NAME: ADWAIT S PURAO
UID: 2021300101
EXP NO. :4
AIM: To perform Insert and Delete operations on Doubly Linked List

THEORY:

Doubly Linked List is a variation of Linked list in which navigation is possible in both ways, either forward and backward easily as compared to Single Linked List. Following are the important terms to understand the concept of doubly linked list.

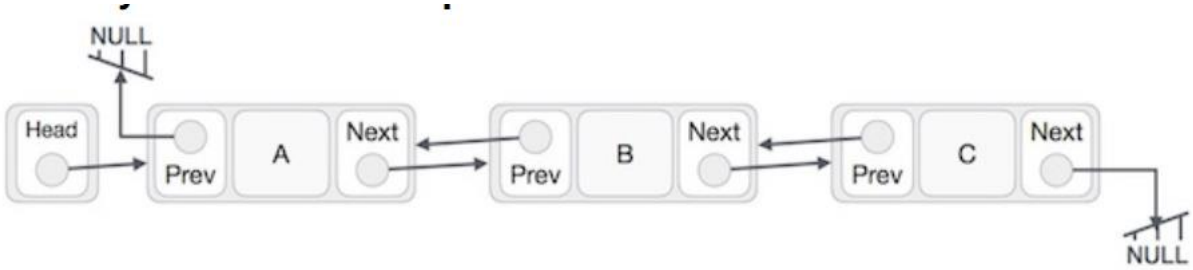
Link – Each link of a linked list can store a data called an element.

Next – Each link of a linked list contains a link to the next link called Next.

Prev – Each link of a linked list contains a link to the previous link called Prev.

LinkedList – A Linked List contains the connection link to the first link called First and to the last link called Last.

Doubly Linked List Representation



As per the above illustration, following are the important points to be considered.

Doubly Linked List contains a link element called first and last.

Each link carries a data field(s) and two link fields called next and prev.

Each link is linked with its next link using its next link.

Each link is linked with its previous link using its previous link.

The last link carries a link as null to mark the end of the list.

Advantages of DLL over the singly linked list:

A DLL can be traversed in both forward and backward directions.

The delete operation in DLL is more efficient if a pointer to the node to be deleted is given.

We can quickly insert a new node before a given node.

In a singly linked list, to delete a node, a pointer to the previous node is needed. To get this previous node, sometimes the list is traversed. In DLL, we can get the previous node using the previous pointer.

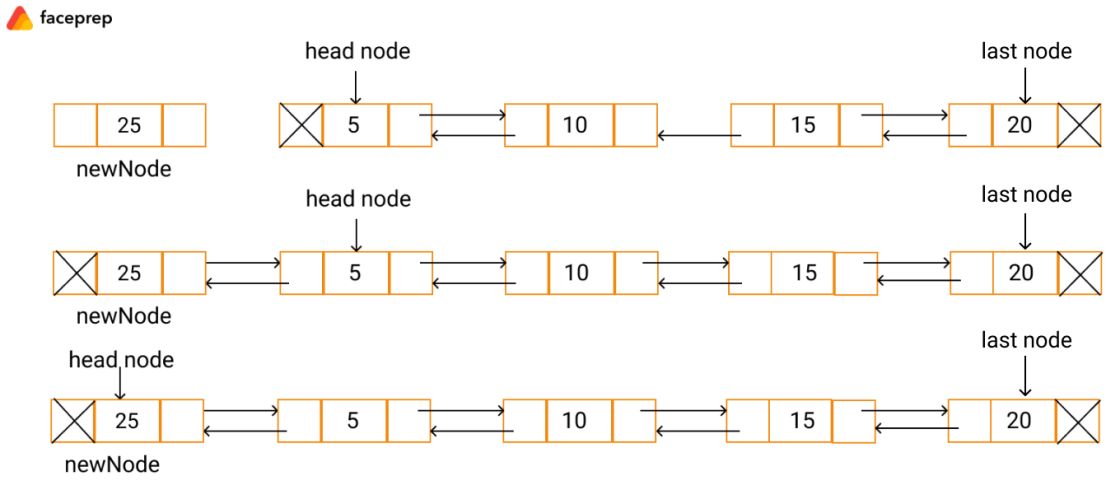
Disadvantages of DLL over the singly linked list:

Every node of DLL Requires extra space for a previous pointer. It is possible to implement DLL with a single pointer though (See this and this).

All operations require an extra pointer previous to be maintained. For example, in insertion, we need to modify previous pointers together with the next pointers. For example in the following functions for insertions at different positions, we need 1 or 2 extra steps to set the previous pointer.

Insertion in DLL:

1) Insert a node at the front:



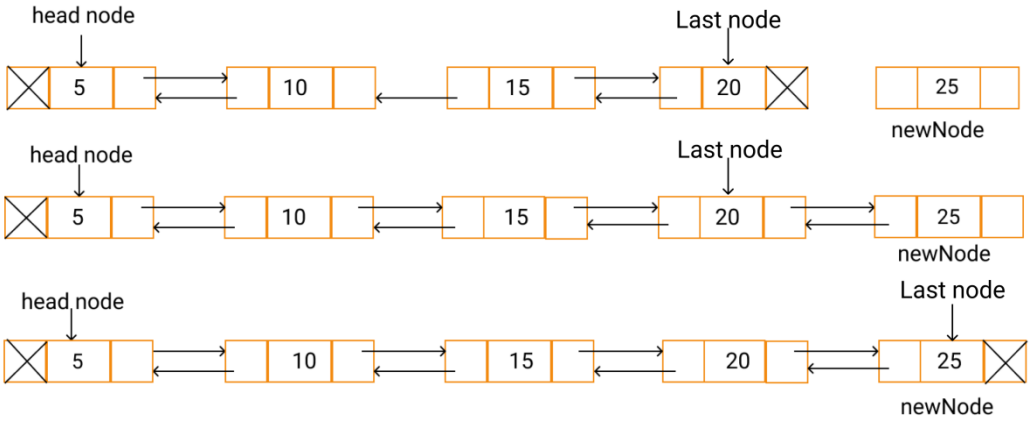
Let us assume a newNode as shown above. The newNode with data = 25 has to be inserted at the beginning of the list.

The next pointer of the newNode is referenced to the head node and its previous pointer is referenced to NULL.

The previous pointer of the head node is referenced to the newNode.

The newNode is then made as the head node.

2) Insert a node at the End:



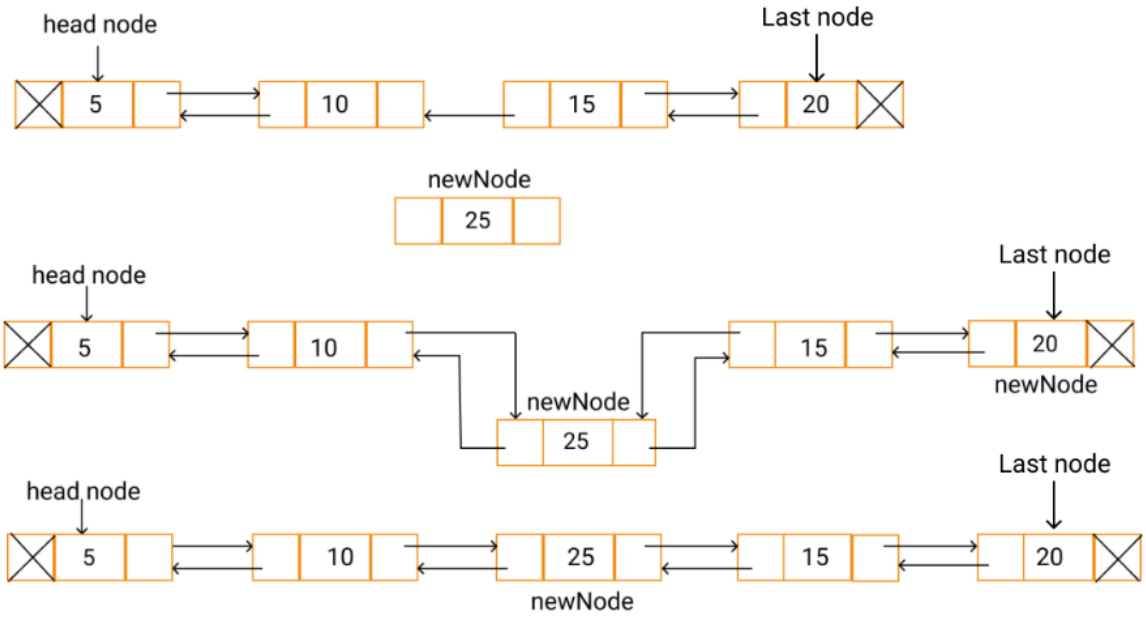
Now, let us assume a newNode as shown above. The newNode with data = 25 has to be inserted at the end of the linked list.

