TUTORIAL IX:

Circular Linked List Implementation

U19CS012 [D-12]

Implement the following operations in context to ***Circular linked list***:

1) Creation

2) Insertion (at beginning, middle and end)

3) Deletion (from beginning, middle and end)

---------------------Additional Functions in Assignment-----------------------

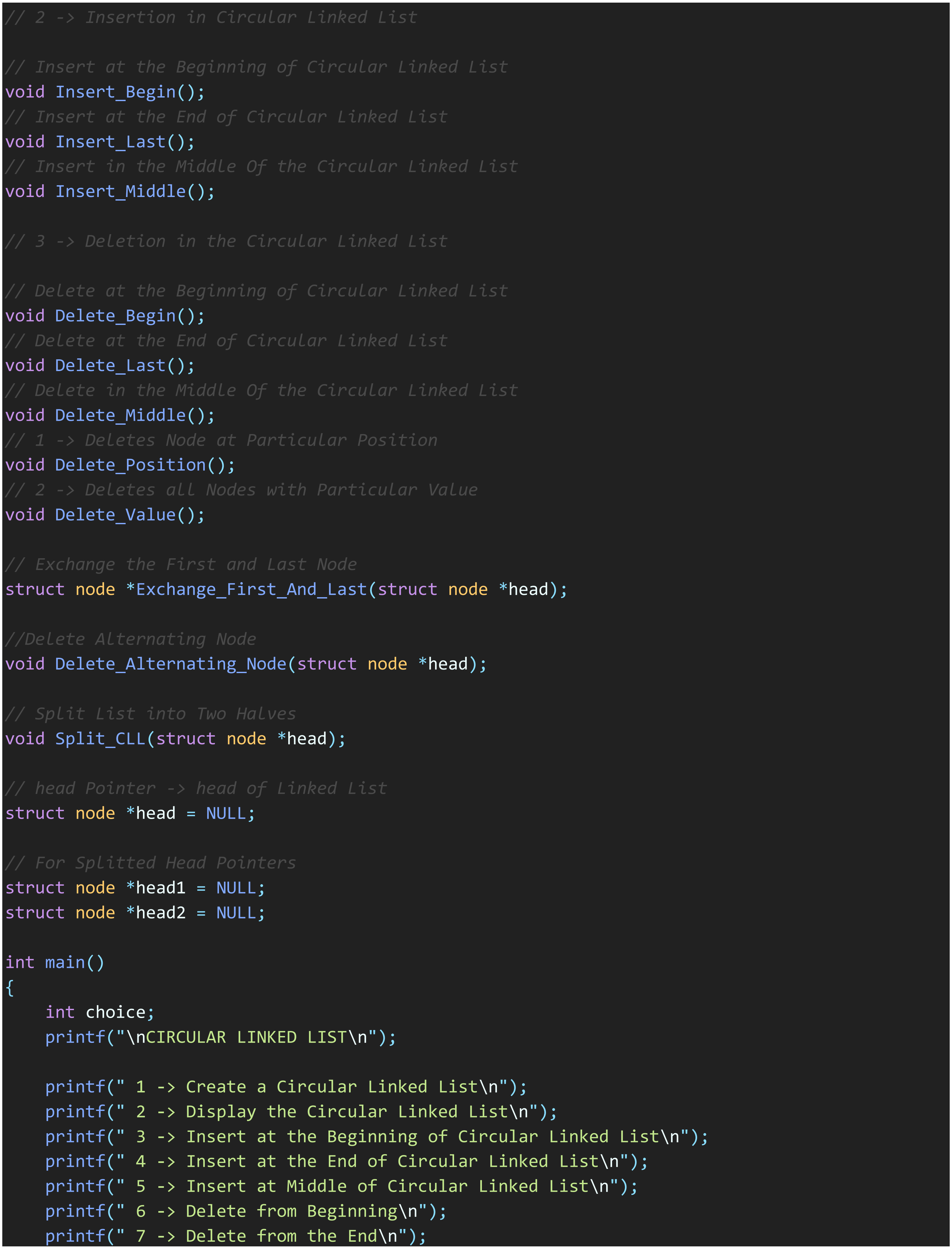
4) Exchange First and Last Node of List

5) Delete Alternating Nodes of Circular Linked List

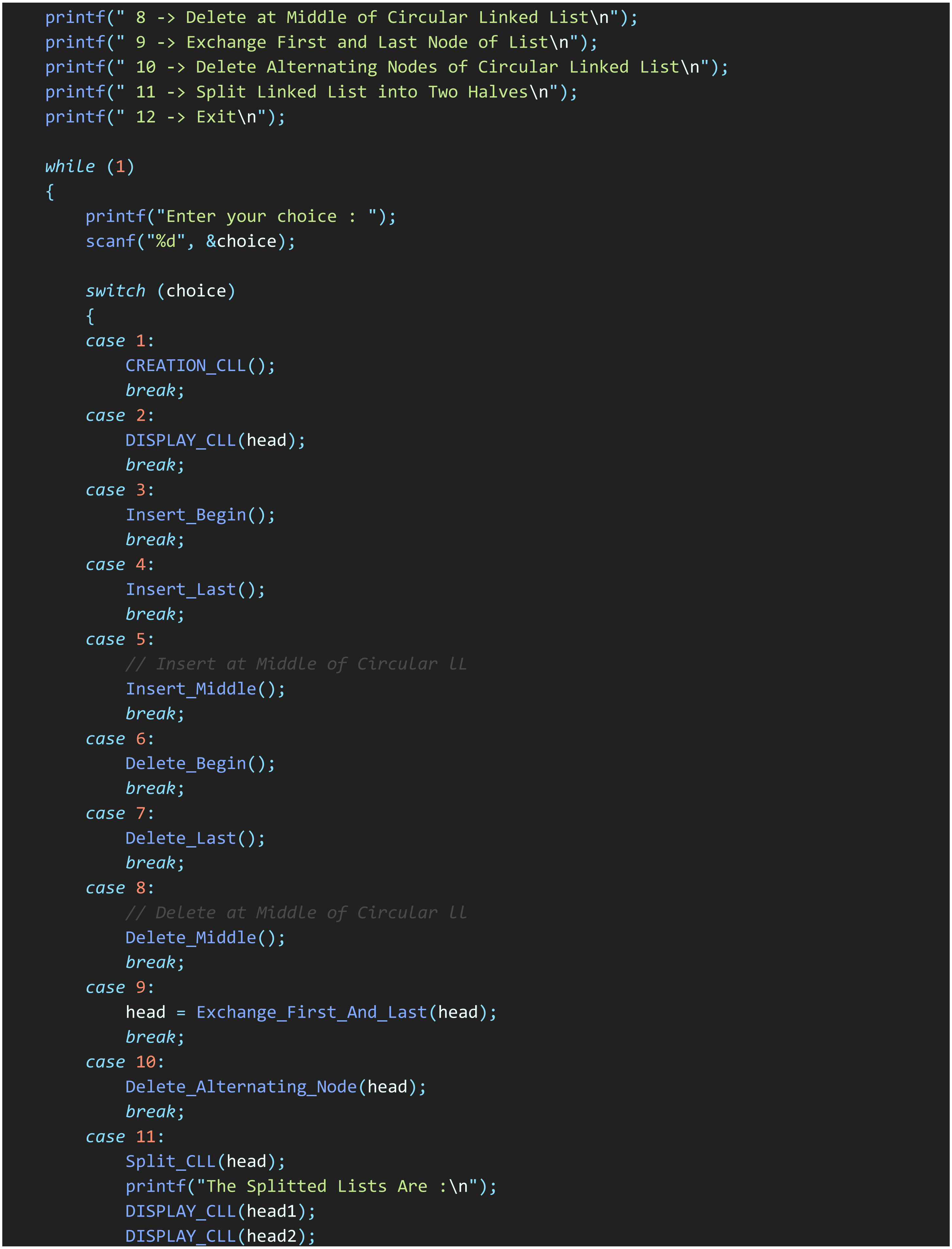
6.) Split Linked List into Two Halves

Code:

