ASSIGNMENT IX:
Doubly Linked List Implementation
U19CS012 [D-12]

Implement the following operations in context to singly linked list:

1) Creation & Display of Doubly Linked List
2) Insertion (at beginning, middle and end)
3) Deletion (from beginning, middle and end)
4.) Search for a Specific Element
5.) Find the Maximum and Minimum Element in Doubly Linked List

Code:

```c
#include <stdio.h>
// For Exit Function
#include <stdlib.h>

// Structure for Each Node
struct node
{
    struct node *prev;
    int data;
    struct node *next;
};

// head Pointer -> head of Linked List
struct node *head = NULL;

//Helper Functions

// 1 -> Creation of Linked List

// Creation of the Doubly Linked List
void CREATION_DLL();
// Display of the Whole Doubly Linked List
void DISPLAY_DLL();
// Returns the Length of Doubly Linked List
int LENGTH_DLL();

// 2 -> Insertion in Linked List

// Insert at the Beginning of Linked List
void Insert_Begin();
```

```c
// Insert at the End of Linked List
void Insert_End();
// Insert in the Middle Of the Linked List
void Insert_Middle();

// 3 -> Deletion in the Linked List

// Delete at the Beginning of Linked List
void Delete_Begin();
// Delete at the End of Linked List
void Delete_End();
// Delete in the Middle Of the Linked List
void Delete_Middle();
//Deletes Node at Particular Position
void Delete_Position();
// Deletes all Nodes with Particular Value
void Delete_Value();

// 4 -> Search in the Doubly Linked List
void Search();

// 5 -> Find the Max and Min in Doubly Linked List
void Max_Min();

void main()
{
    printf("\nDOUBLY LINKED LIST\n");

    printf(" 1 -> Create a Doubly Linked List\n");
    printf(" 2 -> Display the Doubly Linked List\n");
    printf(" 3 -> Insert at the Beginning of Doubly Linked List\n");
    printf(" 4 -> Insert at the End of Doubly Linked List\n");
    printf(" 5 -> Insert at Middle of Doubly Linked List\n");
    printf(" 6 -> Delete from Beginning of Doubly Linked List\n");
    printf(" 7 -> Delete from the End of Doubly Linked List\n");
    printf(" 8 -> Delete at Middle of Doubly Linked List\n");
    printf(" 9 -> Search in Doubly Linked List\n");
    printf(" 10 -> Find Maximum and Minimum in Doubly Linked List\n");
    printf(" 11 -> Exit\n");

    int choice;
    while (1)
    {
        printf("Enter your choice : ");
        scanf("%d", &choice);

        switch (choice)
        {
        case 1:
            CREATION_DLL();
```

```
            break;
        case 2:
            DISPLAY_DLL();
            break;
        case 3:
            Insert_Begin();
            break;
        case 4:
            Insert_End();
            break;
        case 5:
            // Insert at Middle of DLL
            Insert_Middle();
            break;
        case 6:
            Delete_Begin();
            break;
        case 7:
            Delete_End();
            break;
        case 8:
            // Delete at Middle of DLL
            Delete_Middle();
            break;
        case 9:
            Search();
            break;
        case 10:
            Max_Min();
            break;
        case 11:
            exit(0);
            break;
        default:
            printf("Enter a Valid Choice!");
            break;
        }
    }
}

