Dynamic allocation of memory

Pointer: Pointer is an address of a memory location. A variable, which holds an address of a memory location, is known as a Pointer Variable (or simply pointer).

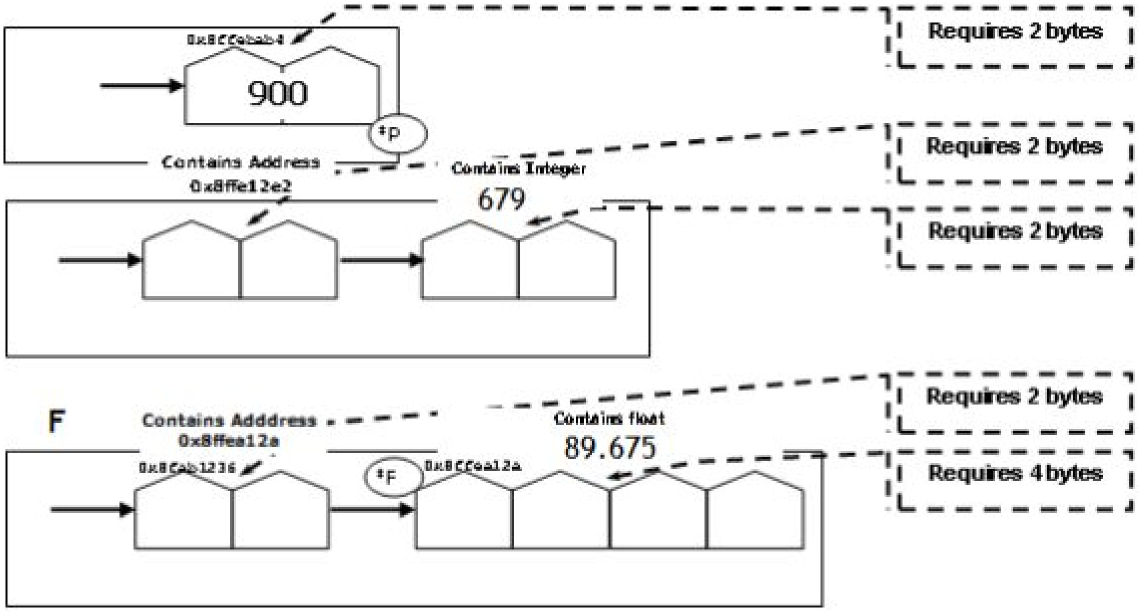
Declaration of a pointer variable

```
int   *P;  //Pointer to an integer
float *F;  //Pointer to a float
char  *Ch; //Pointer to a character
```

When a simple variable is declared as

```
int Amt=900;
```

It means Amt is a place in memory area that holds an integer type value.



The reference operator **&** returns an address of a memory location of a variable to which it is applied.

```
int Amt=900;
int *Ptr;       //Ptr points to int
Ptr=&Amt;       //Ptr holds the address of Amt
Amt+=100;
(*Ptr)-=50;
cout<<"Amt="<<Amt<<" *Ptr="<<*Ptr<<endl;
cout<<"&Amt="<<&Amt<<" Ptr="<<Ptr<<endl;
```

Above program will display the following output as Ptr holds an address of Amt and hence any change in Amt will be same as change in *Ptr.

```
Amt=950 *Ptr=950
&Amt=0x8ffebab4 Ptr=0x8ffebab4
```

Using new operator

new operator in C++ returns the address of a block of unallocated bytes (depending on data type a pointer pointing to).

```
float *F,*G;     //F and G point to float
F=new float;     //Allocates storage for 1 float
*F=89.675;       //Assigns a float value to *F
G=F;             //G shares the same address as F
cout<<"*F="<<*F<<"*G="<<*G<<" F="<<F<<" G="<<G<<endl;
```

The program on execution will display the following output as F and G are sharing the same address and so the content.

```
*F=89.675 *G=89.675 F=0x8ffea12a G=0x8ffea12a
```

(All addresses shown above are hypothetical)

Using delete operator

delete operator in C++ reverses the process of new operator, by releasing the memory location from a pointer. (It de-allocates the address allocated by new)

```
float *F;        //F points to float
F=new float;     //Allocates storage for one float
*F=89.675;       //Assigns a float value to *F
:
 delete F;       //De-allocates address from F
```

Pointer to an array

A pointer, which stores an address of an array, is known as pointer to an array.

