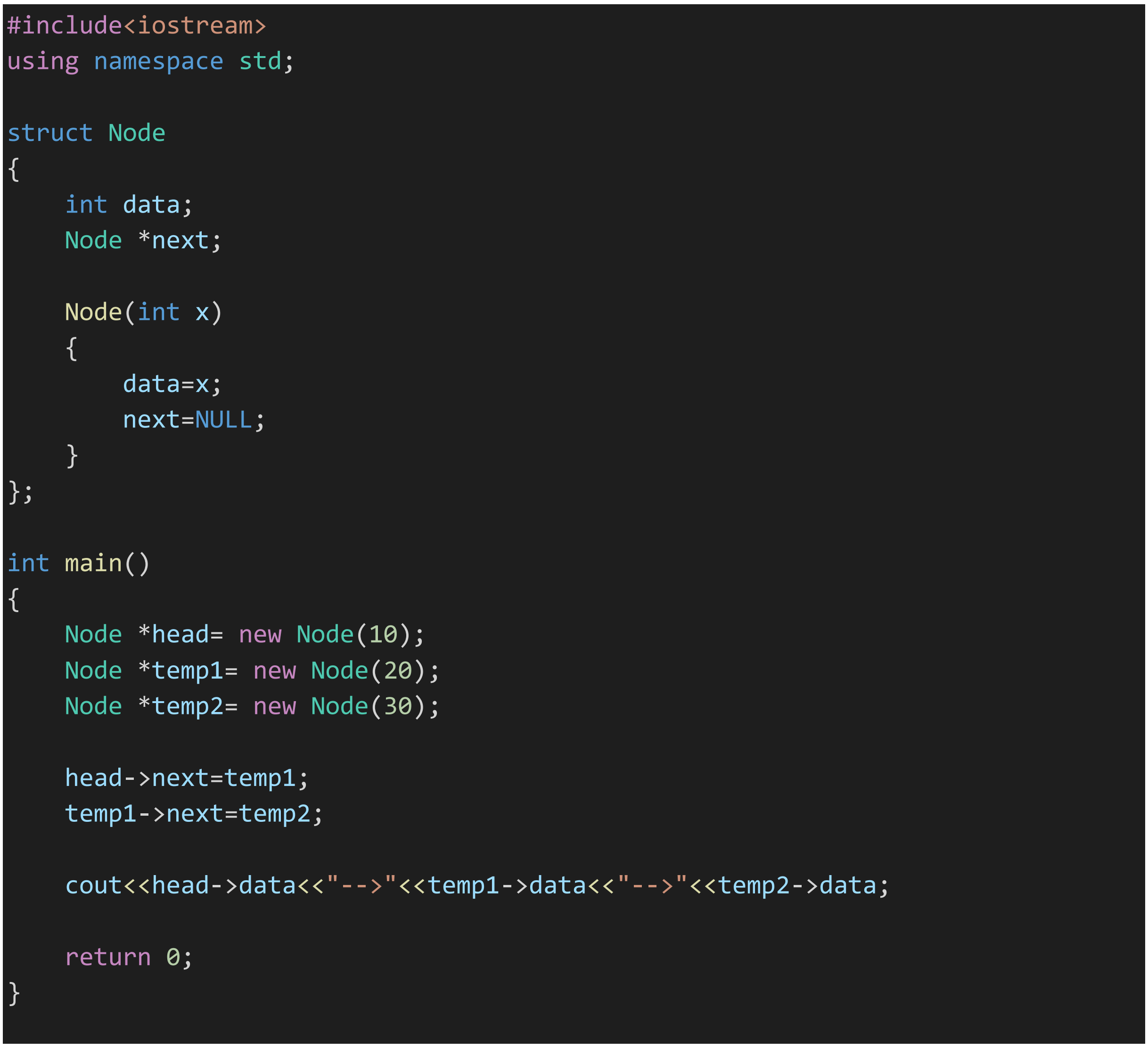
Linked List

Simple lined list implementation :



```cpp
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;

    Node(int x)
    {
        data=x;
        next=NULL;
    }
};

int main()
{
    Node *head= new Node(10);
    Node *temp1= new Node(20);
    Node *temp2= new Node(30);

    head->next=temp1;
    temp1->next=temp2;

    cout<<head->data<<"-->"<<temp1->data<<"-->"<<temp2->data;

    return 0;
}
```

OUTPUT :

```
10-->20-->30
```

Traversing a linked list in c++

traversal of a linked list from head to last node.

```cpp
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int x)
    {
        data=x;
        next=NULL;
    }
};

void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
}

int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    head->next->next->next=new Node(40);

    printList(head);

    return 0;
}
```

OUTPUT :

```
10 20 30 40
```

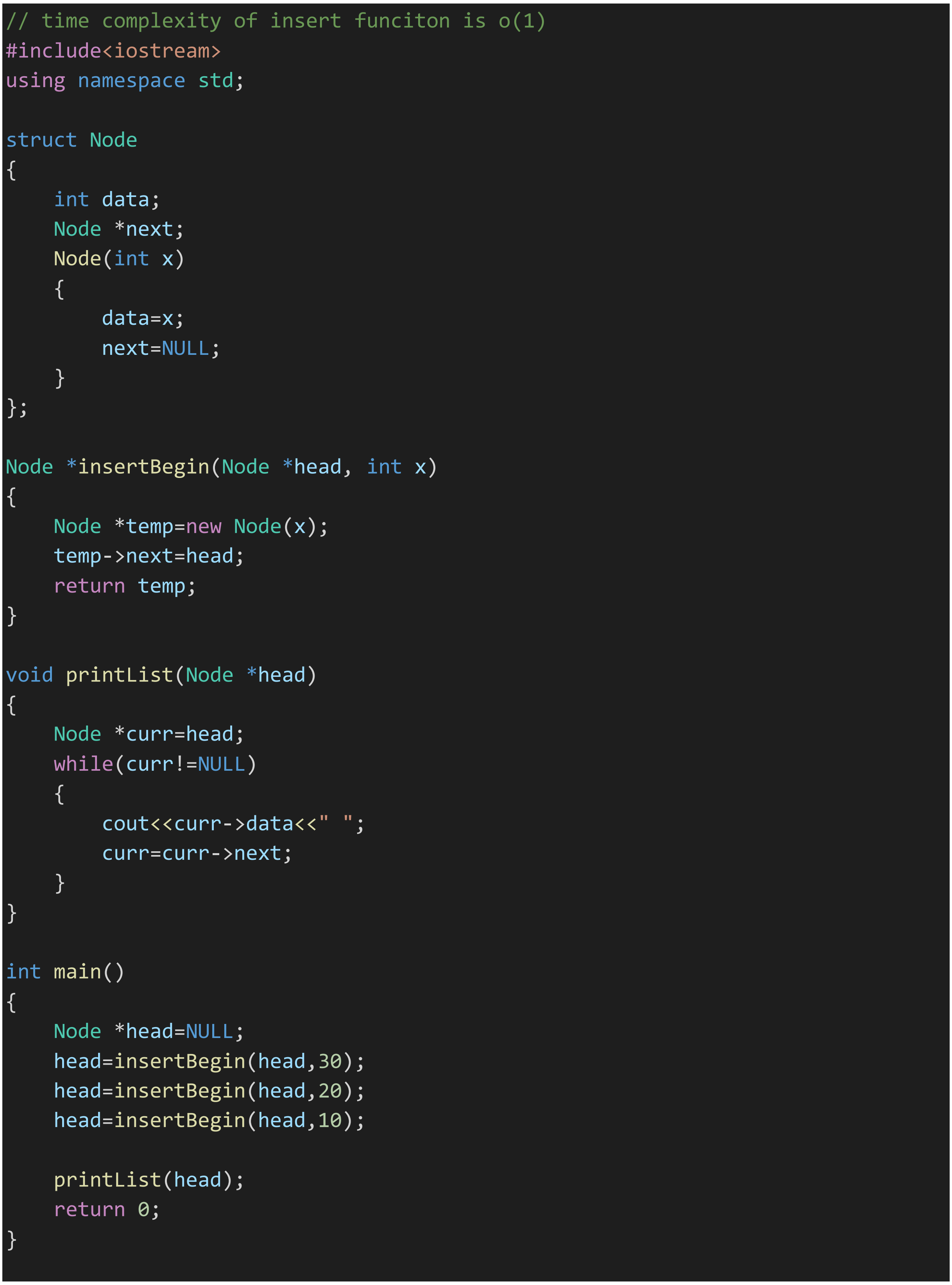
Recursive traversal of singly linked list

```
//time complexity o(n) and auxilary space is o(n)

#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int x)
    {
        data=x;
        next=NULL;
    }
};

void printList(Node *head)
{
    if(head==NULL)
        return;
    else
        {
            cout<<head->data<<" ";
            printList(head->next);
        }
}

int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    head->next->next->next=new Node(40);

    printList(head);

    return 0;
}
```

OUTPUT :

```
10 20 30 40
```

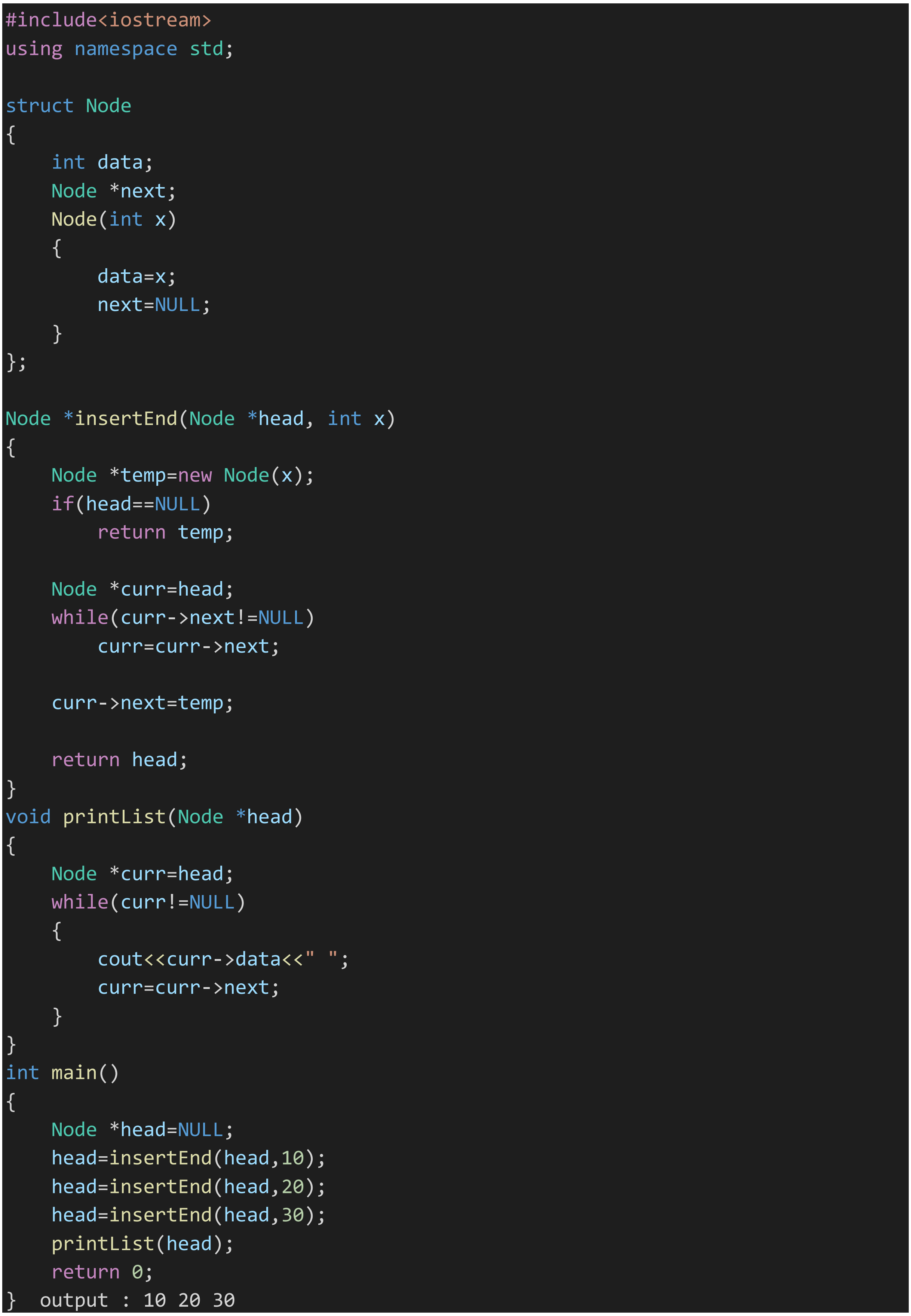
Insert at the begin of singly linked list



```cpp
// time complexity of insert funciton is o(1)
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int x)
    {
        data=x;
        next=NULL;
    }
};

Node *insertBegin(Node *head, int x)
{
    Node *temp=new Node(x);
    temp->next=head;
    return temp;
}

void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
}

int main()
{
    Node *head=NULL;
    head=insertBegin(head,30);
    head=insertBegin(head,20);
    head=insertBegin(head,10);

    printList(head);
    return 0;
}
```

OUTPUT : 10 20 30

Insert at the end of singly linked list :



