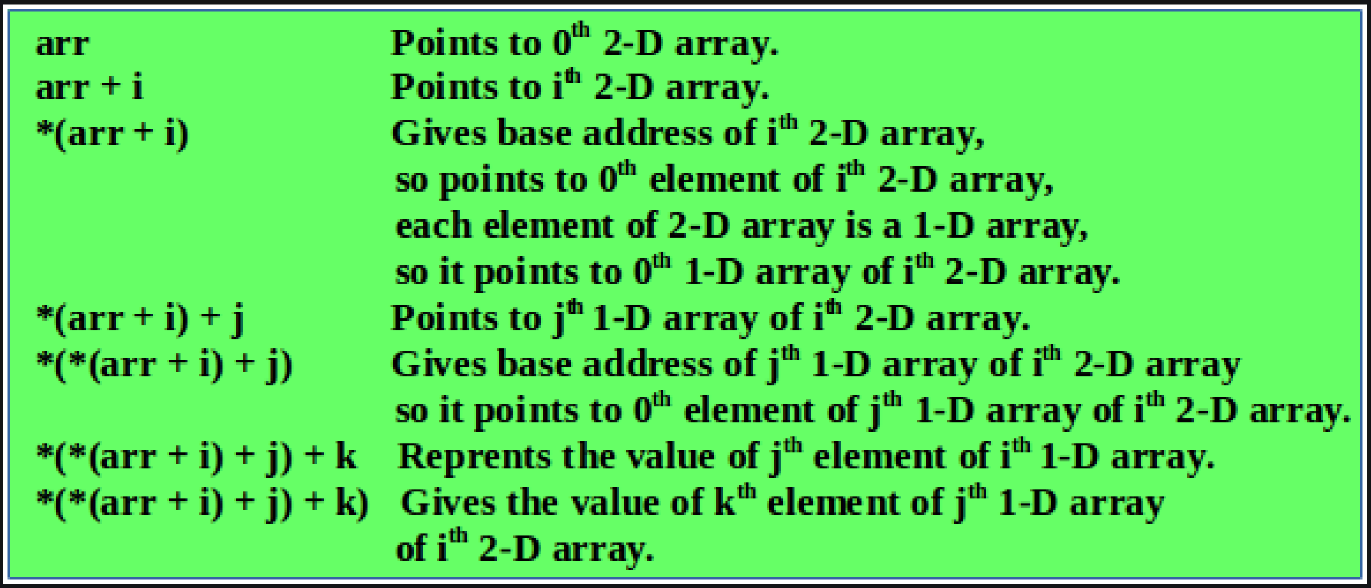
- Since arr + i points to i^{th} element of *arr*, on dereferencing it will get i^{th} element of *arr* which is of course a 1-D array. Thus the expression **(arr + i)* gives us the base address of i^{th} 1-D array.
- We know, the pointer expression **(arr + i)* is equivalent to the subscript expression

D array, we can get the addresses of subsequent elements in the i^{th} 1-D array by adding integer values to **(arr + i)*.

- For example **(arr + i) + 1* will represent the address of 1st element of 1stelement of i^{th} 1-D array and **(arr+i)+2* will represent the address of 2nd element of i^{th} 1-D array.
- Similarly *(arr + i) + j will represent the address of j^{th} element of i^{th} 1-D array. On dereferencing this expression we can get the j^{th} element of the i^{th} 1-D array.
- **Pointers and Three Dimensional Arrays**
  In a three dimensional array we can access each element by using three subscripts. Let us take a 3-D array-

```
int arr[2][3][2] = { {{5, 10}, {6, 11}, {7, 12}}, {{20, 30}, {21, 31}, {22, 3
```

We can consider a three dimensional array to be an array of 2-D array i.e each element of a 3-D array is considered to be a 2-D array. The 3-D array *arr* can be considered as an array consisting of two elements where each element is a 2-D array. The name of the array *arr* is a pointer to the 0th 2-D array.



