

POINTERS

- Pointer is a variable that holds a memory address of another variable of same type.
- It supports dynamic allocation routines.
- It can improve the efficiency of certain routines.

C++ Memory Map :

- Program Code : It holds the compiled code of the program.
- Global Variables : They remain in the memory as long as program continues.
- Stack : It is used for holding return addresses at function calls, arguments passed to the functions, local variables for functions. It also stores the current state of the CPU.
- Heap : It is a region of free memory from which chunks of memory are allocated via DMA functions.

Static Memory Allocation : The amount of memory to be allocated is known in advance and it allocated during compilation, it is referred to as Static Memory Allocation.

e.g. `int a;` // This will allocate 2 bytes for a during compilation.

Dynamic Memory Allocation : The amount of memory to be allocated is not known beforehand rather it is required to allocated as and when required during runtime, it is referred to as dynamic memory allocation.

C++ offers two operator for DMA – **new and delete**.

e.g. `int x = new int;` `float y = new float;` // dynamic allocation
`delete x;` `delete y;` //dynamic deallocation

Free Store : It is a pool of unallocated heap memory given to a program that is used by the program for dynamic memory allocation during execution.

Declaration and Initialization of Pointers :

`Datatype *variable_name;`

Syntax : `Datatype *variable_name;`

`Int *p; float *p1; char *c;`

Eg. `Int *p;` `float *p1;` `char *c;`

Two special unary operator `*` and `&` are used with pointers. The `&` is a unary operator that returns the memory address of its operand.

Eg. `Int a = 10; int *p; p = &a;`

Pointer arithmetic:

Two arithmetic operations, addition and subtraction, may be performed on pointers.

When you add 1 to a pointer, you are actually adding the size of whatever the pointer is pointing at. That is, each time a pointer is incremented by 1, it points to the memory location of the next element of its base type.

e.g. `int *p;` `P++;`

If current address of p is 1000, then `p++` statement will increase p to 1002, not 1001.

If `*c` is char pointer and `*p` is integer pointer then

Char pointer	C	c+1	c+2	c+3	c+4	c+5	c+6	c+7
Address	100	101	102	103	104	105	106	107
Int pointer	p		p+1		p+2		p+3	

Adding 1 to a pointer actually adds the size of pointer's base type.

Base address : A pointer holds the address of the very first byte of the memory location where it is pointing to. **The address of the first byte is known as BASE ADDRESS.**

Dynamic Allocation Operators :

C++ dynamic allocation allocate memory from the free store/heap/pool, the pool of unallocated heap memory provided to the program. C++ defines two unary operators **new** and **delete** that perform the task of allocating and freeing memory during runtime.

Creating Dynamic Array :

Syntax : pointer-variable = new data-type [size];

e.g. int * array = new int[10];

Not array[0] will refer to the first element of array, array[1] will refer to the second element.

No initializes can be specified for arrays.

All array sizes must be supplied when new is used for array creation.

Two dimensional array :

```
int *arr, r, c;
```

```
r = 5; c = 5;
```

```
arr = new int [r * c];
```

Now to read the element of array, you can use the following loops :

```
For (int i = 0; i < r; i++)
```

```
{
```

```
    cout << "\n Enter element in row " << i + 1 << " : ";
```

```
    For (int j=0; j < c; j++)
```

```
        cin >> arr [ i * c + j];
```

```
}
```

Memory released with delete as below:

Syntax for simple variable :	For array :
delete pointer-variable;	delete [size] pointer variable;
eg. delete p;	Eg. delete [] arr;

Pointers and Arrays :

C++ treats the name of an array as constant pointer which contains base address i.e address of first location of array. Therefore Pointer variables are efficiently used with arrays for declaration as well as accessing elements of arrays, because array is continuous block of same memory locations and therefore pointer arithmetic help to traverse in the array easily.

```
void main()
```

```
{
```

```
    int *m;
```

```
    int marks[10] = { 50,60,70,80,90,80,80,85,75,95};
```

```
    m = marks; // address of first location of array or we can write it as m=&marks[0]
```

```
    for(int i=0;i<10;i++)
```

```
        cout<< *m++;
```

```
    // or
```

```
    m = marks; // address of first location of array or we can write it as m=&marks[0]
```

```
    for(int i=0;i<10;i++)
```

```
        cout<< *(m+i);
```

```
}
```

Array of Pointers :

To declare an array holding 10 int pointers –

```
int * ip[10];
```

That would be allocated for 10 pointers that can point to integers.