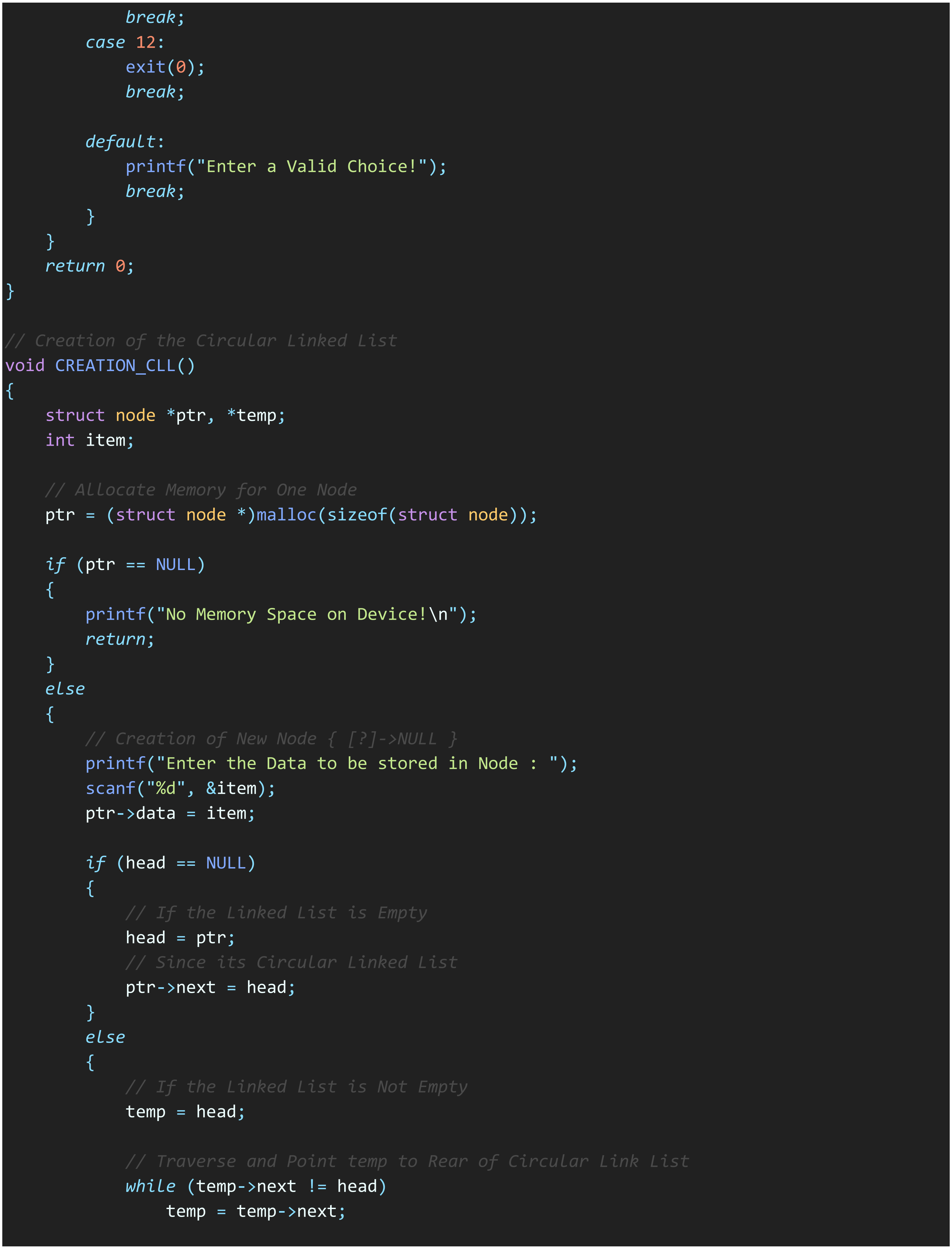
```
// Implement the following operations in context to Circular linked list:
// 1) Creation
// 2) Insertion (at begining, middle and end)
// 3) Deletion (from begining, middle and end)

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

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

//Helper Functions

// 1 -> Creation of Circular Linked List

// Creation of the Circular Linked List
void CREATION_CLL();
// Display of the Whole Circular Linked List
void DISPLAY_CLL();
// Returns the Length of Circular Linked List
int LENGTH_CLL();
```



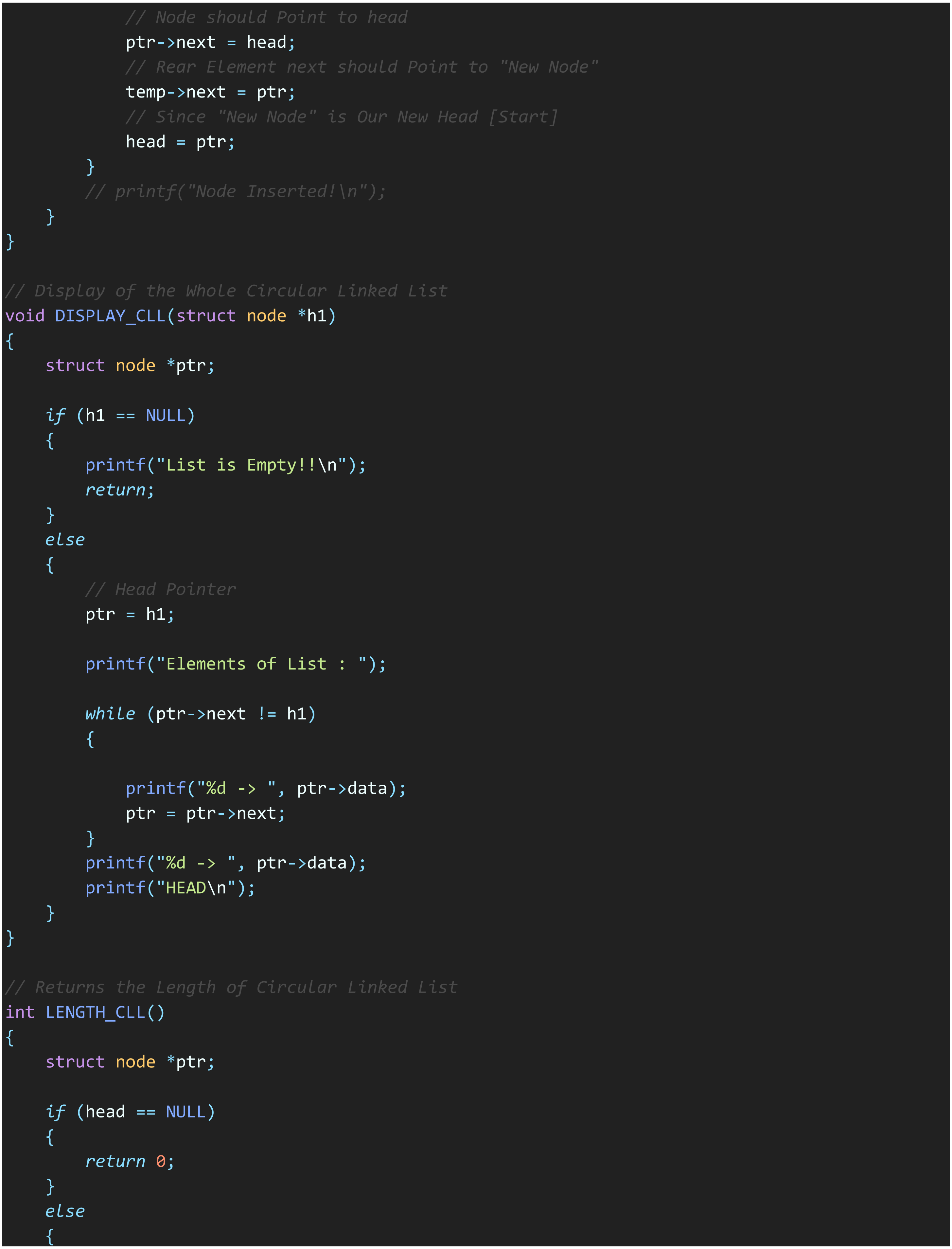
```c
// 2 -> Insertion in Circular Linked List

// Insert at the Beginning of Circular Linked List
void Insert_Begin();
// Insert at the End of Circular Linked List
void Insert_Last();
// Insert in the Middle Of the Circular Linked List
void Insert_Middle();

// 3 -> Deletion in the Circular Linked List

// Delete at the Beginning of Circular Linked List
void Delete_Begin();
// Delete at the End of Circular Linked List
void Delete_Last();
// Delete in the Middle Of the Circular Linked List
void Delete_Middle();
// 1 -> Deletes Node at Particular Position
void Delete_Position();
// 2 -> Deletes all Nodes with Particular Value
void Delete_Value();

// Exchange the First and Last Node
struct node *Exchange_First_And_Last(struct node *head);

//Delete Alternating Node
void Delete_Alternating_Node(struct node *head);

// Split List into Two Halves
void Split_CLL(struct node *head);

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

// For Splitted Head Pointers
struct node *head1 = NULL;
struct node *head2 = NULL;

int main()
{
    int choice;
    printf("\nCIRCULAR LINKED LIST\n");

    printf(" 1 -> Create a Circular Linked List\n");
    printf(" 2 -> Display the Circular Linked List\n");
    printf(" 3 -> Insert at the Beginning of Circular Linked List\n");
    printf(" 4 -> Insert at the End of Circular Linked List\n");
    printf(" 5 -> Insert at Middle of Circular Linked List\n");
    printf(" 6 -> Delete from Beginning\n");
    printf(" 7 -> Delete from the End\n");
```