// Creation of the Doubly Linked List
void CREATION_DLL()
{
    struct node *ptr;

    ptr = (struct node *)malloc(sizeof(struct node));

    if (ptr == NULL)
    {
        printf("No Memory Space on Device!\n");
```

```
    }
    else
    {
        int Element;
        printf("Enter Value of Node : ");
        scanf("%d", &Element);

        if (head == NULL)
        {
            // List is Empty
            ptr->next = NULL;
            ptr->prev = NULL;
            ptr->data = Element;
            // Point the new Node to head
            head = ptr;
        }
        else
        {
            // Insert at Beginning by Default
            ptr->data = Element;
            ptr->prev = NULL;
            ptr->next = head;
            head->prev = ptr;
            head = ptr;
        }
        printf("Node Inserted Successfully!\n");
    }
}

// Display of the Whole Doubly Linked List
void DISPLAY_DLL()
{
    struct node *ptr;

    printf("DOUBLY LINKED LIST : \n");
    ptr = head;

    if (ptr == NULL)
    {
        printf("List is Empty! List has No Nodes!\n");
        return;
    }
    else
    {
        printf("NULL <=> ");
        while (ptr != NULL)
        {
            printf("%d <=> ", ptr->data);
            ptr = ptr->next;
        }
```

```
        printf("NULL\n");
    }
}

// Display the Length of Linked List
int LENGTH_DLL()
{
    struct node *ptr;
    ptr = head;
    if (ptr == NULL)
    {
        // Empty List
        return 0;
    }
    else
    {
        int cnt = 0;
        // ptr is Pointing to Head
        while (ptr != NULL)
        {
            cnt++;
            ptr = ptr->next;
        }
        return cnt;
    }
}

// Insert at the Beginning of Linked List
void Insert_Begin()
{
    struct node *ptr;
    int Element;

    ptr = (struct node *)malloc(sizeof(struct node));

    if (ptr == NULL)
    {
        printf("No Memory Space on Device!\n");
    }
    else
    {
        printf("Enter Value of Node : ");
        scanf("%d", &Element);

        // If the Linked List is Empty
        if (head == NULL)
        {
            ptr->next = NULL;
            ptr->prev = NULL;
            ptr->data = Element;
```

```
            head = ptr;
        }
        else
        {
            // If the Linked List is Not Empty
            // Insert at Beginning
            ptr->data = Element;
            ptr->prev = NULL;
            ptr->next = head;

            head->prev = ptr;
            head = ptr;
        }
        printf("Node Inserted Succesfully!\n");
    }
}

// Insert at the End of Linked List
void Insert_End()
{
    struct node *ptr, *temp;
    ptr = (struct node *)malloc(sizeof(struct node));

    if (ptr == NULL)
    {
        printf("No Memory Space on Device!\n");
    }
    else
    {
        int Element;
        printf("Enter Value of Node : ");
        scanf("%d", &Element);
        ptr->data = Element;

        if (head == NULL)
        {
            // If List is Empty
            ptr->next = NULL;
            ptr->prev = NULL;
            head = ptr;
        }
        else
        {
            // Traverse till End of List
            temp = head;
            while (temp->next != NULL)
            {
                temp = temp->next;
            }
            // Link Management
```