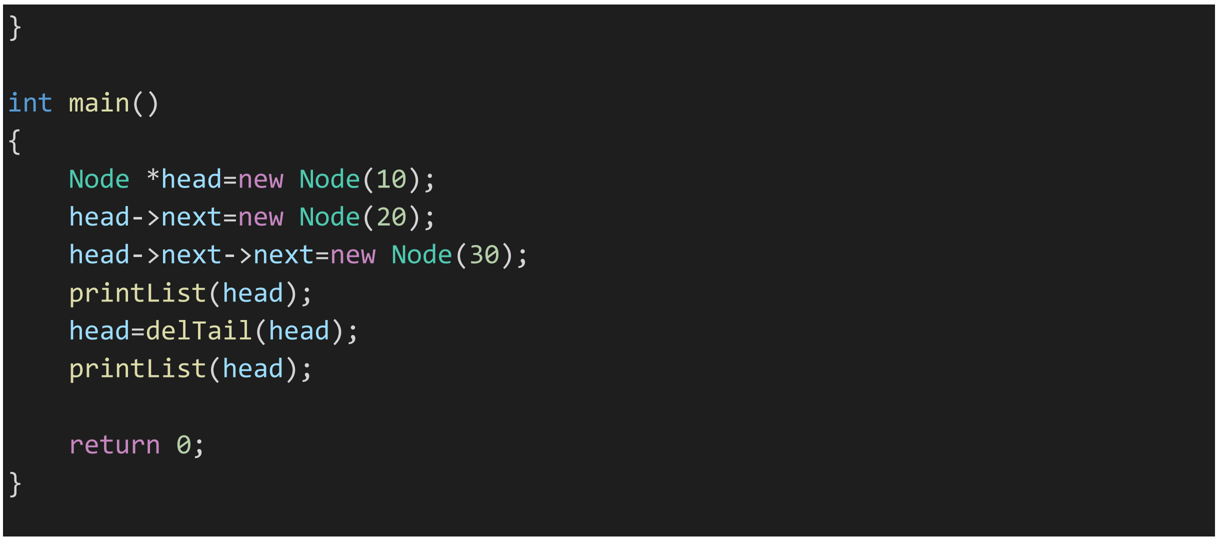
```cpp
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int x)
    {
        data=x;
        next=NULL;
    }
};

Node *insertEnd(Node *head, int x)
{
    Node *temp=new Node(x);
    if(head==NULL)
        return temp;

    Node *curr=head;
    while(curr->next!=NULL)
        curr=curr->next;

    curr->next=temp;

    return head;
}
void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
}
int main()
{
    Node *head=NULL;
    head=insertEnd(head,10);
    head=insertEnd(head,20);
    head=insertEnd(head,30);
    printList(head);
    return 0;
}  output : 10 20 30
```

Delete first Node of singly linked list :

```
// time complexity of delHead funciton is o(1)
#include<iostream>
using namespace std;
struct Node
{
    int data;
    Node *next=NULL;
    Node(int x)
    {
        data=x;
        next=NULL;
    }
};
Node *delHead(Node *head)
{
    if(head==NULL)
        return NULL;
    else
    {
        Node *temp=head->next;
        delete(head);
        return temp;
    }

}
void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}
int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    printList(head);
    head=delHead(head);
    printList(head);
    return 0;
}  OUTPUT : 10 20 30
20 30
```

Delete last Node of singly linked list :

```
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int x)
    {
        data=x;
        next=NULL;
    }
};

Node *delTail(Node *head)
{
    if(head==NULL)
        return NULL;
     if(head->next==NULL)
    {
        delete head;
        return NULL;
    }

    else
    {
        Node *curr=head;
        while (curr->next->next!=NULL)
            curr=curr->next;

        delete(curr->next);
        curr->next=NULL;
        return head;

    }
}

void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
```

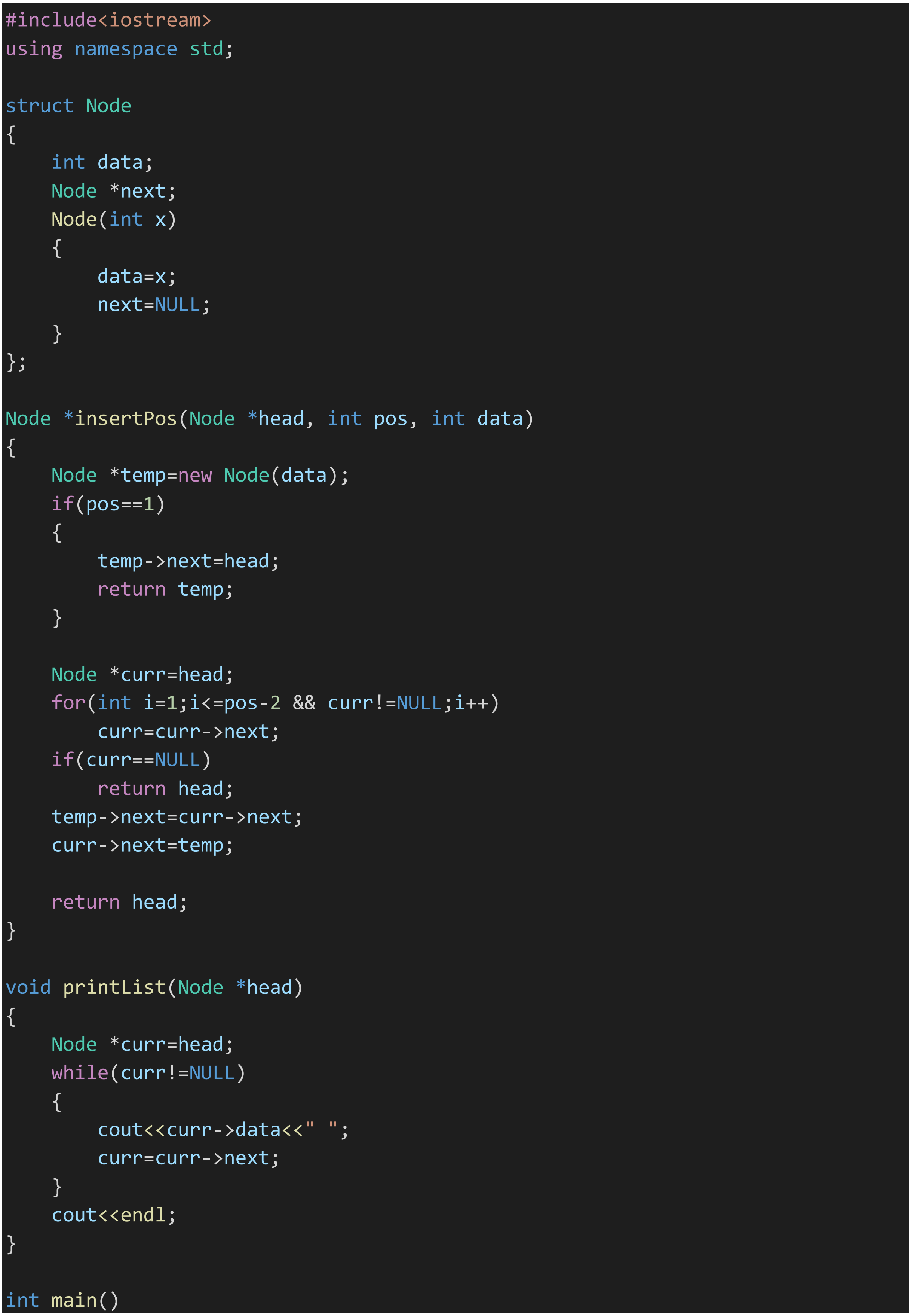


```
}

int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    printList(head);
    head=delTail(head);
    printList(head);

    return 0;
}
```

OUTPUT :

```
10 20 30

10 20
```

Insert at given position in linked list:



```
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int x)
    {
        data=x;
        next=NULL;
    }
};

Node *insertPos(Node *head, int pos, int data)
{
    Node *temp=new Node(data);
    if(pos==1)
    {
        temp->next=head;
        return temp;
    }

    Node *curr=head;
    for(int i=1;i<=pos-2 && curr!=NULL;i++)
        curr=curr->next;
    if(curr==NULL)
        return head;
    temp->next=curr->next;
    curr->next=temp;

    return head;
}

void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

int main()
```

```
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    printList(head);
    head=insertPos(head,2,15);
    printList(head);

    return 0;
}
```

OUTPUT :

```
10 20 30

10 15 20 30
```

Search in linked list :

Iterative :

```
//time complexity of o(n) auxiliary space theta(n)

#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int x)
    {
        data=x;
        next=NULL;
    }
};

int search(Node *head, int x)
{
    int pos=1;
    Node *curr=head;
    while(curr!=NULL)
    {
        if(curr->data==x)
            return pos;
        else
        {
            pos++;
            curr=curr->next;
        }
    }
    return -1;
}

void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}
```

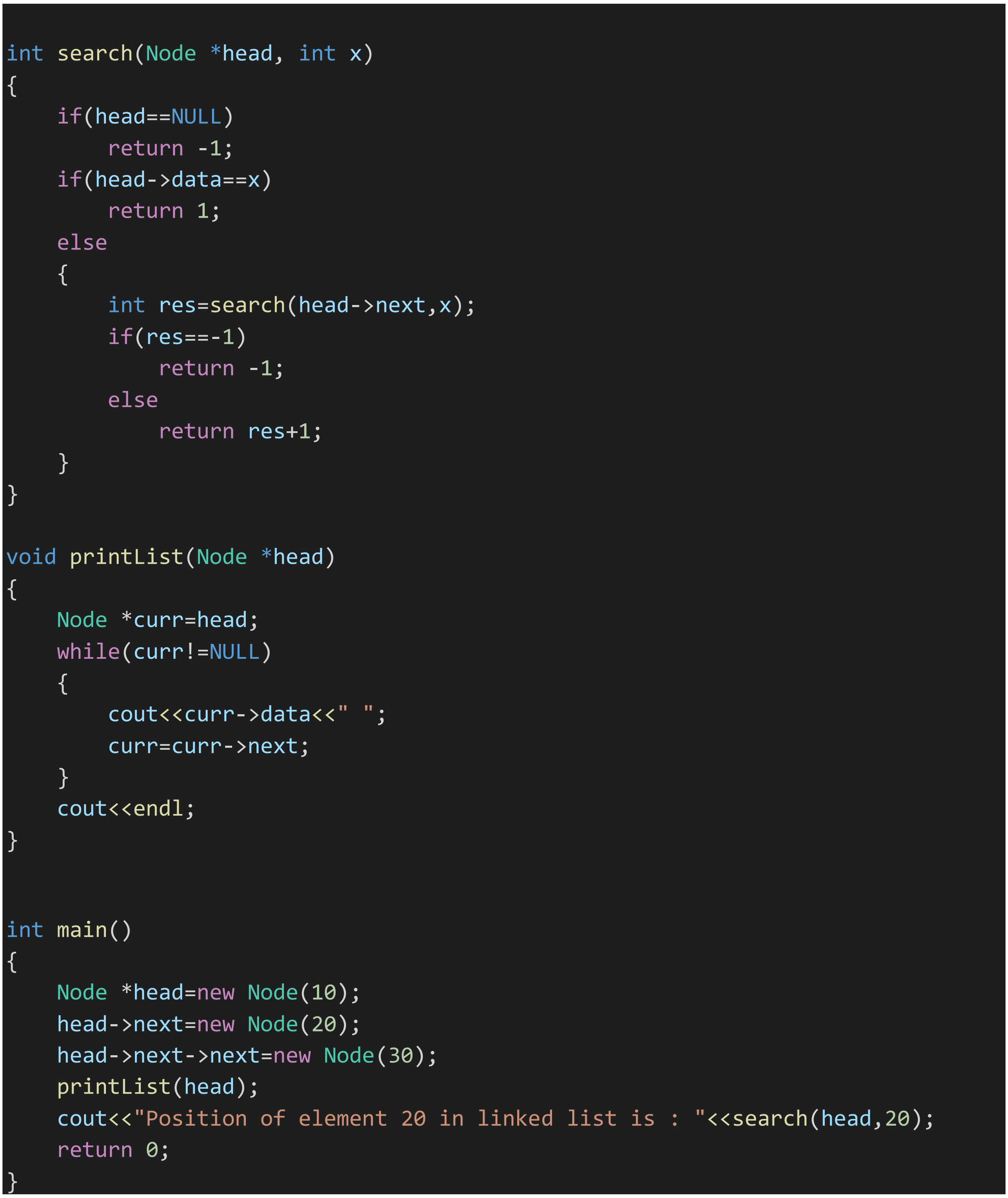
```
int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    printList(head);
    cout<<"Position of element 20 in linked list "<<search(head,20);
    return 0;
}
```

OUTPUT :

```
10 20 30

Position of element 20 in linked list 2
```

Recursive :

```
//time complexity of o(n) auxiliary space o(1)
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int x)
    {
        data=x;
        next=NULL;
    }
};
```

