# Short-term Hands-on Supplementary Course on C Programming

## Session 10: More on Pointers

## Dec 05, 2022

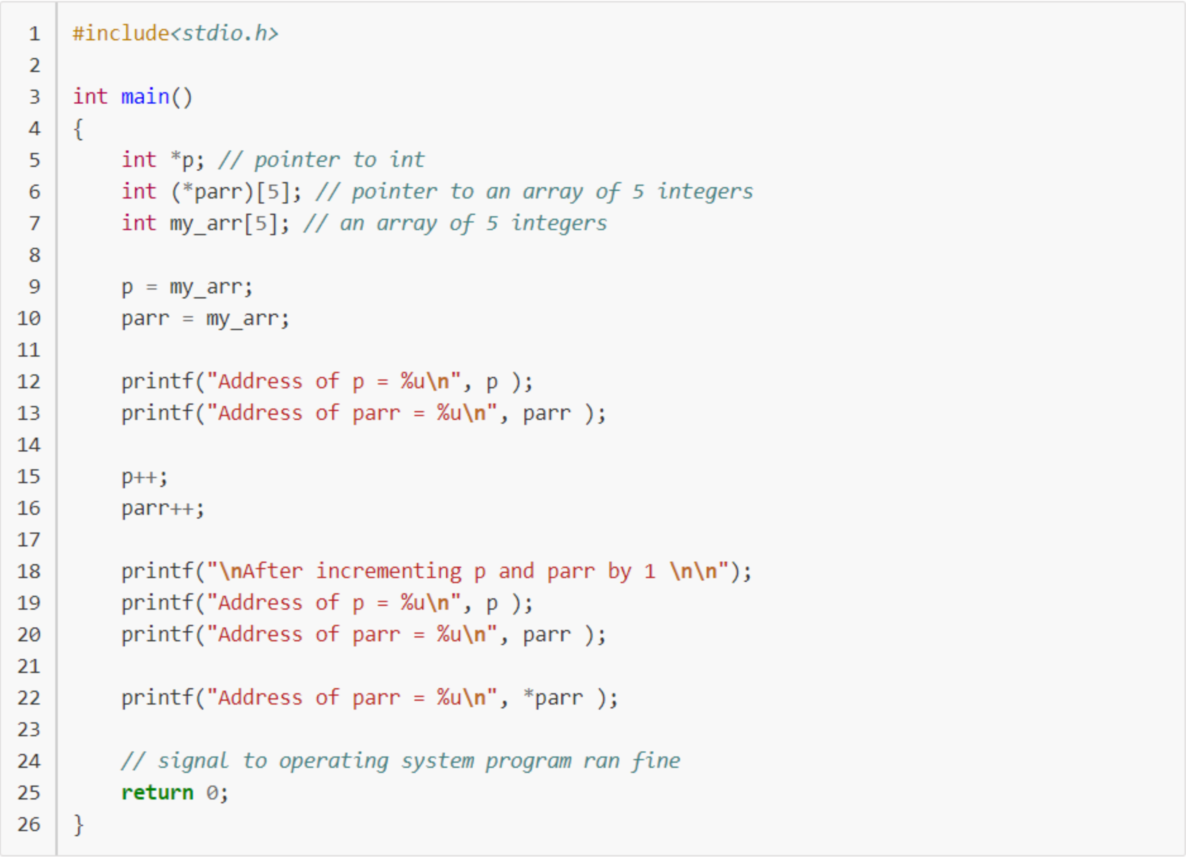
### Pointers and Arrays

We can also create a pointer that can point to the whole array instead of only one element of the array. This is known as a pointer to an array. Here is how you can declare a pointer to an array.

```c
int (*p)[10];
```