arr	Points to 0th 2-D array.
arr + i	Points to i^{th} 2-D array.
*(arr + i)	Gives base address of i^{th} 2-D array, so points to 0th element of i^{th} 2-D array, each element of 2-D array is a 1-D array, so it points to 0th 1-D array of i^{th} 2-D array.
*(arr + i) + j	Points to j^{th} 1-D array of i^{th} 2-D array.
((arr + i) + j)	Gives base address of j^{th} 1-D array of i^{th} 2-D array so it points to 0th element of j^{th} 1-D array of i^{th} 2-D array.
((arr + i) + j) + k	Reprents the value of j^{th} element of i^{th} 1-D array.
((arr + i) + j) + k)	Gives the value of k^{th} element of j^{th} 1-D array of i^{th} 2-D array.

array and arr[i][j] represents the base address of the j^{th} 1-D array.

C++

```
// C++ program to print the elements of 3-D
// array using pointer notation
#include <iostream>
using namespace std;
int main()
{
  int arr[2][3][2] = {
                       {
                         {5, 10},
                         {6, 11},
                         {7, 12},
                       },
                       {
                         {20, 30},
                         {21, 31},
                         {22, 32},
                       }
                     };
  int i, j, k;
  for (i = 0; i < 2; i++)
  {
    for (j = 0; j < 3; j++)
    {
       for (k = 0; k < 2; k++)
          cout << *(*(*(arr + i) + j) +k) << "\t";
       cout <<"\n";
    }
  }

  return 0;
}

// this code is contributed by shivanisinghss2110
```

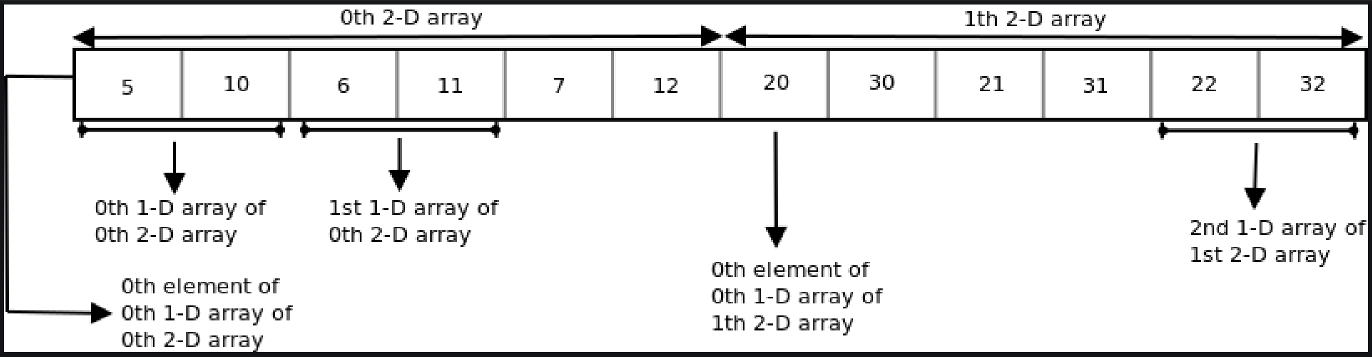
C

```
                       {
                         {5, 10},
                         {6, 11},
                         {7, 12},
                       },
                       {
                         {20, 30},
                         {21, 31},
                         {22, 32},
                       }
                     };
  int i, j, k;
  for (i = 0; i < 2; i++)
  {
    for (j = 0; j < 3; j++)
    {
       for (k = 0; k < 2; k++)
         printf("%d\t", *(*(*(arr + i) + j) +k));
       printf("\n");
    }
  }

  return 0;
}
```

