Pointers

Pointers

Fundamentals

Definition: A **pointer** is a variable that represents the **location** (rather than the **value)** of a data item, such as a variable or an array element.

Useful applications:

- Allows to **return multiple data items** from a function via function arguments.
- Allows **passing one function** to another function
- Allows **alternate ways to access arrays**
- Allows to **access group of strings** with ease
- Allows **passing structures** from one function to another function

Fundamentals…

How to access the address of a data item?

We need to know the address of the variable which stores this data item.

Address of operator (&)

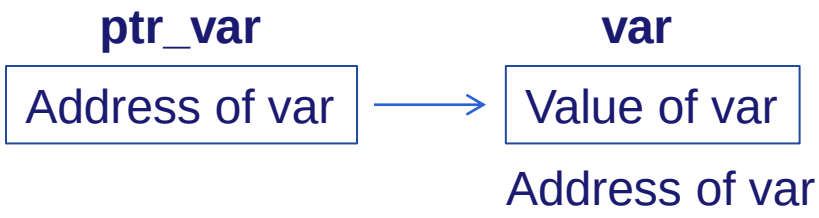
Ex: If the variable name is **var** then the address can be accessed using **&var**

We can assign the address of V to another variable.

Ex: type *ptr_var = &var

This new variable ptr_var is called as a pointer variable which points to **var**.

PV points to the location where V is stored.



Fundamentals…

How to access the data item stored in V using PV?

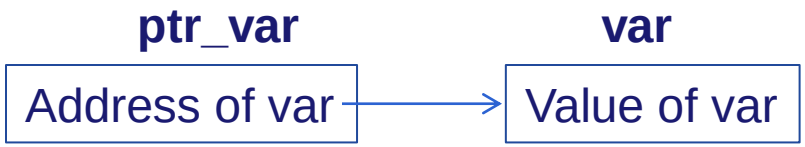
Using **Indirection Operator (*)**.

Ex: *ptr_var

Here, ***ptr_var** and **var** represents the same data item.

This new variable **ptr_var** is called as a pointer variable which points to **var**.

ptr_var points to the location where **V** is stored.



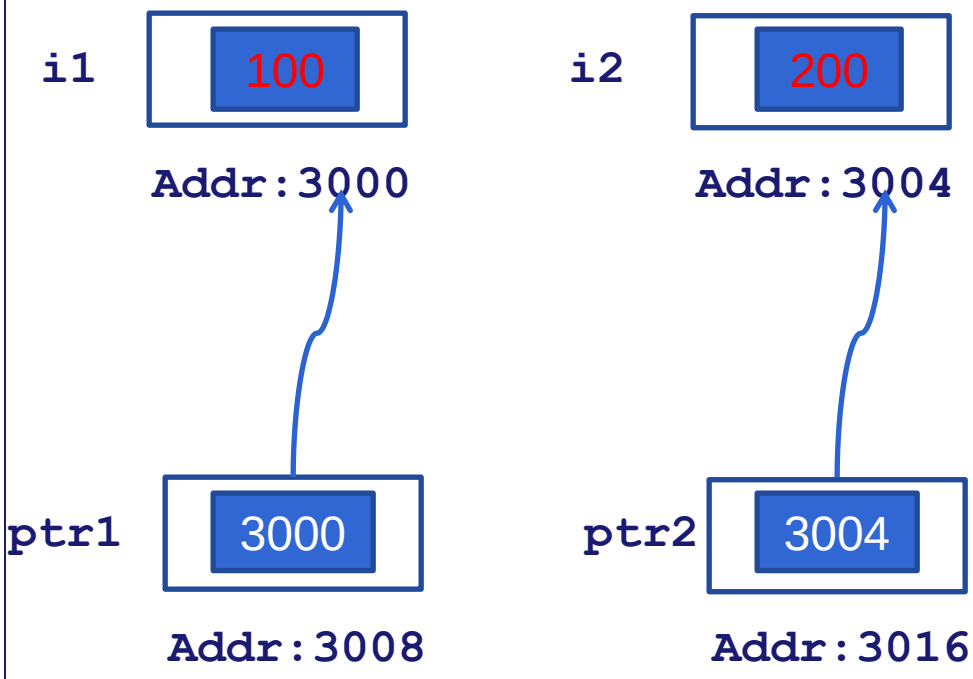
Pointers…

- Creation of a pointer
  - type *ptr_variable- Creates a pointer variable
- Dereferencing a pointer
  - *ptr_variable - Returns contents stored at address
- Indirect assignment
  - * ptr_variable =val - Stores value at address pointed by the pointer
- Assignment
  - pointer =ptr - Stores pointer in another variable