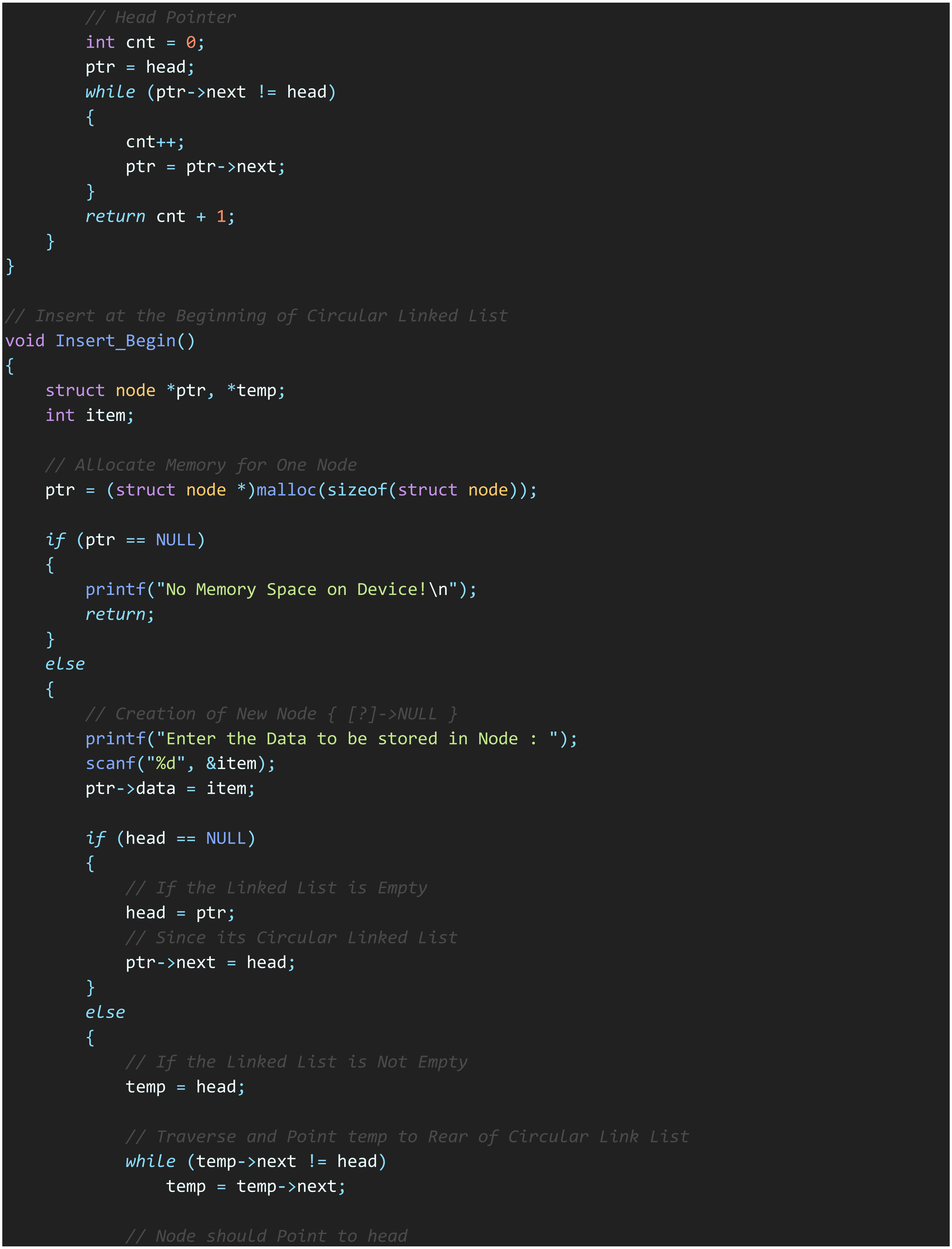
```c
    printf(" 8 -> Delete at Middle of Circular Linked List\n");
    printf(" 9 -> Exchange First and Last Node of List\n");
    printf(" 10 -> Delete Alternating Nodes of Circular Linked List\n");
    printf(" 11 -> Split Linked List into Two Halves\n");
    printf(" 12 -> Exit\n");

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

        switch (choice)
        {
        case 1:
            CREATION_CLL();
            break;
        case 2:
            DISPLAY_CLL(head);
            break;
        case 3:
            Insert_Begin();
            break;
        case 4:
            Insert_Last();
            break;
        case 5:
            // Insert at Middle of Circular LL
            Insert_Middle();
            break;
        case 6:
            Delete_Begin();
            break;
        case 7:
            Delete_Last();
            break;
        case 8:
            // Delete at Middle of Circular Ll
            Delete_Middle();
            break;
        case 9:
            head = Exchange_First_And_Last(head);
            break;
        case 10:
            Delete_Alternating_Node(head);
            break;
        case 11:
            Split_CLL(head);
            printf("The Splitted Lists Are :\n");
            DISPLAY_CLL(head1);
            DISPLAY_CLL(head2);
```



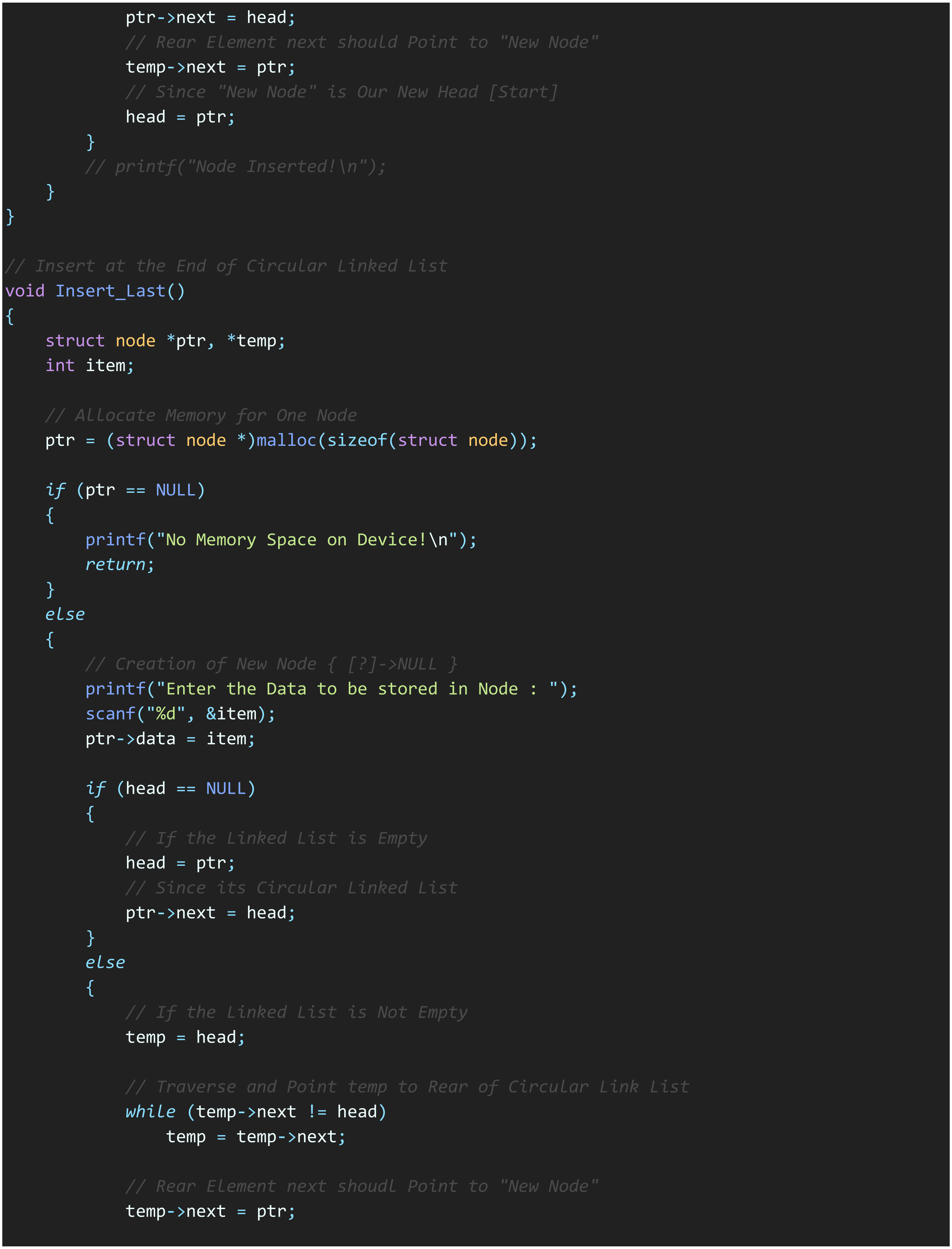
```
            break;
        case 12:
            exit(0);
            break;

        default:
            printf("Enter a Valid Choice!");
            break;
        }
    }
    return 0;
}

// Creation of the Circular Linked List
void CREATION_CLL()
{
    struct node *ptr, *temp;
    int item;

    // Allocate Memory for One Node
    ptr = (struct node *)malloc(sizeof(struct node));

    if (ptr == NULL)
    {
        printf("No Memory Space on Device!\n");
        return;
    }
    else
    {
        // Creation of New Node { [?]->NULL }
        printf("Enter the Data to be stored in Node : ");
        scanf("%d", &item);
        ptr->data = item;

        if (head == NULL)
        {
            // If the Linked List is Empty
            head = ptr;
            // Since its Circular Linked List
            ptr->next = head;
        }
        else
        {
            // If the Linked List is Not Empty
            temp = head;

            // Traverse and Point temp to Rear of Circular Link List
            while (temp->next != head)
                temp = temp->next;
```