Now each of the pointers, the elements of pointer array, may be initialized. To assign the address of an integer variable phy to the forth element of the pointer array, we have to write `ip[3] = &phy;`

Now with `*ip[3]`, we can find the value of phy. `int *ip[5];`

Index	0	1	2	3	4
address	1000	1002	1004	1006	1008

```
int a = 12, b = 23, c = 34, d = 45, e = 56;
```

Variable	a	b	c	d	e
Value	12	23	34	45	56
address	1050	1065	2001	2450	2725

```
ip[0] = &a; ip[1] = &b; ip[2] = &c; ip[3] = &d; ip[4] = &e;
```

Index	ip[0]	ip[1]	ip[2]	ip[3]	ip[4]
Array ip value	1050	1065	2001	2450	2725
address	1000	1002	1004	1006	1008

`ip` is now a pointer pointing to its first element of `ip`. Thus `ip` is equal to address of `ip[0]`, i.e. 1000

`*ip` (the value of `ip[0]`) = 1050

`*(* ip)` = the value of `*ip` = 12

`** (ip+3)` = `** (1006)` = `*(2450)` = 45

Pointers and Strings :

Pointer is very useful to handle the character array also. E.g :

```
void main()
```

```
{    char str[] = "computer";
    char *cp;
    cp=str;
    cout<<str ; //display string
    cout<<cp; // display string
    for (cp =str; *cp != '\0'; cp++) // display character by character
        cout << "--"<<*cp;
    // arithmetic
    str++; // not allowed because str is an array and array name is constant pointer
    cp++; // allowed because pointer is a variable
    cout<<cp;}
```

Output :

Computer

Computer

--c--o--m--p--u--t--e--r

omputer

An array of char pointers is very useful for storing strings in memory. Char

```
*subject[] = { "Chemistry", "Phycics", "Maths", "CS", "English" };
```

In the above given declaration subject[] is an array of char pointers whose element pointers contain base addresses of respective names. That is, the element pointer subject[0] stores the base address of string "Chemistry", the element pointer subject[1] stores the above address of string "Physics" and so forth.

An array of pointers makes more efficient use of available memory by consuming lesser number of bytes to store the string.

An array of pointers makes the manipulation of the strings much easier. One can easily exchange the positions of strings in the array using pointers without actually touching their memory locations.

Pointers and CONST :

A constant pointer means that the pointer in consideration will always point to the same address. Its address can not be modified.

A pointer to a constant refers to a pointer which is pointing to a symbolic constant. Look the following example :

```
int m = 20;           // integer m declaration
int *p = &m;          // pointer p to an integer m
++ (*p);              // ok : increments int pointer p
int * const c = &n;    // a const pointer c to an intger n
++ (* c);             // ok : increments int pointer c i.e. its contents
++ c;                 // wrong : pointer c is const – address can't be modified
const int cn = 10;     // a const integer cn
const int *pc = &cn;   // a pointer to a const int
++ (* pc);            // wrong : int * pc is const – contents can't be modified
++ pc;                // ok : increments pointer pc
const int * const cc = *k; // a const pointer to a const integer
++ (* cc);            // wrong : int *cc is const
++ cc;                // wrong : pointer cc is const
```

Pointers and Functions :

A function may be invoked in one of two ways :

1. call by value
2. call by reference

The second method call by reference can be used in two ways :

1. by passing the references
2. by passing the pointers

Reference is an alias name for a variable. For ex : int m =

```
23;
```

```
int &n = m;
```

```
int *p;
```

```
p = &m;
```

Then the value of m i.e. 23 is printed in the following ways : cout <<

```
m;    // using variable name
```

```
cout << n;    // using reference name
```

```
cout << *p;    // using the pointer
```

Invoking Function by Passing the References :

When parameters are passed to the functions by reference, then the formal parameters become

references (or aliases) to the actual parameters to the calling function.

That means the called function does not create its own copy of original values, rather, it refers to the original values by different names i.e. their references.

For example the program of swapping two variables with reference method :

```
#include<iostream.h>
void main()
{
    void swap(int &, int &);
    int a = 5, b = 6;
    cout << "\n Value of a : " << a << " and b : " << b;
    swap(a, b);
    cout << "\n After swapping value of a : " << a << "and b : " << b;
}
void swap(int &m, int &n)
{
    int temp; temp = m;
    m = n;
    n = temp;
}
```

output :

Value of a : 5 and b : 6

After swapping value of a : 6 and b : 5

Invoking Function by Passing the Pointers:

When the pointers are passed to the function, the addresses of actual arguments in the calling function are copied into formal arguments of the called function.