Using Pointers

How to use the pointers – A simple Example

```
int  i1;
int  i2;
int *ptr1;
int *ptr2;

i1 = 100;
i2 = 200;

ptr1 = &i1;
ptr2 = &i2;
```



i1 value 100,
*ptr1 value 100

i2 value 200
*ptr2 value 200

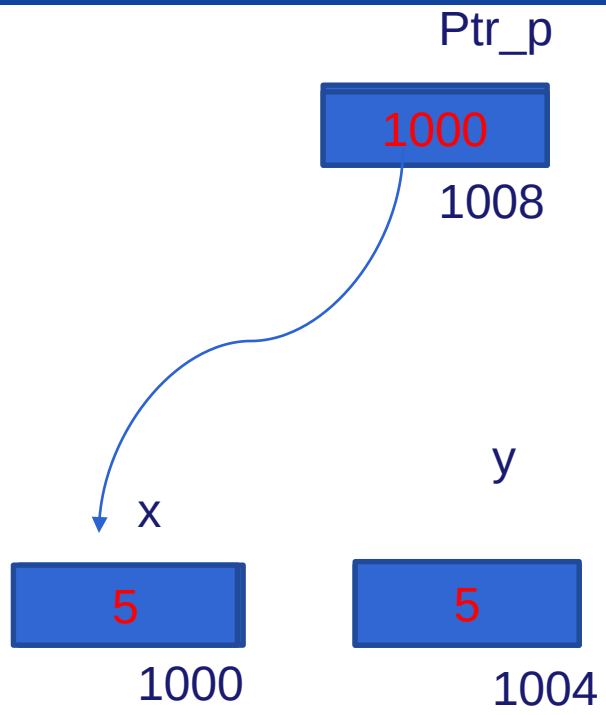
Note: *pointer - Returns contents stored at address

Pointers

```
#include<stdio.h>
void main()
{
        int  i1;
        int  i2;
        int *ptr1;
        int *ptr2;

        i1 = 100;
        i2 = 200;
        ptr1 = &i1;
        ptr2 = &i2;
        printf("i1 address.....%u\n",&i1);
        printf("i2 address.....%u\n",&i2);

        printf("ptr1  address...%u\n",ptr1);
        printf("ptr2  address...%u\n",ptr2);

        printf("ptr1  address...%u\n",&ptr1);
        printf("ptr2  address...%u\n",&ptr2);

            printf("*ptr1  ...%d\n",*ptr1);
             printf("*ptr2  ...%d\n",*ptr2);
}
```

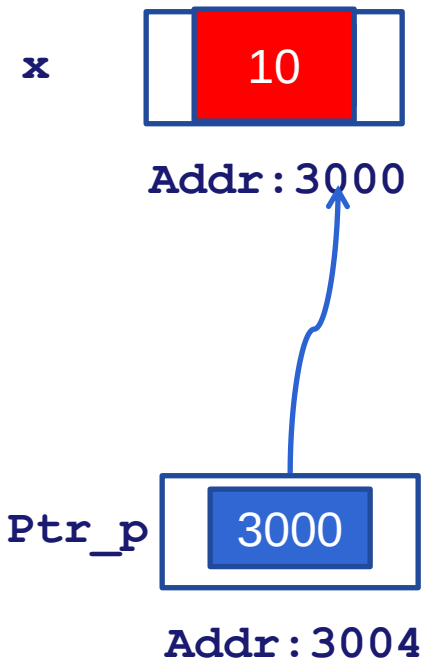
What is the Value of y?

```
#include<stdio.h>

int main()

{

        int x,y;

        int *ptr_p;

        x = 5;

        ptr_p = &x;

        y = *ptr_p; // *ptr_p Returns contents stored at address

        printf("%d\n", y);

        return 0;

 }
```