Example

```
int A[]={90,85,35,75};
int *Ptr;
Ptr=A;           // Pointer to an Array (same as Ptr=&A[0])
cout<<"*Ptr="<<*Ptr<<endl;
Ptr+=2;          // Increment of Ptr by 4 bytes
cout<<"*Ptr="<<*Ptr<<endl;
(*Ptr)-=10;           // A[2] or *Ptr becomes 25
cout<<"A[2]="<<A[2]<<endl;
Ptr--;           // Decrement of Ptr by 2 bytes
cout<<"*Ptr="<<*Ptr<<endl;
```

Output

```
*Ptr=90
*Ptr=35
A[2]=25
*Ptr=85
```

Array of pointers

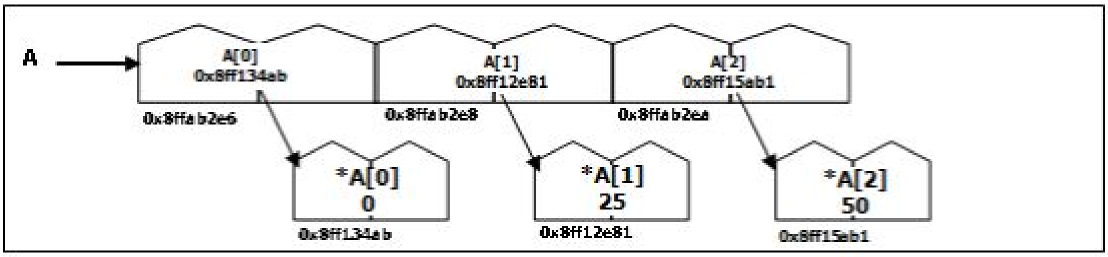
An array, whose each element is pointer type, is known as Array of pointers.

Example

```
int *A[3];
for (int I=0;I<3;I++)
{
  A[I]=new int;
  *A[I]=I*25;
}
for (I=2;I>=0;I--) cout<<"*A["<<I<<"]="<<*A[I]<<endl;
:
for (I=0;I<3;I++) delete A[I];
```

Output

```
*A[2]=50
*A[1]=25
*A[0]=0
```



(All addresses shown above are hypothetical)

Pointer to character

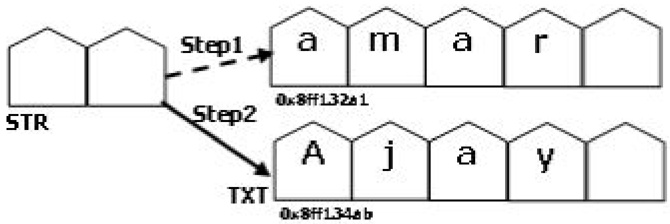
Pointer to character is a special pointer.

Example

```
char *STR="amar"; //Pointer to character initialization [step1]
char TXT[]="Ajay";//Array of character
cout<<STR<<endl;  //amar
cout<<TXT<<endl;  //Ajay
STR=TXT; //STR will point to the address of TXT array   [step2]
cout<<STR<<endl;  //Ajay
cout<<*STR<<endl; //A

while (*STR!='\0')
{
  cout<<*STR<<":"<<STR<<endl;
  STR++;
}

/* Output of the code in while loop
A:Ajay
j:jay
a:ay
y:y
*/
```



Pointer to structure

A pointer, which stores the address of struct type data, is known as Pointer to structure.

Example

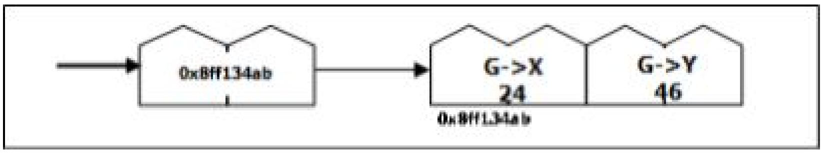
```
struct Graph
{
  int X,Y;
};

void main()
{
  Graph *G;            //Pointer to structure Graph
```

```
    G=new Graph;
    //*G.X=24;Not Allowed
    //G.*X=24;Not Allowed
    //G.X=24; Not Allowed
    G->X=24;       //-> is deference operator
    G->Y=G->X*2-2;
    cout<<"G->X="<<G->X<<" G->Y="<<G->Y<<endl;
    delete G;
  }
```

Output

```
G->X=24 G->Y=46
```



Using Alias

Another name given to an existing variable is known as alias.

