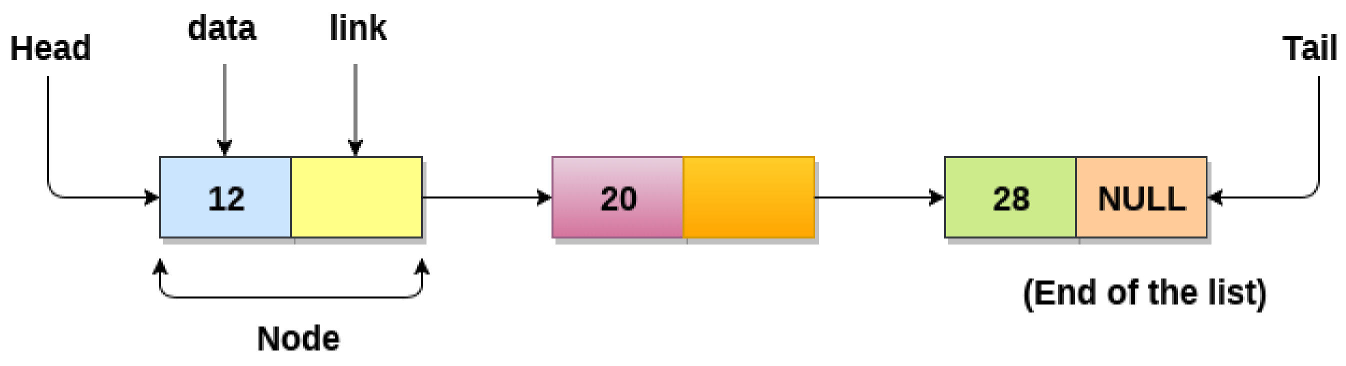
Linked List UNIT 1

- Linked List can be defined as collection of objects called **nodes** that are randomly stored in the memory.
- A node contains two fields i.e. data stored at that particular address and the pointer which contains the address of the next node in the memory.
- The last node of the list contains pointer to the null.



Uses of Linked List

- The list is not required to be contiguously present in the memory. The node can reside any where in the memory and linked together to make a list. This achieves optimized utilization of space.
- list size is limited to the memory size and doesn't need to be declared in advance.
- Empty node can not be present in the linked list.
- We can store values of primitive types or objects in the singly linked list.

Why use linked list over array?

Till now, we were using array data structure to organize the group of elements that are to be stored individually in the memory. However, Array has several advantages and disadvantages which must be known in order to decide the data structure which will be used throughout the program.

Array contains following limitations:

1. The size of array must be known in advance before using it in the program.
2. Increasing size of the array is a time taking process. It is almost impossible to expand the size of the array at run time.

3. All the elements in the array need to be contiguously stored in the memory. Inserting any element in the array needs shifting of all its predecessors.

Linked list is the data structure which can overcome all the limitations of an array. Using linked list is useful because,

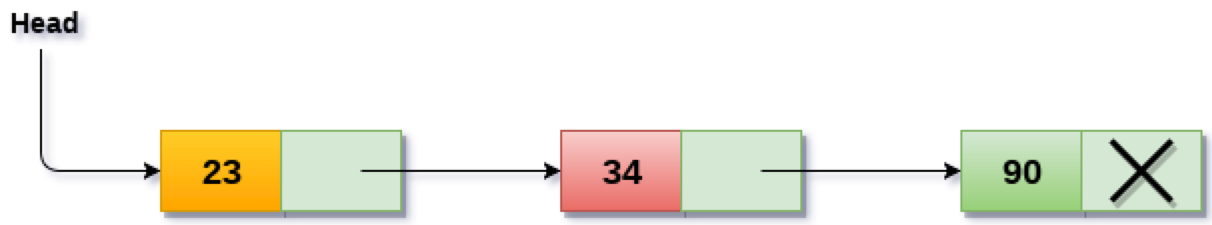
1. It allocates the memory dynamically. All the nodes of linked list are non-contiguously stored in the memory and linked together with the help of pointers.
2. Sizing is no longer a problem since we do not need to define its size at the time of declaration. List grows as per the program's demand and limited to the available memory space.

Singly linked list or One way chain

Singly linked list can be defined as the collection of ordered set of elements. The number of elements may vary according to need of the program. A node in the singly linked list consist of two parts: data part and link part. Data part of the node stores actual information that is to be represented by the node while the link part of the node stores the address of its immediate successor.

One way chain or singly linked list can be traversed only in one direction. In other words, we can say that each node contains only next pointer, therefore we can not traverse the list in the reverse direction.

Consider an example where the marks obtained by the student in three subjects are stored in a linked list as shown in the figure.



In the above figure, the arrow represents the links. The data part of every node contains the marks obtained by the student in the different subject. The last node in the list is identified by the null pointer which is present in the address part of the last node. We can have as many elements we require, in the data part of the list.

Operations on Singly Linked List

There are various operations which can be performed on singly linked list. A list of all such operations is given below.

Node Creation

```
struct node
{
   int data;
   struct node *next;
};
struct node *head, *ptr;
ptr = (struct node *)malloc(sizeof(struct node *));
```

LINKED LIST OPERATIONS

Traversing in singly linked list

Traversing is the most common operation that is performed in almost every scenario of singly linked list. Traversing means visiting each node of the list once in order to perform some operation on that. This will be done by using the following statements.

```
ptr = head;
      while (ptr!=NULL)
         {
            ptr = ptr -> next;
         }
```

Algorithm

```
○ STEP 1: SET PTR = HEAD/ START
○ STEP 2: IF PTR = NULL

      WRITE "EMPTY LIST"
     GOTO STEP 7
     END OF IF

○ STEP 4: REPEAT STEP 5 AND 6 UNTIL PTR != NULL
○ STEP 5: PRINT PTR→ DATA
○ STEP 6: PTR = PTR → NEXT/ LINK[PTR]

    [END OF LOOP]

○ STEP 7: EXIT
```

PROGRAMMING

```
#include<stdio.h>
#include<stdlib.h>
void create(int);
void traverse();
struct node
{
   int data;
   struct node *next;
};
struct node *head;
void main ()
{
   int choice,item;
   do
   {
      printf("\n1.Append List\n2.Traverse\n3.Exit\n4.Enter your choice?");
      scanf("%d",&choice);
      switch(choice)
      {
         case 1:
         printf("\nEnter the item\n");
         scanf("%d",&item);
         create(item);
         break;
         case 2:
         traverse();
         break;
         case 3:
         exit(0);
         break;
         default:
         printf("\nPlease enter valid choice\n");
      }

   }while(choice != 3);
}
void create(int item)
   {
      struct node *ptr = (struct node *)malloc(sizeof(struct node *));
      if(ptr == NULL)
      {
         printf("\nOVERFLOW\n");
      }
```

```
        else
        {
            ptr->data = item;
            ptr->next = head;
            head = ptr;
            printf("\nNode inserted\n");
        }

    }
void traverse()
    {
        struct node *ptr;
        ptr = head;
        if(ptr == NULL)
        {
            printf("Empty list..");
        }
        else
        {
            printf("printing values . . . . .\n");
            while (ptr!=NULL)
            {
                printf("\n%d",ptr->data);
                ptr = ptr -> next;
            }
        }
     }
```

OUTPUT

```
1.Append List
2.Traverse
3.Exit
4.Enter your choice?1

Enter the item
23

Node inserted

1.Append List
2.Traverse
3.Exit
4.Enter your choice?1

Enter the item
```

```
233

Node inserted

1.Append List
2.Traverse
3.Exit
4.Enter your choice?2
printing values . . . . .

233
23
```

Searching in singly linked list

Searching is performed in order to find the location of a particular element in the list. Searching any element in the list needs traversing through the list and makes the comparison of every element of the list with the specified element. If the element is matched with any of the list element then the location of the element is returned from the function.