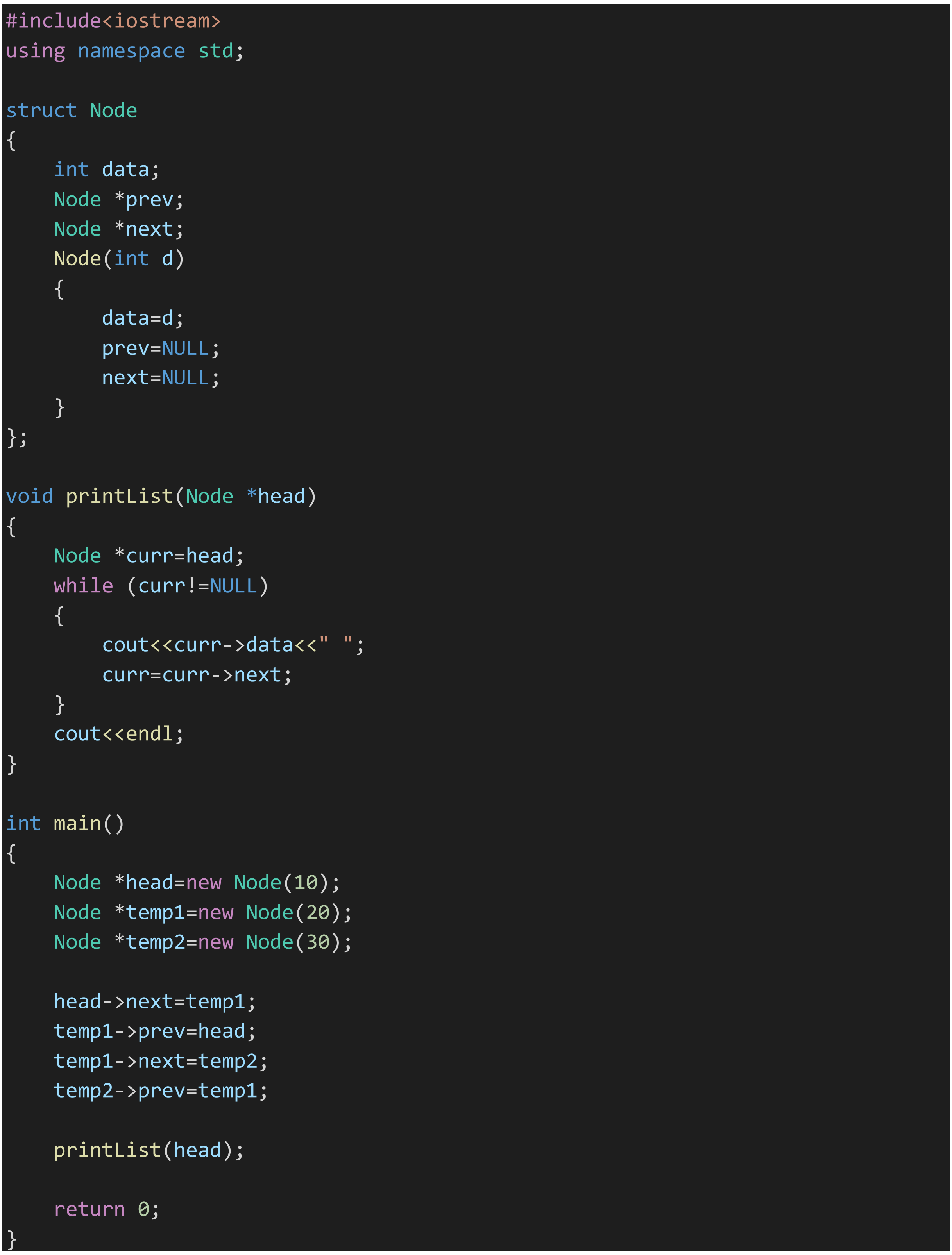


```cpp
int search(Node *head, int x)
{
    if(head==NULL)
        return -1;
    if(head->data==x)
        return 1;
    else
    {
        int res=search(head->next,x);
        if(res==-1)
            return -1;
        else
            return res+1;
    }
}

void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}


int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    printList(head);
    cout<<"Position of element 20 in linked list is : "<<search(head,20);
    return 0;
}
```

OUTPUT ;

```
10 20 30

Position of element 20 in linked list is : 2
```

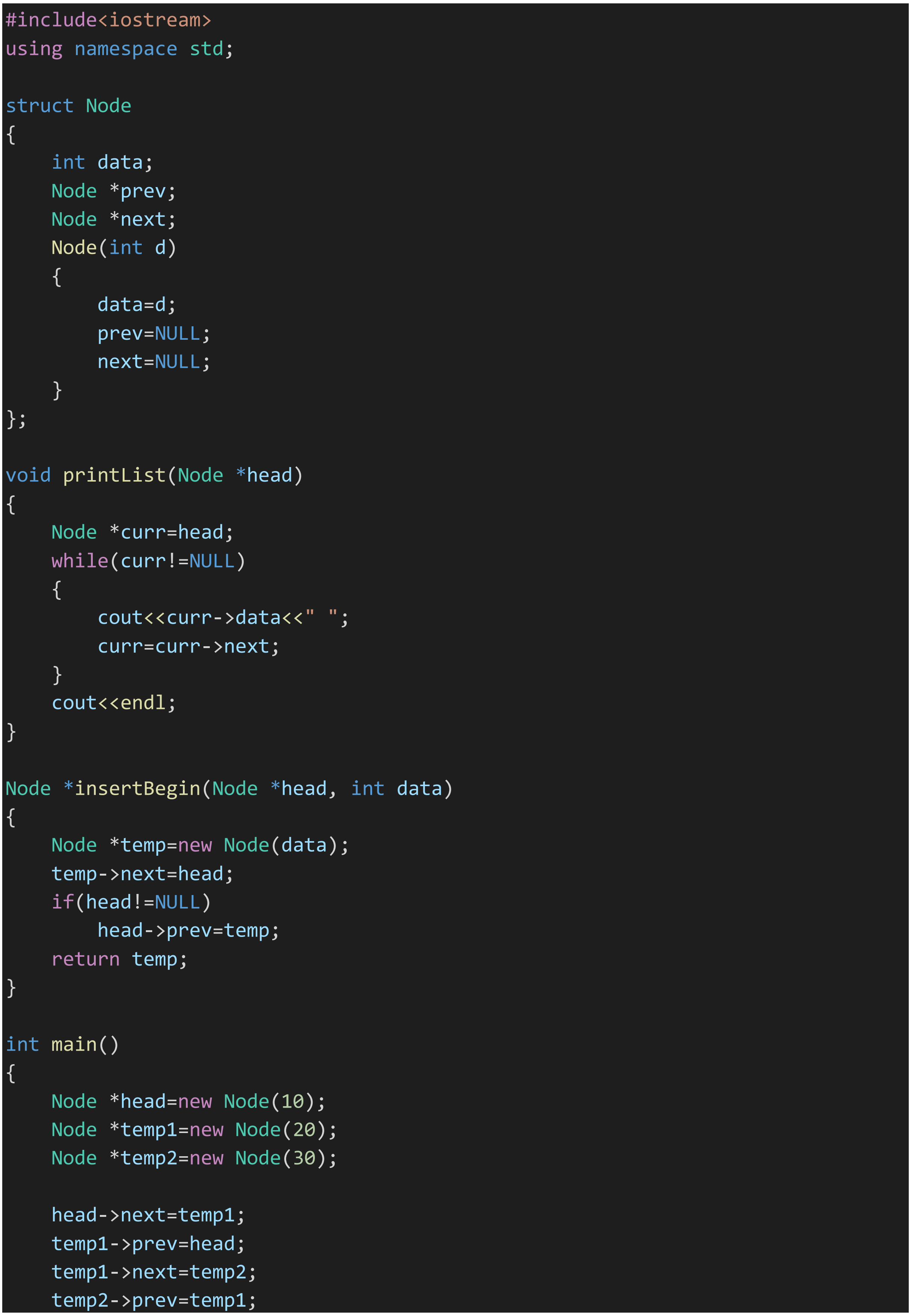
Doubly linked list :



```cpp
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *prev;
    Node *next;
    Node(int d)
    {
        data=d;
        prev=NULL;
        next=NULL;
    }
};

void printList(Node *head)
{
    Node *curr=head;
    while (curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

int main()
{
    Node *head=new Node(10);
    Node *temp1=new Node(20);
    Node *temp2=new Node(30);

    head->next=temp1;
    temp1->prev=head;
    temp1->next=temp2;
    temp2->prev=temp1;

    printList(head);

    return 0;
}
```

OUTPUT : 10 20 30

Insert at begin of doubly linked list :



```cpp
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *prev;
    Node *next;
    Node(int d)
    {
        data=d;
        prev=NULL;
        next=NULL;
    }
};

void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

Node *insertBegin(Node *head, int data)
{
    Node *temp=new Node(data);
    temp->next=head;
    if(head!=NULL)
        head->prev=temp;
    return temp;
}

int main()
{
    Node *head=new Node(10);
    Node *temp1=new Node(20);
    Node *temp2=new Node(30);

    head->next=temp1;
    temp1->prev=head;
    temp1->next=temp2;
    temp2->prev=temp1;
    printList(head);
    head=insertBegin(head, 5);

    printList(head);

    return 0;
}
```

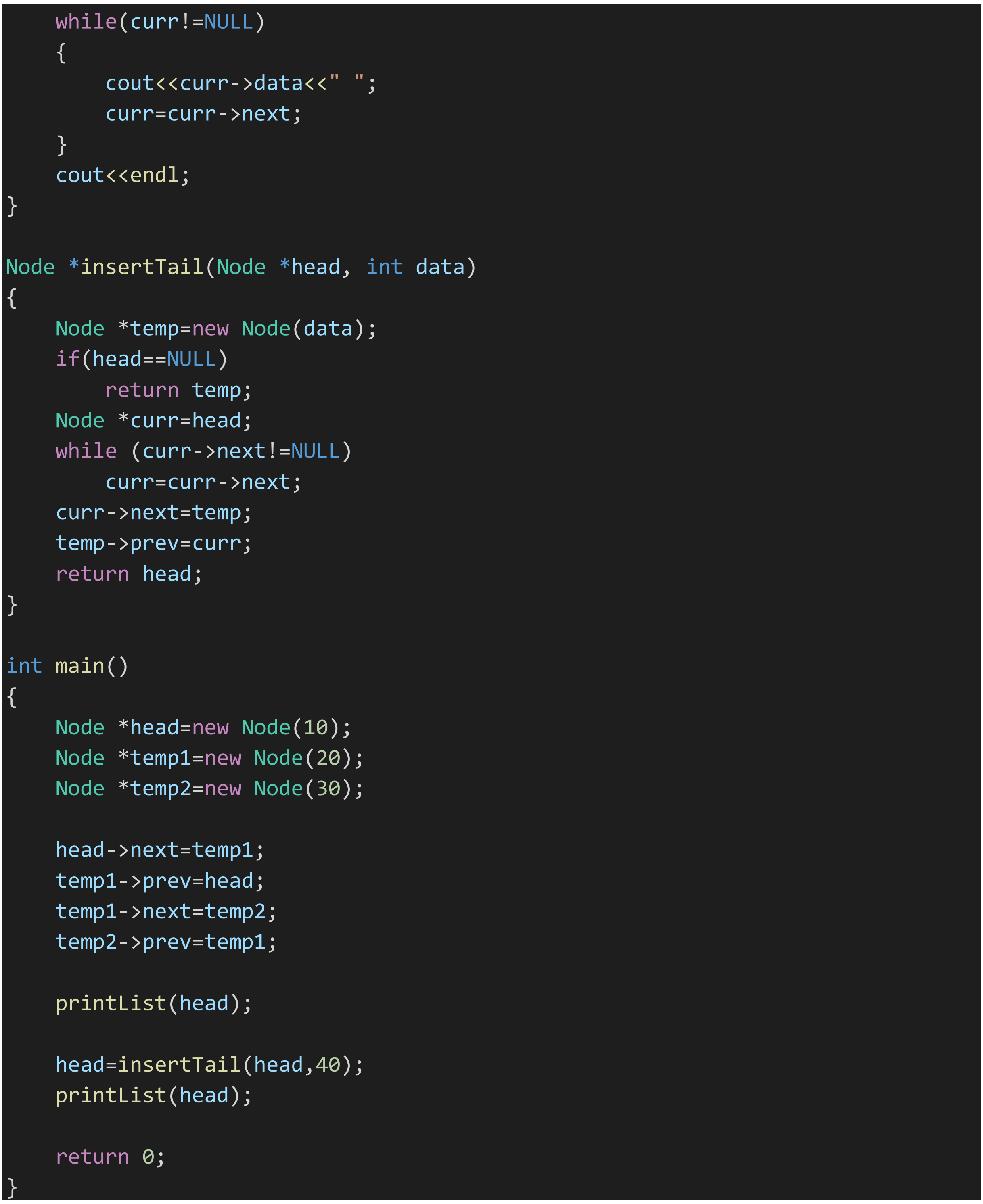
OUTPUT :

10 20 30

5 10 20 30

Insert at end of doubly linked list :

```
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *prev;
    Node *next;
    Node(int d)
    {
        data=d;
        prev=NULL;
        next=NULL;
    }
};

void printList(Node *head)
{
    Node *curr=head;
```



```
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

Node *insertTail(Node *head, int data)
{
    Node *temp=new Node(data);
    if(head==NULL)
        return temp;
    Node *curr=head;
    while (curr->next!=NULL)
        curr=curr->next;
    curr->next=temp;
    temp->prev=curr;
    return head;
}

int main()
{
    Node *head=new Node(10);
    Node *temp1=new Node(20);
    Node *temp2=new Node(30);

    head->next=temp1;
    temp1->prev=head;
    temp1->next=temp2;
    temp2->prev=temp1;

    printList(head);

    head=insertTail(head,40);
    printList(head);

    return 0;
}
```

OUTPUT :

```
10 20 30

10 20 30 40
```

Reverse a doubly linked list:

```
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *prev;
    Node *next;
    Node(int d)
    {
        data=d;
        prev=NULL;
        next=NULL;
    }
};


void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

Node *reverseDLL(Node *head)
{
    if(head==NULL || head->next==NULL)
        return head;
    Node *prev=NULL , *curr=head;
    while (curr!=NULL)
    {
        prev=curr->prev;      //swapping
        curr->prev=curr->next;
        curr->next=prev;
        curr=curr->prev;
    }
    return prev->prev;
}

int main()
{
    Node *head=new Node(10);
    Node *temp1=new Node(20);
    Node *temp2=new Node(30);

    head->next=temp1;
    temp1->prev=head;
    temp1->next=temp2;
    temp2->prev=temp1;

    printList(head);

    head=reverseDLL(head);

    printList(head);

    return 0;
}
```

OUTPUT :

```
10 20 30

30 20 10
```

Delete head of doubly linked list :

```
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *prev;
    Node *next;
    Node(int d)
    {
        data=d;
        prev=NULL;
        next=NULL;
    }
};

void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

Node *delHead(Node *head)
{
    if(head==NULL)
        return NULL;
    if(head->next==NULL)
    {
        delete head;
        return NULL;
    }
    else{
        Node *temp=head;
        head=head->next;
        delete(temp);
        return head;
    }
}

int main()
{
    Node *head=new Node(10);
    Node *temp1=new Node(20);
    Node *temp2=new Node(30);

    head->next=temp1;
    temp1->prev=head;
    temp1->next=temp2;
    temp2->prev=temp1;

    printList(head);

    head=delHead(head);

    printList(head);

    return 0;
}
```

