Pointers in C

Introduction

- A pointer is a variable that represents the location (rather than the value) of a data item.
- They have a number of useful applications.
  - Enables us to access a variable that is defined outside the function.
  - Can be used to pass information back and forth between a function and its reference point.
  - More efficient in handling data tables.
  - Reduces the length and complexity of a program.
  - Sometimes also increases the execution speed.

Basic Concept

- In memory, every stored data item occupies one or more contiguous memory cells (bytes).
  - The number of bytes required to store a data item depends on its type (char, int, float, double, etc.).
- Whenever we declare a variable, the system allocates memory location(s) to hold the value of the variable.
  - Since every byte in memory has a unique address, this location will also have its own (unique) address.

Contd.

- **Consider the statement**

```
int  xyz = 50;
```

  - This statement instructs the compiler to allocate a location for the integer variable `xyz`, and put the value `50` in that location.
  - Suppose that the address location chosen is `1380`.

xyz	→	variable
50	→	value
1380	→	address

Contd.

- During execution of the program, the system always associates the name `xyz` with the address `1380`.
  - The value `50` can be accessed by using either the name `xyz` or the address `1380`.
- Since memory addresses are simply numbers, they can be assigned to some variables which can be stored in memory.
  - Such variables that hold memory addresses are called *pointers*.
  - Since a pointer is a variable, its value is also stored in some memory location.

Contd.

- Suppose we assign the address of `xyz` to a "pointer" variable `p`.
  - `p` is said to point to the variable `xyz`.

Variable	Value	Address
xyz	50	1380
p	1380	2545

```
p = &xyz;
```

Accessing the Address of a Variable

- The address of a variable can be determined using the '&' operator.
  - The operator '&' immediately preceding a variable returns the *address* of the variable.
- Example:

```
p = &xyz;
```

  - The *address* of xyz (1380) is assigned to p.
- The '&' operator can be used only with a *simple variable* or an *array element*.

```
&distance
&x[0]
&x[i-2]
```

Contd.

- **Following usages are illegal:**

```
&235                    -- Pointing at a constant.

int  arr[20];
  :
&arr;                   -- Pointing at array name.

&(a+b)                  -- Pointing at expression.
```

Example

```
#include  <stdio.h>
main()
{
    int   a;
    float  b, c;
    double  d;
    char  ch;

    a = 10;   b = 2.5;  c = 12.36;  d = 12345.66;  ch = 'A';
    printf  ("%d is stored in location %u \n",  a,  &a) ;
    printf  ("%f is stored in location %u \n",  b,  &b) ;
    printf  ("%f is stored in location %u \n",  c,  &c) ;
    printf  ("%ld is stored in location %u \n", d,  &d) ;
    printf  ("%c is stored in location %u \n",  ch, &ch) ;
}
```

Output:

```
10 is stored in location 3221224908
2.500000 is stored in location 3221224904
12.360000 is stored in location 3221224900
12345.660000 is stored in location 3221224892
A is stored in location 3221224891
```

Pointer Declarations

- Pointer variables must be declared before we use them.
- General form:

```
data_type *pointer_name;
```

- Three things are specified in the above declaration:
  - The asterisk (*) tells that the variable `pointer_name` is a pointer variable.
  - `pointer_name` needs a memory location.
  - `pointer_name` points to a variable of type `data_type`.

Contd.

- **Example:**

```
int  *count;
float *speed;
```

- **Once a pointer variable has been declared, it can be made to point to a variable using an assignment statement like:**

```
int *p, xyz;
 :
p = &xyz;
```

  - **This is called *pointer initialization*.**

Things to Remember

- Pointer variables must always point to a data item of the ***same type***.

```
float   x;
int    *p;
:
p = &x;
```