Algorithm

```
○ Step 1: SET PTR = HEAD / START
○ Step 2: Set I = 0
○ STEP 3: IF PTR = NULL

    WRITE "EMPTY LIST"
    GOTO STEP 8
    END OF IF

○ STEP 4: REPEAT STEP 5 TO 7 UNTIL PTR != NULL
○ STEP 5: if ptr → data = item

  SET LOC = PTR

    Write i+1
   End of IF

○ STEP 6: I = I + 1
○ STEP 7: PTR = PTR → NEXT / LINK [PTR]

  [END OF LOOP]

○ STEP 8: EXIT
```

PROGRAMING

```
#include<stdio.h>
#include<stdlib.h>
void create(int);
void search();
struct node
{
    int data;
    struct node *next;
};
struct node *head;
void main ()
{
    int choice,item,loc;
    do
    {
        printf("\n1.Create\n2.Search\n3.Exit\n4.Enter your choice?");
        scanf("%d",&choice);
        switch(choice)
        {
            case 1:
            printf("\nEnter the item\n");
            scanf("%d",&item);
            create(item);
            break;
            case 2:
            search();
            case 3:
            exit(0);
            break;
            default:
            printf("\nPlease enter valid choice\n");
        }

    }while(choice != 3);
}
    void create(int item)
    {
        struct node *ptr = (struct node *)malloc(sizeof(struct node *));
        if(ptr == NULL)
        {
            printf("\nOVERFLOW\n");
        }
        else
        {
            ptr->data = item;
            ptr->next = head;
            head = ptr;
            printf("\nNode inserted\n");
        }

    }
void search()
{
    struct node *ptr;
    int item,i=0,flag;
    ptr = head;
    if(ptr == NULL)
    {
        printf("\nEmpty List\n");
    }
    else
    {
        printf("\nEnter item which you want to search?\n");
        scanf("%d",&item);
        while (ptr!=NULL)
        {
            if(ptr->data == item)
            {
                printf("item found at location %d ",i+1);
                flag=0;
            }
            else
            {
                flag=1;
            }
            i++;
            ptr = ptr -> next;
        }
        if(flag==1)
        {
            printf("Item not found\n");
        }
    }

}
```

OUTPUT

```
1.Create
2.Search
3.Exit
```

```
4.Enter your choice?1

Enter the item
23

Node inserted

1.Create
2.Search
3.Exit
4.Enter your choice?1

Enter the item
34

Node inserted

1.Create
2.Search
3.Exit
4.Enter your choice?2

Enter item which you want to search?
34
item found at location 1
```

Insertion

The insertion into a singly linked list can be performed at different positions. Based on the position of the new node being inserted, the insertion is categorized into the following categories.

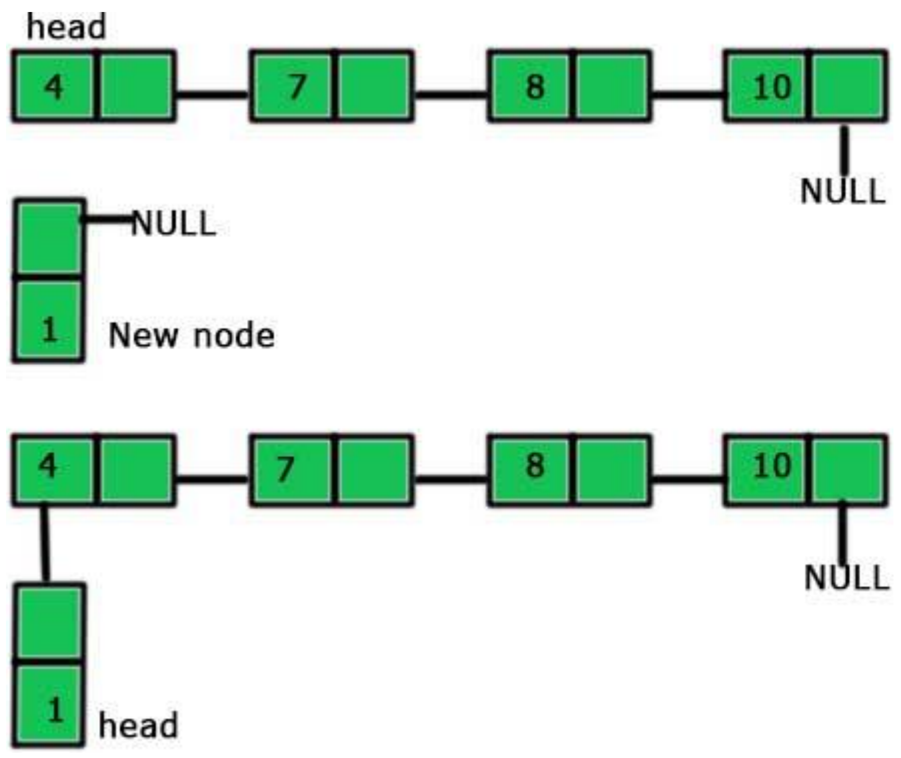
There are three different possibilities for inserting a node into a linked list. These three possibilities are:

1. Insertion at the beginning of the list.

2. Insertion at the end of the list

3. Inserting a new node except the above-mentioned positions.

In the first case, we make a new node and points its next to the head of the existing list and then change the head to the newly added node. It is similar to picture given below.



So, the steps to be followed are as follows:

1. Make a new node
2. Point the ‘next’ of the new node to the ‘head’ of the linked list.
3. Mark new node as ‘head’.

Thus, the code representing the above steps is:

```
struct node* front(struct node *head,int value)
{
        struct node *p;
        p=malloc(sizeof(struct node));
        p->data=value;
        p->next=head;
        return (p);
}


/*
```

```
main funtion will be something like:

main()

{

    head=front(head,10);

}

*/
```

The code is very simple to understand. We just made a new node in these three lines of the code:

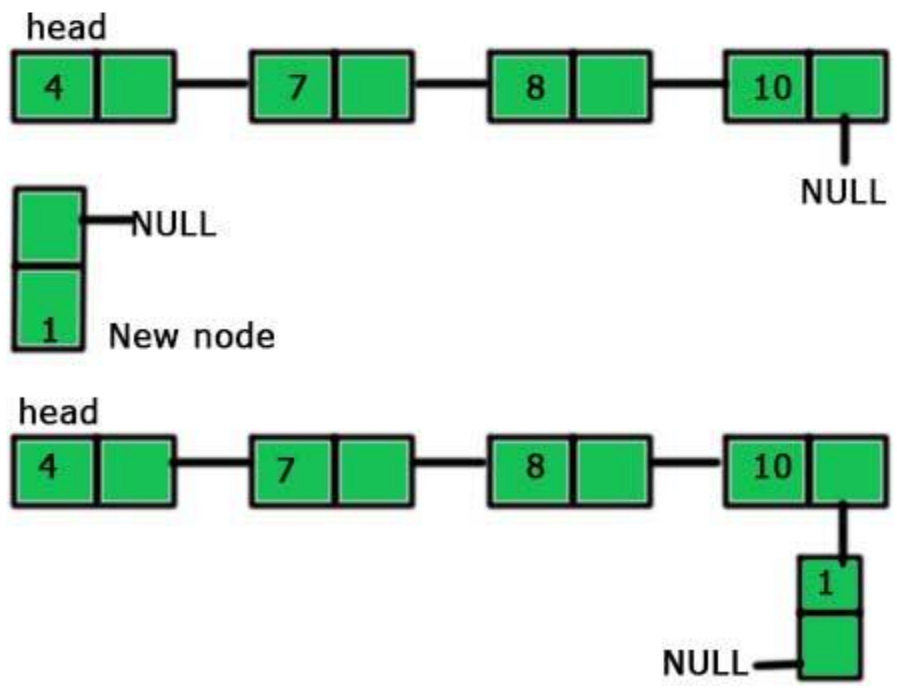
```
struct node *p;
p=malloc(sizeof(struct node));
p->data=value;
```

`p->next=head` – In this line, we have followed the second step which is to point the ‘next’ of the new node to the head of the linked list.

```
return (p);
head=front(head,10);
```

These two lines are the part of marking the new node as ‘head’. We are returning the new node from our function and making it head in the main function.

The second case is the simplest one. We just add a new node at the end of the existing list. It is shown in the picture given below:



So, the steps to add the ends if a linked list are:

1. Make a new node
2. Point the last node of the linked list to the new node

And the code representing the above steps are:

```
end(struct node *head,int value)
{
    struct node *p,*q;
    p=malloc(sizeof(struct node));
    p->data=value;
    p->next=NULL;
    q=head;
    while(q->next!=NULL)
    {
        q = q->next;
    }
    q->next = p;
}
/*
    main function will contain something like:
    end(head,20);
*/
```

```
p=malloc(sizeof(struct node));
p->data=value;
p->next=NULL;
```

The above-mentioned lines are just creating a new node.

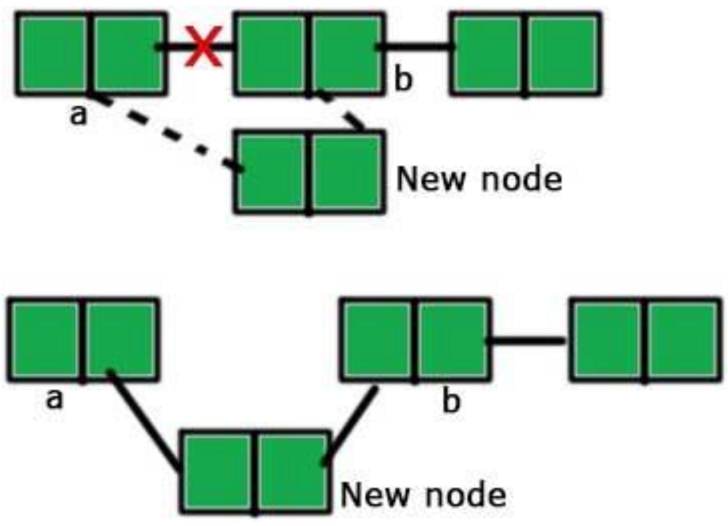
```
while(q->next!=NULL)
{
 q = q->next;
}
```

We are traversing to the end of the list using the above lines of code to make ‘q’ the last element of the list.

Now ‘q’ is the last element of the list, so we can add the new node next to it and we are doing the same by the code written after the while loop:

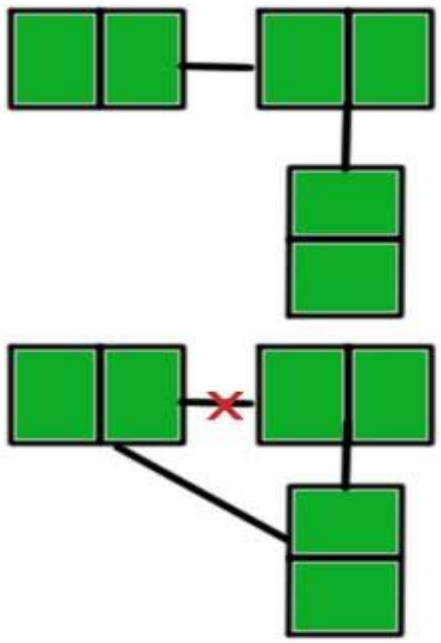
```
q = q->next
```

The third and the last case is a little bit complicated. To insert a node in between a linked list, we need to first break the existing link and then create two new links. It will be clear from the picture given below.



The steps for inserting a node after node ‘a’ (as shown in the picture) are:

1. Make a new node
2. Point the ‘next’ of the new node to the node ‘b’ (the node after which we have to insert the new node). Till now, two nodes are pointing the same node ‘b’, the node ‘a’ and the new node.



3. Point the ‘next’ of ‘a’ to the new node.

The code for the above steps is:

```
after(struct node *a, int value)
{
    struct node *p;
    p = malloc(sizeof(struct node));
    p->data = value;
    /*
    if initial linked list is
     _______      _______      _______
    |  1   |____\ |  3   |____\ |  5   |____\ NULL
    |_______|    / |_______|    / |_______|    /
    and new node's value is 10
    then the next line will do something like
     ________       ________       ________
    |   1   |____\ |   3   |____\ |   5   |____\ NULL
    |_______|    / |_______|    / |_______|    /
                /\
                 |
                 |
              ___|___
             |  10  |
             |_______|
    */
p->next = a->next;
    a->next = p;
    /*
    now the linked list will look like:
     ________      ________       ________       ________
    |   1   |____\|  10  |____\ |   3   |____\ |   5   |____\ NULL
    |_______|    /|_______|   / |_______|    / |_______|    /
    */
}
```

p = malloc(sizeof(struct node));
p->data = value;

We are creating a new node using the above lines.

p->next = a->next – We are making the ‘next’ of the new node to point to the node after which insertion is to be made. See the comments for better understanding.

a->next = p – We are pointing the ‘next’ of a to the new node.