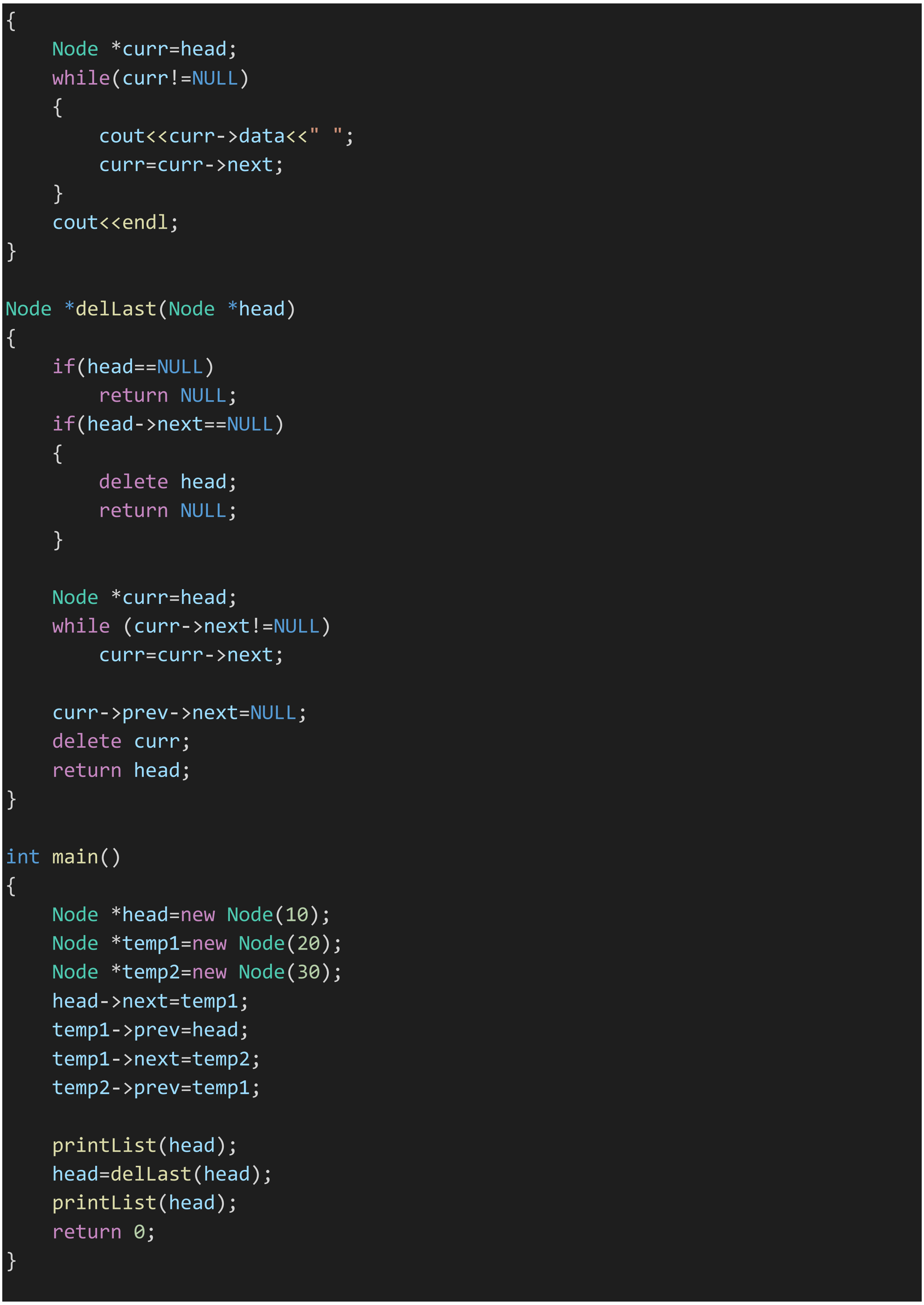
OUTPUT :

10 20 30

20 30

Delete last of doubly linked list :

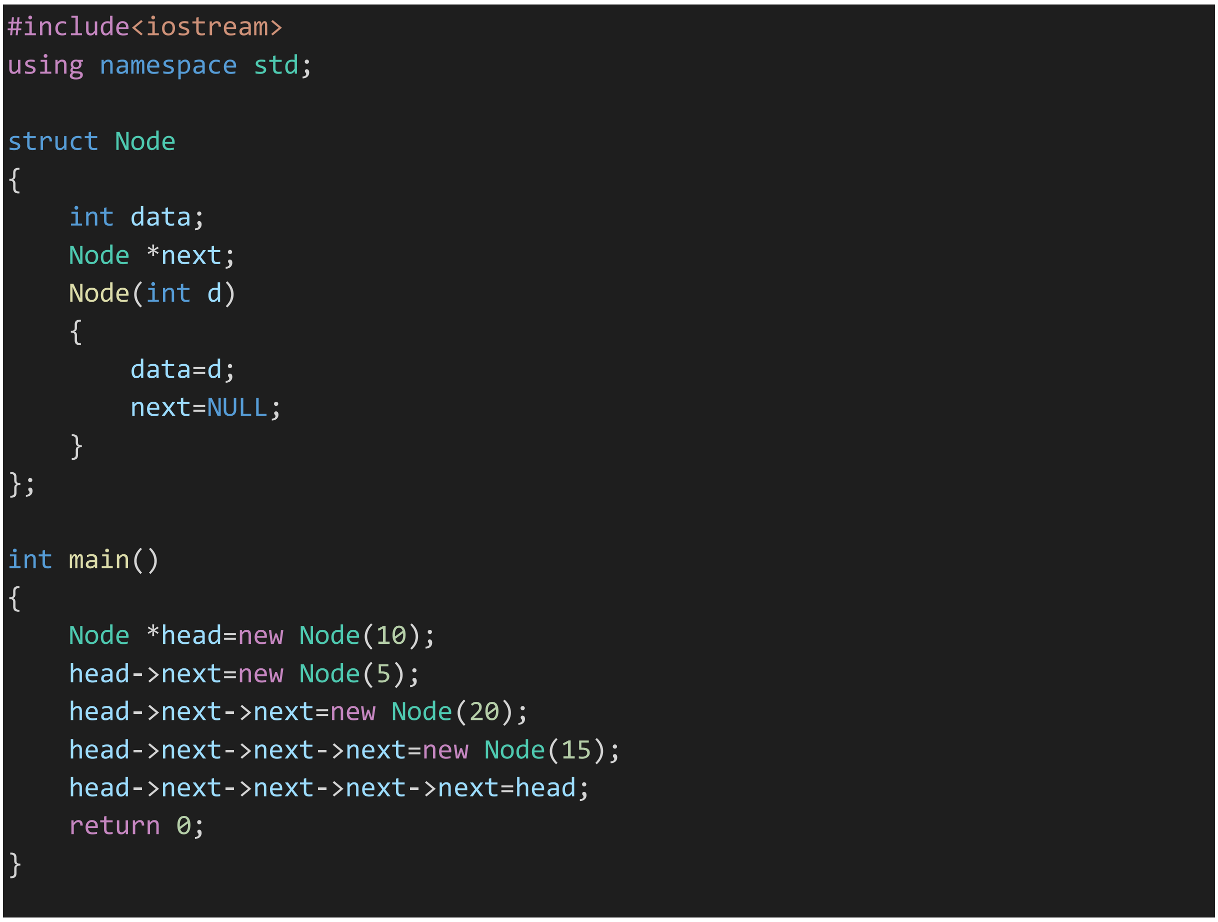
```
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *prev;
    Node *next;
    Node(int d)
    {
        data=d;
        prev=NULL;
        next=NULL;
    }
};

void printList(Node *head)
```



```
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

Node *delLast(Node *head)
{
    if(head==NULL)
        return NULL;
    if(head->next==NULL)
    {
        delete head;
        return NULL;
    }

    Node *curr=head;
    while (curr->next!=NULL)
        curr=curr->next;

    curr->prev->next=NULL;
    delete curr;
    return head;
}

int main()
{
    Node *head=new Node(10);
    Node *temp1=new Node(20);
    Node *temp2=new Node(30);
    head->next=temp1;
    temp1->prev=head;
    temp1->next=temp2;
    temp2->prev=temp1;

    printList(head);
    head=delLast(head);
    printList(head);
    return 0;
}
```

OUTPUT ;   10 20 30\n   10 20

Circular linked list :



```cpp
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

int main()
{
    Node *head=new Node(10);
    head->next=new Node(5);
    head->next->next=new Node(20);
    head->next->next->next=new Node(15);
    head->next->next->next->next=head;
    return 0;
}
```

Circular linked list traversal :

Method 1 : for loop :

```
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    if(head==NULL)
        return;
    cout<<head->data<<" ";
    for(Node *p=head->next;p!=head;p=p->next)
        cout<<p->data<<" ";
}

int main()
{
    Node *head=new Node(10);
    head->next=new Node(5);
    head->next->next=new Node(20);
    head->next->next->next=new Node(15);
    head->next->next->next->next=head;
    printList(head);
    return 0;
}
```

OUTPUT :

```
10 5 20 15
```

Method 2 : do while loop :

```
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};


void printList(Node *head)
{
    if(head==NULL)
        return;
    Node *p=head;
    do{
        cout<<p->data<<" ";
        p=p->next;
    }while (p!=head);

}

int main()
{
    Node *head=new Node(10);
    head->next=new Node(5);
    head->next->next=new Node(20);
    head->next->next->next=new Node(15);
    head->next->next->next->next=head;
    printList(head);
    return 0;
}
```

OUTPUT :

```
10 5 20 15
```

Insert at begin of circular linked list :

Naïve : O(n) :

```
//time complexity o(n)

#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    if(head==NULL)
        return;
    Node *p=head;
    do{
        cout<<p->data<<" ";
        p=p->next;
    }while(p!=head);
    cout<<endl;
}

Node *insertBegin(Node *head, int x)
{
    Node *temp=new Node(x);
    if(head==NULL)
        temp->next=temp;
    else{
        Node *curr=head;
        while (curr->next!=head)
            curr=curr->next;
        curr->next=temp;
        temp->next=head;
    }

    return temp;
}
```

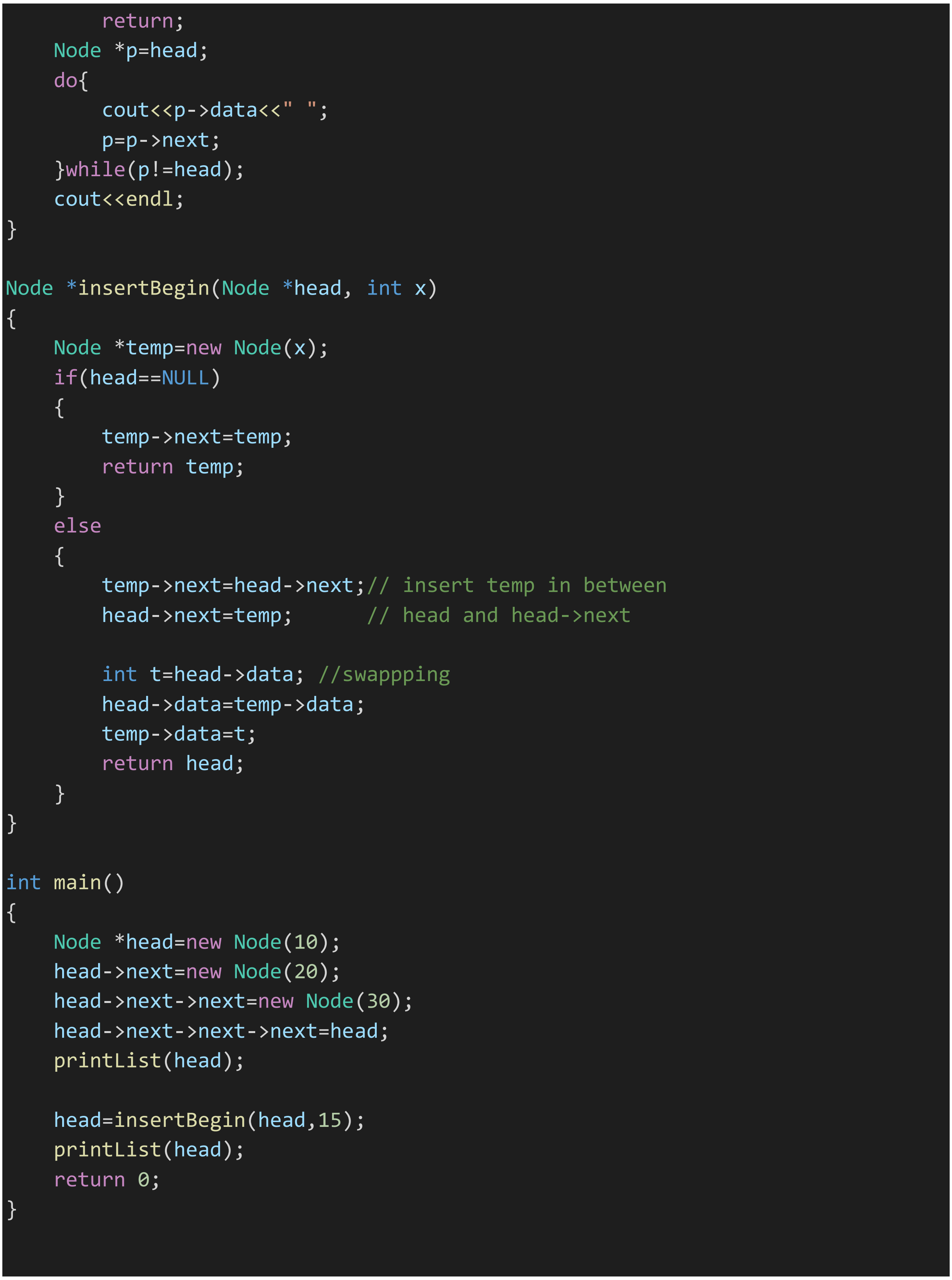
```
int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    head->next->next->next=head;
    printList(head);

    head=insertBegin(head,15);
    printList(head);
    return 0;
}
```