Example 1

```
int A=900;
int &B=A;        //B is alias of A
A+=950;
cout<<"A="<<A<<" B="<<B<<endl;
```

Output (Example 1)

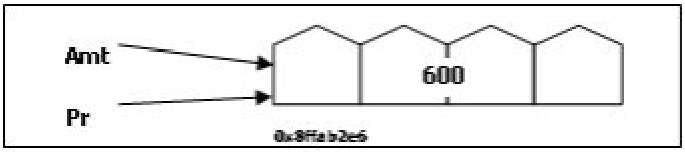
```
A=1850 B=1850
```

Example 2

```
float Amt,Qty=50,Price=10,Rate=10,Time=2,SI;
float& Pr=Amt;//Pr is alias of Amt
Amt=Price*Qty;
cout<<"Initial Amount:"<<Amt<<endl;
SI=(Pr*Rate*Time)/100;
cout<<"Simple Interest:"<<SI<<endl;
Amt=Pr+SI;
cout<<"Amount with Interest="<<Amt<<endl;
```

Output (Example 2)

```
Initial Amount:500
Simple Interest:100
Amount with Interest=600
```



Self Referential Pointer

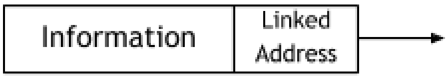
In this type, a structure has a pointer to itself i.e., the pointer stores the address of the structure variable of the same type.

Example

```
struct NODE
{
  int Eno;
  char Name[20];
  NODE *Next;
};
```

Linked List

It is a dynamic data structure and has a collection of nodes, where each node is divided in two parts (a) Information Part and (b) Linked Address Part.



> Note: NODE in C++ is defined with the help of self-referential pointer as shown above.

While storing elements of arrays, we do not require linked address because the elements of array are stored on consecutive blocks of addresses. In the next page, programs of stack and queue are shown using the concept of linked list.

Dynamic Stack

```
struct NODE
{
  int Data; NODE *Next;
};
class Stack
{
  NODE *Top;
public:
  Stack(){Top=NULL;}
  void Push();
  void Pop();
  void Disp();
  ~Stack();
};

void Stack::Push()
{
  NODE *Temp;
  Temp=new NODE;
  cout<<"Data:";
  cin>>Temp->Data;
  Temp->Next=Top;
  Top=Temp;
}
void Stack::Pop()
{
  if (Top!=NULL)
  {
    NODE *Temp=Top;
```

Dynamic Queue

```
struct NODE
{
  int Data;  NODE *Next;
};
class Queue
{
  NODE *Rear,*Front;
public:
  Queue(){Rear=NULL;Front=NULL;}
  void Insert();
  void Delete();
  void Show();
  ~Queue();
};

void Queue::Insert()
{
  NODE *Temp;
  Temp=new NODE;
  cout<<"Data:";
  cin>>Temp->Data;
  Temp->Next=NULL;


  if (Rear==NULL)
  {
    Rear=Temp;
    Front=Temp;
  }
```

```
    cout<<Top->Data<<"Deleted.."<<endl;
    Top=Top->Next;
    delete Temp;
  }
  else
    cout<<"Stack Empty.."<<endl;
}

void Stack::Disp()
{
  NODE *Temp=Top;
  while(Temp!=NULL)
  {
    cout<<Temp->Data<<endl;
    Temp=Temp->Next;
  }
}

Stack::~Stack() //Destructor Function
{
  while (Top!=NULL)
  {
    NODE *Temp=Top;
    Top=Top->Next;
    delete Temp;
  }
}
void main()
{
  Stack ST; char Ch;
  do
  {
    cout<<"P/O/D/Q ";cin>>Ch;
    switch (Ch)
    {
      case 'P':ST.Push();break;
      case 'O':ST.Pop();break;
      case 'D':ST.Disp();
    }
  }
  while (Ch!='Q');
}
//Destructor function will be called
//automatically when the scope of
//the object ST gets over
```

```
  else
  {
    Rear->Next=Temp;
    Rear=Temp;
  }
}

void Queue::Delete()
{
  if (Front!=NULL)
  {
    NODE *Temp=Front;
    cout<<Front->Data<<"Deleted.."<<endl;
    Front=Front->Next;
    delete Temp;
    if (Front==NULL) Rear=NULL;
  }
  else
    cout<<"Queue Empty.."<<endl;
}

void Queue::Show()
{
  NODE *Temp=Front;
  while(Temp!=NULL)
  {
    cout<<Temp->Data<<endl;
    Temp=Temp->Next;
  }
}
Queue::~Queue()//Destructor Function
{
  while (Front!=NULL)
  {
    NODE *Temp=Front;
    Front=Front->Next; delete Temp;
  }
}
void main()
{
  Queue Q; char Ch;
  do
  {
    cout<<"I/D/S/Q ";cin>>Ch;
    switch (Ch)
    {
      case 'I':Q.Insert();break;
      case 'D':Q.Delete();break;
      case 'S':Q.Show();
    }
  }while (Ch!='Q');
}
```