The entire code is:

```
#include <stdio.h>
#include <stdlib.h>

struct node
{
    int data;
    struct node *next;
};

display(struct node *head)
{
    if(head == NULL)
    {
        printf("NULL\n");
    }
    else
    {
        printf("%d\n", head -> data);
        display(head->next);
    }
}
struct node* front(struct node *head,int value)
{
    struct node *p;
    p=malloc(sizeof(struct node));
    p->data=value;
    p->next=head;
    return (p);
}
```

```
end(struct node *head,int value)
{
    struct node *p,*q;
    p=malloc(sizeof(struct node));
    p->data=value;
    p->next=NULL;
    q=head;
    while(q->next!=NULL)
    {
        q = q->next;
    }
    q->next = p;
}
after(struct node *a, int value)
{
    if (a->next != NULL)
    {
        struct node *p;
        p = malloc(sizeof(struct node));
        p->data = value;
        /*
        if initial linked list is
         _______      _______      _______
        |   1   |____\ |   3   |____\ |   5   |____\ NULL
        |_______|    / |_______|    / |_______|    /
        and new node's value is 10
        then the next line will do something like
         _______      _______      _______
        |   1   |____\ |   3   |____\ |   5   |____\ NULL
        |_______|    / |_______|    / |_______|    /
```

```
                  / \
                   |
                   |
                ___|___
               |  10  |
               |______|
        */
        p->next = a->next;
        a->next = p;
}
    else
    {
        printf("Use end function to insert at the end\n");
    }
}

int main()
{
    struct node *prev,*head, *p;
    int n,i;
    printf ("number of elements:");
    scanf("%d",&n);
    head=NULL;
    for(i=0;i<n;i++)
    {
        p=malloc(sizeof(struct node));
        scanf("%d",&p->data);
        p->next=NULL;
        if(head==NULL)
            head=p;
        else
            prev->next=p;
prev=p;
    }
    head = front(head,10);
    end(head,20);
    after(head->next->next,30);
    display(head);
    return 0;
}
```

Insertion in singly linked list at beginning

Inserting a new element into a singly linked list at beginning is quite simple. We just need to make a few adjustments in the node links. There are the following steps which need to be followed in order to inser a new node in the list at beginning.

- Allocate the space for the new node and store data into the data part of the node. This will be done by the following statements.

```
ptr = (struct node *) malloc(sizeof(struct node *));
        ptr → data = item
```

- Make the link part of the new node pointing to the existing first node of the list. This will be done by using the following statement.

  ```
  ptr->next = head;
  ```

- At the last, we need to make the new node as the first node of the list this will be done by using the following statement.

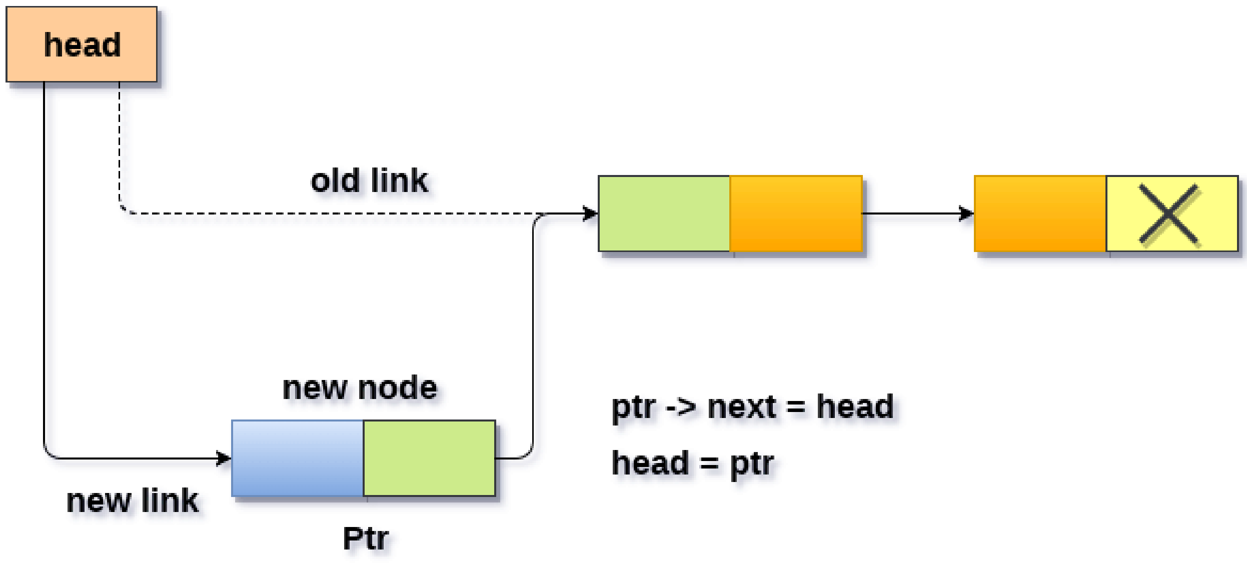
  ```
  head = ptr;
  ```

Algorithm

- **Step 1:** IF PTR = NULL

Write OVERFLOW AND Go to Step 7
[END OF IF]

- **Step 2:** SET NEW_NODE = PTR
- **Step 3:** SET PTR = PTR → NEXT
- **Step 4:** SET NEW_NODE → DATA = VAL
- **Step 5:** SET NEW_NODE → NEXT = HEAD
- **Step 6:** SET HEAD = NEW_NODE
- **Step 7:** EXIT



PROGRAMMING

```
#include<stdio.h>
#include<stdlib.h>
void beginsert(int);
struct node
{
   int data;
   struct node *next;
};
struct node *head;
void main ()
{
   int choice,item;
   do
```

```
    {
        printf("\nEnter the item which you want to insert?\n");
        scanf("%d",&item);
        beginsert(item);
        printf("\nPress 0 to insert more ?\n");
        scanf("%d",&choice);
    }while(choice == 0);
}
void beginsert(int item)
    {
        struct node *ptr = (struct node *)malloc(sizeof(struct node *));
        if(ptr == NULL)
        {
            printf("\nOVERFLOW\n");
        }
        else
        {
            ptr->data = item;
            ptr->next = head;
            head = ptr;
            printf("\nNode inserted\n");
        }

    }
```

OUTPUT

```
Enter the item which you want to insert?
12

Node inserted

Press 0 to insert more ?
0

Enter the item which you want to insert?
23

Node inserted

Press 0 to insert more ?
2
```

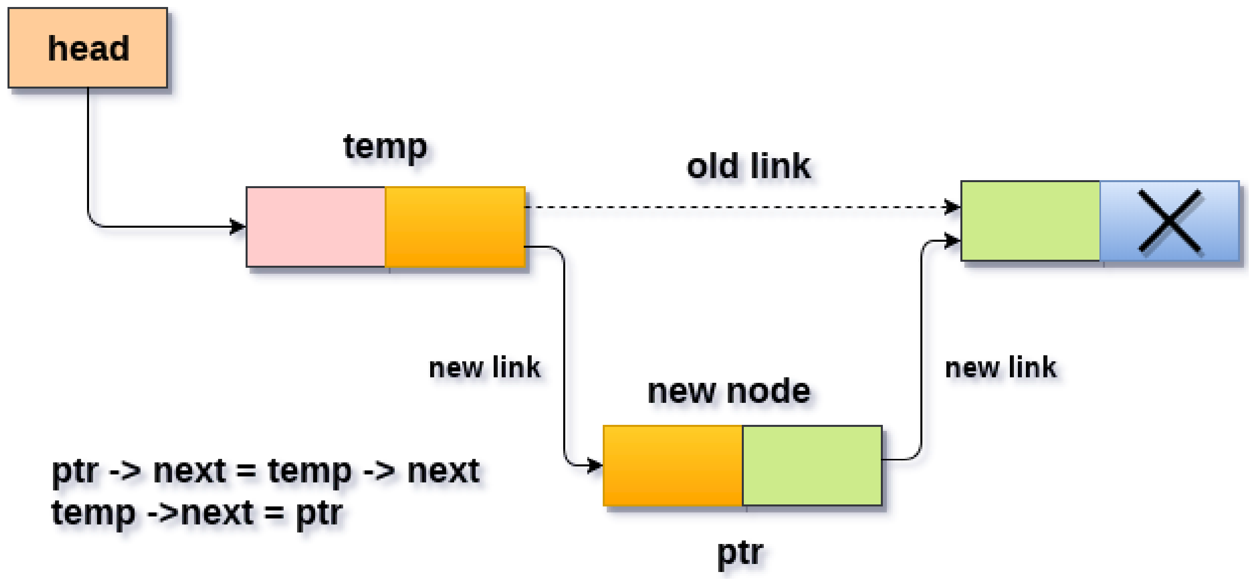
Insertion in singly linked list after specified Node