What is the Value of x?

```
#include<stdio.h>
int main()
{
        int x;
        int *ptr_p;
        x = 5;
        ptr_p = &x;
        *ptr_p = 10;
        printf("%d\n", x);
        return 0;
}
```



Note: *ptr_p =10 means , contents stored at address ptr_p is changed to 10

What is the Value ?

```
#include<stdio.h>
 int main(void)
{
        int *ptr_p;
        printf("%d\n",*ptr_p);
        return 0;
 }
```

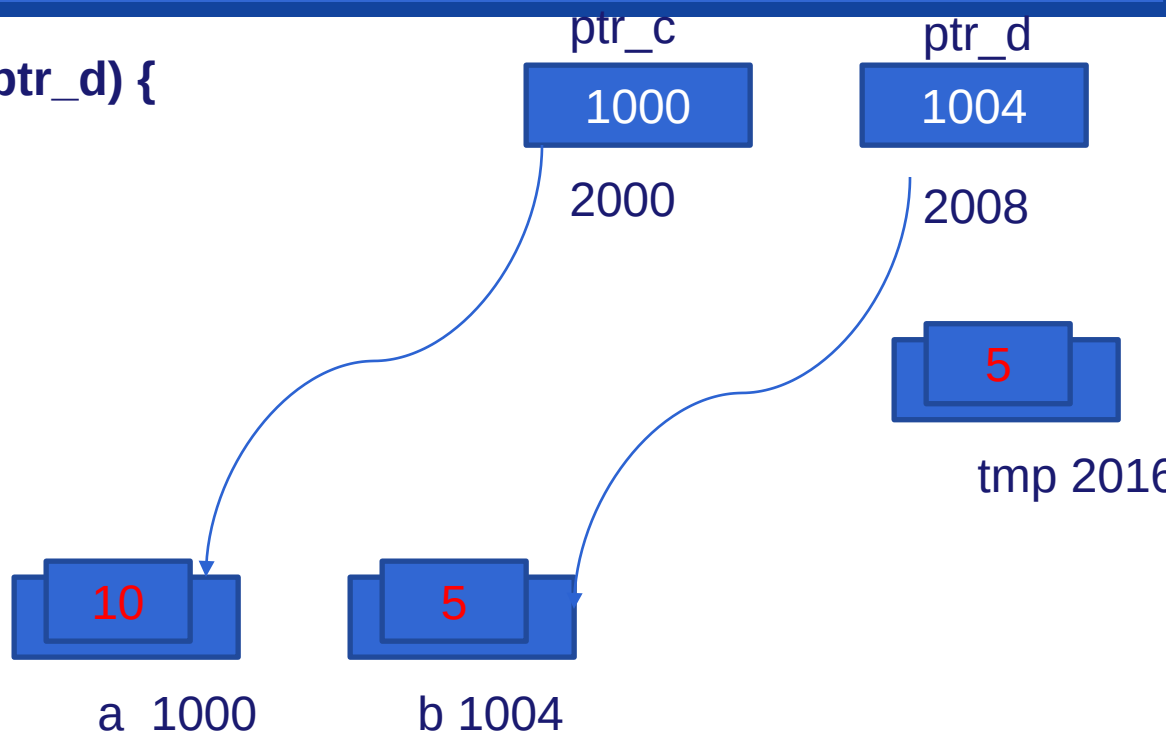
The result of this program is a segmentation fault, some other run-time error or the random address is printed. The meaning of a segmentation fault is that you have used a pointer that points to an invalid address. In most cases, a pointer that is not initialized or a wrong pointer address is the cause of segmentation faults.