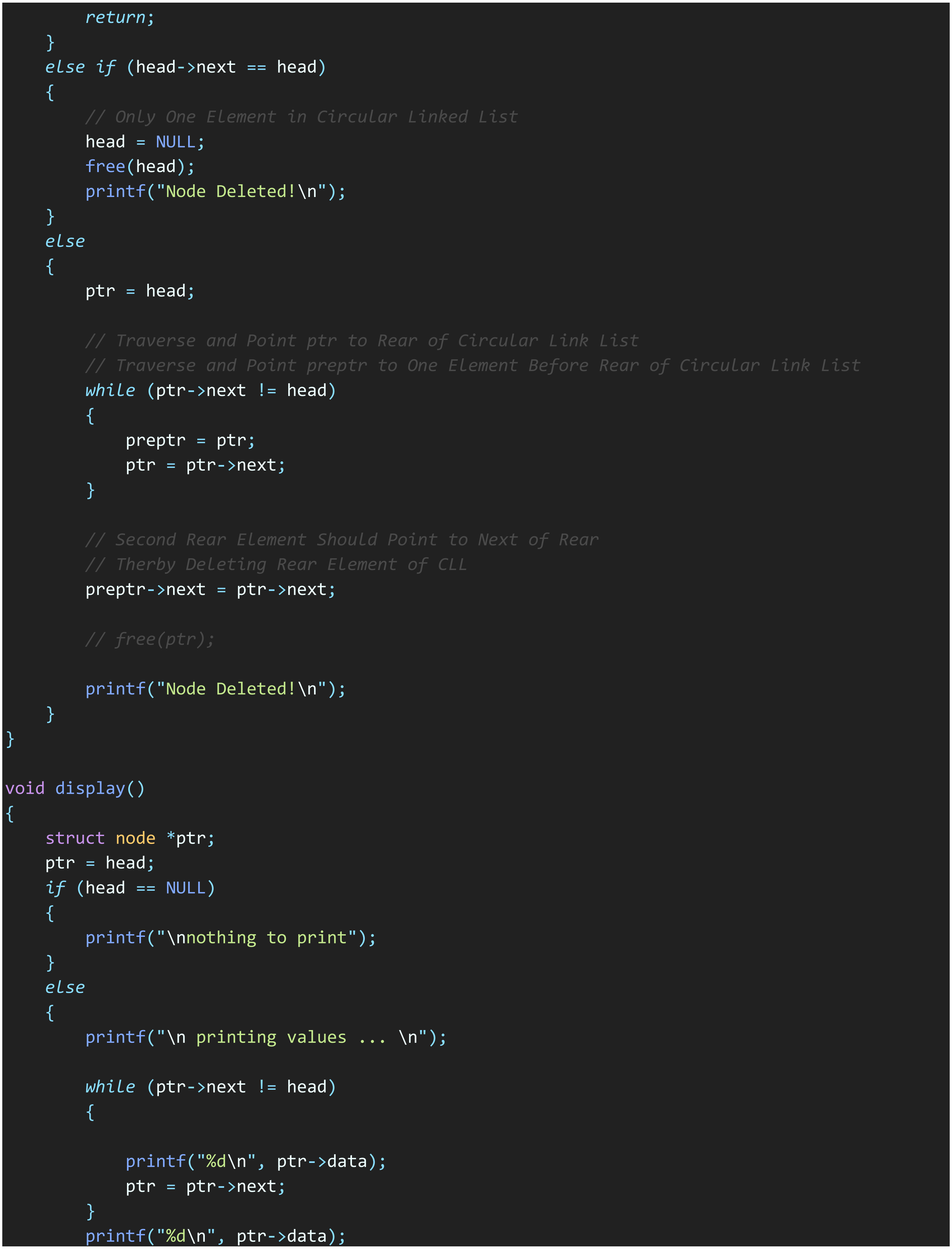
```c
            // Node should Point to head
            ptr->next = head;
            // Rear Element next should Point to "New Node"
            temp->next = ptr;
            // Since "New Node" is Our New Head [Start]
            head = ptr;
        }
        // printf("Node Inserted!\n");
    }
}

// Display of the Whole Circular Linked List
void DISPLAY_CLL(struct node *h1)
{
    struct node *ptr;

    if (h1 == NULL)
    {
        printf("List is Empty!!\n");
        return;
    }
    else
    {
        // Head Pointer
        ptr = h1;

        printf("Elements of List : ");

        while (ptr->next != h1)
        {

            printf("%d -> ", ptr->data);
            ptr = ptr->next;
        }
        printf("%d -> ", ptr->data);
        printf("HEAD\n");
    }
}

// Returns the Length of Circular Linked List
int LENGTH_CLL()
{
    struct node *ptr;

    if (head == NULL)
    {
        return 0;
    }
    else
    {
```



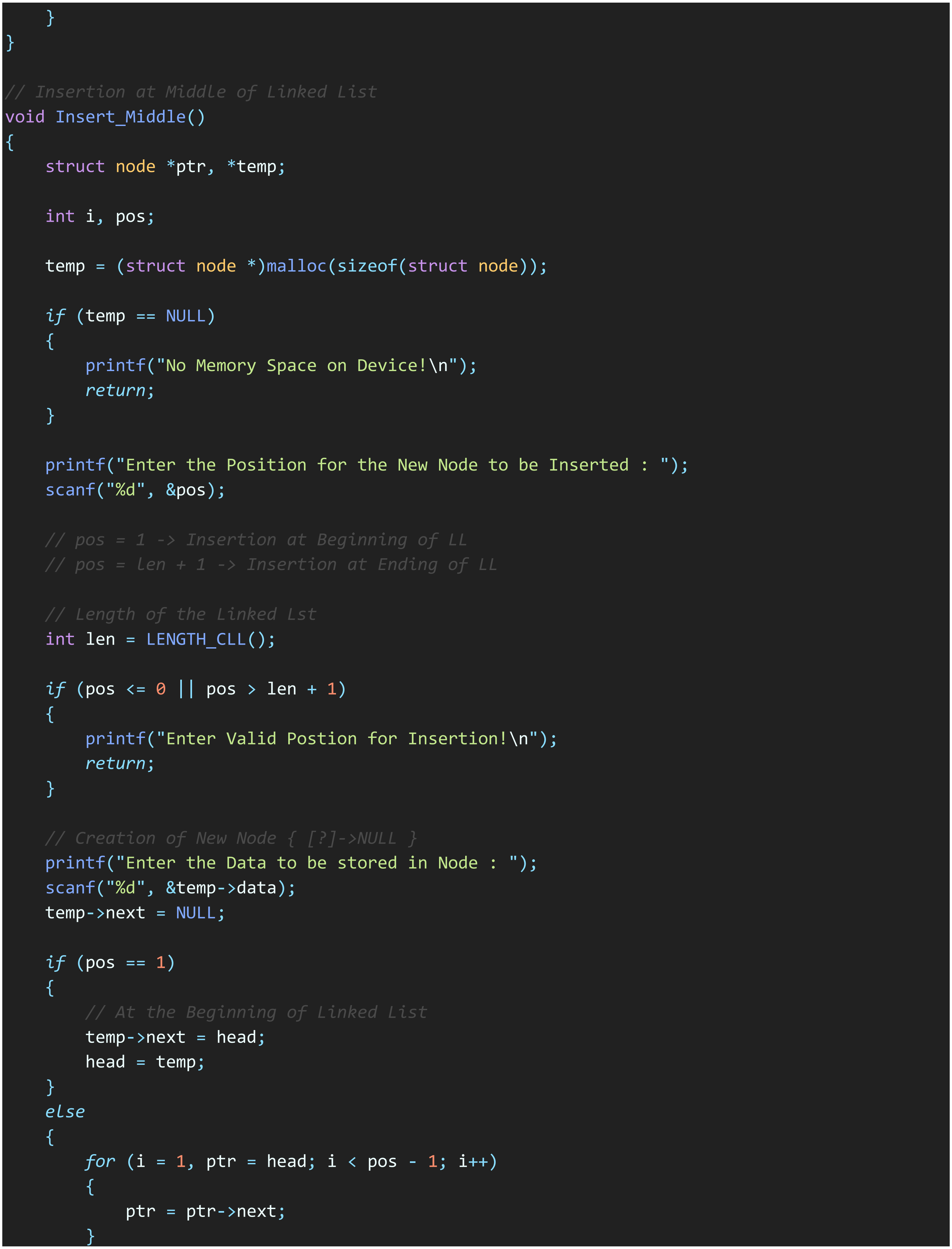
```
        // Head Pointer
        int cnt = 0;
        ptr = head;
        while (ptr->next != head)
        {
            cnt++;
            ptr = ptr->next;
        }
        return cnt + 1;
    }
}

// Insert at the Beginning of Circular Linked List
void Insert_Begin()
{
    struct node *ptr, *temp;
    int item;

    // Allocate Memory for One Node
    ptr = (struct node *)malloc(sizeof(struct node));

    if (ptr == NULL)
    {
        printf("No Memory Space on Device!\n");
        return;
    }
    else
    {
        // Creation of New Node { [?]->NULL }
        printf("Enter the Data to be stored in Node : ");
        scanf("%d", &item);
        ptr->data = item;

        if (head == NULL)
        {
            // If the Linked List is Empty
            head = ptr;
            // Since its Circular Linked List
            ptr->next = head;
        }
        else
        {
            // If the Linked List is Not Empty
            temp = head;

            // Traverse and Point temp to Rear of Circular Link List
            while (temp->next != head)
                temp = temp->next;

            // Node should Point to head
```



