C Pointers

- Pointers in C language is a variable that stores/points to the address of another variable.
- A Pointer in C is used to allocate memory dynamically i.e. at run time. The pointer variable might be belonging to any of the data type such as int, float, char, double, short etc.
- Pointer Syntax : data_type *var_name; Example : int *p; char *p;
- Where, * is used to denote that "p" is pointer variable and not a normal variable.

Features of Pointers:

1. Pointers save memory space.
2. Execution time with pointers is faster because data are manipulated with the address, that is, direct access to memory location.
3. Memory is accessed efficiently with the pointers. The pointer assigns and releases the memory as well. Hence it can be said the Memory of pointers is dynamically allocated.
4. Pointers are used with data structures. They are useful for representing two-dimensional and multi-dimensional arrays.
5. An array, of any type can be accessed with the help of pointers, without considering its subscript range.
6. Pointers are used for file handling.

Uses of pointers:

1. To pass arguments by reference
2. For accessing array elements
3. To return multiple values
4. Dynamic memory allocation
5. To implement data structures
6. To do system level programming where memory addresses are useful

KEY POINTS TO REMEMBER ABOUT POINTERS IN C:

- Normal variable stores the value whereas pointer variable stores the address of the variable.
- The content of the C pointer always be a whole number i.e. address.
- Always C pointer is initialized to null, i.e. int *p = null.
- The value of null pointer is 0.
- & symbol is used to get the address of the variable.
- * symbol is used to get the value of the variable that the pointer is pointing to.

- If a pointer in C is assigned to NULL, it means it is pointing to nothing.
- Two pointers can be subtracted to know how many elements are available between these two pointers.
- But, Pointer addition, multiplication, division are not allowed.
- The size of any pointer is 2 byte (for 16 bit compiler).

Address in C

If you have a variable `var` in your program, `&var` will give you its address in the memory.
We have used address numerous times while using the `scanf()` function.

```
scanf("%d", &var);
```

Here, the value entered by the user is stored in the address of `var` variable.
Example.

```
#include <stdio.h>
int main()
{
  int var = 5;
  printf("var: %d\n", var);

  // Notice the use of & before var
  printf("address of var: %p", &var);
  return 0;
}
```

Output

```
var: 5
address of var: 2686778
```

Note: You will probably get a different address when you run the above code.

Pointer Syntax

Here is how we can declare pointers.

```
int* p;
```

Here, we have declared a pointer `p` of `int` type.

It can also be declared in these ways.

```
int *p1;
int * p2;
```

Let's take another example of declaring pointers.

```
int* p1, p2;
```

Here, we have declared a pointer `p1` and a normal variable `p2`.

Assigning addresses to Pointers

Let's take an example.

```
int* pc, c;
c = 5;
pc = &c;
```

Here, 5 is assigned to the `c` variable. And, the address of `c` is assigned to the `pc` pointer.

Get Value of data Pointed by Pointers

To get the value of the dataa pointed by the pointers, we can use the `*` operator. For example:

```
int* pc, c;
c = 5;
pc = &c;
printf("%d", *pc);   // Output: 5
```

Here, the address of `c` is assigned to the `pc` pointer. To get the value stored in that address, we used `*pc`.

Note: In the above example, `pc` is a pointer, not `*pc`. You cannot and should not do something like `*pc = &c;`

By the way, `*` is called the dereference operator (when working with pointers). It operates on a pointer and gives the value stored in that pointer.

Changing Value Pointed by Pointers

Let's take an example.

```
int* pc, c;
c = 5;
pc = &c;
c = 1;
printf("%d", c);    // Output: 1
printf("%d", *pc);  // Ouptut: 1
```

We have assigned the address of `c` to the `pc` pointer.
Then, we changed the value of `c` to 1. Since `pc` and the address of `c` is the same, `*pc` gives us 1.