What is the Value of the a and b ?

```
void swapping(int c, int d)
 {
        int tmp;
        tmp = c;
        c = d;
        d = tmp;
        printf("In function: %d %d\n", c , d);
}
void main( )
{        int a,b;
         a=5; b=10;
         printf("input: %d %d\n", a, b);
        swapping(a,b);
        printf("output: %d %d\n", a, b);
}
```

What is the Value of the a and b ?

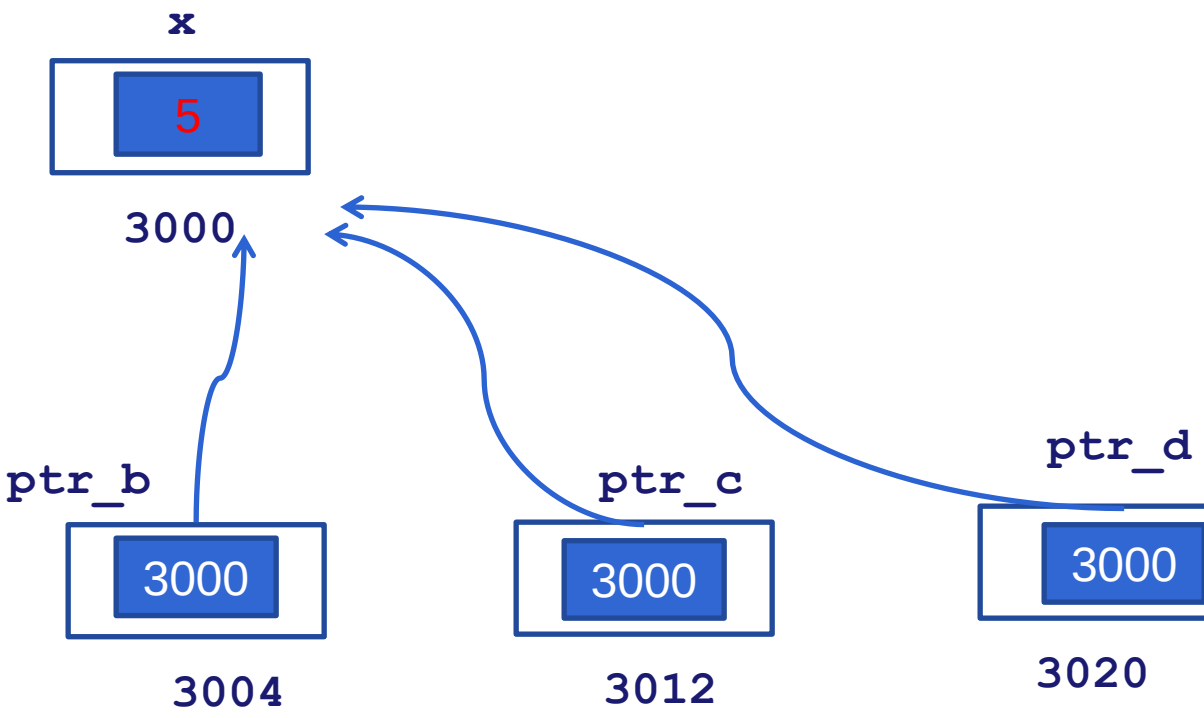
```
void swapping(int *ptr_c, int *ptr_d) {
        int tmp;
       tmp = *ptr_c;
       *ptr_c = *ptr_d;
        *ptr_d = tmp;
 }
void  main( )
{
   int a=5,b=10;
   printf("Before swapping: %d %d\n", a, b);
   swapping(&a,&b);
   printf(" Before swapping : %d %d\n", a, b);
}
```



- **Why do we need to pass a pointer to a function?**
  - **It allows a function to alter or change the value of a variable outside their scope.**

Pointing to the same address

```
#include<stdio.h>
void main()
{
     int x;
    int *ptr_b , *ptr_c, *ptr_d;
    x=5;
    ptr_b = &x;
    ptr_c = &x;
    ptr_d = ptr_b;

    printf (" %d , %d , %d, %d  ", x, *ptr_b ,
    *ptr_c, *ptr_d);
}
```