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

            ptr->next = NULL;
        }
    }
    printf("Node Inserted Succesfully!\n");
}

// Insert in the Middle Of the Linked List
void Insert_Middle()
{
    struct node *ptr;
    int pos;
    struct node *temp;
    int Element, i;
    ptr = (struct node *)malloc(sizeof(struct node));

    if (ptr == NULL)
    {
        printf("No Memory Space on Device!\n");
    }
    else
    {

        temp = (struct node *)malloc(sizeof(struct node));

        printf("Enter the Position for the New Node to be Inserted : ");
        scanf("%d", &pos);

        // pos = 1 -> Insertion at Beginning of LL
        // pos = len + 1 -> Insertion at Ending of LL

        // Length of the Linked List
        int len = LENGTH_DLL();

        if (pos <= 0 || pos > len + 1)
        {
            printf("Enter Valid Postion for Insertion!\n");
            return;
        }

        // Creation of New Node { NULL<-[?]->NULL }
        printf("Enter the Data to be stored in Node : ");
        scanf("%d", &Element);
        ptr->data = Element;

        if (pos == 1)
        {
            // At the Beginning of Linked List
```

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

            head->prev = ptr;
            head = ptr;
        }
        else if (pos == len + 1)
        {

            // Traverse till End of List
            temp = head;
            while (temp->next != NULL)
            {
                temp = temp->next;
            }
            // Link Management
            temp->next = ptr;
            ptr->prev = temp;

            ptr->next = NULL;
        }
        else
        {
            for (i = 1, temp = head; i < pos - 1; i++)
            {
                temp = temp->next;
            }
            // Link Management
            // [temp] -> [temp->next]
            ptr->next = temp->next;
            ptr->prev = temp;

            temp->next = ptr;
            (temp->next)->prev = ptr;
        }

        printf("Node Inserted Succesfully!\n");
    }
}

// Delete at the Beginning of Linked List
void Delete_Begin()
{
    struct node *ptr;
    if (head == NULL)
    {
        printf("List is Empty! UnderFlow Condition!\n");
    }
    else if (head->next == NULL)
    {
```

```
        // Only One Element in the Linked List
        head = NULL;
        // Release the Memory
        free(head);
        printf("Node Deleted Succesfully!\n");
    }
    else
    {
        // To Hold Address of Node to be Deleted
        ptr = head;
        // Delete Front Logic
        head = head->next;
        head->prev = NULL;
        // Release the Memory
        free(ptr);
        printf("Node Deleted Successfully!\n");
    }
}

// Delete at the End of Linked List
void Delete_End()
{
    struct node *ptr;
    if (head == NULL)
    {
        printf("List is Empty! UnderFlow Condition!\n");
        return;
    }
    else if (head->next == NULL)
    {
        // Only One Element in the Linked List
        head = NULL;
        // Release the Memory
        free(head);
        printf("Node Deleted Successfully!\n");
        return;
    }
    else
    {
        if (ptr == NULL)
        {
            printf("No Memory Space on Device!\n");
            return;
        }

        ptr = head;

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

```
        }

        (ptr->prev)->next = ptr->next;

        free(ptr);
        printf("Node Deleted Successfully!\n");
    }
}

// Delete in the Middle Of the Linked List
void Delete_Middle()
{
    if (head == NULL)
    {
        printf("List is Empty! No Deletion Possible!!\n");
        return;
    }
    else
    {
        int ch = 0;
        printf("Delete A Node By : \n");
        printf(" 1 -> Position\n");
        printf(" 2 -> Value\n");
        printf("Enter Your Choice : ");
        scanf("%d", &ch);

        switch (ch)
        {
        case 1:
            Delete_Position();
            break;
        case 2:
            Delete_Value();
            break;
        default:
            printf("Enter a Valid Choice!\n");
            break;
        }
    }
}

//Deletes Node at Particular Position
void Delete_Position()
{
    int i, pos;
    struct node *temp, *ptr;

    printf("Enter the Position of the Node to be Deleted : ");
    scanf("%d", &pos);
```

```c
    // pos = 1 -> Deletion at Beginning of LL
    // pos = len -> Deletion at Ending of LL

    // Length of the Linked Lst
    int len = LENGTH_DLL();

    if (pos <= 0 || pos > len)
    {
        printf("Enter Valid Postion for Deletion!\n");
        return;
    }

    if (pos == 1)
    {
        Delete_Begin();
    }
    else if (pos == len)
    {
        Delete_End();
    }
    else
    {
        ptr = head;
        for (i = 1; i < pos; i++)
        {
            ptr = ptr->next;
        }
        // point the prev of {element to be deleted} to "next of deleted"
        // []     []     []
        //       ptr
        printf("ptr data : %d\n", ptr->data);
        temp = ptr->prev;
        temp->next = ptr->next;
        (ptr->next)->prev = temp;

        printf("Node Deleted Successfully!\n");
        free(ptr);
    }
}

// Deletes all Nodes with Particular Value
void Delete_Value()
{
    int value;
    struct node *temp, *ptr;

    printf("Enter the Value of the Node to be Deleted : ");
    scanf("%d", &value);

    int flag = 0;
```

```
if (head == NULL)
{
    printf("List is Empty!No Deletions Possible\n");
    return;
}
else
{
    // Head Pointer
    ptr = head;
    while (ptr != NULL)
    {

        // If the Value of Node = Value of Node to be Deleted
        if (ptr->data == value)
        {
            if (ptr == head)
            {
                Delete_Begin();
                flag = 1;
            }
            else
            {
                // Element to be deleted is Not the Last Node
                if (ptr->next != NULL)
                {
                    (ptr->prev)->next = ptr->next;
                    (ptr->next)->prev = ptr->prev;
                    printf("Node Deleted Successfully!\n");
                    free(ptr);
                }
                else
                {
                    Delete_End();
                }
                flag = 1;
            }
        }
        // ptr now points to next node
        ptr = ptr->next;
    }

    if (flag == 0)
    {
        printf("Node with Given Value Does Not Exist! OR Deleted Earlier!\n");
    }
    else
    {
        printf("Node with Given Value Found and Deleted Successfully!\n");
    }
```