Let's take another example.

```
int* pc, c;
c = 5;
pc = &c;
*pc = 1;
printf("%d", *pc);  // Ouptut: 1
printf("%d", c);    // Output: 1
```

We have assigned the address of `c` to the `pc` pointer.
Then, we changed `*pc` to 1 using `*pc = 1;`. Since `pc` and the address of `c` is the same, `c` will be equal to 1.
Let's take one more example.

```
int* pc, c, d;
c = 5;
d = -15;

pc = &c; printf("%d", *pc); // Output: 5
pc = &d; printf("%d", *pc); // Ouptut: -15
```

Initially, the address of `c` is assigned to the `pc` pointer using `pc = &c;`. Since `c` is 5, `*pc` gives us 5.
Then, the address of `d` is assigned to the `pc` pointer using `pc = &d;`. Since `d` is -15, `*pc` gives us -15.

Example: Working of Pointers

Let's take a working example.

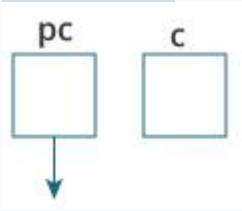
```c
#include <stdio.h>
int main()
{
  int* pc, c;
  c = 22;
  printf("Address of c: %p\n", &c);
  printf("Value of c: %d\n\n", c);  // 22

  pc = &c;
  printf("Address of pointer pc: %p\n", pc);
  printf("Content of pointer pc: %d\n\n", *pc); // 22

  c = 11;
  printf("Address of pointer pc: %p\n", pc);
  printf("Content of pointer pc: %d\n\n", *pc); // 11

  *pc = 2;
  printf("Address of c: %p\n", &c);
  printf("Value of c: %d\n\n", c); // 2
  return 0;
}
```

Output

```
Address of c: 2686784
Value of c: 22

Address of pointer pc: 2686784
Content of pointer pc: 22

Address of pointer pc: 2686784
Content of pointer pc: 11

Address of c: 2686784
Value of c: 2
```

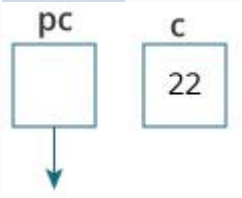
Explanation of the program

1. `int* pc, c;`



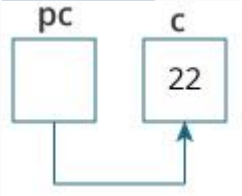
Here, a pointer `pc` and a normal variable `c`, both of type `int`, is created.
Since `pc` and `c` are not initialized at initially, pointer `pc` points to either no address or a random address. And, variable `c` has an address but contains random garbage value.

2. `c = 22;`



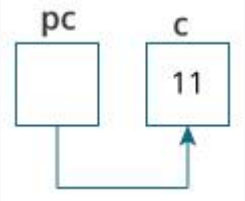
This assigns 22 to the variable `c`. That is, 22 is stored in the memory location of variable `c`.

3. `pc = &c;`



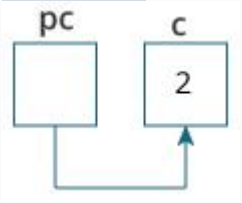
This assigns the address of variable `c` to the pointer `pc`.

4. `c = 11;`



This assigns 11 to variable `c`.

5. `*pc = 2;`



This change the value at the memory location pointed by the pointer `pc` to 2.

Common mistakes when working with pointers

Suppose, you want pointer `pc` to point to the address of `c`. Then,

```
int c, *pc;

// pc is address but c is not
pc = c; // Error

// &c is address but *pc is not
*pc = &c; // Error

// both &c and pc are addresses
pc = &c;

// both c and *pc values
*pc = c;
```

Here's an example of pointer syntax often find confusing.

```
#include <stdio.h>
int main() {
  int c = 5;
  int *p = &c;

  printf("%d", *p);  // 5
  return 0;
}
```

Why didn't we get an error when using `int *p = &c;`?