Make the next pointer of the last node to point to the newNode .

The next pointer of the newNode is referenced to NULL and its prev pointer is made to point to the last node.

Then, the newNode is made as the last node.

3) Insert a node before a given node:



Bring a pointer to the node(element) before which you want to insert the node

Make the previous of newNode to the previous of p

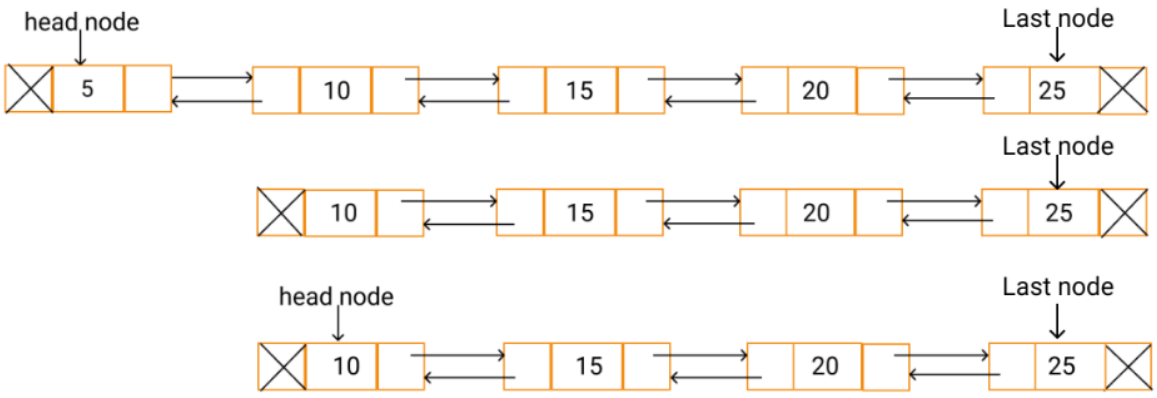
Make the next of previous of p to newNode

Make the next of newNode to p

Set the previous of p to newNode

Deletion in a DLL:

4)Deletion at start



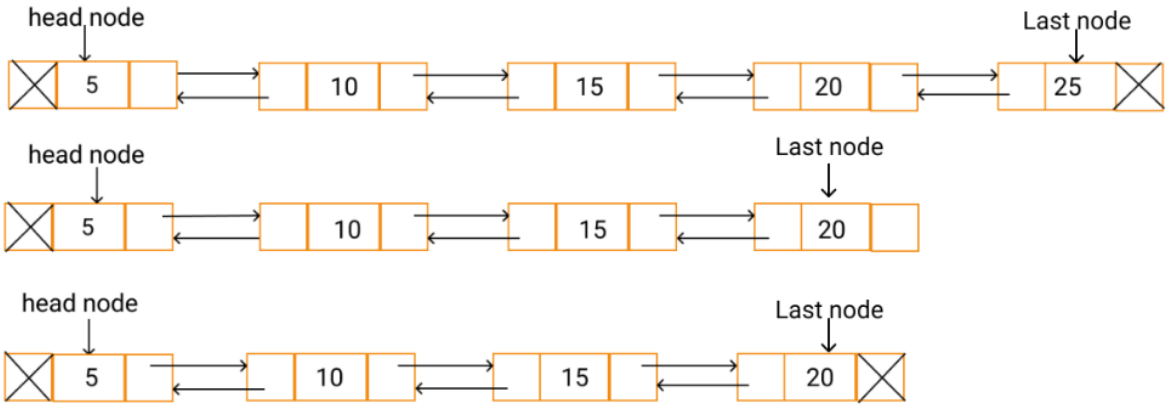
Copy the head node in some temporary node.

Make the second node as the head node.

The prev pointer of the head node is referenced to NULL.

Delete the temporary node.

5) Deletion at end



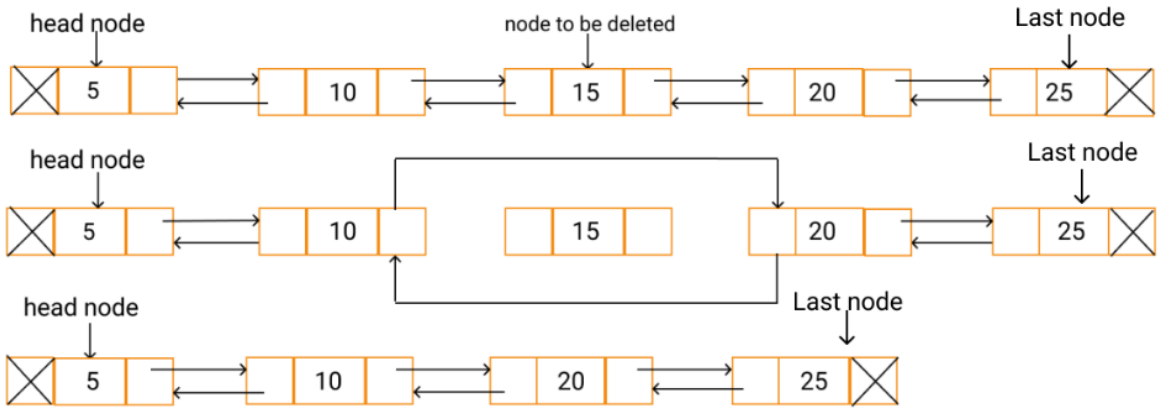
Copy the last node to a temporary node.

Shift the last node to the second last position.

Make the last node's next pointer as NULL.

Delete the temporary node.