Using Pointers…

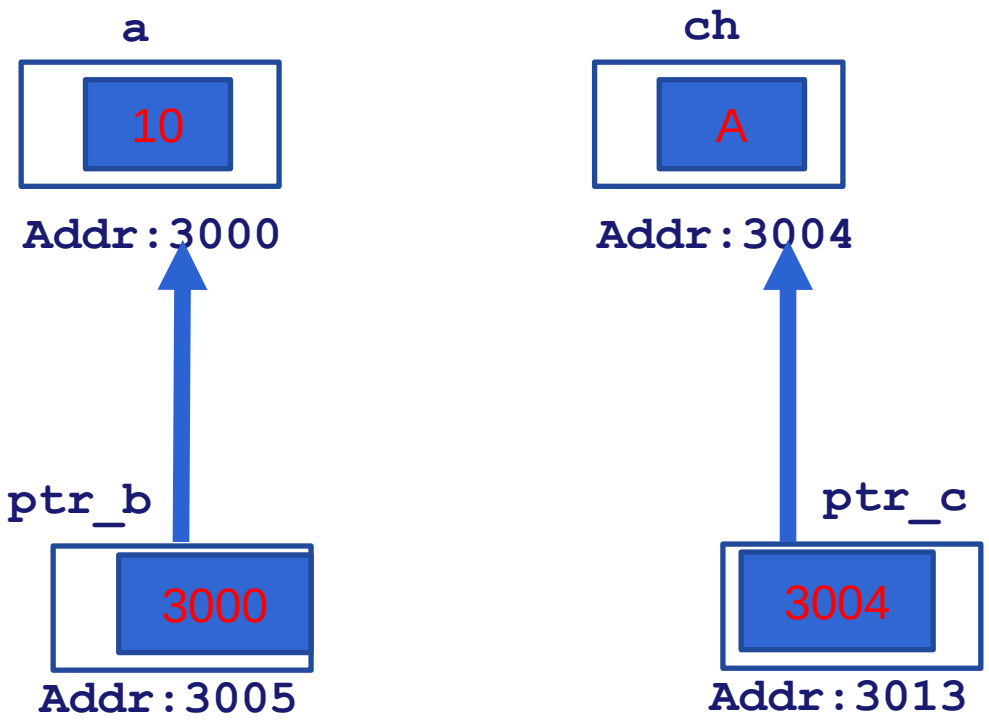
```
int  m     = 20;   /* Simple Integers  */
int  n     = 30;

int *ptr1 = &m;  /* get addresses of data  */
int *ptr2 = &n;

*ptr1 = ptr2;
```

What happens?

Type check warning: `ptr2` is not an `int`

Size of pointers

```
#include<stdio.h>
void main()  {
        int a=10;
        char ch='A';
        int *ptr_b;
        char  *ptr_c;
        ptr_b = &a;
        ptr_c = &ch;

        printf (" %d \n",sizeof(a) );
        printf (" %d \n",sizeof(ch) );
        printf (" %d , %d , %d \n",a,*ptr_b,sizeof(ptr_b) );
        printf (" %c , %c , %d \n",ch,*ptr_c,sizeof(ptr_c) );
}
```



Quiz – pointer ex:

```
/* A program which shows a simple demo on pointer variables */
#include<stdio.h>
int main( )
{
        int U = 3, v;
        int *pu;    /* pointer t o an integer */
        int *pv;    /* pointer t o an integer */
        pu = &U; /* assign address of U to pu */
        v = *pu;  /* assign value of U to v */
        pv = &v; /* assign address of v to pv */
        printf("\nu=%d &u=%p pu=%p *pu=%d", U, &U, pu, *pu);
        printf("\n\nv=%d &v=%p pv=%p *pv=%d", v, &v, pv, *pv);
        return 0;
}
```

sizeof pointers and arrays

```
int main()
{
        int a[10], i;
        int *ptr;
         ptr=&i;
         printf("%d\n", sizeof(ptr));
        printf("%d\n", sizeof(int *));
        printf("%d\n", sizeof(char *));
        printf("%d\n", sizeof(float *));
        printf("%d\n", sizeof(void *));
         printf("%d\n", sizeof(a));
 }
```