OUTPUT :

```
10 20 30

15 10 20 30
```

Efficient : O(n) :

```
//time complexity o(1)
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    if(head==NULL)
```



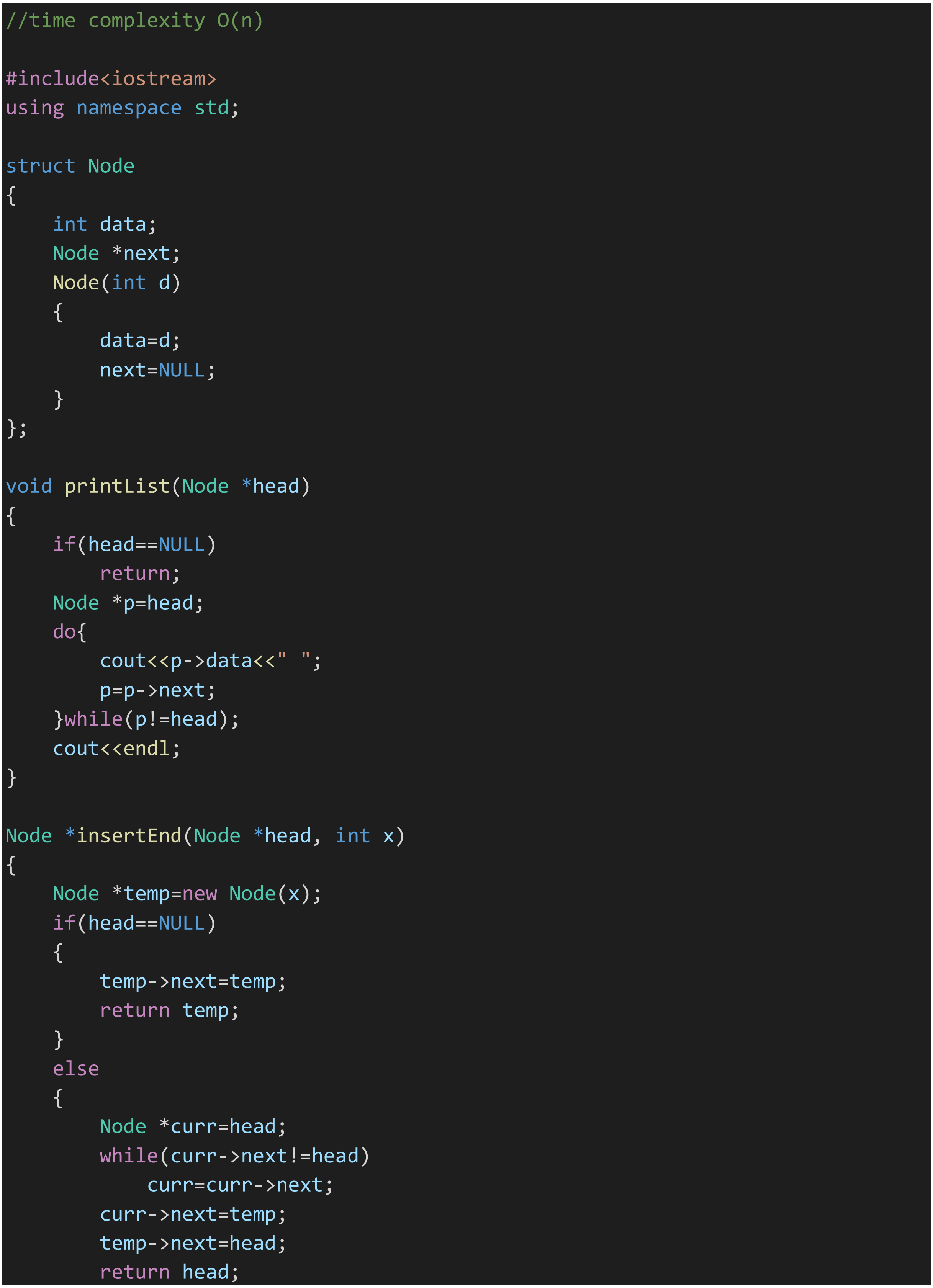
```
        return;
    Node *p=head;
    do{
        cout<<p->data<<" ";
        p=p->next;
    }while(p!=head);
    cout<<endl;
}

Node *insertBegin(Node *head, int x)
{
    Node *temp=new Node(x);
    if(head==NULL)
    {
        temp->next=temp;
        return temp;
    }
    else
    {
        temp->next=head->next;// insert temp in between
        head->next=temp;      // head and head->next

        int t=head->data; //swappping
        head->data=temp->data;
        temp->data=t;
        return head;
    }
}

int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    head->next->next->next=head;
    printList(head);

    head=insertBegin(head,15);
    printList(head);
    return 0;
}
```

OUTPUT : 10 20 30

15 10 20 30

Insert at end of circular linked list :

Niave : O(n) :



```
//time complexity O(n)

#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    if(head==NULL)
        return;
    Node *p=head;
    do{
        cout<<p->data<<" ";
        p=p->next;
    }while(p!=head);
    cout<<endl;
}

Node *insertEnd(Node *head, int x)
{
    Node *temp=new Node(x);
    if(head==NULL)
    {
        temp->next=temp;
        return temp;
    }
    else
    {
        Node *curr=head;
        while(curr->next!=head)
            curr=curr->next;
        curr->next=temp;
        temp->next=head;
        return head;
    }
}

int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    head->next->next->next=head;
    printList(head);

    head=insertEnd(head,15);
    printList(head);
    return 0;
}
```

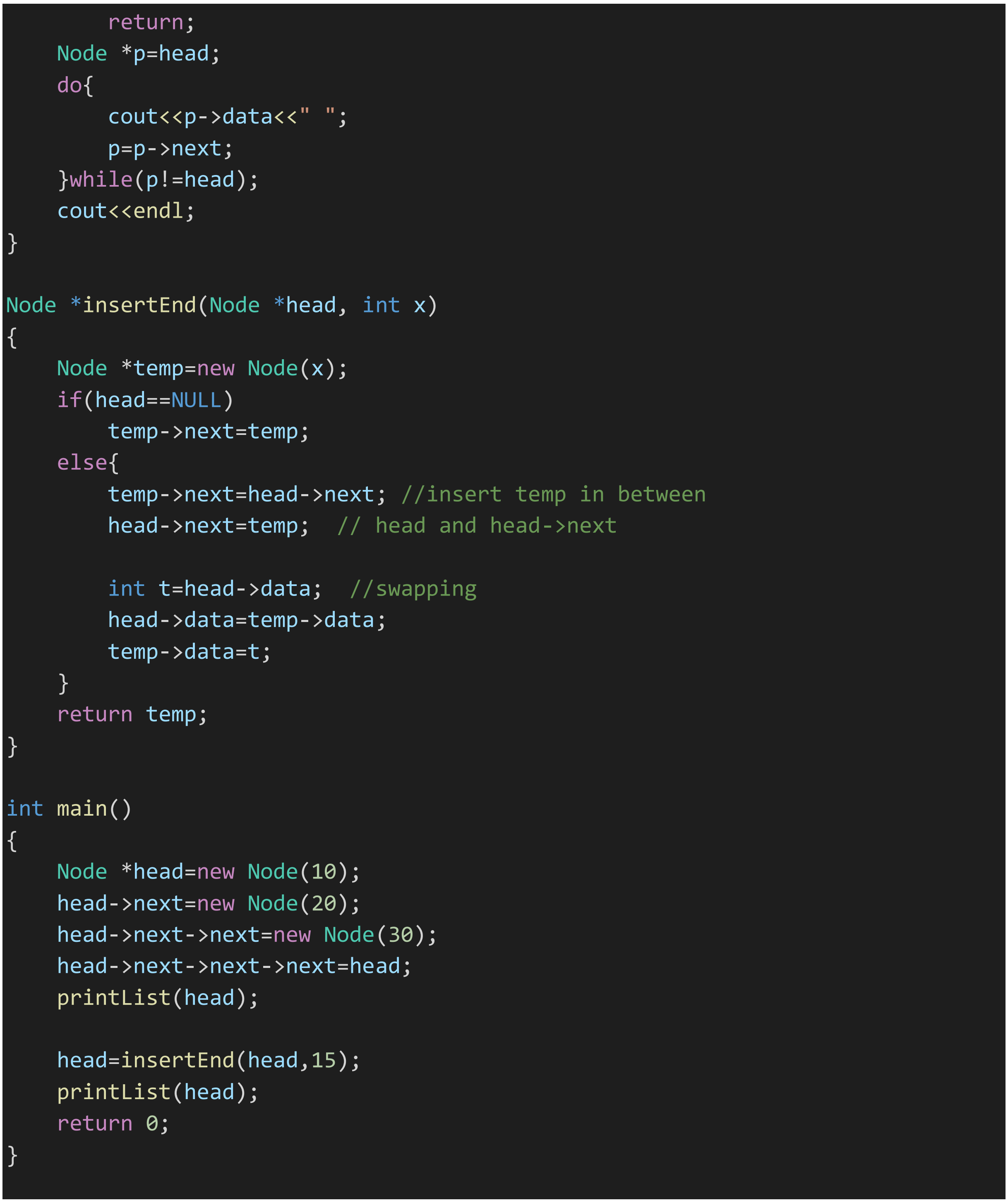
OUTPUT :

10 20 30

10 20 30 15

Efficient : O(n) :

```
//time complexity O(1)

#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    if(head==NULL)
```



```
        return;
    Node *p=head;
    do{
        cout<<p->data<<" ";
        p=p->next;
    }while(p!=head);
    cout<<endl;
}

Node *insertEnd(Node *head, int x)
{
    Node *temp=new Node(x);
    if(head==NULL)
        temp->next=temp;
    else{
        temp->next=head->next; //insert temp in between
        head->next=temp;  // head and head->next

        int t=head->data;  //swapping
        head->data=temp->data;
        temp->data=t;
    }
    return temp;
}

int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    head->next->next->next=head;
    printList(head);

    head=insertEnd(head,15);
    printList(head);
    return 0;
}
```

OUTPUT ;

```
10 20 30

10 20 30 15
```

delete head of circular linked list :

Naïve :

```
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    if(head==NULL)
        return;
    Node *p=head;
    do{
        cout<<p->data<<" ";
        p=p->next;
    }while(p!=head);
    cout<<endl;
}

Node *delHead(Node *head)
{
    if(head==NULL)
        return NULL;
    if(head->next==head)
    {
        delete head;
        return NULL;
    }

    Node *curr=head;
    while(curr->next!=head)
        curr=curr->next;
    curr->next=head->next;
    delete head;
    return curr->next;
}
```

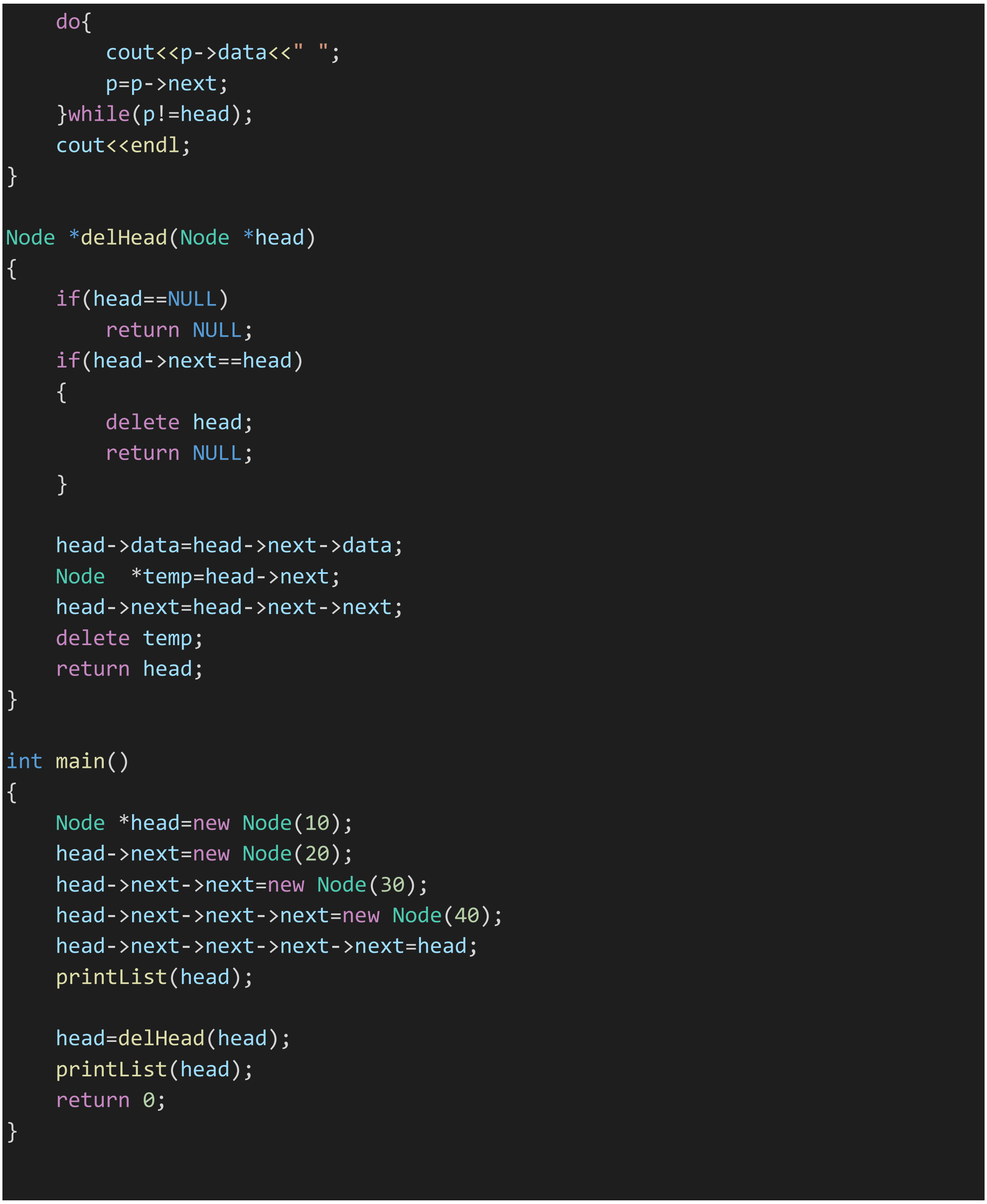
```
int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    head->next->next->next=new Node(40);
    head->next->next->next->next=head;
    printList(head);

    head=delHead(head);
    printList(head);
    return 0;
}
```