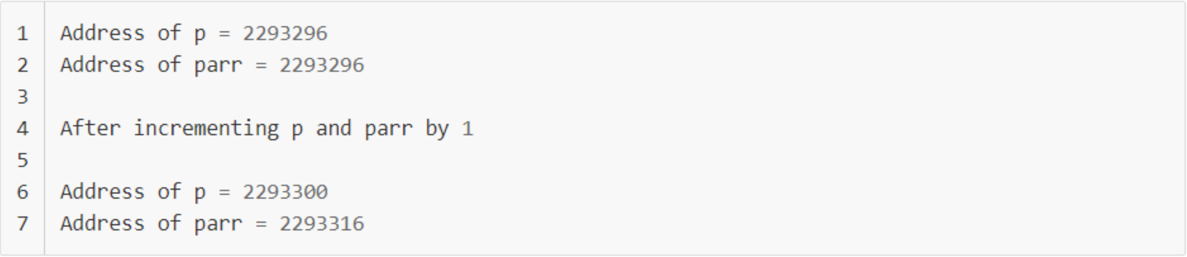
Here `p` is a pointer that can point to an array of `10` integers. In this case, the type or base type of `p` is a pointer to an array of `10` integers. Note that parentheses around `p` are necessary.

A pointer that points to the 0th element of an array and a pointer that points to the whole array are totally different. The following program demonstrates this concept.



```c
#include<stdio.h>

int main()
{
    int *p; // pointer to int
    int (*parr)[5]; // pointer to an array of 5 integers
    int my_arr[5]; // an array of 5 integers

    p = my_arr;
    parr = my_arr;

    printf("Address of p = %u\n", p );
    printf("Address of parr = %u\n", parr );

    p++;
    parr++;

    printf("\nAfter incrementing p and parr by 1 \n\n");
    printf("Address of p = %u\n", p );
    printf("Address of parr = %u\n", parr );

    printf("Address of parr = %u\n", *parr );

    // signal to operating system program ran fine
    return 0;
}
```

**Expected Output:**



```
Address of p = 2293296
Address of parr = 2293296

After incrementing p and parr by 1

Address of p = 2293300
Address of parr = 2293316
```

### How it works:

Here `p` is a pointer which points to the 0th element of the array `my_arr`, while `parr` is a pointer which points to the whole array `my_arr`. The base type of `p` is of type (`int *`) or pointer to `int` and base type of `parr` is pointer to an array of `5` integers. Since the pointer arithmetic is performed relative to the base type of the pointer, that's why `parr` is incremented by `20` bytes i.e ( `5 x 4 = 20` bytes ). On the other hand, `p` is incremented by `4` bytes only.

The important point you need to remember about pointer to an array is this:

Whenever a pointer to an array is dereferenced, we get the address (or base address) of the array to which it points.

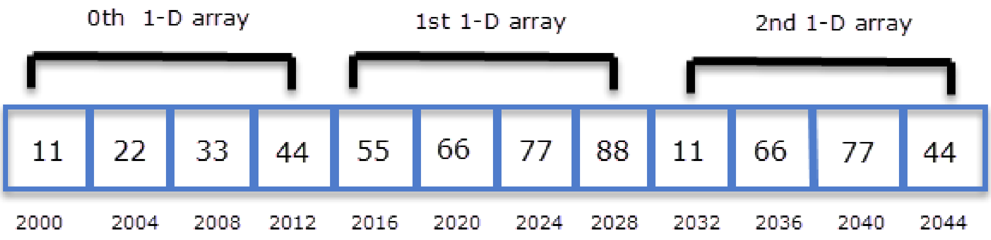
So, on dereferencing `parr`, you will get `*parr`. The important thing to notice is although `parr` and `*parr` points to the same address, but parr's base type is a pointer to an array of `5` integers, while `*parr` base type is a pointer to int. This is an important concept and will be used to access the elements of a 2-D array.

### Pointers and 2D Array

In C, arrays are stored row-major order. This simply means that first row 0 is stored, then next to it row 1 is stored, next to it row 2 is stored and so on.

```
int arr[3][4] = {
                    {11,22,33,44},
                    {55,66,77,88},
                    {11,66,77,44}
                };
```

The following figure shows how a 2-D array is stored in the memory.



A 2-D array is actually a 1-D array in which each element is itself a 1-D array. So arr is an array of 3 elements where each element is a 1-D array of 4 integers.

We know that the name of the array is a constant pointer that points to the 0th element of the array. In the case of a 2-D array, 0th element is a 1-D array. So, the name of the array in case of a 2-D array represents a pointer to the 0th 1-D array. Therefore, in this case `arr` is a pointer to an array of `4` elements. If the address of the 0th 1-D is `2000`, then according to pointer arithmetic (`arr + 1`) will represent the address `2016`, similarly (`arr + 2`) will represent the address `2032`.