In order to insert an element after the specified number of nodes into the linked list, we need to skip the desired number of elements in the list to move the pointer at the position after which the node will be inserted. This will be done by using the following statements.

```
emp=head;
    for(i=0;i<loc;i++)
     {
         temp = temp->next;
         if(temp == NULL)
         {
             return;
         }

     }
```

Algorithm

```
○ STEP 1: IF PTR = NULL

  WRITE OVERFLOW
     GOTO STEP 12
    END OF IF

○ STEP 2: SET NEW_NODE = PTR
○ STEP 3: NEW_NODE → DATA = VAL
○ STEP 4: SET TEMP = HEAD
○ STEP 5: SET I = 0
○ STEP 6: REPEAT STEP 5 AND 6 UNTIL I<loc< li=""></loc<>
○ STEP 7: TEMP = TEMP → NEXT
○ STEP 8: IF TEMP = NULL

  WRITE "DESIRED NODE NOT PRESENT"
  GOTO STEP 12
  END OF IF
  END OF LOOP

○ STEP 9: PTR → NEXT = TEMP → NEXT
○ STEP 10: TEMP → NEXT = PTR
○ STEP 11: SET PTR = NEW_NODE
○ STEP 12: EXIT
```



PROGRAMMING

```
#include<stdio.h>
#include<stdlib.h>
void randominsert(int);
void create(int);
struct node
{
   int data;
   struct node *next;
};
struct node *head;
void main ()
{
   int choice,item,loc;
   do
   {
      printf("\nEnter the item which you want to insert?\n");
      scanf("%d",&item);
      if(head == NULL)
      {
         create(item);
      }
      else
      {
         randominsert(item);
```

```
        }
        printf("\nPress 0 to insert more ?\n");
        scanf("%d",&choice);
    }while(choice == 0);
}
void create(int item)
{

        struct node *ptr = (struct node *)malloc(sizeof(struct node *));
        if(ptr == NULL)
        {
            printf("\nOVERFLOW\n");
        }
        else
        {
            ptr->data = item;
            ptr->next = head;
            head = ptr;
            printf("\nNode inserted\n");
        }
}
void randominsert(int item)
    {
        struct node *ptr = (struct node *) malloc (sizeof(struct node));
        struct node *temp;
        int i,loc;
        if(ptr == NULL)
        {
            printf("\nOVERFLOW");
        }
        else
        {

            printf("Enter the location");
            scanf("%d",&loc);
            ptr->data = item;
            temp=head;
            for(i=0;i<loc;i++)
            {
                temp = temp->next;
                if(temp == NULL)
                {
                    printf("\ncan't insert\n");
                    return;
                }

            }
            ptr ->next = temp ->next;
            temp ->next = ptr;
            printf("\nNode inserted");
        }

    }
```

Output

```
Enter the item which you want to insert?
12

Node inserted

Press 0 to insert more ?
2
```

Insertion in singly linked list at the end

In order to insert a node at the last, there are two following scenarios which need to be mentioned.

1. The node is being added to an empty list
2. The node is being added to the end of the linked list

In the first case,

- The condition (head == NULL) gets satisfied. Hence, we just need to allocate the space for the node by using malloc statement in C. Data and the link part of the node are set up by using the following statements.

```
ptr->data = item;
ptr -> next = NULL;
```

- Since, **ptr** is the only node that will be inserted in the list hence, we need to make this node pointed by the head pointer of the list. This will be done by using the following Statements.

  Head = ptr

In the second case,

- The condition **Head = NULL** would fail, since Head is not null. Now, we need to declare a temporary pointer temp in order to traverse through the list. **temp** is made to point the first node of the list.

  Temp = head

- Then, traverse through the entire linked list using the statements:

  ```
  while (temp→ next != NULL)
   temp = temp → next;
  ```

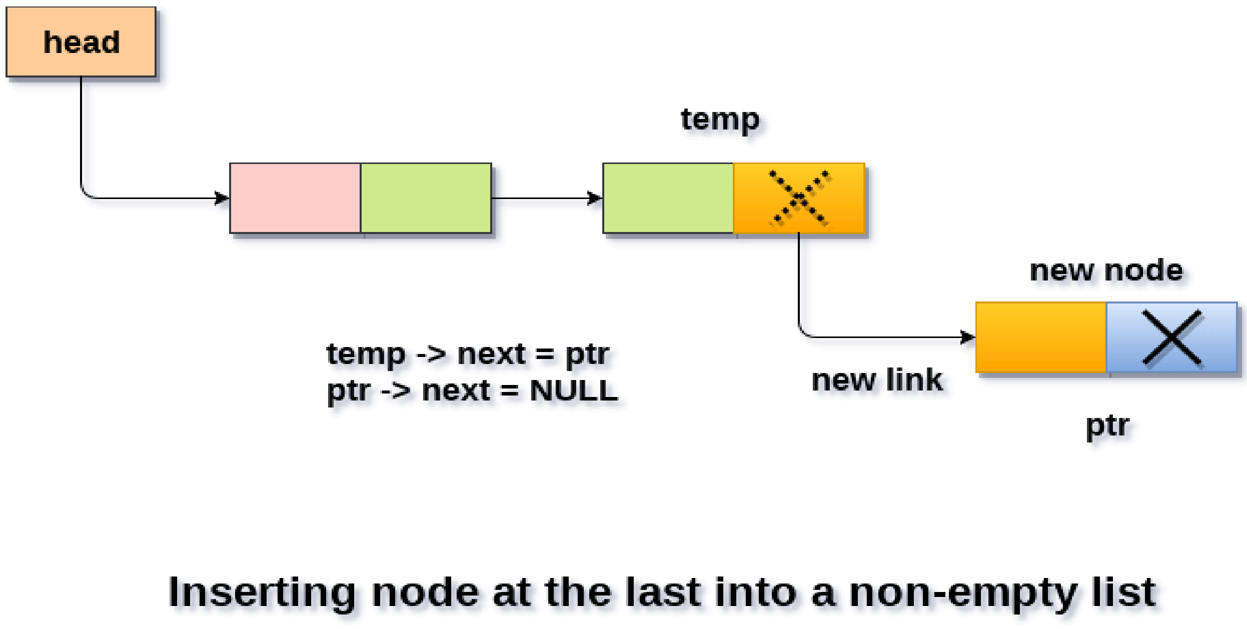
- At the end of the loop, the temp will be pointing to the last node of the list. Now, allocate the space for the new node, and assign the item to its data part. Since, the new node is going to be the last node of the list hence, the next part of this node needs to be pointing to the **null**. We need to make the next part of the temp node (which is currently the last node of the list) point to the new node (ptr) .

```
temp = head;
     while (temp -> next != NULL)
     {
        temp = temp -> next;
     }
     temp->next = ptr;
     ptr->next = NULL;
```