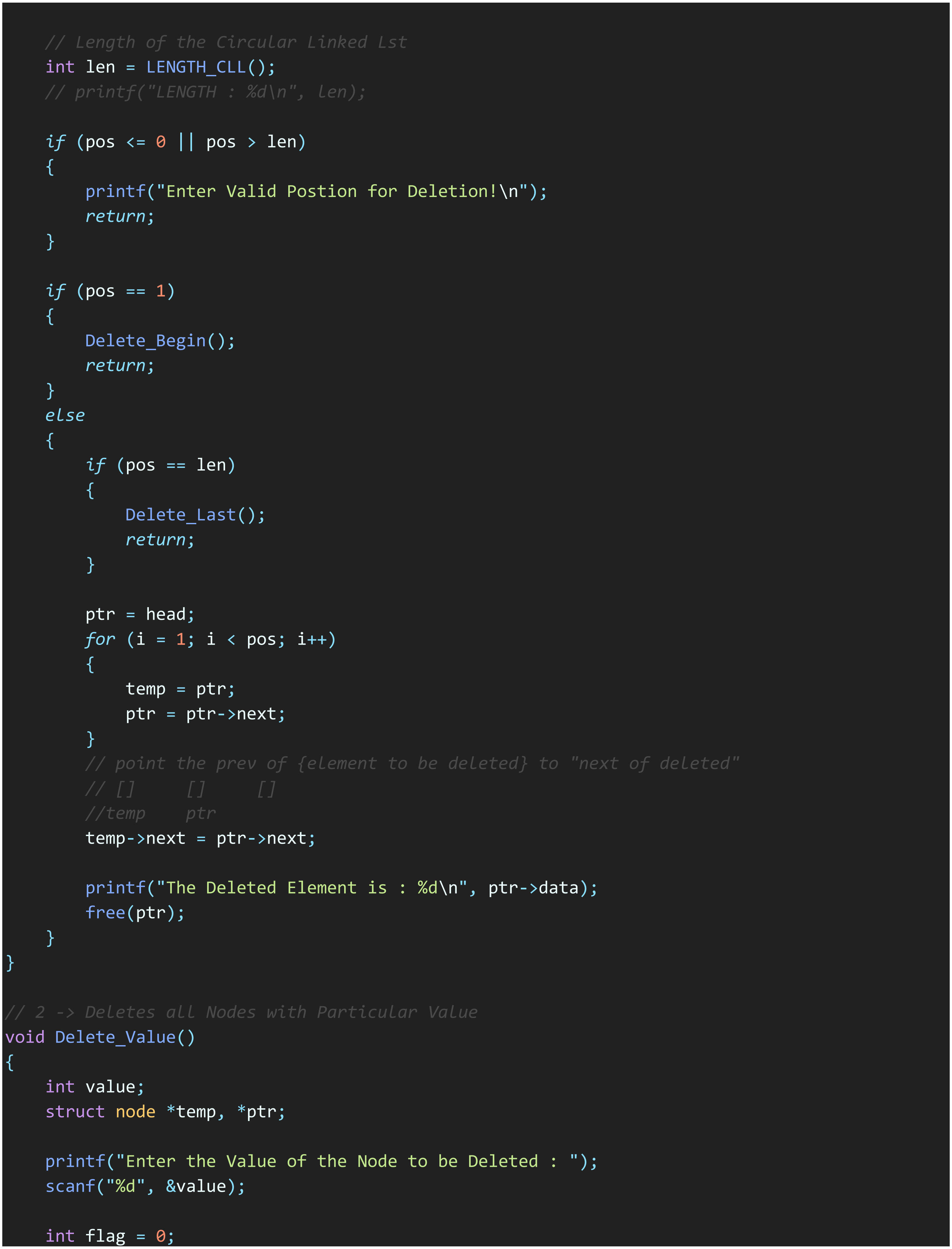
```c
            ptr->next = head;
            // Rear Element next should Point to "New Node"
            temp->next = ptr;
            // Since "New Node" is Our New Head [Start]
            head = ptr;
        }
        // printf("Node Inserted!\n");
    }
}

// Insert at the End of Circular Linked List
void Insert_Last()
{
    struct node *ptr, *temp;
    int item;

    // Allocate Memory for One Node
    ptr = (struct node *)malloc(sizeof(struct node));

    if (ptr == NULL)
    {
        printf("No Memory Space on Device!\n");
        return;
    }
    else
    {
        // Creation of New Node { [?]->NULL }
        printf("Enter the Data to be stored in Node : ");
        scanf("%d", &item);
        ptr->data = item;

        if (head == NULL)
        {
            // If the Linked List is Empty
            head = ptr;
            // Since its Circular Linked List
            ptr->next = head;
        }
        else
        {
            // If the Linked List is Not Empty
            temp = head;

            // Traverse and Point temp to Rear of Circular Link List
            while (temp->next != head)
                temp = temp->next;

            // Rear Element next shoudl Point to "New Node"
            temp->next = ptr;
            // Node should Point to head
            ptr->next = head;
        }
        // printf("Node Inserted!\n");
    }
}

// Delete at the Beginning of Circular Linked List
void Delete_Begin()
{
    // temporary pointer to store old head
    struct node *ptr;

    if (head == NULL)
    {
        printf("List is Empty! No Deletion Possible!!\n");
        return;
    }
    else if (head->next == head)
    {
        // Only One Element in Circular Linked List
        head = NULL;
        free(head);
        printf("Node Deleted!\n");
    }
    else
    {
        ptr = head;

        // Traverse and Point ptr to Rear of Circular Link List
        while (ptr->next != head)
            ptr = ptr->next;

        // Point the Rear Element of CLL to Second Element of CLL
        ptr->next = head->next;
        // free(head);
        // head is pointing to Second Element of CLL
        head = ptr->next;
        printf("Node Deleted!\n");
    }
}

// Delete at the End of Circular Linked List
void Delete_Last()
{
    struct node *ptr, *preptr;

    if (head == NULL)
    {
        printf("List is Empty! No Deletion Possible!!\n");
```