➔ will result in erroneous output

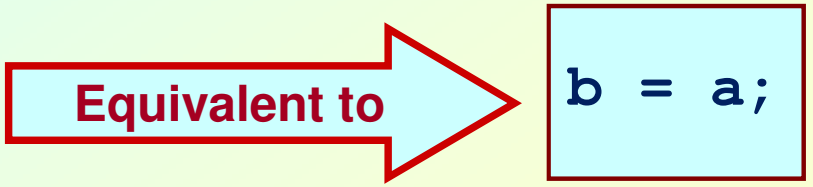
- Assigning an absolute address to a pointer variable is prohibited.

```
int   *count;
:
count = 1268;
```

Accessing a Variable Through its Pointer

- Once a pointer has been assigned the *address* of a variable, the *value* of the variable can be accessed using the *indirection operator* (*).

```
int   a, b;
int   *p;
:
p = &a;
b = *p;
```



Example 1

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

    a  =  4  *  (c  +  5) ;

    p  =  &c;
    b  =  4  *  (*p  +  5) ;
    printf  ("a=%d  b=%d \n",  a, b);
}
```

Equivalent

```
a=40 b=40
```

Example 2

```
#include  <stdio.h>
main()
{
    int  x, y;
    int  *ptr;

    x = 10 ;
    ptr = &x ;
    y = *ptr ;
    printf (”%d is stored in location %u \n”,  x,  &x) ;
    printf (”%d is stored in location %u \n”,  *&x,  &x) ;
    printf (”%d is stored in location %u \n”,  *ptr,  ptr) ;
    printf (“%d is stored in location %u \n”,  y,  &*ptr) ;
    printf (“%u is stored in location %u \n”,  ptr, &ptr) ;
    printf (“%d is stored in location %u \n”,  y,  &y) ;

    *ptr = 25;
    printf (”\nNow x = %d \n”, x);
}
```

```
Address of x:      3221224908
Address of y:      3221224904
Address of ptr:    3221224900
```

Output:

```
10 is stored in location 3221224908
10 is stored in location 3221224908
10 is stored in location 3221224908
10 is stored in location 3221224908
3221224908 is stored in location 3221224900
10 is stored in location 3221224904

Now x = 25
```

Pointer Expressions

- Like other variables, pointer variables can be used in expressions.
- If p1 and p2 are two pointers, the following statements are valid:

```
sum = *p1 + *p2;
prod = *p1 * *p2;
prod = (*p1) * (*p2);
*p1 = *p1 + 2;
x = *p1 / *p2 + 5;
```

`*p1` can appear on the left hand side

Contd.

- What are allowed in C?
  - Add an integer to a pointer.
  - Subtract an integer from a pointer.
  - Subtract one pointer from another (related).
    - If p1 and p2 are both pointers to the same array, then p2–p1 gives the number of elements between p1 and p2.

- **What are not allowed?**
  - **Add two pointers.**

```
p1 = p1 + p2;
```

  - **Multiply / divide a pointer in an expression.**

```
p1 = p2 / 5;
p1 = p1 - p2 * 10;
```

Scale Factor

- We have seen that an integer value can be added to or subtracted from a pointer variable.

```
int  *p1, *p2;
int  i, j;
:
p1 = p1 + 1;
p2 = p1 + j;
p2++;
p2 = p2 - (i + j);
```

  - In reality, it is not the integer value which is added/subtracted, but rather the *scale factor* times *the value*.

Contd.

Data Type	Scale Factor
char	1
int	4
float	4
double	8

– If p1 is an integer pointer, then

p1++

will increment the value of p1 by 4.

- **Note:**
  - The exact scale factor may vary from one machine to another.
  - Can be found out using the `sizeof` function.
  - Syntax:

```
sizeof (data_type)
```

Example: to find the scale factors

```
#include  <stdio.h>
main()
{
  printf ("No. of bytes occupied by int is %d \n",    sizeof(int));
  printf ("No. of bytes occupied by float is %d \n",  sizeof(float));
  printf ("No. of bytes occupied by double is %d \n", sizeof(double));
  printf ("No. of bytes occupied by char is %d \n",   sizeof(char));
}
```

Output:

```
Number of bytes occupied by int is  4
Number of bytes occupied by float is  4
Number of bytes occupied by double is  8
Number of bytes occupied by char is  1
```