OUTPUT :

```
10 20 30 40

20 30 40
```

Efficient :

```
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    if(head==NULL)
        return;
    Node *p=head;
```



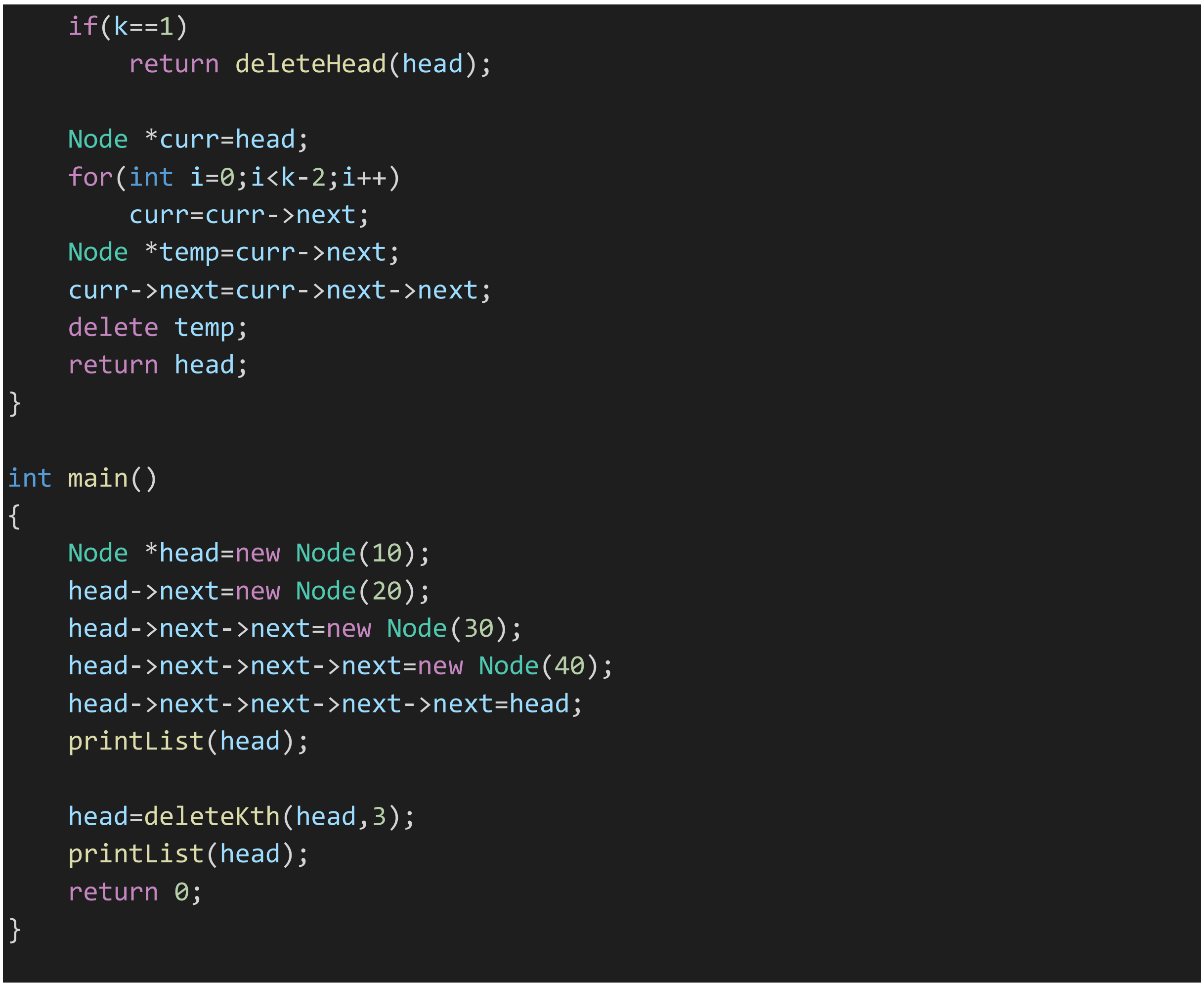
```
    do{
        cout<<p->data<<" ";
        p=p->next;
    }while(p!=head);
    cout<<endl;
}

Node *delHead(Node *head)
{
    if(head==NULL)
        return NULL;
    if(head->next==head)
    {
        delete head;
        return NULL;
    }

    head->data=head->next->data;
    Node  *temp=head->next;
    head->next=head->next->next;
    delete temp;
    return head;
}

int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    head->next->next->next=new Node(40);
    head->next->next->next->next=head;
    printList(head);

    head=delHead(head);
    printList(head);
    return 0;
}
```

OUTPUT :

```
10 20 30 40

20 30 40
```

Delete k^{th} of circular linked list :

```
//deleting kth node of a circular linked list where k is less than or equal to
 the number of nodes in the list.

#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    if(head==NULL)
        return;
    Node *p=head;
    do{
        cout<<p->data<<" ";
        p=p->next;
    }while(p!=head);
    cout<<endl;
}

Node *deleteHead(Node *head){
    if(head==NULL)return NULL;
    if(head->next==head){
        delete head;
        return NULL;
    }
    head->data=head->next->data;
    Node *temp=head->next;
    head->next=head->next->next;
    delete temp;
    return head;
}

Node *deleteKth(Node *head, int k)
{
    if(head==NULL)
        return head;
```

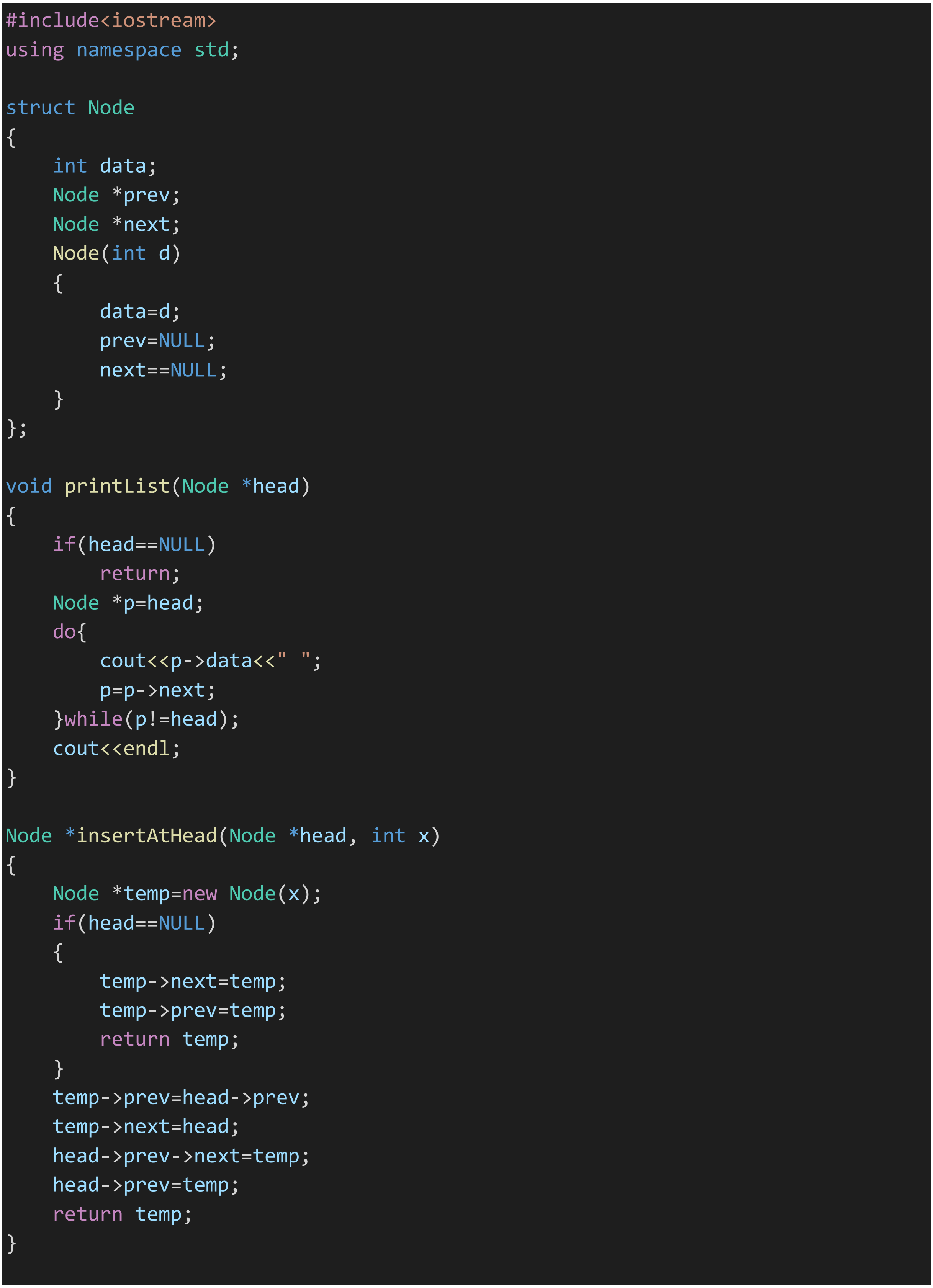


```
    if(k==1)
        return deleteHead(head);

    Node *curr=head;
    for(int i=0;i<k-2;i++)
        curr=curr->next;
    Node *temp=curr->next;
    curr->next=curr->next->next;
    delete temp;
    return head;
}

int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    head->next->next->next=new Node(40);
    head->next->next->next->next=head;
    printList(head);

    head=deleteKth(head,3);
    printList(head);
    return 0;
}
```

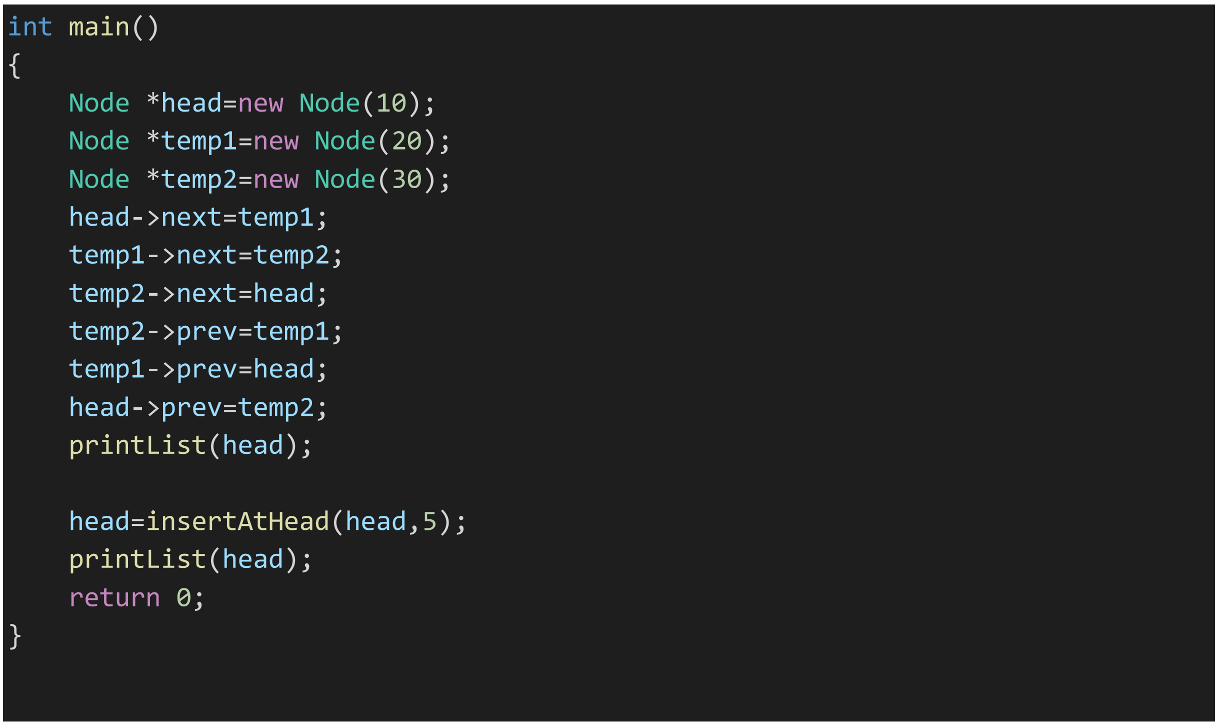
OUTPUT :

```
10 20 30 40

10 20 40
```

Insert at head of circular Doubly linked list :



```
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *prev;
    Node *next;
    Node(int d)
    {
        data=d;
        prev=NULL;
        next==NULL;
    }
};

void printList(Node *head)
{
    if(head==NULL)
        return;
    Node *p=head;
    do{
        cout<<p->data<<" ";
        p=p->next;
    }while(p!=head);
    cout<<endl;
}

Node *insertAtHead(Node *head, int x)
{
    Node *temp=new Node(x);
    if(head==NULL)
    {
        temp->next=temp;
        temp->prev=temp;
        return temp;
    }
    temp->prev=head->prev;
    temp->next=head;
    head->prev->next=temp;
    head->prev=temp;
    return temp;
}
```