6) Delete a node with a given value



Bring a pointer p to the element which you want to delete

Set a temporary pointer r to previous of p

Make next of r to next of p

Make the previous of next of p to the previous of p

Free p

Return head

ALGORITHM:

1)Struct node

Data members

struct node*prev

int data

struct node*next

2)Function struct node*DeleteAtEnd(struct node*head)

If head==NULL

Print Can't delete because list is empty

Return null

Else if head->next==null

Head=null

Free head

Print list is empty now

Return null

Else

Bring a pointer to the last node with the help of a while loop

Set struct node*q to p

Make p=p->prev

Free q

Return head

3) Function struct node*DeleteAtFront(struct node*head)

If head==null

Print Can't delete because the list is empty

Return null

Else if head->next==null and head->prev==null

Free head

Print list is empty now

Return null

Else

Set struct node*p =head

Set head to next of head

Make head->prev==null

Free p

Return head

4) Function struct node*InsertAtEnd(struct node*head,int data)

Allocate memory for a pointer ptr

Set ptr->data =data

If head == null

Make ptr->prev=null

Make ptr->next=null

Store ptr in head

Return head

Else

Set struct node*p = head

Bring a pointer p to the last node

Make ptr->prev=p

Make p->next =ptr

Make ptr->next =null

Return head

5) Function struct node*InsertAtFront(struct node*head,int data)

Allocate memory for ptr

Set ptr->data=data

If head==null

Make ptr->prev=null

Make ptr->next=null

Store ptr in head

Return head

Else

Make ptr->next=head

Make head->prev = ptr

Store head in ptr

Return head

6) Function struct node*InsertBeforePosition(struct node*head,int checkData,int insData)

Allocate memory for ptr

Set struct node*p = head

Store insData in ptr->data

If head==null

Print List is empty so can't insert anything

Bring a pointer to the data before which you want to insert

Set struct node*q=p->prev

If p->next ==null and p->data is not equal to checkData

Print No such element exists

Return head

Else if p->prev==null

Set ptr->prev=null

Set ptr->next=head

Set head->prev=ptr

Return head

Else

Set ptr->prev=p->prev

Set q->next=ptr

Set ptr->next=p

Set p->prev=ptr

Return head

7)Function void Display

Set struct node*temp=head

If head==null

Print List is empty

Else

Print Traversal of entire linked list

Traverse the list while temp is not equal to null

Print temp->data

Set temp=temp->next

8)Function struct node*DeleteAtPosition(struct node*head,int checkData)

Set struct node*p =head

If head==null

Print No such element exists

Return null

Traverse the list to bring pointer p to checkData

If p->next==null and p->data is not equal to checkData

Print no such element exists

Return head

Else If p->next==null and p->prev==null

Free p

Print List is empty now

Return null

Else if p->next==null

Call function DeleteAtEnd(head)

Else If p->prev==null

Call function DeleteAtFront(head)

Return head

Else If p is not equal to null

Set struct node*r= p->prev

Make r->next=p->next

Make p->next->prev=p->prev

Free p

Return head

9) Main Function

Set struct node*head=null

Initialize flag to 0

Do while (flag is not equal to 1)

Print the menu

Take user input ch

Switch (ch)

Case 1:

Take input ele

Call function InsertAtFront(head,ele)

Call function Display(head)

Case 2:

Take input ele

Call function InsertAtEnd(head,ele)

Call function Display(head)

Case 3:

Take input the element you want to insert(ele)

Take input the element before which you want to insert(check)

Call function InsertBeforePosition(head,check,ele)

Call function Display(head)

Case 4:

Call function DeleteAtFront(head)

Call function Display(head)

Case 5:

Call function DeleteAtEnd(head)

Call function Display

Case 6:

Take input of the element which you want to delete(check)

Call function DeleteAtPosition(head,check)

Call function Display

Case 7:

Set flag=1

Print Program finished

Break

Default:

Print Invalid choice

PROBLEM SOLVING ON CONCEPT:

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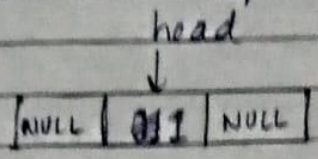
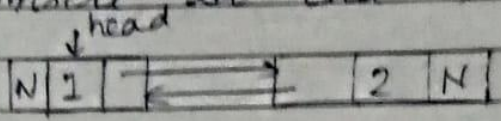
Initially, head = NULL

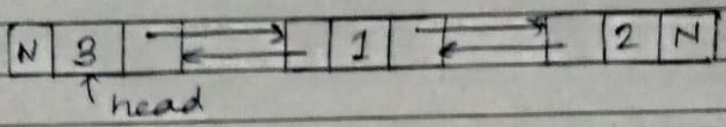
1) Insert at
1) Insert at First position (1)



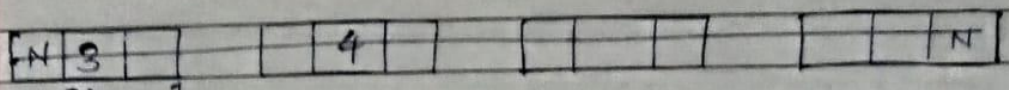
2) Insert at End (2)



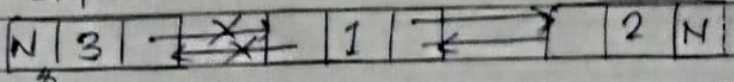
3) Insert at Front (3)

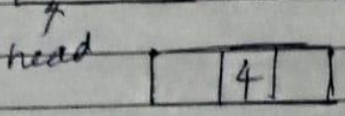


4) Insert 4 before element 1

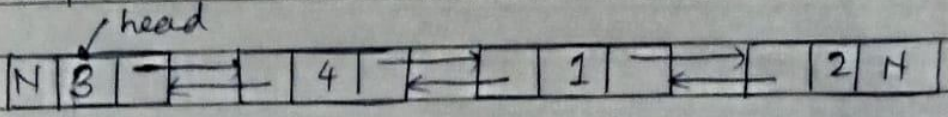


Step : 1



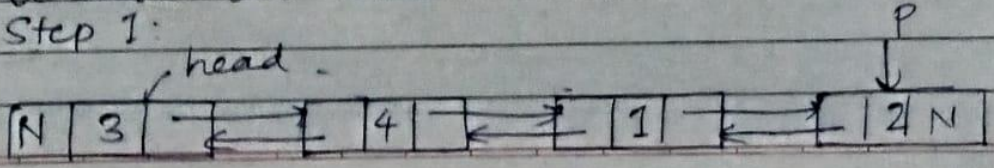


Step : 2



5) Delete at End

Step 1:



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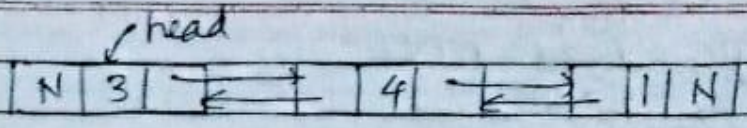
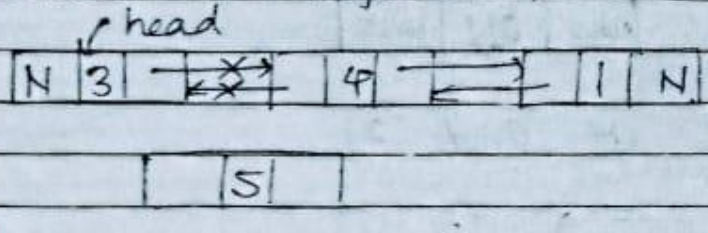


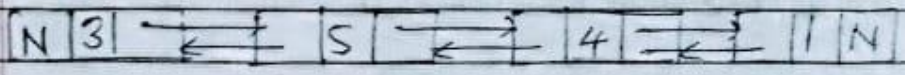
free (p)

6) Insert 5 before 4

Step : 1

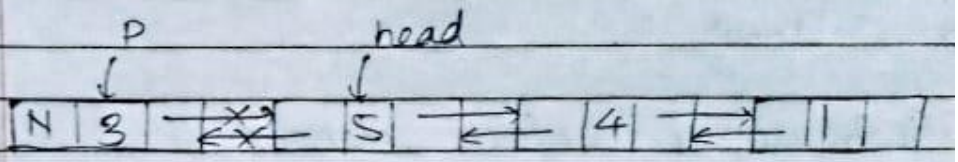


Step : 2



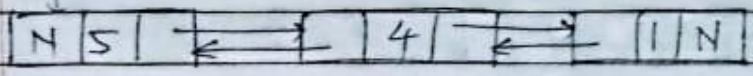
7) Delete at Front

Step : 1



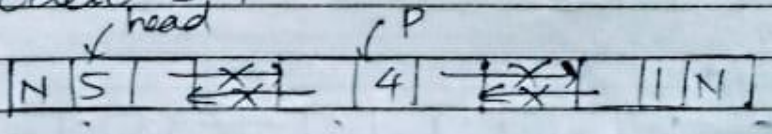
free(p)