From the above discussion, we can conclude that:

`arr` points to 0th 1-D array.
`(arr + 1)` points to 1st 1-D array.
`(arr + 2)` points to 2nd 1-D array.

In general, we can write:

`(arr + i)` points to ith 1-D array.

As we discussed earlier in this chapter that dereferencing a pointer to an array gives the base address of the array. So dereferencing `arr` we will get `*arr`, base type of `*arr` is `(int*)`. Similarly, on dereferencing `arr+1` we will get `*(arr+1)`. In general, we can say that:

`*(arr+i)` points to the base address of the ith 1-D array.

### So how you can use arr to access individual elements of a 2-D array?

Since `*(arr + i)` points to the base address of every ith 1-D array and it is of base type pointer to `int`, by using pointer arithmetic we should we able to access elements of ith 1-D array.

Let's see how we can do this:

`*(arr + i)` points to the address of the 0th element of the 1-D array. So,
`*(arr + i) + 1` points to the address of the 1st element of the 1-D array
`*(arr + i) + 2` points to the address of the 2nd element of the 1-D array

Hence, we can conclude that:

`*(arr + i) + j` points to the base address of jth element of ith 1-D array.

On dereferencing `*(arr + i) + j` we will get the value of jth element of ith 1-D array.

```
*( *(arr + i) + j)
```

By using this expression we can find the value of jth element of ith 1-D array.

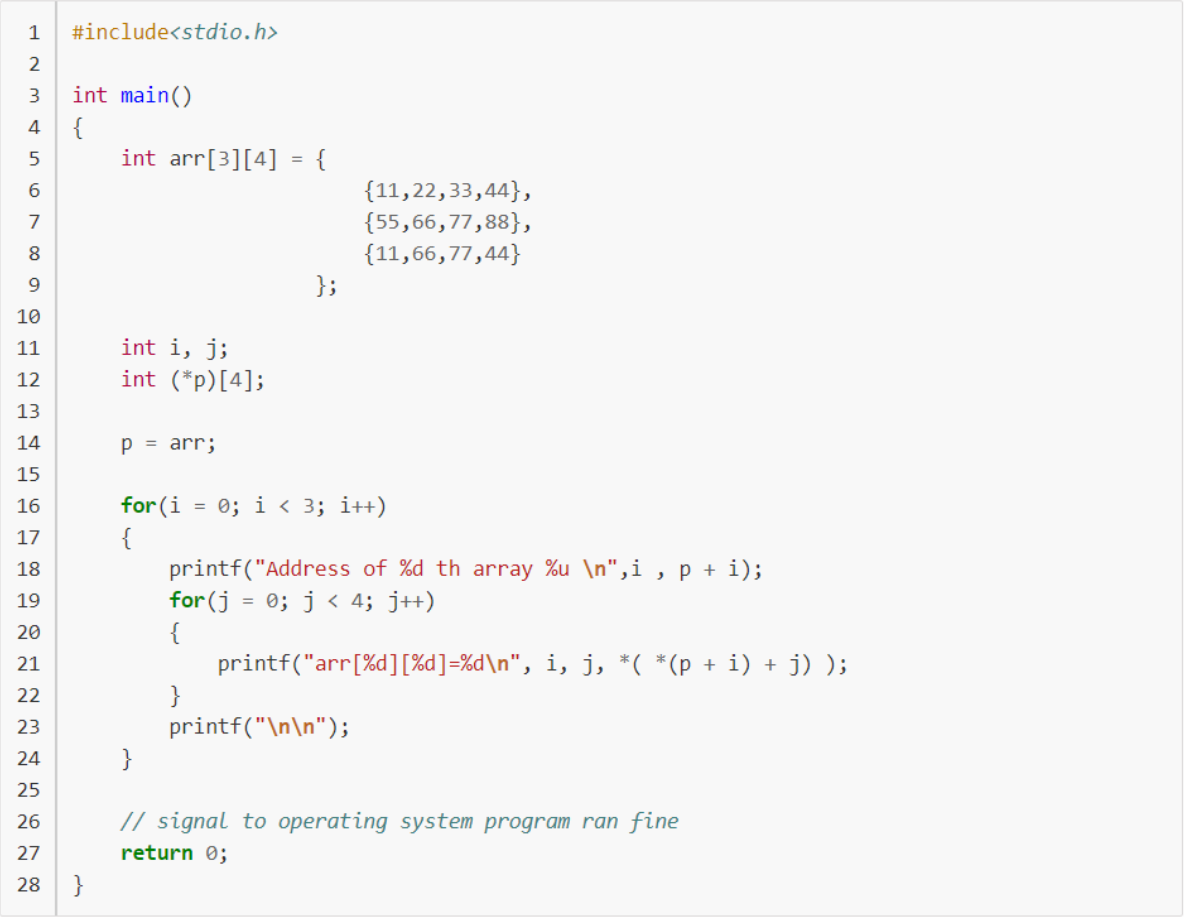
Furthermore, the pointer notation `*(*(arr + i) + j)` is equivalent to the subscript notation.