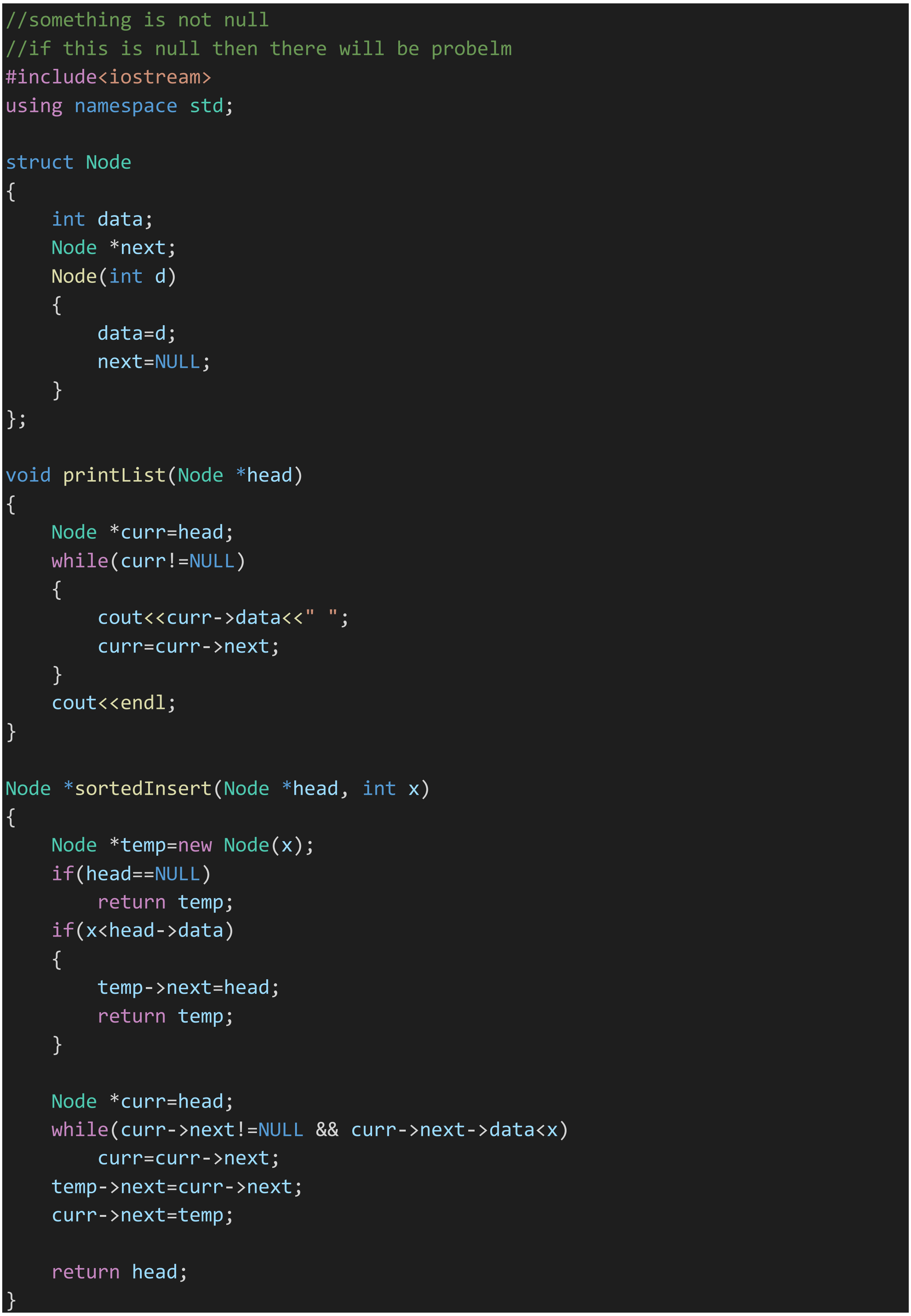


```
int main()
{
    Node *head=new Node(10);
    Node *temp1=new Node(20);
    Node *temp2=new Node(30);
    head->next=temp1;
    temp1->next=temp2;
    temp2->next=head;
    temp2->prev=temp1;
    temp1->prev=head;
    head->prev=temp2;
    printList(head);

    head=insertAtHead(head,5);
    printList(head);
    return 0;
}
```

OUTPUT :

```
10 20 30

5 10 20 30
```

Sorted insert in singly linked list :



```
//something is not null
//if this is null then there will be probelm
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

Node *sortedInsert(Node *head, int x)
{
    Node *temp=new Node(x);
    if(head==NULL)
        return temp;
    if(x<head->data)
    {
        temp->next=head;
        return temp;
    }

    Node *curr=head;
    while(curr->next!=NULL && curr->next->data<x)
        curr=curr->next;
    temp->next=curr->next;
    curr->next=temp;

    return head;
}
```

```
int main()
{
    Node *head=NULL;
    head=sortedInsert(head, 50);
    printList(head);
    head=sortedInsert(head,40);
    printList(head);
    head=sortedInsert(head,80);
    printList(head);
    head=sortedInsert(head,60);
    printList(head);

    return 0;
}
```

OUTPUT :

```
50

40 50

40 50 80

40 50 60 80
```

Middle of Linked list :

This is an important interview problem where one needs to find the middle of a linked list of a given linked list.

Naïve :

```
// This is an important interview problem where one needs
//to find the middle of a linked list of a given linked list.

//if there are even elemnt then then print second middle element
//and if odd print middle element
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

void printMiddle(Node *head)
{
    if(head==NULL)
        return;
    int count=0;
    Node *curr;
    for(curr=head;curr!=NULL;curr=curr->next)
        count++;
    curr=head;
    for(int i=0;i<count/2;i++)
        curr=curr->next;
    cout<<curr->data;
}

int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    head->next->next->next=new Node(40);
    head->next->next->next->next=new Node(50);
    printList(head);
    cout<<"Middle of Linked List: ";
    printMiddle(head);
    return 0;
}
```

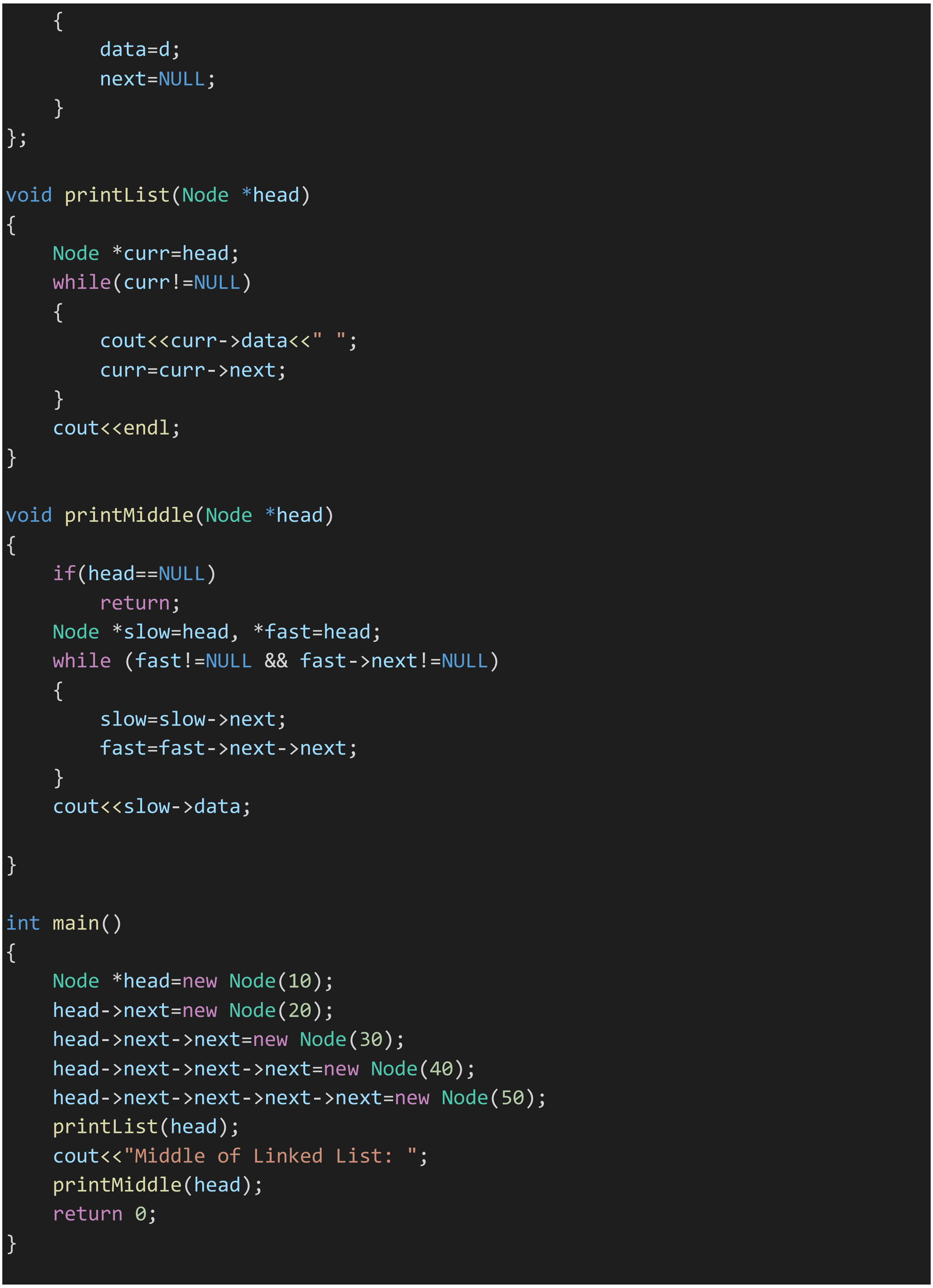
OUTPUT :

10 20 30 40 50

Middle of Linked List: 30

Efficient for Middle of linked list :

```
// This is an important interview problem where one needs
//to find the middle of a linked list of a given linked list.

//if there are even elemnt then then print second middle element
//and if odd print middle element

#include<iostream>
using namespace std;

struct  Node
{
    int data;
    Node *next;
    Node(int d)
```



```
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

void printMiddle(Node *head)
{
    if(head==NULL)
        return;
    Node *slow=head, *fast=head;
    while (fast!=NULL && fast->next!=NULL)
    {
        slow=slow->next;
        fast=fast->next->next;
    }
    cout<<slow->data;

}

int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    head->next->next->next=new Node(40);
    head->next->next->next->next=new Node(50);
    printList(head);
    cout<<"Middle of Linked List: ";
    printMiddle(head);
    return 0;
}
```

OUTPUT : 10 20 30 40 50

Middle of Linked List: 30

Nth node from end of linked list :

Naïve :Method 1: using length linked list :

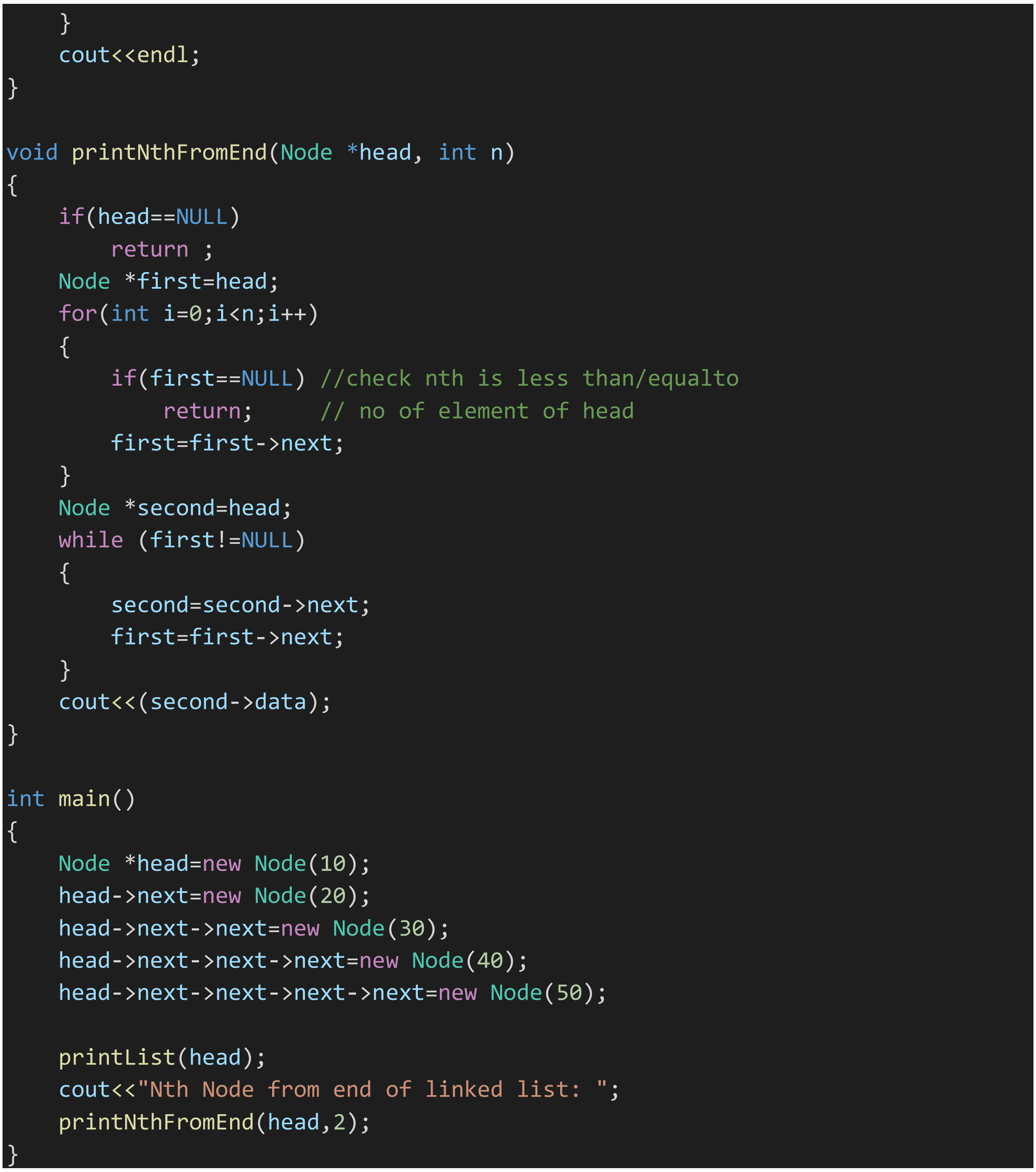
```
//problem on finding the n-th node from the end of a given linked list.

// Method 1(Using length of Linked List)
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

void printNthFromEnd(Node *head, int n)
{
    Node *curr;
    int len=0;
    for(curr=head;curr!=NULL;curr=curr->next)
        len++;
    curr=head;
    for(int i=1;i<len-n+1;i++)
        curr=curr->next;
    cout<<curr->data;
}

int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    head->next->next->next=new Node(40);
    head->next->next->next->next=new Node(50);
    printList(head);
    cout<<"Nth node from end of Linked List: ";
    printNthFromEnd(head,2);
    return 0;
}
```