Step 2 :



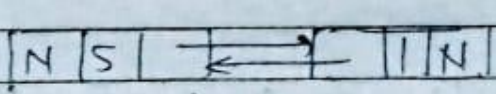
8) Delete 4

Step 1 :



free (p)

Step 2 : Final list



CODE:

```
#include<stdio.h>
#include<stdlib.h>
struct node{
    struct node*prev;
    int data;
    struct node*next;
};

struct node*DeleteAtEnd(struct node*head){
    struct node*p=head;

    if(head==NULL){
        printf("Can't delete because list is empty\n");
        return NULL;
    }
    else if(head->next==NULL){
        head=NULL;
        free(head);
        printf("List is empty now\n");
        return NULL;
    }
    else{
         while(p->next!=NULL){
            p=p->next;
        }
    struct node*q=p;
    p=p->prev;
    if(p!=NULL)
        p->next=NULL;
    free(q);
    return head;
    }
}

struct node*DeleteAtFront(struct node*head){
    if(head==NULL){
        printf("Can't delete because the list is empty\n");
        return NULL;
    }
    else if(head->next==NULL && head->prev==NULL){
        free(head);
        printf("List is empty now\n");
        return NULL;
    }
    else{
    struct node*p=head;
```

```
    head=head->next;
    head->prev=NULL;
    free(p);
    return head;
    }
}

struct node*InsertAtEnd(struct node*head,int data){
    struct node*ptr=(struct node*)malloc(sizeof(struct node));
    ptr->data=data;

    if(head==NULL){
        ptr->prev=NULL;
        ptr->next=NULL;
        head=ptr;
        return head;
    }
    else{
        struct node*p=head;

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

        ptr->prev=p;
        p->next=ptr;
        ptr->next=NULL;
        return head;
    }

}

struct node*InsertAtFront(struct node*head,int data){
    struct node*ptr=(struct node*)malloc(sizeof(struct node));
    //struct node*p=head;
    ptr->data=data;
    if(head==NULL){

        ptr->prev=NULL;
        ptr->next=NULL;
        head=ptr;
        return head;
    }
    else{

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

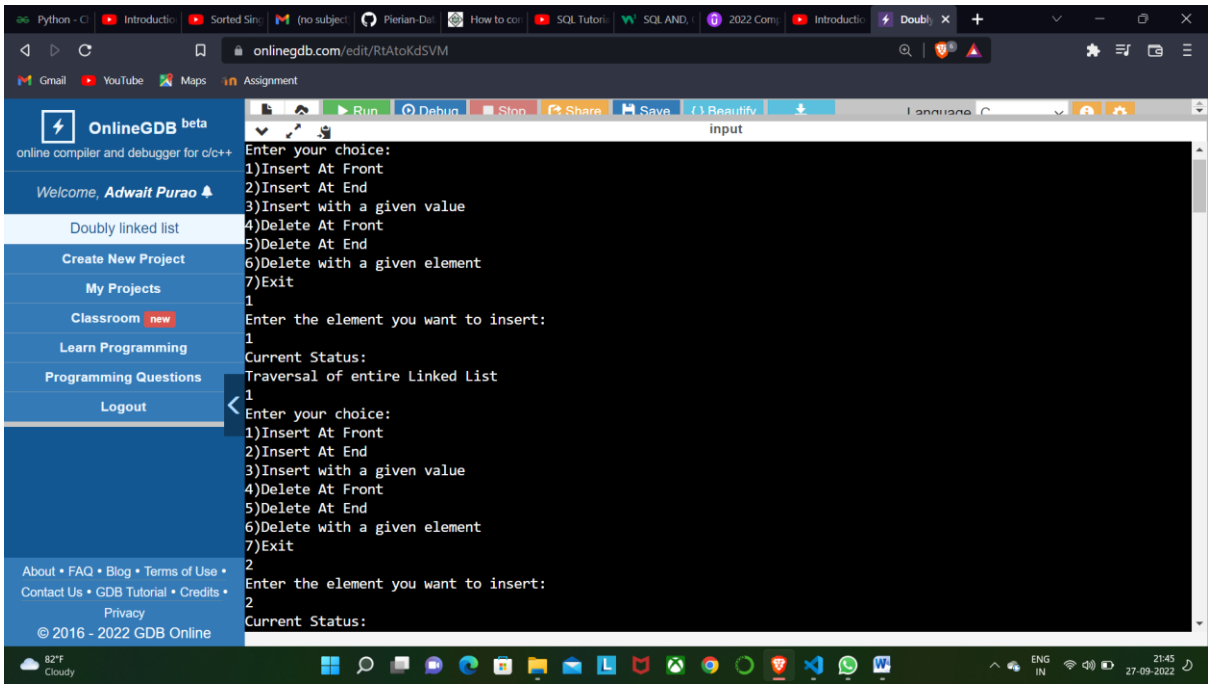
```
    return head;
    }
}

struct node*InsertBeforePosition(struct node*head,int checkData,int insData){
    struct node*ptr=(struct node*)malloc(sizeof(struct node));
    struct node*p=head;

    ptr->data=insData;

    while(p->data!=checkData && p->next!=NULL){
        p=p->next;
    }

    struct node*q=p->prev;
    if(p->next==NULL && p->data!=checkData){
        printf("No such element exists!\n");
        return head;
    }
    else if(p->prev==NULL){
        ptr->prev=NULL;
        ptr->next=head;
        head->prev=ptr;
        head=ptr;
        return head;
    }
    else{
        ptr->prev=p->prev;
        q->next=ptr;
        ptr->next=p;
        p->prev=ptr;
        return head;
    }

}

void Display(struct node*head){
    struct node*temp=head;
    if(head==NULL)
        printf("List is empty!\n");

    else{
    printf("Traversal of entire Linked List\n");
    while(temp!=NULL){
        printf("%d ",temp->data);
        temp=temp->next;
        }
    }
```

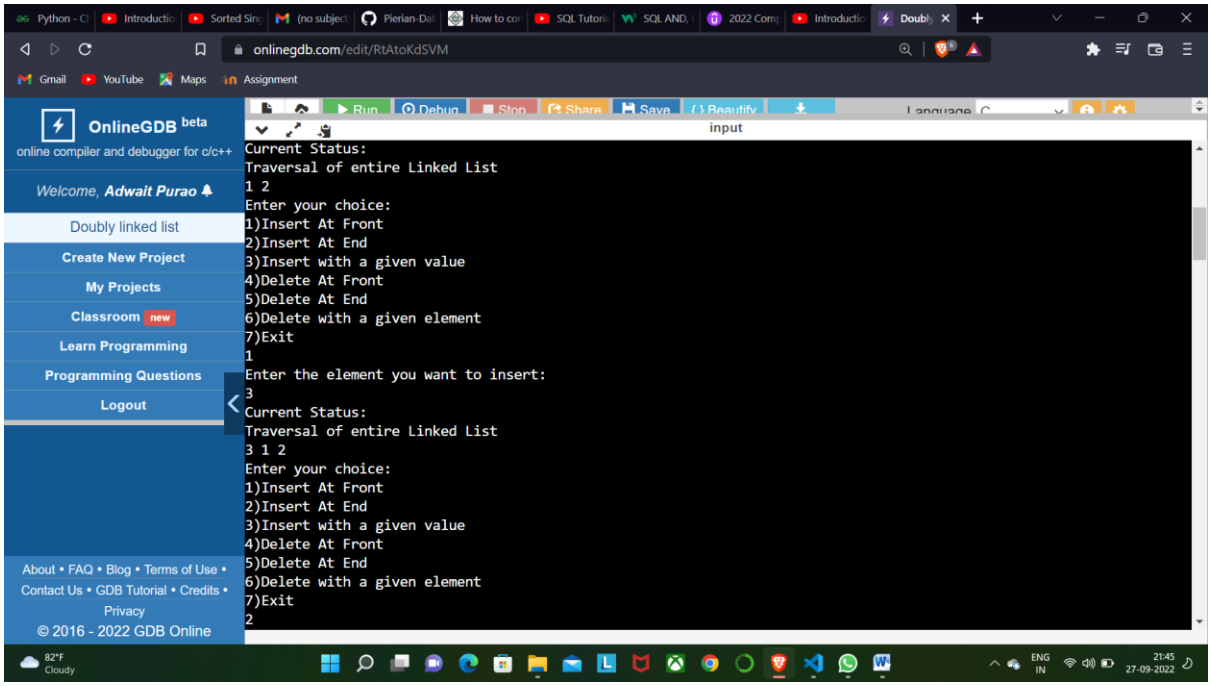
```
}