If a 2-D array has `3` rows and `4` cols i.e `int arr[3][4]`, then you will need a pointer to an array of `4` integers.

```
int (*p)[3];
```

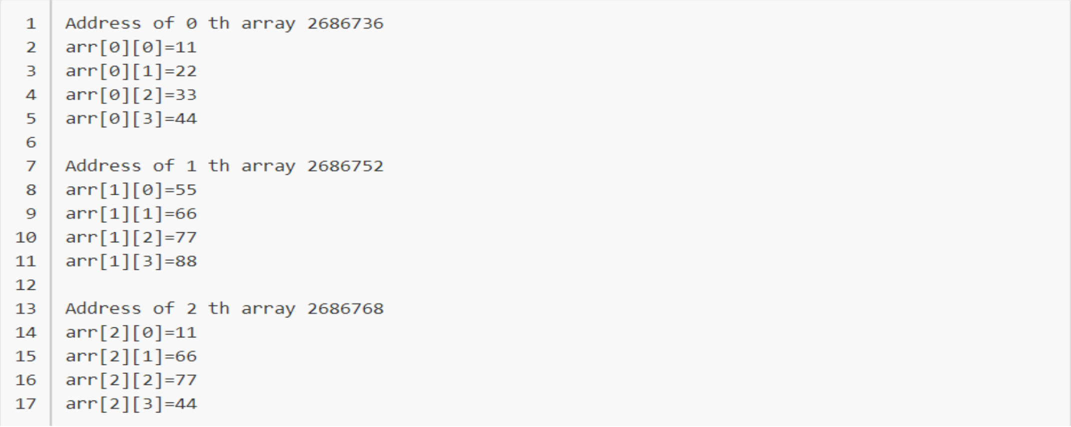
Here `p` is a pointer to an array of `3` integers. So according to pointer arithmetic `p+i` points to the ith 1-D array. The base type of (`p+i`) is a pointer to an array of `3` integers. If we dereference (`p+i`) then we will get the base address of ith 1-D array.

The following program demonstrates how to access elements of a 2-D array using a pointer to an array.



```c
#include<stdio.h>

int main()
{
    int arr[3][4] = {
                        {11,22,33,44},
                        {55,66,77,88},
                        {11,66,77,44}
                    };

    int i, j;
    int (*p)[4];

    p = arr;

    for(i = 0; i < 3; i++)
    {
        printf("Address of %d th array %u \n",i , p + i);
        for(j = 0; j < 4; j++)
        {
            printf("arr[%d][%d]=%d\n", i, j, *( *(p + i) + j) );
        }
        printf("\n\n");
    }

    // signal to operating system program ran fine
    return 0;
}
```

Expected Output:



```
Address of 0 th array 2686736
arr[0][0]=11
arr[0][1]=22
arr[0][2]=33
arr[0][3]=44

Address of 1 th array 2686752
arr[1][0]=55
arr[1][1]=66
arr[1][2]=77
arr[1][3]=88

Address of 2 th array 2686768
arr[2][0]=11
arr[2][1]=66
arr[2][2]=77
arr[2][3]=44
```