```
    }
}

// 4 -> Search in the Doubly Linked List
void Search()
{
    // Temp Pointer for Traversal
    struct node *ptr;
    ptr = head;

    if (ptr == NULL)
    {
        printf("List is Empty! Search Can't Be Performed!\n");
    }
    else
    {
        int ele, pos = 0;
        int flag = 1;

        printf("Enter Element to be Searched in List : ");
        scanf("%d", &ele);

        while (ptr != NULL)
        {
            if (ptr->data == ele)
            {
                printf("Element Found at Position %d !!\n", pos + 1);
                flag = 0;
                break;
            }
            pos++;
            ptr = ptr->next;
        }

        if (flag == 1)
        {
            printf("Element Not Found !!\n");
        }
    }
}

// 5 -> Find the Max and Min in Doubly Linked List
void Max_Min()
{
    struct node *ptr;

    ptr = head;

    if (ptr == NULL)
    {
```

```
        printf("List is Empty!Can't Find Max/Min Element!\n");
        return;
    }
    else
    {
        int mnn = ptr->data;
        int mxn = ptr->data;
        while (ptr != NULL)
        {
            if (ptr->data > mxn)
            {
                mxn = ptr->data;
            }
            else if (ptr->data < mnn)
            {
                mnn = ptr->data;
            }
            ptr = ptr->next;
        }
        printf("Minimum Element in Doubly Linked List : %d\n", mnn);
        printf("Maximum Element in Doubly Linked List : %d\n", mxn);
    }
}
```

Test Cases:

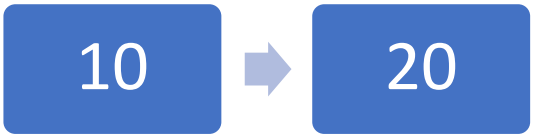
A.) Creation of Linked List

20

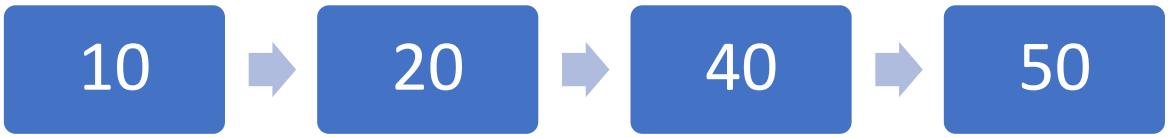
```
DOUBLY LINKED LIST
 1 -> Create a Doubly Linked List
 2 -> Display the Doubly Linked List
 3 -> Insert at the Beginning of Doubly Linked List
 4 -> Insert at the End of Doubly Linked List
 5 -> Insert at Middle of Doubly Linked List
 6 -> Delete from Beginning of Doubly Linked List
 7 -> Delete from the End of Doubly Linked List
 8 -> Delete at Middle of Doubly Linked List
 9 -> Search in Doubly Linked List
 10 -> Find Maximum and Minimum in Doubly Linked List
 11 -> Exit
Enter your choice : 2
DOUBLY LINKED LIST :
List is Empty! List has No Nodes!
Enter your choice : 1
Enter Value of Node : 20
Node Inserted Successfully!
Enter your choice : 2
DOUBLY LINKED LIST :
NULL <=> 20 <=> NULL
```

B.) Insertion of Linked List

1.) Insert 10 at Front of Linked List



2.) Insert 40 & 50 at End of Linked List

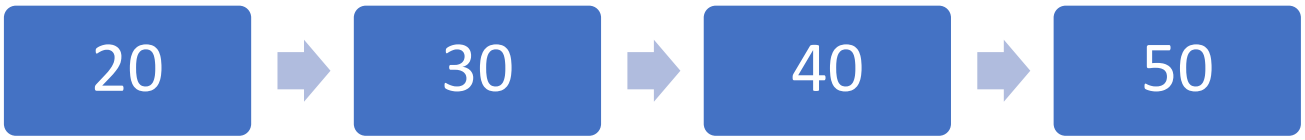


3.) Insert 30 at Middle of Linked List at Position 3