struct node*DeleteAtPosition(struct node*head,int checkData){
    struct node*p=head;

    while(p->data!=checkData){
        p=p->next;
    }
    if(p->next==NULL && p->data!=checkData){
        printf("No such element exists!\n");
        return head;
    }
    else if(p->next==NULL && p->prev==NULL){
        free(p);
        printf("List is empty now\n");
        return NULL;
    }
    else if(p->next==NULL){
        head=DeleteAtEnd(head);
        return head;
    }
    else if(p->prev==NULL){
        head=DeleteAtFront(head);
        return head;
    }
    else if(p!=NULL){
        struct node*r=p->prev;
        r->next=p->next;
        p->next->prev=p->prev;
        free(p);
        return head;
    }
}




int main(){
    struct node*head=NULL;
    int flag=0;
    do {
    int ch;

    printf("\n\nEnter your choice:\n");
    printf("1)Insert At Front\n2)Insert At End\n3)Insert with a given
value\n");
    printf("4)Delete At Front\n5)Delete At End\n6)Delete with a given
element\n7)Exit\n");
    scanf("%d",&ch);
```

```
    switch(ch){
        case 1:
        {
            int ele;
            printf("Enter the element you want to insert:\n");
            scanf("%d",&ele);
            head=InsertAtFront(head,ele);
            printf("Current Status:\n");
            Display(head);
            break;
        }
        case 2:
        {
            int ele;
            printf("Enter the element you want to insert:\n");
            scanf("%d",&ele);
            head=InsertAtEnd(head,ele);
            printf("Current Status:\n");
            Display(head);
            break;
        }
        case 3:
        {
            int ele,check;
            printf("Enter the element you want to insert:\n");
            scanf("%d",&ele);
            printf("Enter the element before which you want to insert:\n");
            scanf("%d",&check);
            head=InsertBeforePosition(head,check,ele);
            printf("Current Status:\n");
            Display(head);
            break;
        }
        case 4:
        {
            head=DeleteAtFront(head);
            printf("Current Status:\n");
            Display(head);
            break;
        }
        case 5:
        {
            head=DeleteAtEnd(head);
            printf("Current Status:\n");
            Display(head);
            break;
        }
        case 6:
```

```
        {
            int check;
            printf("Enter the element which you want to delete:\n");
            scanf("%d",&check);
            head=DeleteAtPosition(head,check);
            printf("Current Status:\n");
            Display(head);
            break;
        }
        case 7:
        {
            flag=1;
            printf("Program finished\n");
            break;
        }
        default:
        {
            printf("Invalid choice!\n");
            break;
        }
    }
    }while(flag!=1);