Algorithm

- **Step 1:** IF PTR = NULL Write OVERFLOW
     Go to Step 1
    [END OF IF]
- **Step 2:** SET NEW_NODE = PTR
- **Step 3:** SET PTR = PTR - > NEXT

- **Step 4:** SET NEW_NODE - > DATA = VAL
- **Step 5:** SET NEW_NODE - > NEXT = NULL
- **Step 6:** SET PTR = HEAD
- **Step 7:** Repeat Step 8 while PTR - > NEXT != NULL
- **Step 8:** SET PTR = PTR - > NEXT
  [END OF LOOP]
- **Step 9:** SET PTR - > NEXT = NEW_NODE
- **Step 10:** EXIT



PROGRAMING IN C

```
#include<stdio.h>
#include<stdlib.h>
void lastinsert(int);
struct node
{
   int data;
   struct node *next;
};
struct node *head;
void main ()
{
   int choice,item;
   do
```

```
    {
        printf("\nEnter the item which you want to insert?\n");
        scanf("%d",&item);
        lastinsert(item);
        printf("\nPress 0 to insert more ?\n");
        scanf("%d",&choice);
    }while(choice == 0);
}
void lastinsert(int item)
    {
        struct node *ptr = (struct node*)malloc(sizeof(struct node));
        struct node *temp;
        if(ptr == NULL)
        {
            printf("\nOVERFLOW");
        }
        else
        {
            ptr->data = item;
            if(head == NULL)
            {
                ptr -> next = NULL;
                head = ptr;
                printf("\nNode inserted");
            }
            else
            {
                temp = head;
                while (temp -> next != NULL)
                {
                    temp = temp -> next;
                }
                temp->next = ptr;
                ptr->next = NULL;
                printf("\nNode inserted");

            }
        }
    }
```

Output

```
Enter the item which you want to insert?
12

Node inserted
Press 0 to insert more ?
0

Enter the item which you want to insert?
23

Node inserted
Press 0 to insert more ?
2
```

DELETION OF A GIVEN NODE FROM A LINKED LIST

Deletion in singly linked list at beginning

Deleting a node from the beginning of the list is the simplest operation of all. It just need a few adjustments in the node pointers. Since the first node of the list is to be deleted, therefore, we just need to make the head, point to the next of the head. This will be done by using the following statements.

```
ptr = head;
head = ptr->next;
```

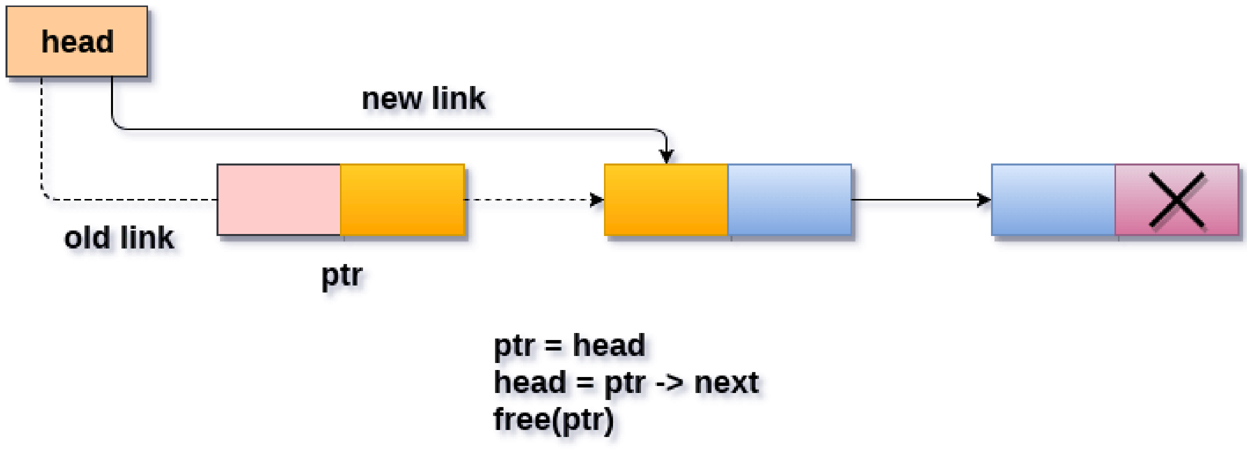
Now, free the pointer ptr which was pointing to the head node of the list. This will be done by using the following statement.

```
free(ptr)
```

Algorithm

```
o Step 1: IF HEAD = NULL

  Write UNDERFLOW
      Go to Step 5
     [END OF IF]

o Step 2: SET PTR = HEAD / START
o Step 3: SET HEAD = HEAD -> NEXT
```

- **Step 4:** FREE PTR
- **Step 5:** EXIT



Deleting a node from the beginning

PROGRAMMING

```
#include<stdio.h>
#include<stdlib.h>
void create(int);
void begdelete();
struct node
{
   int data;
   struct node *next;
};
struct node *head;
void main ()
{
   int choice,item;
   do
   {
      printf("\n1.Append List\n2.Delete node\n3.Exit\n4.Enter your choice?");
      scanf("%d",&choice);
      switch(choice)
      {
         case 1:
            printf("\nEnter the item\n");
            scanf("%d",&item);
            create(item);
            break;
            case 2:
            begdelete();
            break;
            case 3:
            exit(0);
            break;
            default:
            printf("\nPlease enter valid choice\n");
        }

    }while(choice != 3);
}
void create(int item)
    {
        struct node *ptr = (struct node *)malloc(sizeof(struct node *));
        if(ptr == NULL)
        {
            printf("\nOVERFLOW\n");
        }
        else
        {
            ptr->data = item;
            ptr->next = head;
            head = ptr;
            printf("\nNode inserted\n");
        }

    }
void begdelete()
    {
        struct node *ptr;
        if(head == NULL)
        {
            printf("\nList is empty");
        }
        else
    {
        ptr = head;
        head = ptr->next;
        free(ptr);
        printf("\n Node deleted from the begining ...");
    }
}
```

Deletion in singly linked list at beginning

Deleting a node from the beginning of the list is the simplest operation of all. It just need a few adjustments in the node pointers. Since the first node of the list is to be deleted, therefore, we just need to make the head, point to the next of the head. This will be done by using the following statements.