That means using the formal arguments (the addresses of original values) in the called function, we can make changing the actual arguments of the calling function.

For example the program of swapping two variables with Pointers :

```
#include<iostream.h>
void main()
{
    void swap(int *m, int *n);
    int a = 5, b = 6;
    cout << "\n Value of a : " << a << " and b : " << b;
    swap(&a, &b);
    cout << "\n After swapping value of a : " << a << "and b : " << b;
}
void swap(int *m, int *n)
{
    int temp;
    temp = *m;
    *m = *n;
    *n = temp;
}
```

Input :

Value of a : 5 and b : 6

After swapping value of a : 6 and b : 5

Function returning Pointers :

The way a function can return an int, a float, it also returns a pointer. The general form of prototype of a function returning a pointer would be

Type * function-name (argument list);

```
#include <iostream.h>    int
*min(int &, int &); void main()
{
    int a, b, *c;
    cout << "\nEnter a :";    cin >> a;
    cout << "\nEnter b :";    cin >> b;
    c = min(a, b);
    cout << "\n The minimum no is :" << *c;
}
int *min(int &x, int &y)
{
    if (x < y)
        return (&x);
    else
        return (&y)
}
```

Dynamic structures :

The new operator can be used to create dynamic structures also i.e. the structures for which the memory is dynamically allocated.

struct-pointer = new struct-type;

student *stu;

stu = new Student;

A dynamic structure can be released using the deallocation operator delete as shown below :

delete stu;

Objects as Function arguments :

Objects are passed to functions in the same way as any other type of variable is passed.

When it is said that objects are passed through the call-by-value, it means that the called function creates a copy of the passed object.

A called function receiving an object as a parameter creates the copy of the object without invoking the constructor. However, when the function terminates, it destroys this copy of the object by invoking its destructor function.

If you want the called function to work with the original object so that there is no need to create and destroy the copy of it, you may pass the reference of the object. Then the called function refers to the original object using its reference or alias.

Also the object pointers are declared by placing in front of a object pointer's name. Class-name * object-pointer;

Eg. Student *stu;

The member of a class is accessed by the arrow operator (->) in object pointer method.

Eg :

```
#include<iostream.h>
class Point
```

```

{
    int x, y;
public :
    Point()
    {x = y = 0;}
    void getPoint(int x1, int y1)
    {x = x1; y = y1; }
    void putPoint()
    {
        cout << "\n Point : (" << x << ", " << y << ")";
    }
};

void main()
{
    Point p1, *p2;
    cout << "\n Set point at 3, 5 with object";
    p1.getPoint(3,5);
    cout << "\n The point is :";
    p1.putPoint();
    p2 = &p1;
    cout << "\n Print point using object pointer :";
    p2->putPoint();
    cout << "\n Set point at 6,7 with object pointer";
    p2->getPoint(6,7);
    cout<< "\n The point is :";
    p2->putPoint();
    cout << "\n Print point using object :";
    p1.getPoint();}

```

If you make an object pointer point to the first object in an array of objects, incrementing the pointer would make it point to the next object in sequence.

```

student stud[5], *sp;
---
sp = stud;           // sp points to the first element (stud[0])of stud
sp++;               // sp points to the second element (stud[1]) of stud sp + = 2;

// sp points to the fourth element (stud[3]) of stud sp--;           // sp
points to the third element (stud[2]) of stud

```

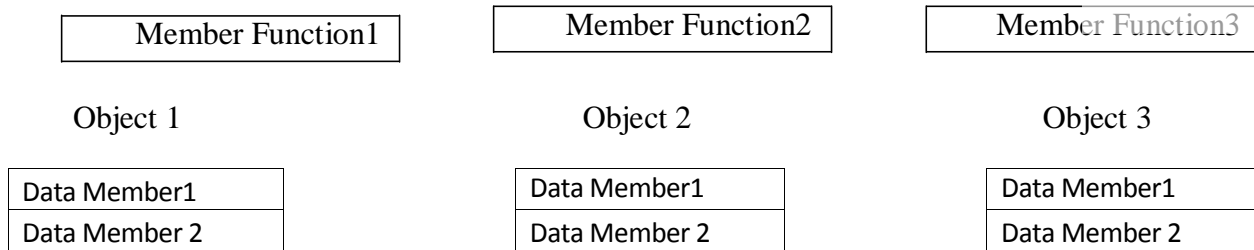
You can even make a pointer point to a data member of an object. Two points should be considered :

1. A Pointer can point to only public members of a class.
2. The data type of the pointer must be the same as that of the data member it points to.

this Pointer :

In class, the member functions are created and placed in the memory space only once. That is only one copy of functions is used by all objects of the class.