    return 0;
}
```

OUTPUT SCREENSHOT:

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OnlineGDB beta
online compiler and debugger for c/c++
Welcome, Adwait Purao
Doubly linked list
Create New Project
My Projects
Classroom new
Learn Programming
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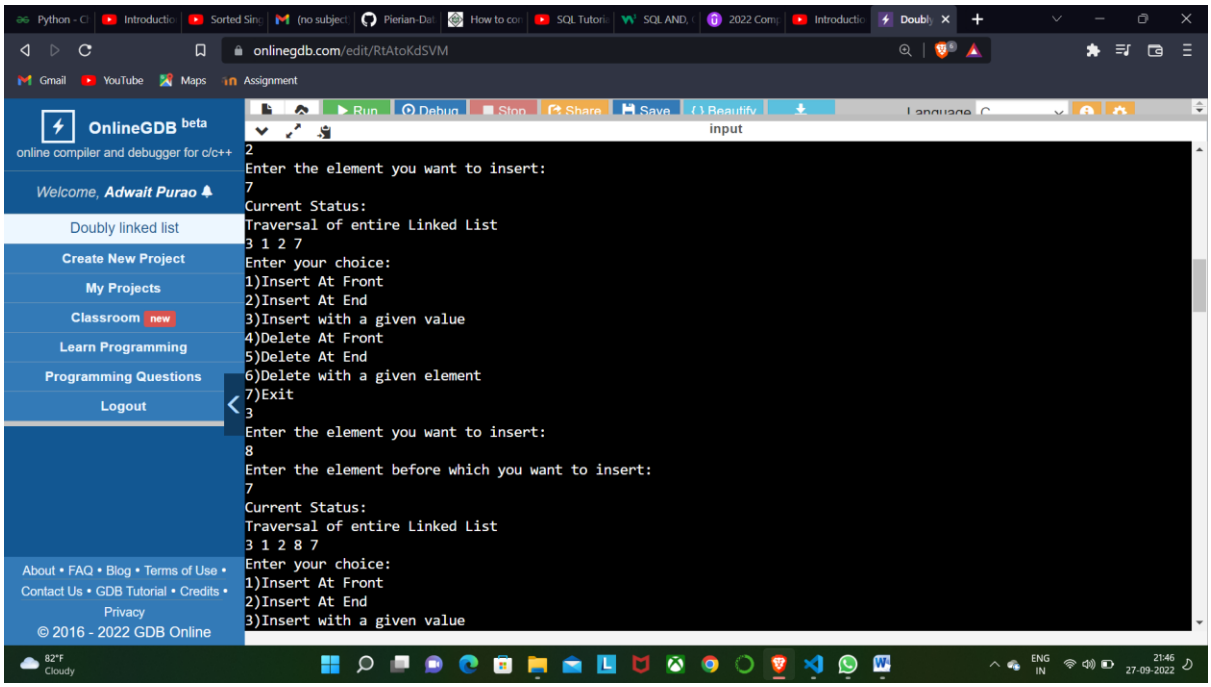
input
Current Status:
Traversal of entire Linked List
1 2
Enter your choice:
1)Insert At Front
2)Insert At End
3)Insert with a given value
4)Delete At Front
5)Delete At End
6)Delete with a given element
7)Exit
1
Enter the element you want to insert:
3
Current Status:
Traversal of entire Linked List
3 1 2
Enter your choice:
1)Insert At Front
2)Insert At End
3)Insert with a given value
4)Delete At Front
5)Delete At End
6)Delete with a given element
7)Exit
2


onlinegdb.com/edit/RtAtoKdSVM
OnlineGDB beta
online compiler and debugger for c/c++
Welcome, Adwait Purao
Doubly linked list
Create New Project
My Projects
Classroom new
Learn Programming
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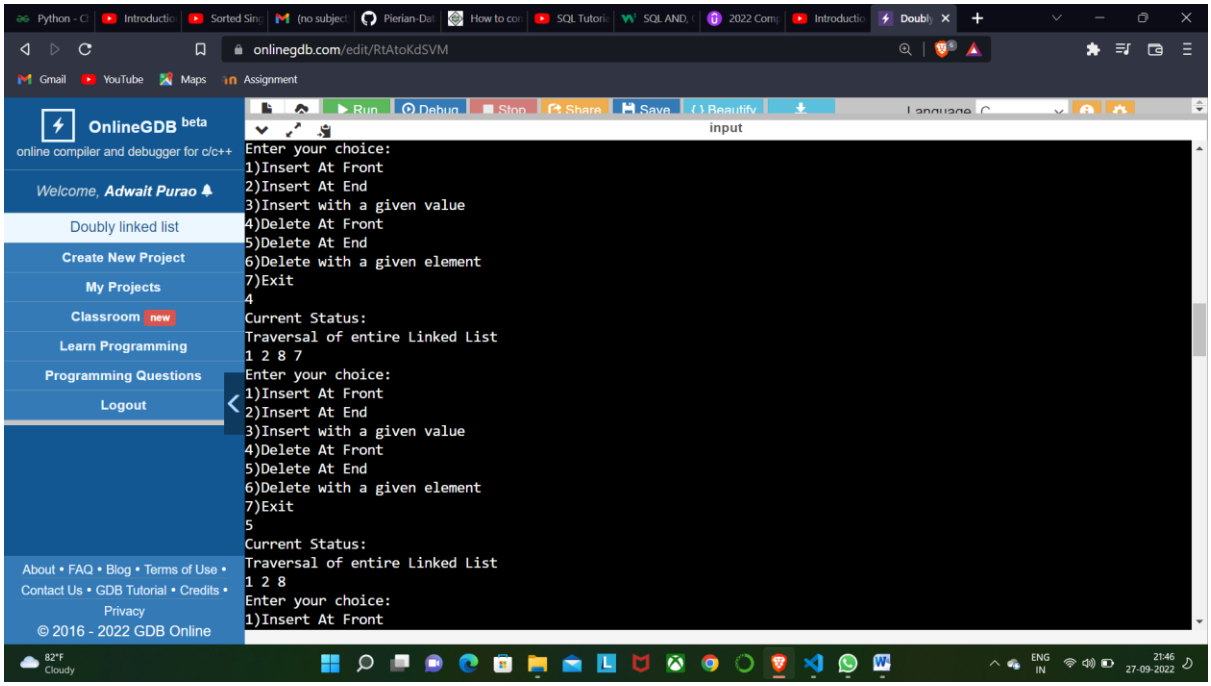
input
2
Enter the element you want to insert:
7
Current Status:
Traversal of entire Linked List
3 1 2 7
Enter your choice:
1)Insert At Front
2)Insert At End
3)Insert with a given value
4)Delete At Front
5)Delete At End
6)Delete with a given element
7)Exit
3
Enter the element you want to insert:
8
Enter the element before which you want to insert:
7
Current Status:
Traversal of entire Linked List
3 1 2 8 7
Enter your choice:
1)Insert At Front
2)Insert At End
3)Insert with a given value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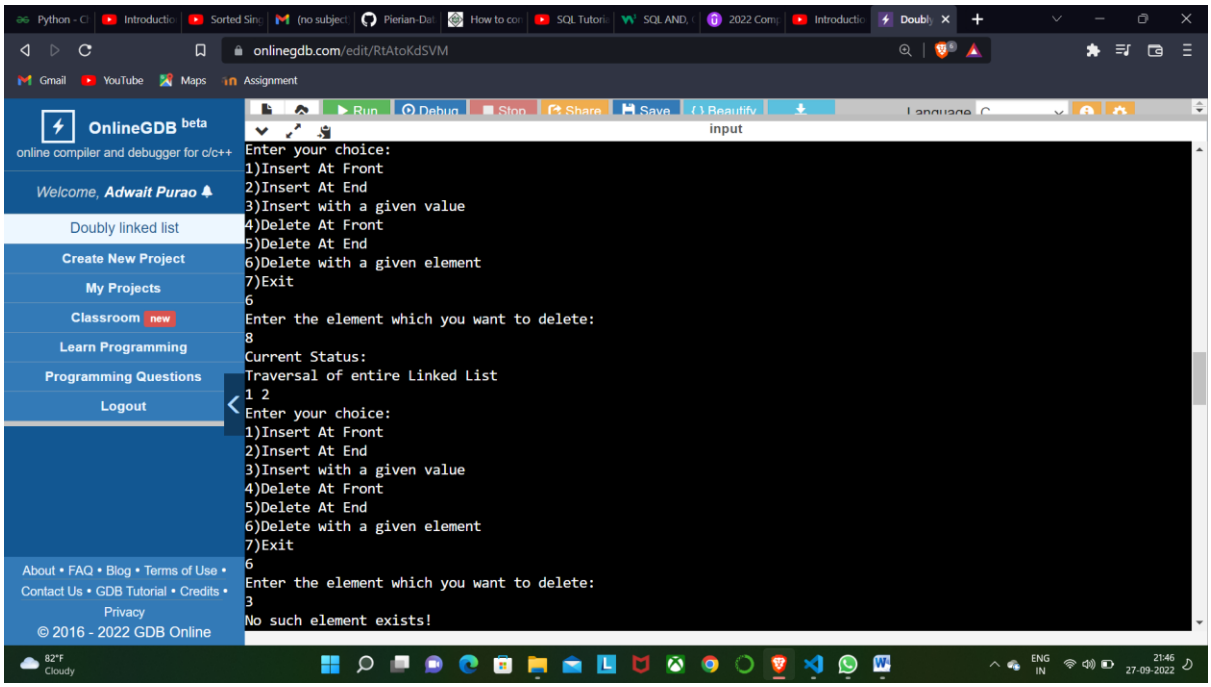
input
Enter your choice:
1)Insert At Front
2)Insert At End
3)Insert with a given value
4)Delete At Front
5)Delete At End
6)Delete with a given element
7)Exit
4
Current Status:
Traversal of entire Linked List
1 2 8 7
Enter your choice:
1)Insert At Front