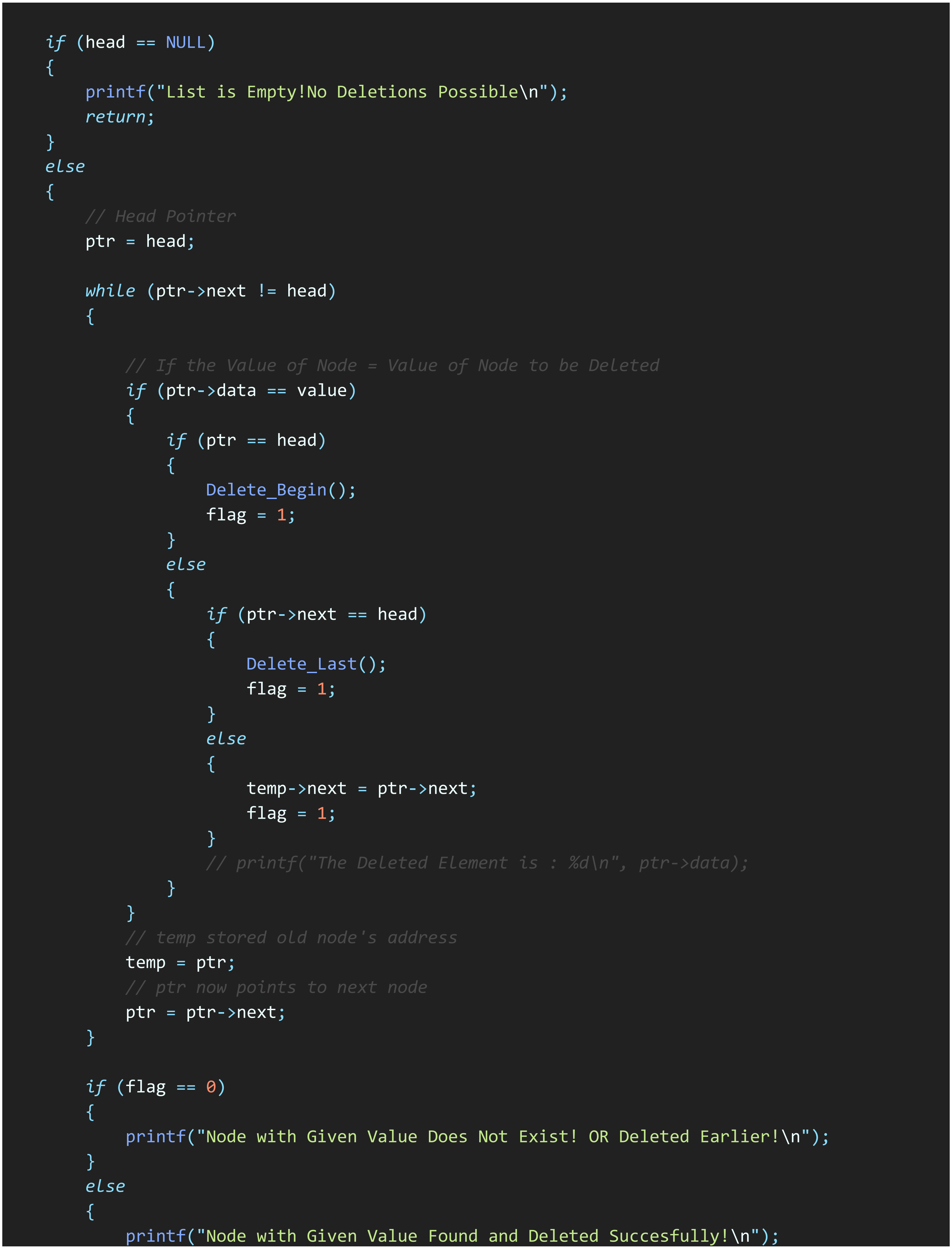
```c
        return;
    }
    else if (head->next == head)
    {
        // Only One Element in Circular Linked List
        head = NULL;
        free(head);
        printf("Node Deleted!\n");
    }
    else
    {
        ptr = head;

        // Traverse and Point ptr to Rear of Circular Link List
        // Traverse and Point preptr to One Element Before Rear of Circular Link List
        while (ptr->next != head)
        {
            preptr = ptr;
            ptr = ptr->next;
        }

        // Second Rear Element Should Point to Next of Rear
        // Therby Deleting Rear Element of CLL
        preptr->next = ptr->next;

        // free(ptr);

        printf("Node Deleted!\n");
    }
}

void display()
{
    struct node *ptr;
    ptr = head;
    if (head == NULL)
    {
        printf("\nnothing to print");
    }
    else
    {
        printf("\n printing values ... \n");

        while (ptr->next != head)
        {

            printf("%d\n", ptr->data);
            ptr = ptr->next;
        }
        printf("%d\n", ptr->data);
```



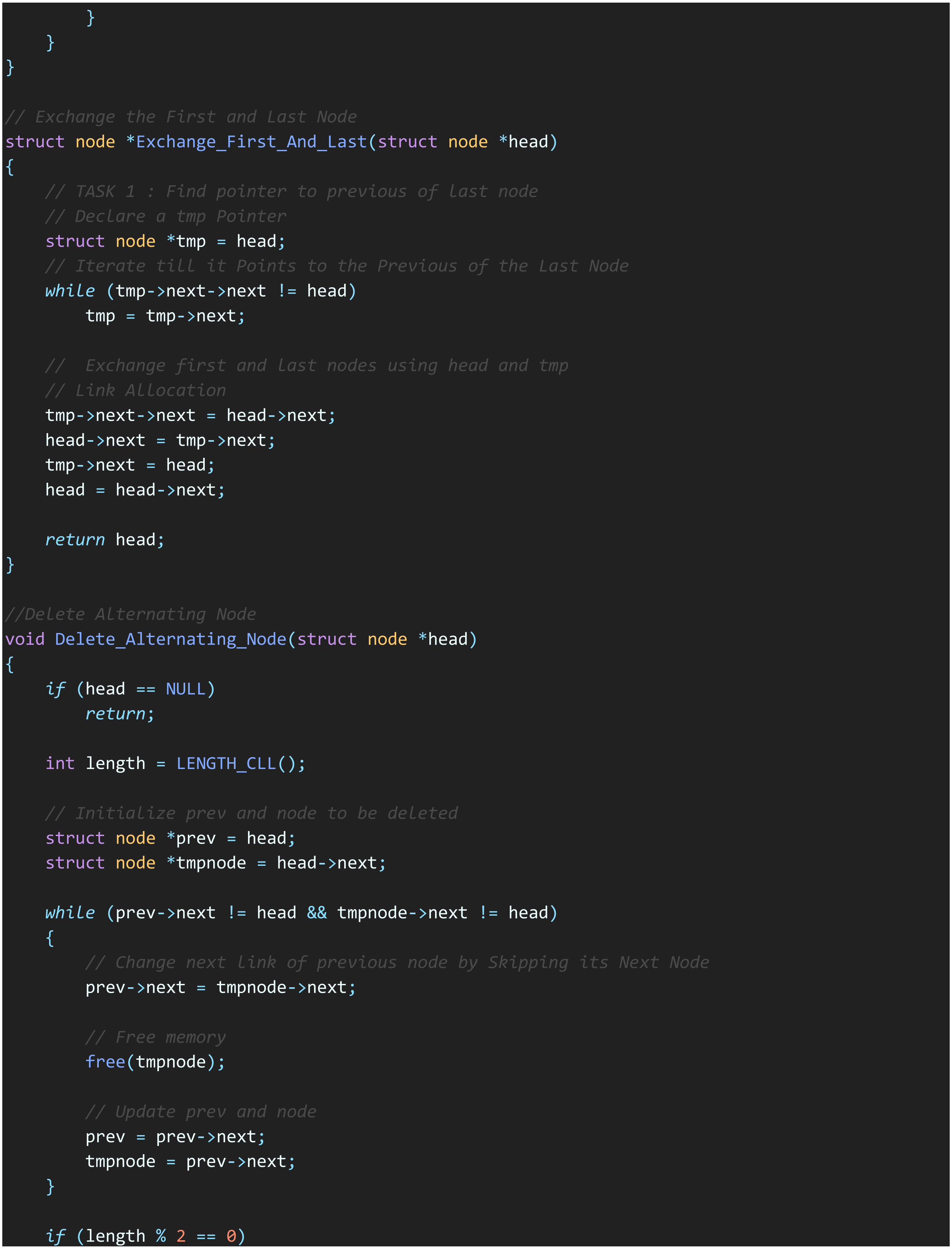
```c
    }
}

// Insertion at Middle of Linked List
void Insert_Middle()
{
    struct node *ptr, *temp;

    int i, pos;

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

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

    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 Lst
    int len = LENGTH_CLL();

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

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

    if (pos == 1)
    {
        // At the Beginning of Linked List
        temp->next = head;
        head = temp;
    }
    else
    {
        for (i = 1, ptr = head; i < pos - 1; i++)
        {
            ptr = ptr->next;
        }
        // temp is also pointing to next of "pos" to be inserted
        temp->next = ptr->next;
        // Make ptr Point to Temp
        ptr->next = temp;
    }
}

// Delete in the Middle Of the Circular Linked List
void Delete_Middle()
{
    if (head == NULL)
    {
        printf("List is Empty! No Deletion Possible!!\n");
        exit(0);
    }
    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;
        }
    }
}

// 1 -> 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);

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



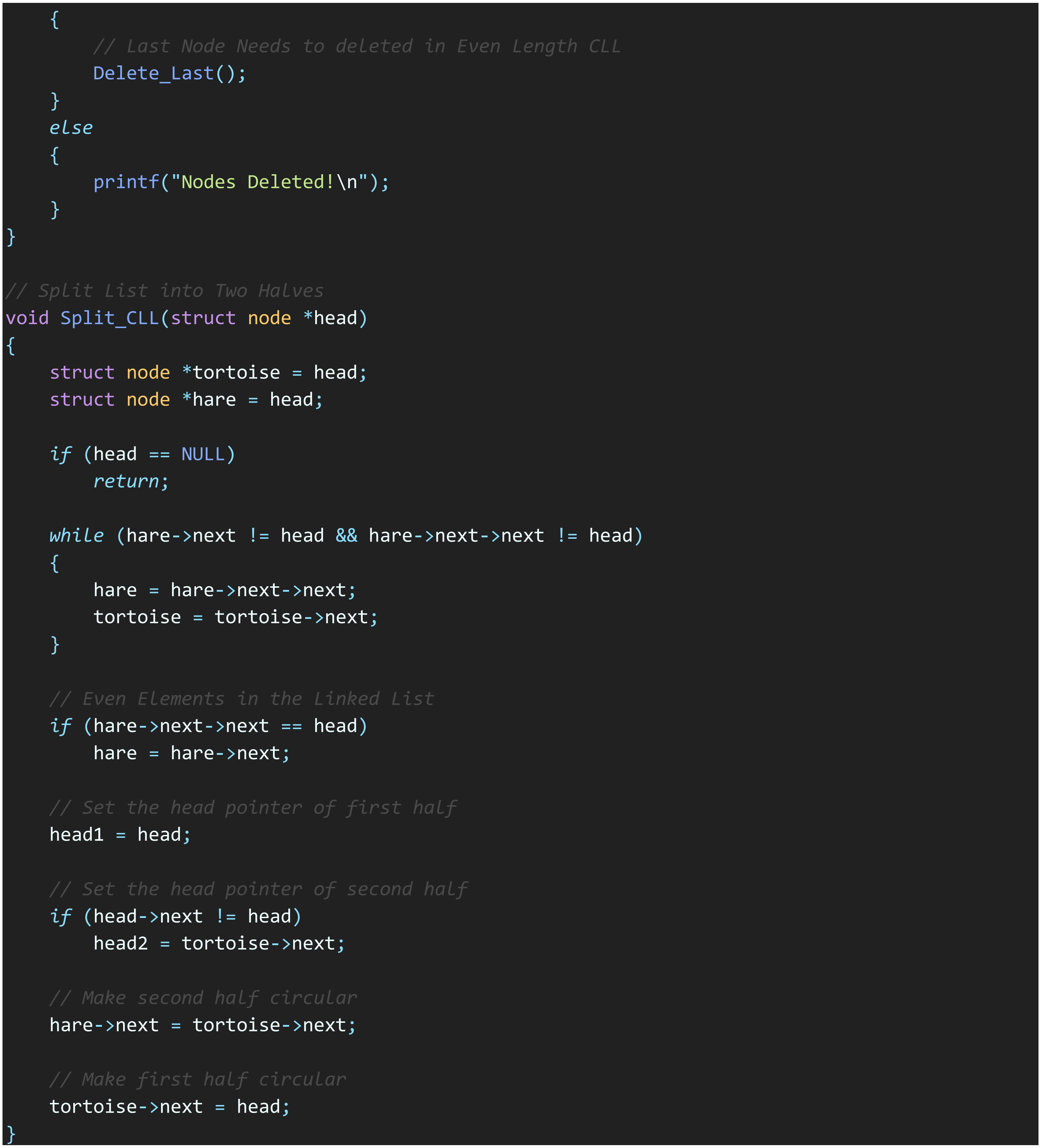
```c
    // Length of the Circular Linked Lst
    int len = LENGTH_CLL();
    // printf("LENGTH : %d\n", len);