Pointer Arithmetic

Addition: pointer + number

Subtraction: pointer - number

Example:

```
char   *ptr;
char    a;
char    b;

ptr = &a;
ptr += 1;
```

Adds 1*sizeof(char) to the memory address

```
int   *p;
int    a;
int    b;

ptr = &a;
ptr += 1;
```

Adds 1*sizeof(int) to the memory address

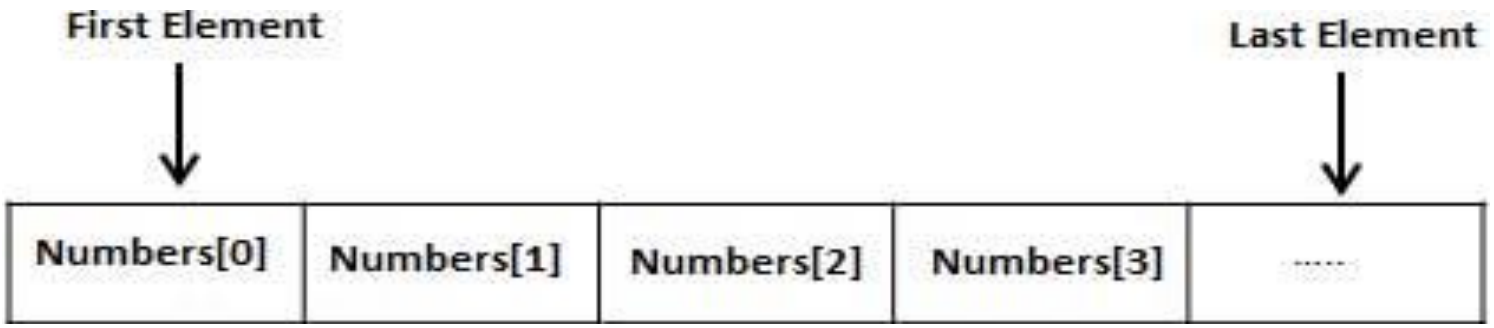
In both the cases, p now points to b
(Assuming compiler doesn't reorder variables in memory)

Warning: Pointer arithmetic need to be performed carefully

Arrays & Pointers

Review of Arrays

- Definition: Array is a derived data type. Array is a collections of variables of same type.
- Fixed size, size defines the number of elements in the array
- Stored in contiguous memory locations
- Array element is accessed by its index value



program on 1-D Array

```
#include <stdio.h>
int main()
{
    int num[] = {21,18,57,45,50};
    int i;
    for(i=0;i<5;i++)
    {
        printf("\n Integer Array Element num[%d] : %d",i,num[i]);
    }
    return 0;
 }
```

Pointer Arithmetic

Example: int A[10];

Memory Allocation:

Base Address is :address of A[0] i.e A

If Base address is 1000

sizeof(int) =4

[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Base Address	**+0**	**+4**	**+8**	**+12**	**+16**	**etc.**			

A+1 means:

Adds 1*sizeof(int) to the memory address

A+4 means:

Adds 4*sizeof(int) to the memory address

- **`A[i] ≡ *(A+i)`**

Warning: Pointer arithmetic need to be performed carefully

Pointers and arrays

int array[10]={5,10,15,20,25,30,35,40,45,50 };
// an array with ten elements.

int *ptr_toarray = &array[0];

*ptr_toarray is nothing but a 0^{th} element in the array i.e array[0]

*(ptr_toarray + 2); // is same as array[2]

*(ptr_toarray + 2); is something different then *(ptr_toarray) + 2;

array+0 .. 0^{th} element address *(array+0) .. 0th element
array+1 .. 1^{st} element address *(array+1) .. 1st element
array+0 .. 2^{nd} element address *(array+2) .. 2nd element

Pointer incrementation

```
#include <stdio.h>
int main()
{
        int num[5] = {21,18,57,45,50};
        int i;
        int *iptr=num;
        for(i=0;i<5;i++)
         {
          printf("\n Integer Array Element num[%d] : %d  addr: %p\n",i,*iptr,iptr);
           iptr++;
          }
     return 0;
}
```