It's because

```
int *p = &c;-
```

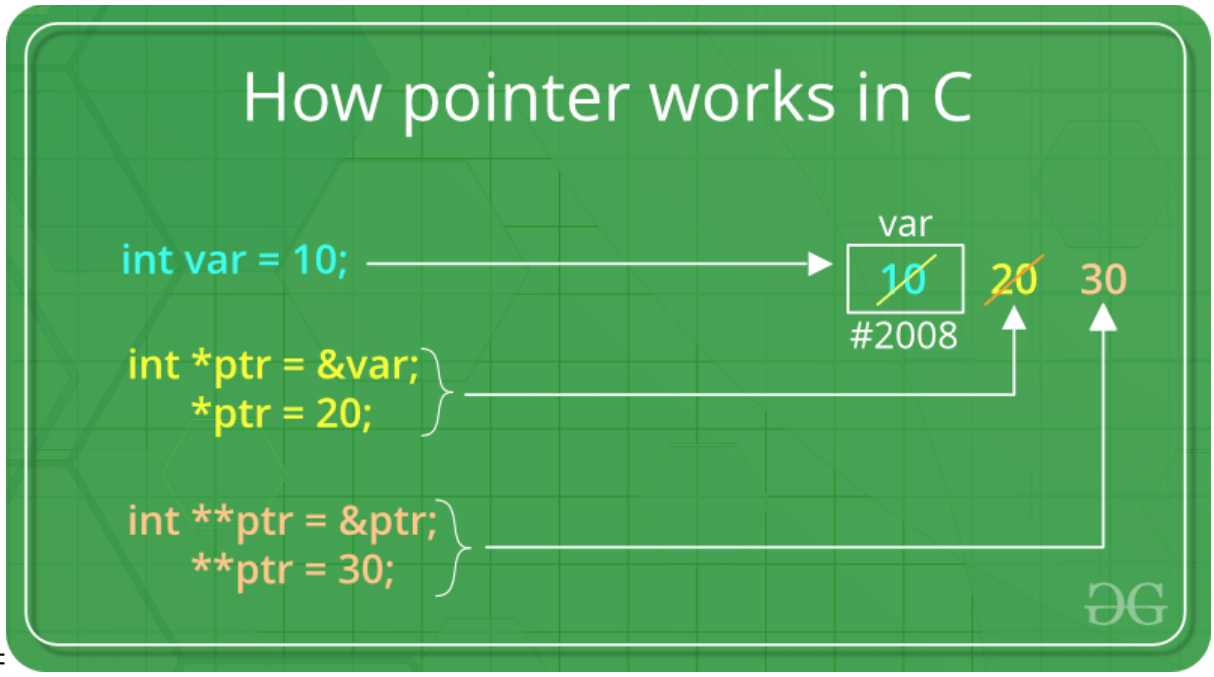
is equivalent to

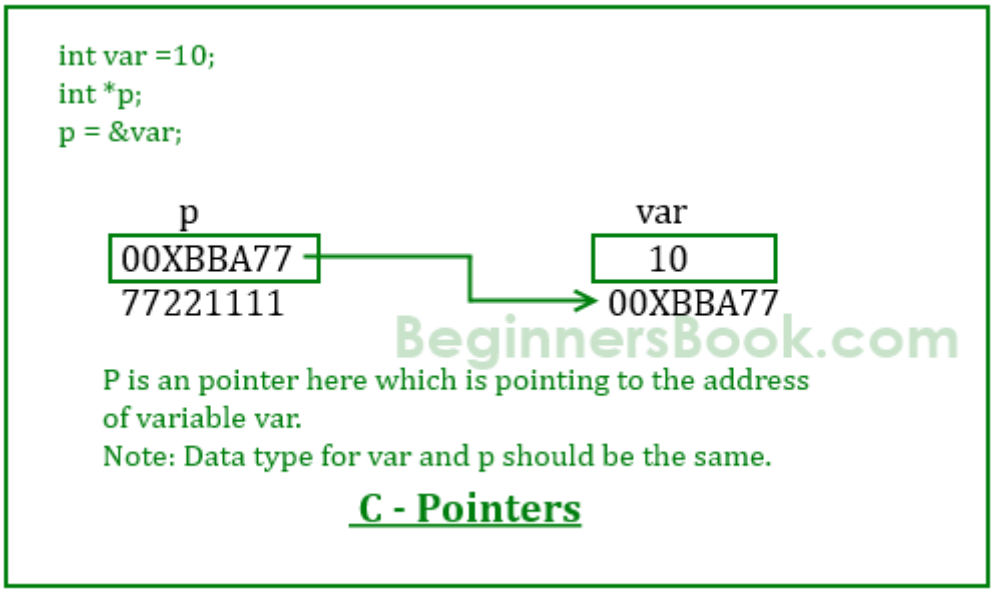
```
int *p:
p = &c;
```

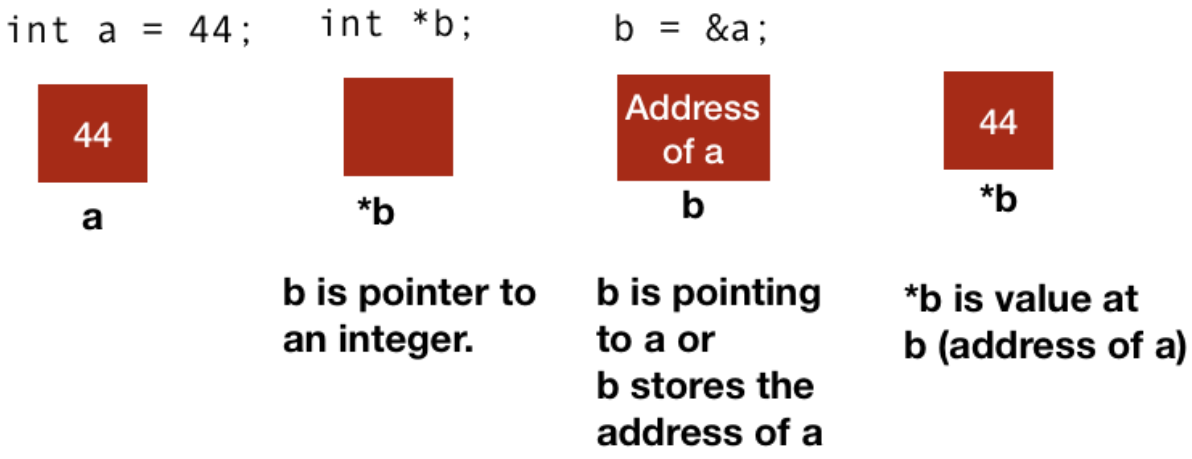
In both cases, we are creating a pointer `p` (not `*p`) and assigning `&c` to it.
To avoid this confusion, we can use the statement like this:

```
int* p = &c;
```