```
Enter your choice : 3
Enter Value of Node : 10
Node Inserted Succesfully!
Enter your choice : 2
DOUBLY LINKED LIST :
NULL <=> 10 <=> 20 <=> NULL
Enter your choice : 4
Enter Value of Node : 40
Node Inserted Succesfully!
Enter your choice : 4
Enter Value of Node : 50
Node Inserted Succesfully!
Enter your choice : 2
DOUBLY LINKED LIST :
NULL <=> 10 <=> 20 <=> 40 <=> 50 <=> NULL
Enter your choice : 5
Enter the Position for the New Node to be Inserted : 3
Enter the Data to be stored in Node : 30
Node Inserted Succesfully!
Enter your choice : 2
DOUBLY LINKED LIST :
NULL <=> 10 <=> 20 <=> 30 <=> 40 <=> 50 <=> NULL
```

C.) Deletion of Linked List

1.) Delete from Beginning of Linked List



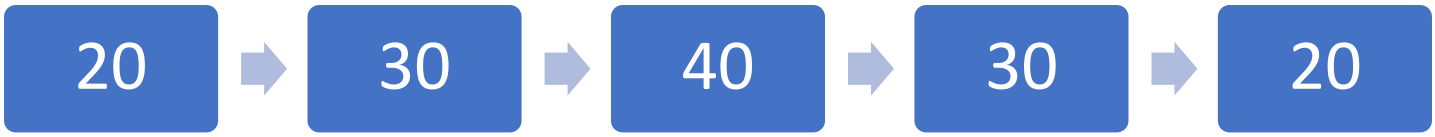

```
Enter your choice : 2
DOUBLY LINKED LIST :
NULL <=> 10 <=> 20 <=> 30 <=> 40 <=> 50 <=> NULL
Enter your choice : 6
Node Deleted Successfully!
Enter your choice : 2
DOUBLY LINKED LIST :
NULL <=> 20 <=> 30 <=> 40 <=> 50 <=> NULL
```

2.) Delete from End of Linked List

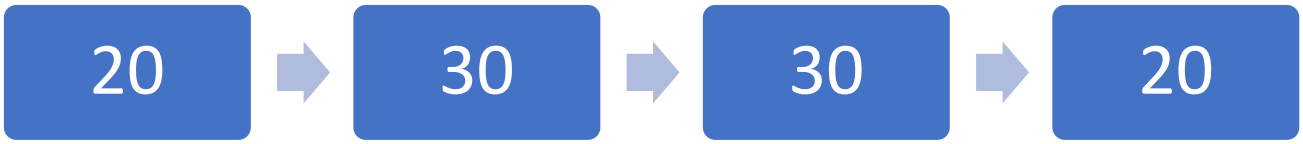

```
Enter your choice : 2
DOUBLY LINKED LIST :
NULL <=> 20 <=> 30 <=> 40 <=> 50 <=> NULL
Enter your choice : 7
Node Deleted Successfully!
Enter your choice : 2
DOUBLY LINKED LIST :
NULL <=> 20 <=> 30 <=> 40 <=> NULL
```

3.) Delete from Middle of Linked List

{Lets Add Some Extra Nodes at End of Linked List: 30 & 20}



A.) Delete by Position {we have Deleted 3rd Position i.e. 40}