Output:

```
5    10
6    11
7    12
20    30
21    31
22    32
```

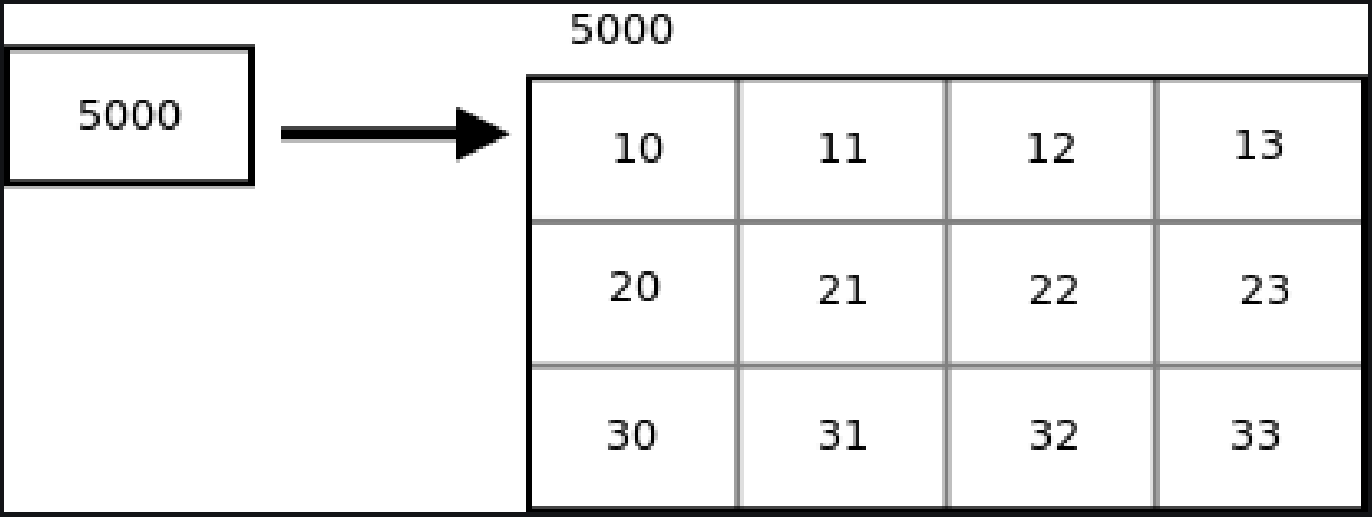
The following figure shows how the 3-D array used in the above program is stored in memory.



Subscripting Pointer to an Array

Suppose *arr* is a 2-D array with 3 rows and 4 columns and *ptr* is a pointer to an array of 4 integers, and *ptr* contains the base address of array *arr*.

```
int arr[3][4] = {{10, 11, 12, 13}, {20, 21, 22, 23}, {30, 31, 32, 33}};
int (*ptr)[4];
ptr = arr;
```



10	11	12	13
20	21	22	23
30	31	32	33

value of the jth element of ith row.

We know that the pointer expression *(*(ptr + i) + j) is equivalent to subscript expression ptr[i][j]. So if we have a pointer variable containing the base address of 2-D array, then we can access the elements of array by double subscripting that pointer variable.

C++

```cpp
// C++ program to print elements of a 2-D array
// by scripting a pointer to an array
#include <iostream>
using namespace std;

int main()
{
  int arr[3][4] = {
                    {10, 11, 12, 13},
                    {20, 21, 22, 23},
                    {30, 31, 32, 33}
                  };
  int (*ptr)[4];
  ptr = arr;
  cout << ptr<< " "<< ptr + 1<< " "<< ptr + 2 << endl;
  cout << *ptr<< " "<< *(ptr + 1)<< " "<< *(ptr + 2)<< endl;
  cout << **ptr<< " "<< *(*(ptr + 1) + 2)<< " "<< *(*(ptr + 2) + 3)<< endl;
  cout << ptr[0][0]<< " "<< ptr[1][2]<< " "<< ptr[2][3]<< endl;
  return 0;
}

// This code is contributed by shivanisinghss2110
```

C

```c
// C program to print elements of a 2-D array
// by scripting a pointer to an array
#include<stdio.h>

int main()
{
  ptr = arr;
  printf("%p %p %p\n", ptr, ptr + 1, ptr + 2);
  printf("%p %p %p\n", *ptr, *(ptr + 1), *(ptr + 2));
  printf("%d %d %d\n", **ptr, *(*(ptr + 1) + 2), *(*(ptr + 2) + 3));
  printf("%d %d %d\n", ptr[0][0], ptr[1][2], ptr[2][3]);
  return 0;
}
```

Output:

```
0x7ffead967560 0x7ffead967570 0x7ffead967580
0x7ffead967560 0x7ffead967570 0x7ffead967580
10 22 33
10 22 33
```

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