=







Double Pointer (Pointer to Pointer) in C

Last Updated: 05-12-2019

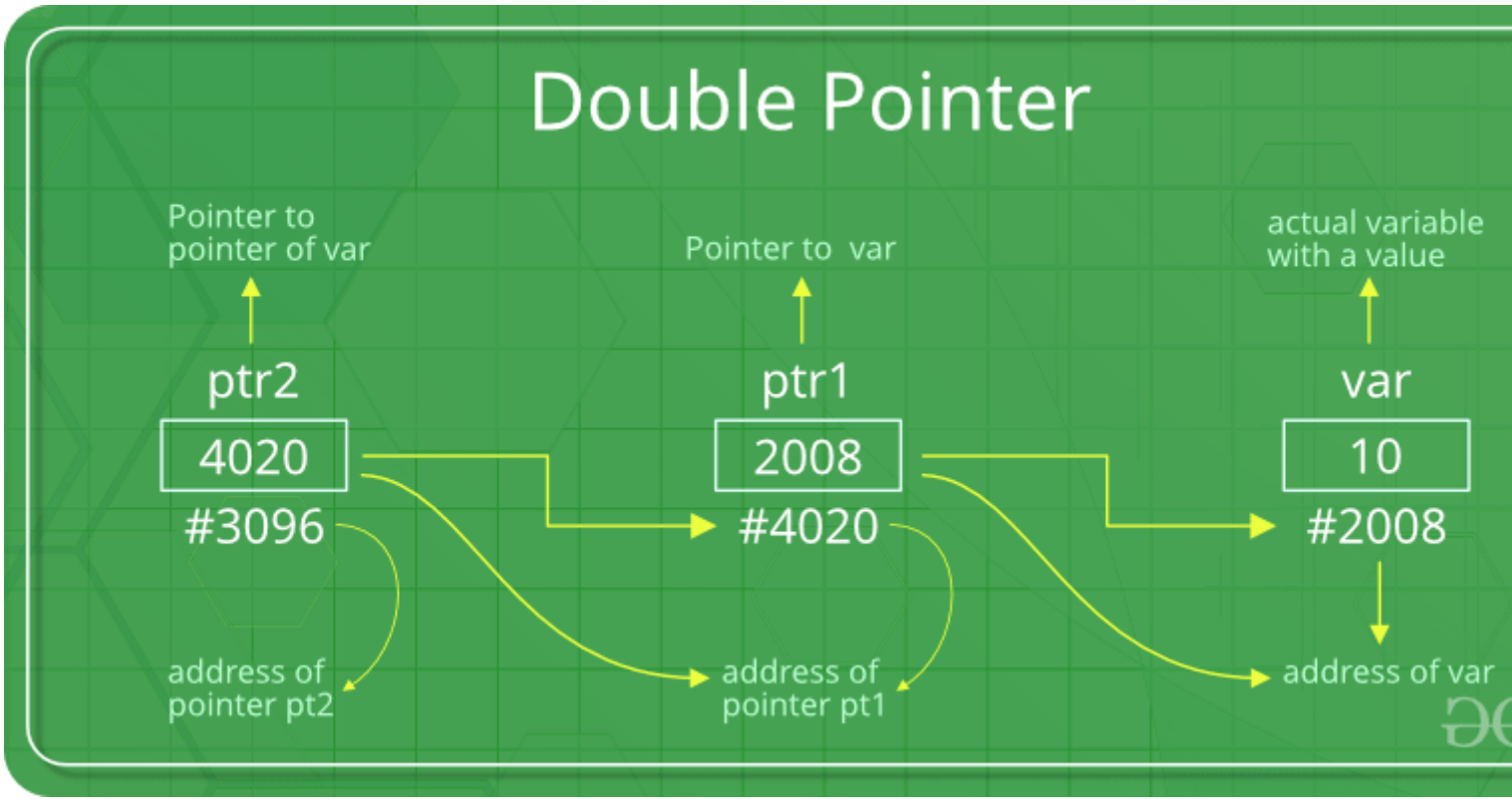
Prerequisite : Pointers in C and C++

We already know that a pointer points to a location in memory and thus used to store the address of variables. So, when we define a pointer to pointer. The first pointer is used to store the address of the variable. And the second pointer is used to store the address of the first pointer. That is why they are also known as double pointers.

How to declare a pointer to pointer in C?
Declaring Pointer to Pointer is similar to declaring pointer in C. The difference is we have to place an additional '*' before the name of pointer.
Syntax:

```
int **ptr;    // declaring double pointers
```

Below diagram explains the concept of Double Pointers:



The above diagram shows the memory representation of a pointer to pointer. The first pointer ptr1 stores the address of the variable and the second pointer ptr2 stores the address of the first pointer.