```
Enter your choice : 4
Enter Value of Node : 30
Node Inserted Succesfully!
Enter your choice : 4
Enter Value of Node : 20
Node Inserted Succesfully!
Enter your choice : 2
DOUBLY LINKED LIST :
NULL <=> 20 <=> 30 <=> 40 <=> 30 <=> 20 <=> NULL
Enter your choice : 8
Delete A Node By :
 1 -> Position
 2 -> Value
Enter Your Choice : 1
Enter the Position of the Node to be Deleted : 3
ptr data : 40
Node Deleted Successfully!
Enter your choice : 2
DOUBLY LINKED LIST :
NULL <=> 20 <=> 30 <=> 30 <=> 20 <=> NULL
```

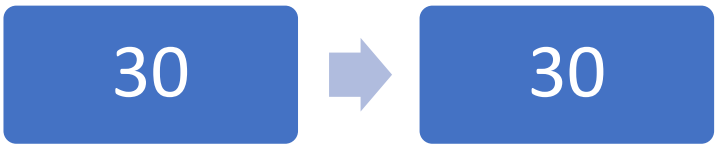
B.) Delete by Value

1.) Deletion of Value that is Not in Linked List {i.e. 15}

{Node with Given Value Does Not Exist! OR Deleted Earlier!}

2.) Deletion of Value that is in Linked List {i.e. 20}

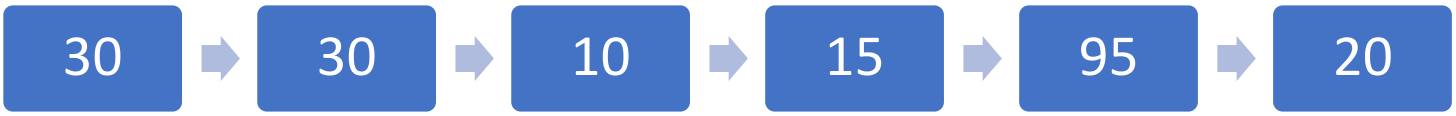
{Node with Given Value Found and Deleted Successfully!}




```
Enter your choice : 8
Delete A Node By :
 1 -> Position
 2 -> Value
Enter Your Choice : 2
Enter the Value of the Node to be Deleted : 15
Node with Given Value Does Not Exist! OR Deleted Earlier!
Enter your choice : 8
Delete A Node By :
 1 -> Position
 2 -> Value
Enter Your Choice : 2
Enter the Value of the Node to be Deleted : 20
Node Deleted Successfully!
Node Deleted Successfully!
Node with Given Value Found and Deleted Successfully!
Enter your choice : 2
DOUBLY LINKED LIST :
NULL <=> 30 <=> 30 <=> NULL
```

D.) Search in Linked List

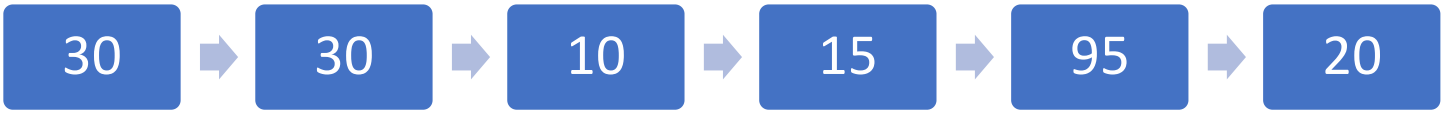
{Lets Add Some Extra Nodes at End of Linked List: 10,15,95 & 20 & Search for 40 [Not Found Case] & 95 [Recently Added Element]}




```
Enter your choice : 4
Enter Value of Node : 10
Node Inserted Succesfully!
Enter your choice : 4
Enter Value of Node : 15
Node Inserted Succesfully!
Enter your choice : 4
Enter Value of Node : 95
Node Inserted Succesfully!
Enter your choice : 4
Enter Value of Node : 20
Node Inserted Succesfully!
Enter your choice : 2
DOUBLY LINKED LIST :
NULL <=> 30 <=> 30 <=> 10 <=> 15 <=> 95 <=> 20 <=> NULL
Enter your choice : 9
Enter Element to be Searched in List : 40
Element Not Found !!
Enter your choice : 9
Enter Element to be Searched in List : 95
Element Found at Position 5 !!
```

E.) Maximum and Minimum of Linked List

{We can clearly observe from List that **95** is the Highest and **10** is the Lowest}




```
Enter your choice : 2
DOUBLY LINKED LIST :
NULL <=> 30 <=> 30 <=> 10 <=> 15 <=> 95 <=> 20 <=> NULL
Enter your choice : 10
Minimum Element in Doubly Linked List : 10
Maximum Element in Doubly Linked List : 95
```