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

    if (pos == 1)
    {
        Delete_Begin();
        return;
    }
    else
    {
        if (pos == len)
        {
            Delete_Last();
            return;
        }

        ptr = head;
        for (i = 1; i < pos; i++)
        {
            temp = ptr;
            ptr = ptr->next;
        }
        // point the prev of {element to be deleted} to "next of deleted"
        // []     []     []
        //temp    ptr
        temp->next = ptr->next;

        printf("The Deleted Element is : %d\n", ptr->data);
        free(ptr);
    }
}

// 2 -> 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;
```



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

    while (ptr->next != head)
    {

        // If the Value of Node = Value of Node to be Deleted
        if (ptr->data == value)
        {
            if (ptr == head)
            {
                Delete_Begin();
                flag = 1;
            }
            else
            {
                if (ptr->next == head)
                {
                    Delete_Last();
                    flag = 1;
                }
                else
                {
                    temp->next = ptr->next;
                    flag = 1;
                }
                // printf("The Deleted Element is : %d\n", ptr->data);
            }
        }
        // temp stored old node's address
        temp = ptr;
        // 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 Succesfully!\n");
```



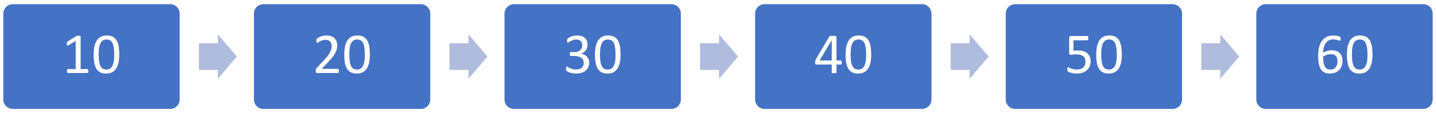
```c
        }
    }
}

// Exchange the First and Last Node
struct node *Exchange_First_And_Last(struct node *head)
{
    // TASK 1 : Find pointer to previous of last node
    // Declare a tmp Pointer
    struct node *tmp = head;
    // Iterate till it Points to the Previous of the Last Node
    while (tmp->next->next != head)
        tmp = tmp->next;

    //  Exchange first and last nodes using head and tmp
    // Link Allocation
    tmp->next->next = head->next;
    head->next = tmp->next;
    tmp->next = head;
    head = head->next;

    return head;
}

//Delete Alternating Node
void Delete_Alternating_Node(struct node *head)
{
    if (head == NULL)
        return;

    int length = LENGTH_CLL();

    // Initialize prev and node to be deleted
    struct node *prev = head;
    struct node *tmpnode = head->next;

    while (prev->next != head && tmpnode->next != head)
    {
        // Change next link of previous node by Skipping its Next Node
        prev->next = tmpnode->next;

        // Free memory
        free(tmpnode);

        // Update prev and node
        prev = prev->next;
        tmpnode = prev->next;
    }

    if (length % 2 == 0)
```

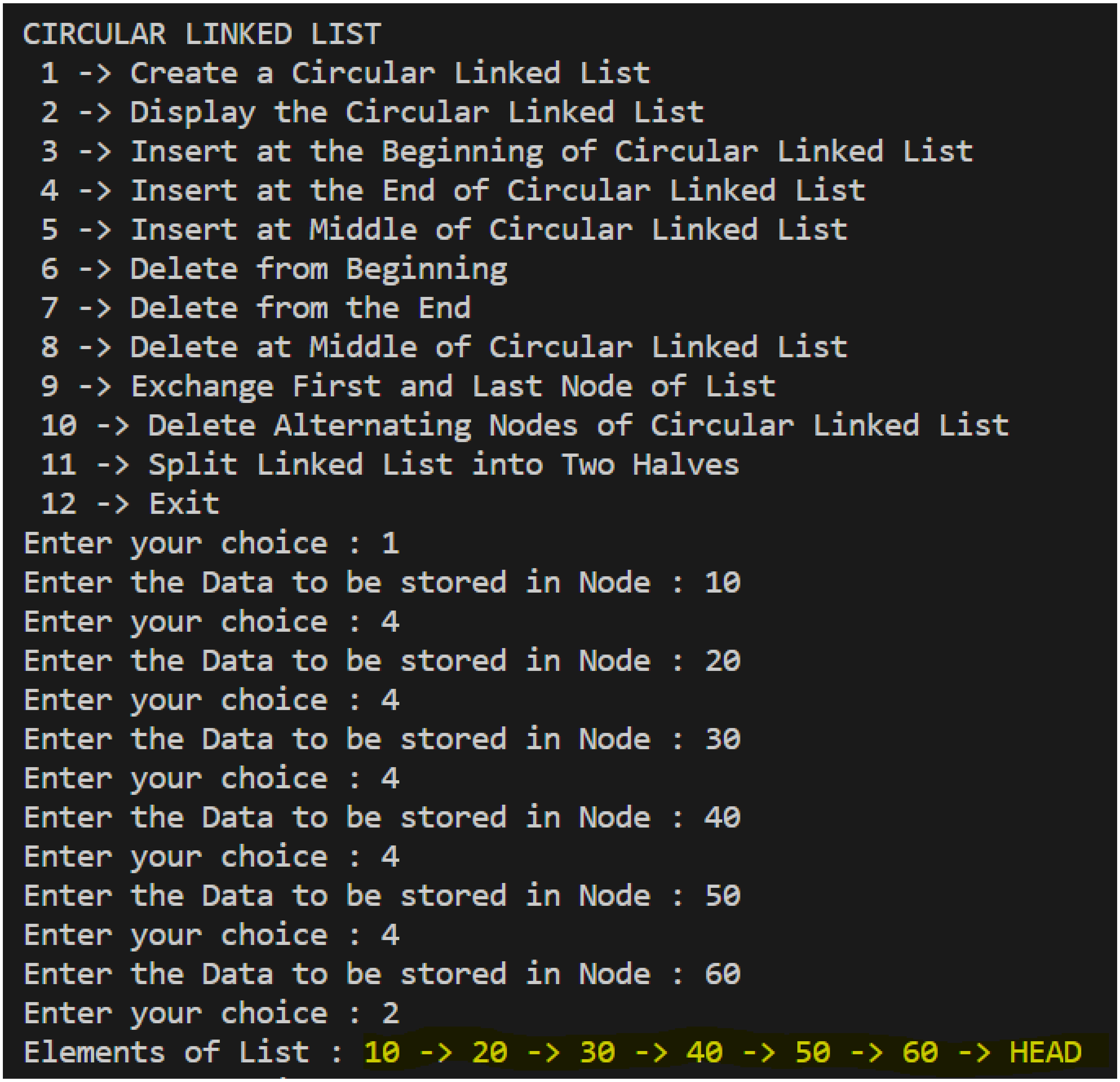


```
    {
        // Last Node Needs to deleted in Even Length CLL
        Delete_Last();
    }
    else
    {
        printf("Nodes Deleted!\n");
    }
}

// Split List into Two Halves
void Split_CLL(struct node *head)
{
    struct node *tortoise = head;
    struct node *hare = head;

    if (head == NULL)
        return;

    while (hare->next != head && hare->next->next != head)
    {
        hare = hare->next->next;
        tortoise = tortoise->next;
    }

    // Even Elements in the Linked List
    if (hare->next->next == head)
        hare = hare->next;

    // Set the head pointer of first half
    head1 = head;

    // Set the head pointer of second half
    if (head->next != head)
        head2 = tortoise->next;

    // Make second half circular
    hare->next = tortoise->next;

    // Make first half circular
    tortoise->next = head;
}
```