Therefore if only one instance of a member function exists, how does it come to know which object's data member is to be manipulated?



For the above figure, if Member Function2 is capable of changing the value of Data Member3 and we want to change the value of Data Member3 of Object3. How would the Member Function2 come to know which Object's Data Member3 is to be changed?

To overcome this problem this pointer is used.

When a member function is called, it is automatically passed an implicit argument that is a pointer to the object that invoked the function. This pointer is called This.

That is if object3 is invoking member function2, then an implicit argument is passed to member function2 that points to object3 i.e. this pointer now points to object3.

The friend functions are not members of a class and, therefore, are not passed a this pointer. The static member functions do not have a this pointer.

Solved Questions

Q. 1 How is *p different from **p ?

Ans : *p means, it is a pointer pointing to a memory location storing a value in it. But **p means, it is a pointer pointing to another pointer which in turn points to a memory location storing a value in it.

Q. 2 How is &p different from *p ?

Ans : &p gives us the address of variable p and *p. dereferences p and gives us the value stored in memory location pointed to by p.

Q. 3 Find the error in following code segment :

```
Float **p1, p2;
P2 = &p1;
```

Ans : In code segment, p1 is pointer to pointer, it means it can store the address of another pointer variable, whereas p2 is a simple pointer that can store the address of a normal variable. So here the statement p2 = &p1 has error.

Q. 4 What will be the output of the following code segment ?

```
char C1 = 'A';
char C2 = 'D';
char *i, *j;
i = &C1;
j = &C2;
*i = j;
cout << C1;
```

Ans : It will print A.

Q. 5 How does C++ organize memory when a program is run ?

Ans : Once a program is compiled, C++ creates four logically distinct regions of memory :

- area to hold the compiled program code
- area to hold global variables
- the stack area to hold the return addresses of function calls, arguments passed to the functions, local variables for functions, and the current state of the CPU.
- The heap area from which the memory is dynamically allocated to the program.

Q. 6 Identify and explain the error(s) in the following code segment :

```
float a[] = { 11.02, 12.13, 19.11, 17.41 };
float *j, *k;
j = a;
k = a + 4;
j = j * 2;
k = k / 2;
cout << " *j = " << *j << ", *k = " << *k << "\n";
```

Ans : The erroneous statements in the code are :

```
j = j * 2;
k = k / 2;
```

Because multiplication and division operations cannot be performed on pointer and j and k are pointers.

Q. 13 How does the functioning of a function differ when

- (i) an object is passed by value ? (ii) an object is passed by reference ?

Ans : (i) When an object is passed by value, the called function creates its own copy of the object by just copying the contents of the passed object. It invokes the object's copy constructor to create its copy of the object. However, the called function destroys its copy of the object by calling the destructor function of the object upon its termination.

(i) When an object is passed by reference, the called function does not create its own copy of the passed object. Rather it refers to the original object using its reference or alias name. Therefore, neither constructor nor destructor function of the object is invoked in such a case.

2 MARKS PRACTICE QUESTIONS

1. Differentiate between static and dynamic allocation of memory.

2. Identify and explain the error in the following program :

```
#include <iostream.h>
int main()
{ int x[] = { 1, 2, 3, 4, 5 };
  for (int i = 0; i < 5; i++)
  {
      cout << *x;
      x++;
  }
  return 0;
}
```

3. Give the output of the following :

```
char *s = "computer";
for (int x = strlen(s) - 1; x >= 0; x--)
{
    for (int y = 0; y <= x; y++)    cout << s[y];
    cout << endl;
}
```

4. Identify the syntax error(s), if any, in the following program. Also give reason for errors.

```
void main()
{const int i = 20;
  const int * const ptr = &i;
  (*ptr++; int j= 15; ptr
   = &j; }
```

5. What is 'this' pointer ? What is its significance ?

6. What will be the output of following program ?

```
#include<iostream.h>
void main()
{
  char name1[] = "ankur"; char
  name2[] = "ankur"; if (name1 !=
  name2)
    cout << "\n both the strings are not equal";
  else
    cout << "\n the strings are equal"; }
```

7. Give and explain the output of the following code :

```
void junk (int, int *);
int main() {
  int i = 6, j = -4;
  junk (i, &j);
  cout << "i = " << i << ", j = " << j << "\n";
  return 0;
}

void junk(int a, int *b)
{
  a = a* a;
  *b = *b * *b; }
```