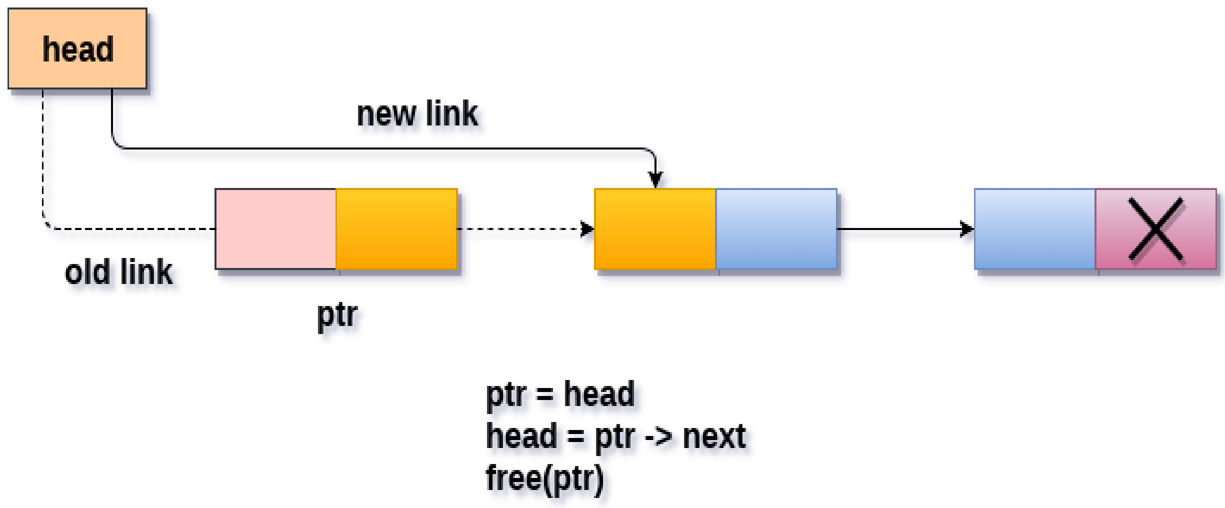
```
1. ptr = head;
2.          head = ptr->next;
```

Now, free the pointer ptr which was pointing to the head node of the list. This will be done by using the following statement.

```
1. free(ptr)
```

Algorithm

```
Step 1: IF HEAD = NULL
        Write UNDERFLOW
            Go to Step 5
          [END OF IF]
Step 2: SET PTR = HEAD
Step 3: SET HEAD = HEAD -> NEXT
Step 4: FREE PTR
Step 5: EXIT
```



Deleting a node from the beginning

C function

```
#include<stdio.h>
#include<stdlib.h>
void create(int);
void begdelete();
struct node
{
   int data;
   struct node *next;
};
struct node *head;
void main ()
{
   int choice,item;
   do
   {
      printf("\n1.Append List\n2.Delete node\n3.Exit\n4.Enter your choice?");
      scanf("%d",&choice);
      switch(choice)
      {
         case 1:
            printf("\nEnter the item\n");
            scanf("%d",&item);
            create(item);
            break;
            case 2:
            begdelete();
            break;
            case 3:
            exit(0);
            break;
            default:
            printf("\nPlease enter valid choice\n");
        }

    }while(choice != 3);
}
void create(int item)
    {
        struct node *ptr = (struct node *)malloc(sizeof(struct node *));
        if(ptr == NULL)
        {
            printf("\nOVERFLOW\n");
        }
        else
        {
            ptr->data = item;
            ptr->next = head;
            head = ptr;
            printf("\nNode inserted\n");
        }

    }
void begdelete()
    {
        struct node *ptr;
        if(head == NULL)
        {
            printf("\nList is empty");
        }
        else
        {
            ptr = head;
            head = ptr->next;
            free(ptr);
            printf("\n Node deleted from the begining ...");
        }
    }
```

Output

```
1.Append List
2.Delete node
3.Exit
4.Enter your choice?1

Enter the item
23

Node inserted

1.Append List
2.Delete node
3.Exit
4.Enter your choice?2
```

Deletion in singly linked list at the end

There are two scenarios in which, a node is deleted from the end of the linked list.

1. There is only one node in the list and that needs to be deleted.
2. There are more than one node in the list and the last node of the list will be deleted.

In the first scenario,

the condition head → next = NULL will survive and therefore, the only node head of the list will be assigned to null. This will be done by using the following statements.

```
ptr = head
  head = NULL
  free(ptr)
```

In the second scenario,

The condition head → next = NULL would fail and therefore, we have to traverse the node in order to reach the last node of the list.

For this purpose, just declare a temporary pointer temp and assign it to head of the list. We also need to keep track of the second last node of the list. For this purpose, two pointers ptr and ptr1 will be used where ptr will point to the last node and ptr1 will point to the second last node of the list.

this all will be done by using the following statements.

```
ptr = head;
        while(ptr->next != NULL)
        {
          ptr1 = ptr;
          ptr = ptr ->next;
        }
```

Now, we just need to make the pointer ptr1 point to the NULL and the last node of the list that is pointed by ptr will become free. It will be done by using the following statements.

```
ptr1->next = NULL;
        free(ptr);
```

Algorithm

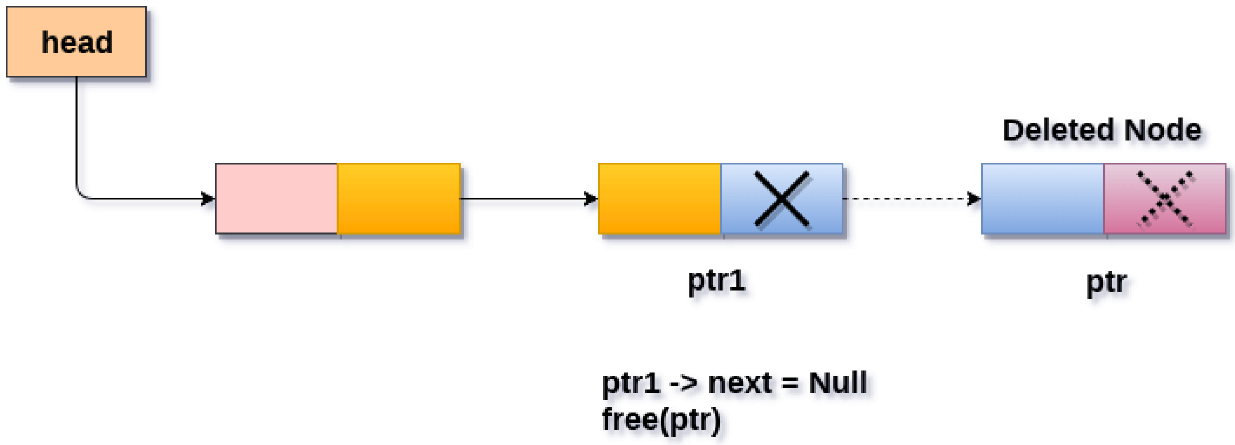
- **Step 1:** IF START = NULL

  Write UNDERFLOW
    Go to Step 8
   [END OF IF]

- **Step 2:** SET PTR = START
- **Step 3:** Repeat Steps 4 and 5 while PTR -> NEXT!= NULL
- **Step 4:** SET PREPTR = PTR
- **Step 5:** SET PTR = PTR -> NEXT

  [END OF LOOP]

- **Step 6:** SET PREPTR -> NEXT = NULL
- **Step 7:** FREE PTR
- **Step 8:** EXIT