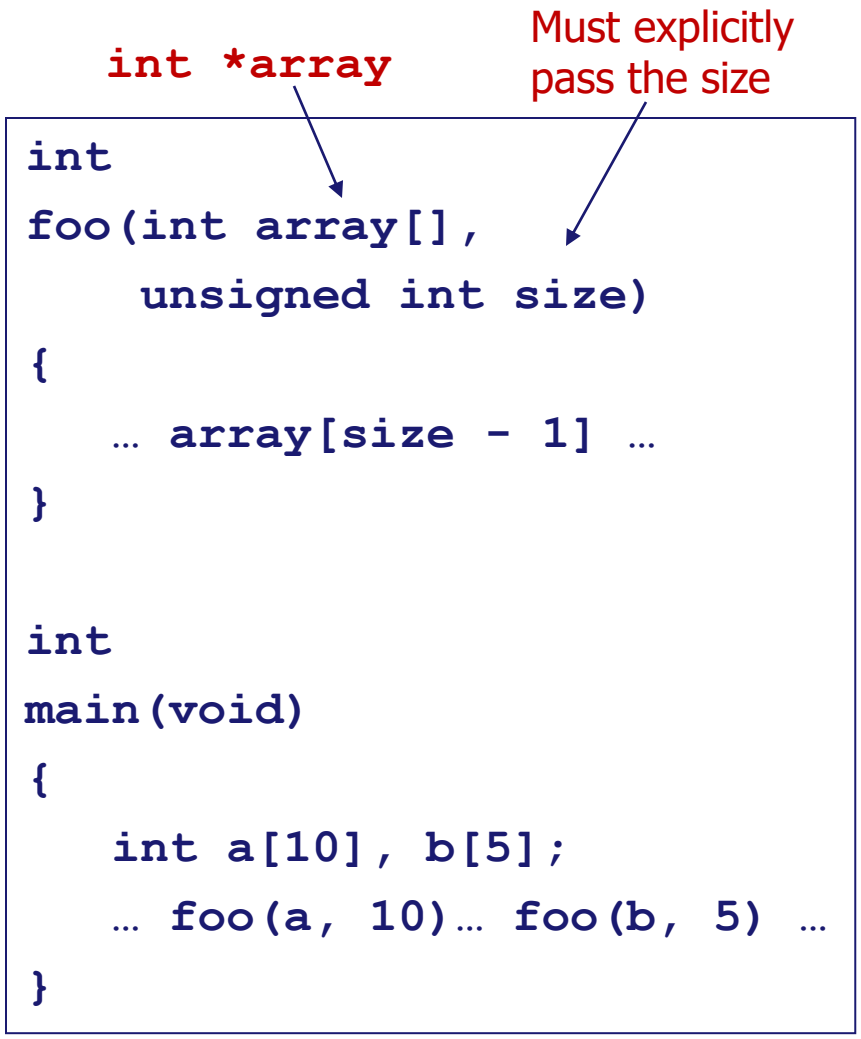
Pointer Decrement

```
#include <stdio.h>
int main()
{
        int num[5] = {21,18,57,45,50};
        int i;
        int *iptr=num+4;
        for(i=0;i<5;i++)
         {
          printf("\n Integer Array Element num[%d] : %d  addr: %p\n",i,*iptr,iptr);
           iptr--;
         }
     return 0;
}
```

Arrays and Pointers

Passing arrays

- Array ≈ pointer to the first (0th) array element
  - `a[i]  ≡  *(a+i)`
- An array is passed to a function as a pointer
  - **The array size is lost** !
- Usually bad style to interchange arrays and pointers



Arrays and Pointers…

```
int
foo(int array[],
    unsigned int size)
{
   …
   printf("%d\n", sizeof(array));
}

int
main(void)
{
   int a[10], b[5];
   … foo(a, 10)… foo(b, 5) …
   printf("%d\n", sizeof(a));
}
```

What does this print?

Prints the size of an pointer: 8

(Because **`array`** is really a pointer)

What does this print?