Test Cases:

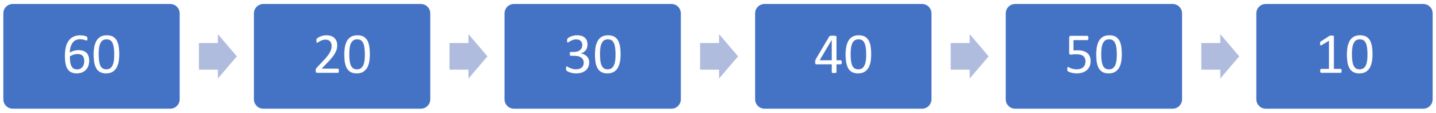
A.) Creation of Circular Linked List



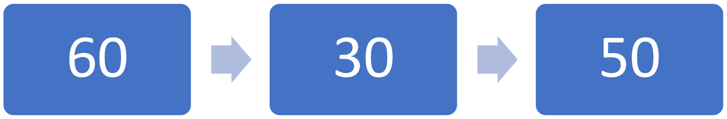


```
CIRCULAR LINKED LIST
 1 -> Create a Circular Linked List
 2 -> Display the Circular Linked List
 3 -> Insert at the Beginning of Circular Linked List
 4 -> Insert at the End of Circular Linked List
 5 -> Insert at Middle of Circular Linked List
 6 -> Delete from Beginning
 7 -> Delete from the End
 8 -> Delete at Middle of Circular Linked List
 9 -> Exchange First and Last Node of List
 10 -> Delete Alternating Nodes of Circular Linked List
 11 -> Split Linked List into Two Halves
 12 -> Exit
Enter your choice : 1
Enter the Data to be stored in Node : 10
Enter your choice : 4
Enter the Data to be stored in Node : 20
Enter your choice : 4
Enter the Data to be stored in Node : 30
Enter your choice : 4
Enter the Data to be stored in Node : 40
Enter your choice : 4
Enter the Data to be stored in Node : 50
Enter your choice : 4
Enter the Data to be stored in Node : 60
Enter your choice : 2
Elements of List : 10 -> 20 -> 30 -> 40 -> 50 -> 60 -> HEAD
```

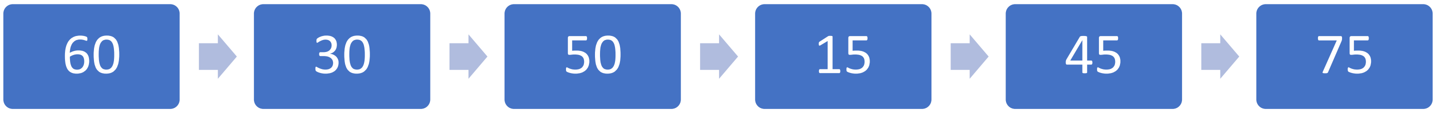
B.) Exchange First and Last Node of Circular Linked List



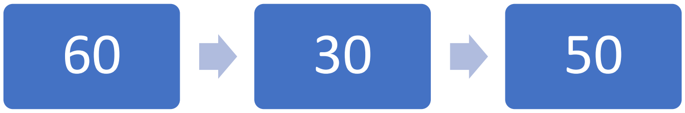
C.) Delete Alternating Nodes of Circular Linked List

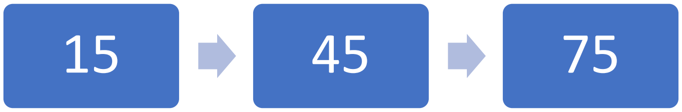


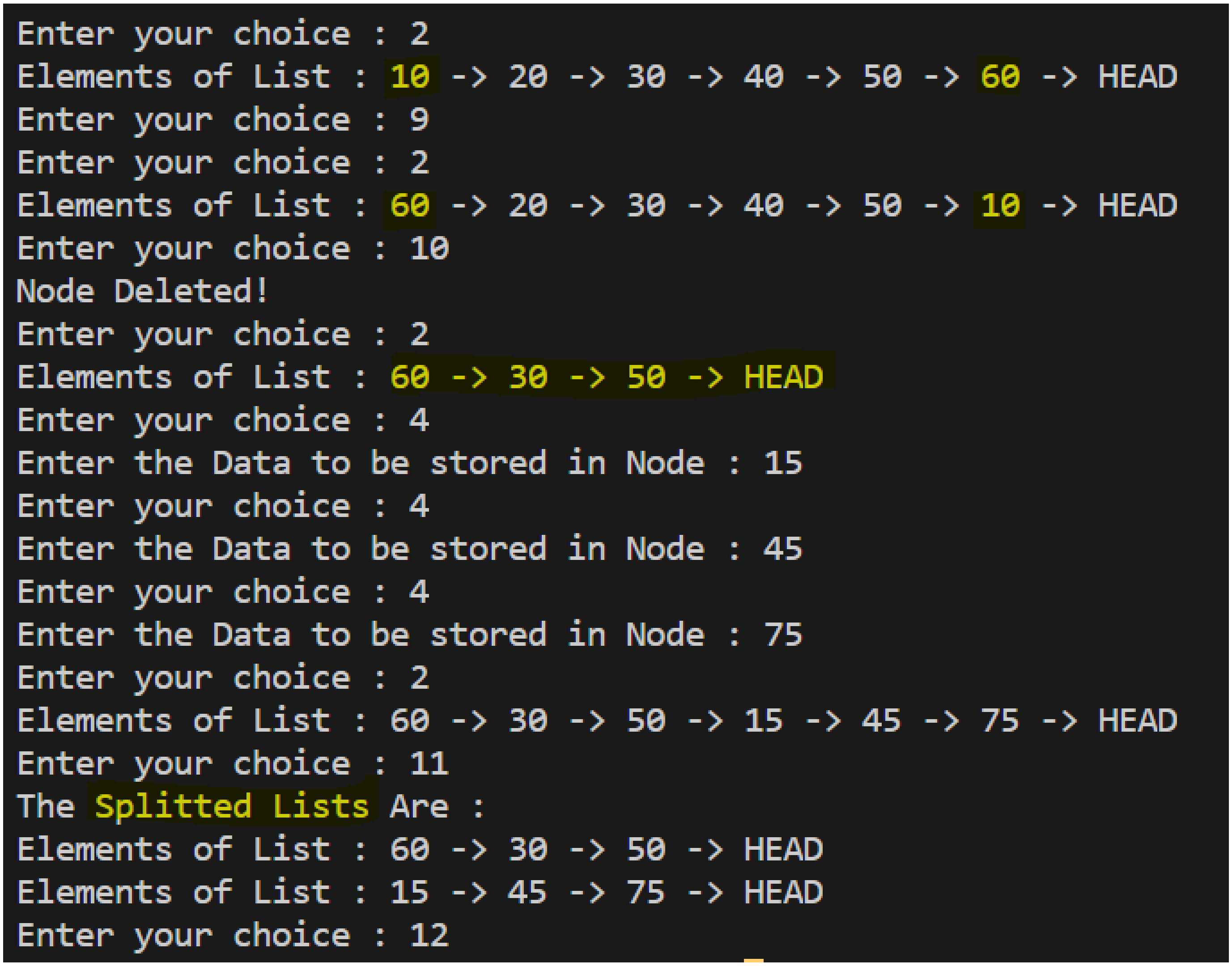
D.) Exchange First and Last Node of Circular Linked List
[Added 3 More Elements in Circular Linked List]



Splitted Circular Linked List into Two Halves:







```
Enter your choice : 2
Elements of List : 10 -> 20 -> 30 -> 40 -> 50 -> 60 -> HEAD
Enter your choice : 9
Enter your choice : 2
Elements of List : 60 -> 20 -> 30 -> 40 -> 50 -> 10 -> HEAD
Enter your choice : 10
Node Deleted!
Enter your choice : 2
Elements of List : 60 -> 30 -> 50 -> HEAD
Enter your choice : 4
Enter the Data to be stored in Node : 15
Enter your choice : 4
Enter the Data to be stored in Node : 45
Enter your choice : 4
Enter the Data to be stored in Node : 75
Enter your choice : 2
Elements of List : 60 -> 30 -> 50 -> 15 -> 45 -> 75 -> HEAD
Enter your choice : 11
The Splitted Lists Are :
Elements of List : 60 -> 30 -> 50 -> HEAD
Elements of List : 15 -> 45 -> 75 -> HEAD
Enter your choice : 12
```