Deleting a node from the last

PROGRAMMING

```
#include<stdio.h>
#include<stdlib.h>
void create(int);
void end_delete();
struct node
{
   int data;
   struct node *next;
};
struct node *head;
void main ()
{
   int choice,item;
   do
   {
      printf("\n1.Append List\n2.Delete node\n3.Exit\n4.Enter your choice?");
      scanf("%d",&choice);
      switch(choice)
      {
            case 1:
            printf("\nEnter the item\n");
            scanf("%d",&item);
            create(item);
            break;
            case 2:
            end_delete();
            break;
            case 3:
            exit(0);
            break;
            default:
            printf("\nPlease enter valid choice\n");
        }

    }while(choice != 3);
}
void create(int item)
    {
        struct node *ptr = (struct node *)malloc(sizeof(struct node *));
        if(ptr == NULL)
        {
            printf("\nOVERFLOW\n");
        }
        else
        {
            ptr->data = item;
            ptr->next = head;
            head = ptr;
            printf("\nNode inserted\n");
        }

    }
void end_delete()
    {
        struct node *ptr,*ptr1;
        if(head == NULL)
        {
            printf("\nlist is empty");
        }
```

```
else if(head -> next == NULL)
{
   head = NULL;
   free(head);
   printf("\nOnly node of the list deleted ...");
}

else
{
   ptr = head;
   while(ptr->next != NULL)
      {
         ptr1 = ptr;
         ptr = ptr ->next;
      }
      ptr1->next = NULL;
      free(ptr);
      printf("\n Deleted Node from the last ...");
   }
}
```

Output

```
1.Append List
2.Delete node
3.Exit
4.Enter your choice?1

Enter the item
12

Node inserted

1.Append List
2.Delete node
3.Exit
4.Enter your choice?2

Only node of the list deleted ...
```

Deletion in singly linked list after the specified node :

In order to delete the node, which is present after the specified node, we need to skip the desired number of nodes to reach the node after which the node will be deleted. We need to keep track of the two nodes. The one which is to be deleted the other one if the node which is present before that node. For this purpose, two pointers are used: ptr and ptr1.

Use the following statements to do so.

```
ptr=head;
        for(i=0;i<loc;i++)
        {
            ptr1 = ptr;
            ptr = ptr->next;

            if(ptr == NULL)
            {
                printf("\nThere are less than %d elements in the list..",loc);
                return;
            }
        }
```

Now, our task is almost done, we just need to make a few pointer adjustments. Make the next of ptr1 (points to the specified node) point to the next of ptr (the node which is to be deleted).

This will be done by using the following statements.

```
ptr1 ->next = ptr ->next;
        free(ptr);
```

Algorithm

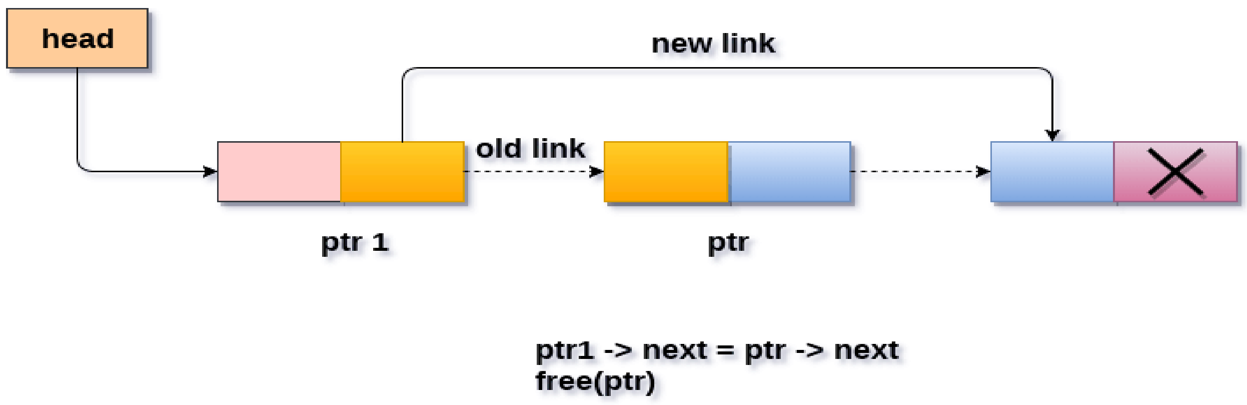
```
○ STEP 1: IF HEAD = NULL

  WRITE UNDERFLOW
      GOTO STEP 10
     END OF IF

○ STEP 2: SET TEMP = HEAD
○ STEP 3: SET I = 0
○ STEP 4: REPEAT STEP 5 TO 8 UNTIL I<loc< li=""></loc<>
○ STEP 5: TEMP1 = TEMP
○ STEP 6: TEMP = TEMP → NEXT
○ STEP 7: IF TEMP = NULL
```

```
WRITE "DESIRED NODE NOT PRESENT"
   GOTO STEP 12
   END OF IF
```

- **STEP 8:** I = I+1

  END OF LOOP

- **STEP 9:** TEMP1 → NEXT = TEMP → NEXT
- **STEP 10:** FREE TEMP
- **STEP 11:** EXIT



Deletion a node from specified position

PROGRAMMING

```
#include<stdio.h>
#include<stdlib.h>
void create(int);
void delete_specified();
struct node
{
   int data;
   struct node *next;
};
struct node *head;
void main ()
{
    int choice,item;
    do
    {
        printf("\n1.Append List\n2.Delete node\n3.Exit\n4.Enter your choice?");
        scanf("%d",&choice);
        switch(choice)
        {
            case 1:
            printf("\nEnter the item\n");
            scanf("%d",&item);
            create(item);
            break;
            case 2:
            delete_specified();
            break;
            case 3:
            exit(0);
            break;
            default:
            printf("\nPlease enter valid choice\n");
        }

    }while(choice != 3);
}
void create(int item)
    {
        struct node *ptr = (struct node *)malloc(sizeof(struct node *));
        if(ptr == NULL)
        {
            printf("\nOVERFLOW\n");
        }
        else
        {
            ptr->data = item;
            ptr->next = head;
            head = ptr;
            printf("\nNode inserted\n");
        }

    }
```

```
void delete_specified()
    {
        struct node *ptr, *ptr1;
        int loc,i;
        scanf("%d",&loc);
        ptr=head;
        for(i=0;i<loc;i++)
        {
            ptr1 = ptr;
            ptr = ptr->next;

            if(ptr == NULL)
            {
                printf("\nThere are less than %d elements in the list..\n",loc);
                return;
            }
        }
        ptr1 ->next = ptr ->next;
        free(ptr);
        printf("\nDeleted %d node ",loc);
    }
```

Output

```
1.Append List
2.Delete node
3.Exit
4.Enter your choice?1

Enter the item
12

Node inserted

1.Append List
2.Delete node
3.Exit
4.Enter your choice?1

Enter the item
23

Node inserted
```

```
1.Append List
2.Delete node
3.Exit
4.Enter your choice?2
12

There are less than 12 elements in the list..

1.Append List
2.Delete node
3.Exit
4.Enter your choice?2
1

Deleted 1 node
```

NOTE: FOR MORE ALGORITHMS REFER TO TEXT BOOK.