2)Insert At End
3)Insert with a given value
4)Delete At Front
5)Delete At End
6)Delete with a given element
7)Exit
5
Current Status:
Traversal of entire Linked List
1 2 8
Enter your choice:
1)Insert At Front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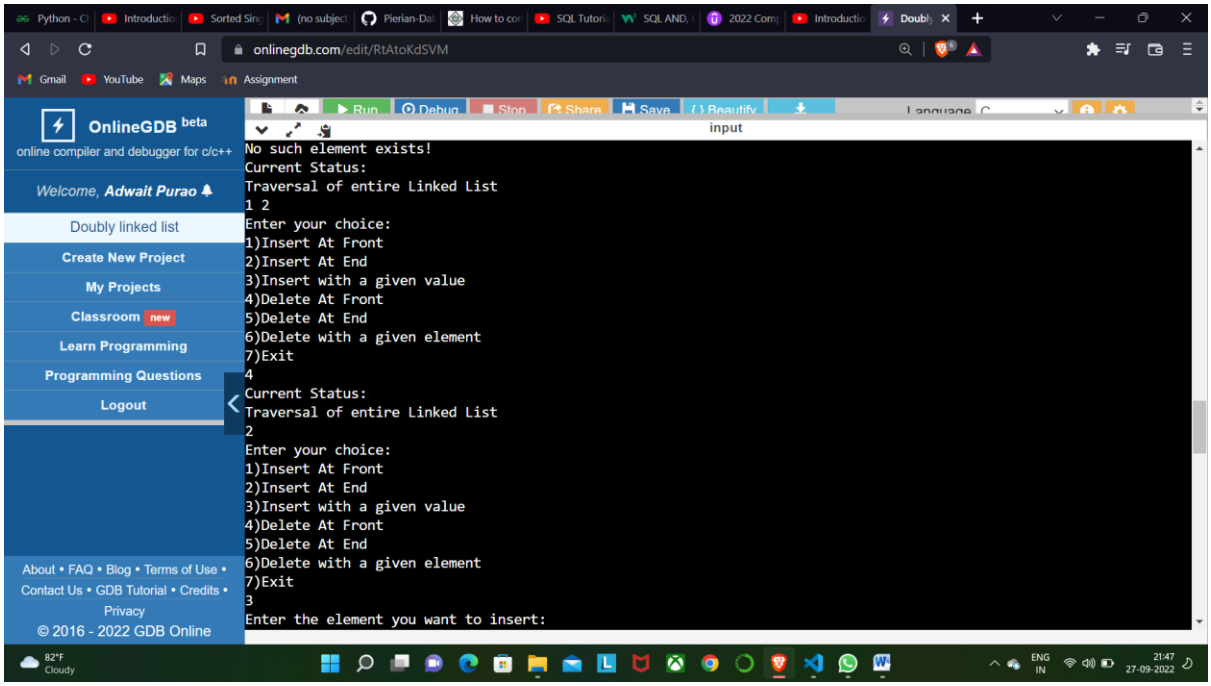
input
Enter your choice:
1)Insert At Front
2)Insert At End
3)Insert with a given value
4)Delete At Front
5)Delete At End
6)Delete with a given element
7)Exit
6
Enter the element which you want to delete:
8
Current Status:
Traversal of entire Linked List
1 2
Enter your choice:
1)Insert At Front
2)Insert At End
3)Insert with a given value
4)Delete At Front
5)Delete At End
6)Delete with a given element
7)Exit
6
Enter the element which you want to delete:
3
No such element exists!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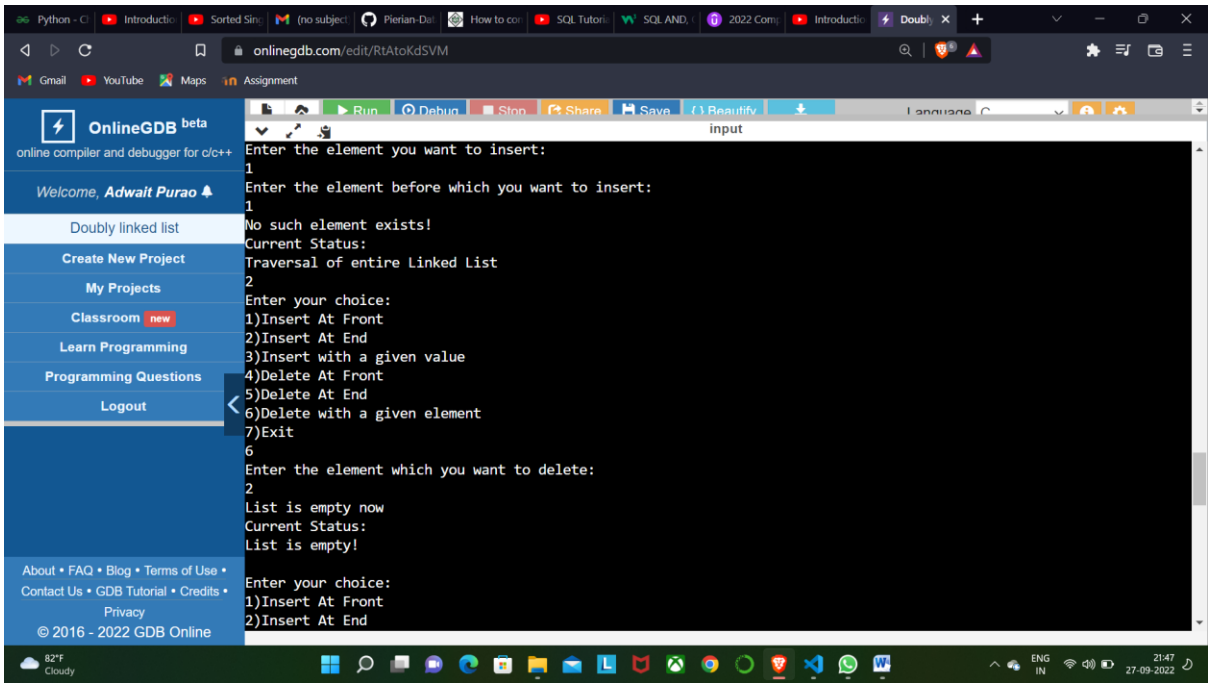
input
No such element exists!
Current Status:
Traversal of entire Linked List
1 2
Enter your choice:
1)Insert At Front
2)Insert At End
3)Insert with a given value
4)Delete At Front
5)Delete At End
6)Delete with a given element
7)Exit
4
Current Status:
Traversal of entire Linked List
2
Enter your choice:
1)Insert At Front
2)Insert At End
3)Insert with a given value
4)Delete At Front
5)Delete At End
6)Delete with a given element
7)Exit
3
Enter the element you want to insert: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Run
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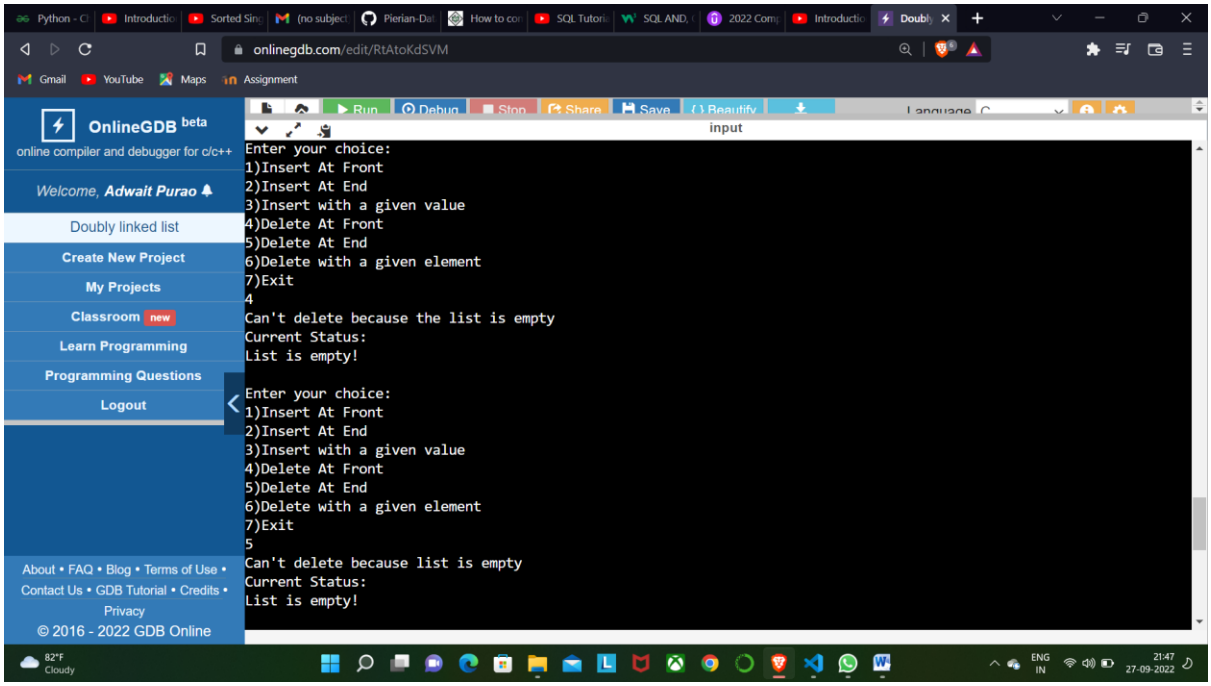
Beautify
input
Enter the element you want to insert:
1
Enter the element before which you want to insert:
1
No such element exists!
Current Status:
Traversal of entire Linked List
2
Enter your choice:
1)Insert At Front
2)Insert At End
3)Insert with a given value
4)Delete At Front
5)Delete At End
6)Delete with a given element
7)Exit
6
Enter the element which you want to delete:
2
List is empty now
Current Status:
List is empty!
Enter your choice:
1)Insert At Front
2)Insert At End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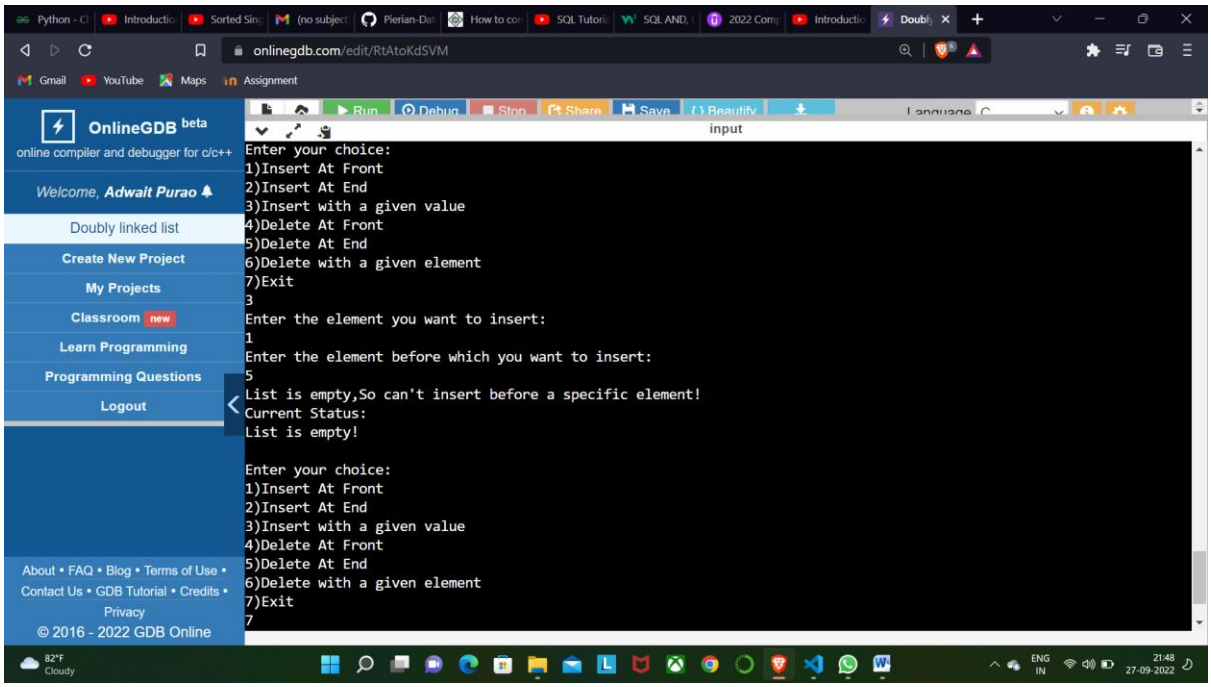
Beautify
input
Enter your choice:
1)Insert At Front
2)Insert At End
3)Insert with a given value
4)Delete At Front
5)Delete At End
6)Delete with a given element
7)Exit
4
Can't delete because the list is empty
Current Status:
List is empty!
Enter your choice:
1)Insert At Front
2)Insert At End
3)Insert with a given value
4)Delete At Front
5)Delete At End
6)Delete with a given element
7)Exit
5
Can't delete because list is empty
Current Status:
List is empty!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Run
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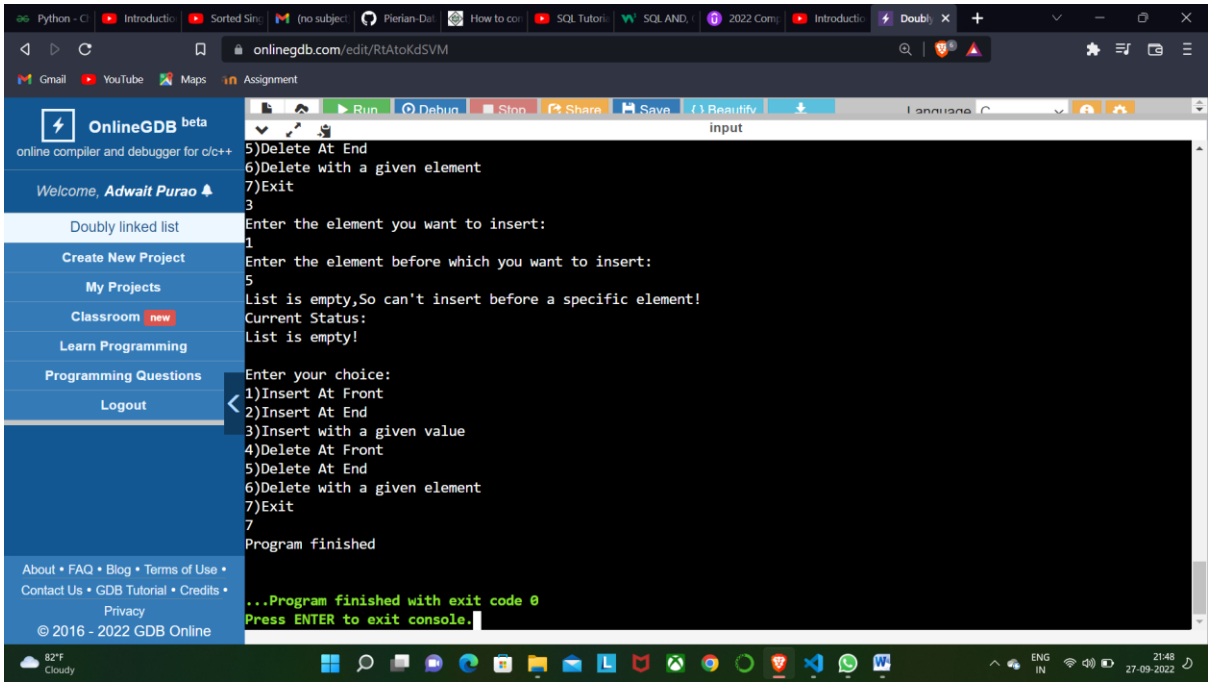
Stop
Share
Save
Beautify
input
Enter your choice:
1)Insert At Front
2)Insert At End
3)Insert with a given value
4)Delete At Front
5)Delete At End
6)Delete with a given element
7)Exit
3
Enter the element you want to insert:
1
Enter the element before which you want to insert:
5
List is empty,So can't insert before a specific element!
Current Status:
List is empty!
Enter your choice:
1)Insert At Front
2)Insert At End
3)Insert with a given value
4)Delete At Front
5)Delete At End
6)Delete with a given element
7)Exit
7



CONCLUSION:

In the help of this experiment we learnt about the Doubly Linked Lists. We understood the internal structure of a Doubly linked list which contains data,pointer to the previous node and pointer to the next node. We learnt that a Doubly linked list has previous of head equal to NULL and next of last node equal to NULL. We learnt about the malloc function used to allocate memory. We performed various functions on Doubly linked list like Insertion at first, Insertion at end, Delete at end, Delete at end , Insert before a particular index, delete before a particular index and Traversal of Doubly linked list.