OUTPUT :

```
10 20 30 40 50

Nth node from end of Linked List: 40
```

Efficient :Method 2: using two pointers :

```
//problem on finding the n-th node from the end of a given linked list.

// Method 2(Using Two Pointers/References)

#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
```



```
    }
    cout<<endl;
}

void printNthFromEnd(Node *head, int n)
{
    if(head==NULL)
        return ;
    Node *first=head;
    for(int i=0;i<n;i++)
    {
        if(first==NULL) //check nth is less than/equalto
            return;     // no of element of head
        first=first->next;
    }
    Node *second=head;
    while (first!=NULL)
    {
        second=second->next;
        first=first->next;
    }
    cout<<(second->data);
}

int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    head->next->next->next=new Node(40);
    head->next->next->next->next=new Node(50);

    printList(head);
    cout<<"Nth Node from end of linked list: ";
    printNthFromEnd(head,2);
}
```

OUTPUT :

10 20 30 40 50

Nth Node from end of linked list: 40

Reverse a linked list iterative :

Naïve :

```cpp
//it required two traversal
//auxiliary space O(n)

#include<iostream>
#include<vector>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

Node *revList(Node *head)
{
    vector<int> arr;
    for(Node *curr=head;curr!=NULL;curr=curr->next)
        arr.push_back(curr->data);

    for(Node *curr=head;curr!=NULL;curr=curr->next)
    {
        curr->data=arr.back();
        arr.pop_back();
    }

    return head;
}
```

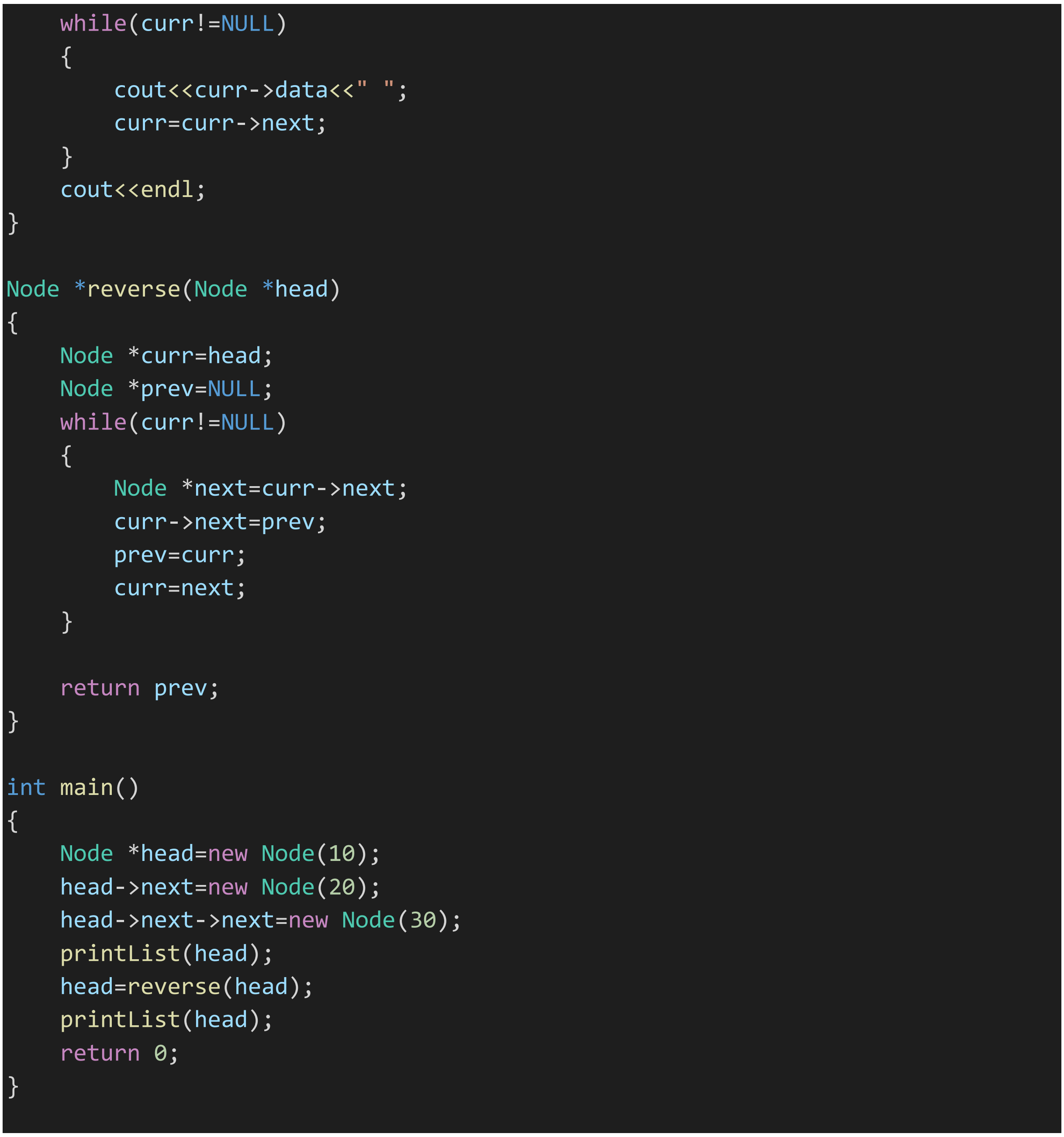
```
int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    printList(head);
    head=revList(head);
    printList(head);

    return 0;
}
```

OUTPUT :

```
10 20 30

30 20 10
```

Efficient for reverse linked list iterative :

```
//the idea is changing the link rather than data

#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    Node *curr=head;
```

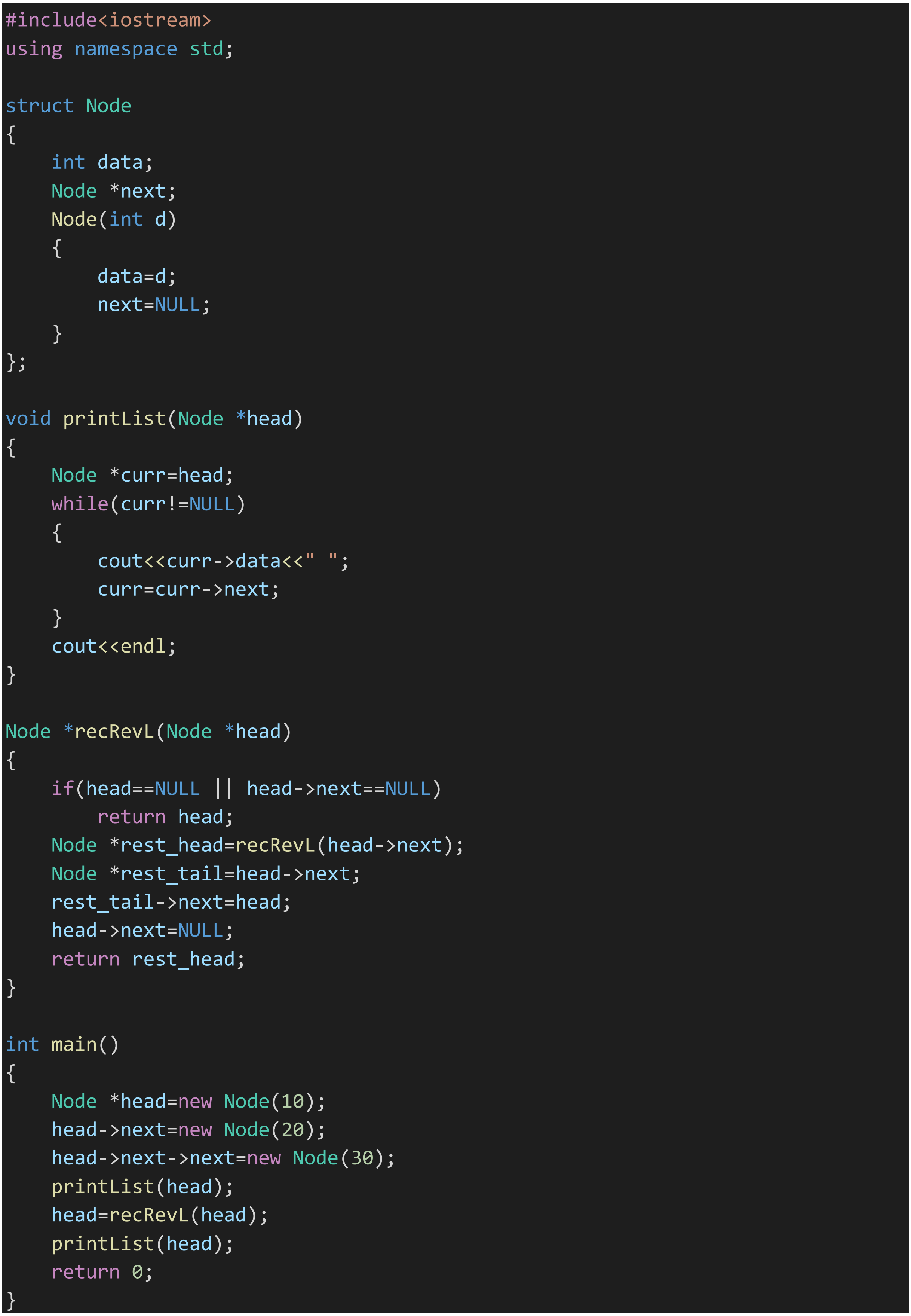


```
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

Node *reverse(Node *head)
{
    Node *curr=head;
    Node *prev=NULL;
    while(curr!=NULL)
    {
        Node *next=curr->next;
        curr->next=prev;
        prev=curr;
        curr=next;
    }

    return prev;
}

int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    printList(head);
    head=reverse(head);
    printList(head);
    return 0;
}
```

OUTPUT :

```
10 20 30

30 20 10
```

Recursive reverse linked list part 1:



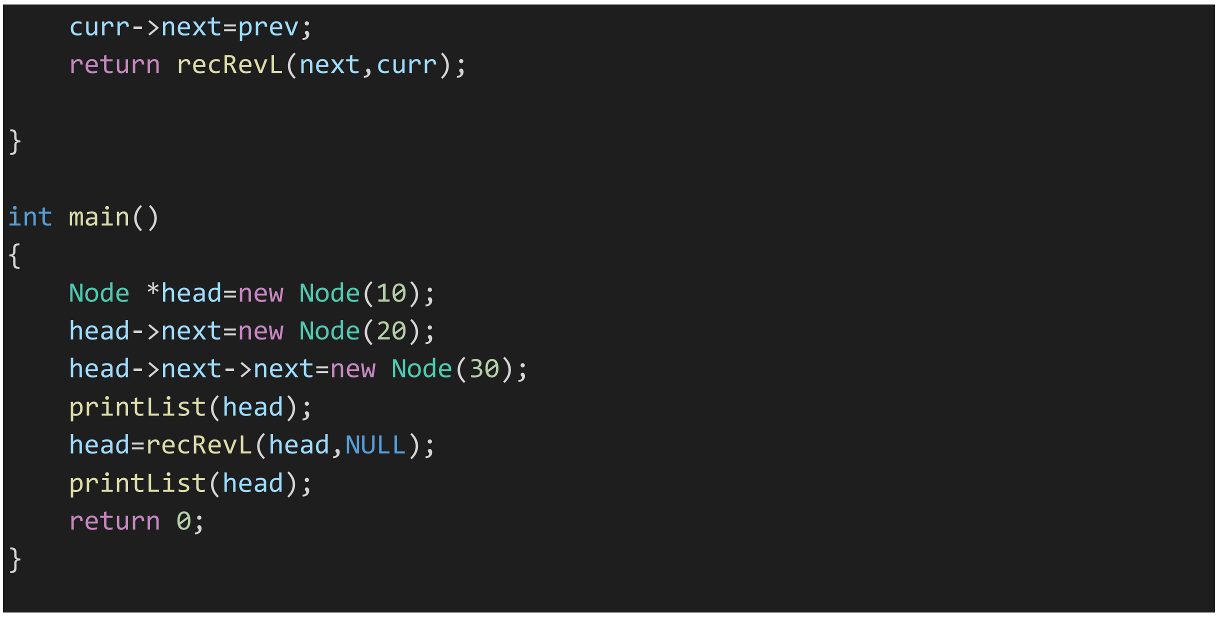
```cpp
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

Node *recRevL(Node *head)
{
    if(head==NULL || head->next==NULL)
        return head;
    Node *rest_head=recRevL(head->next);
    Node *rest_tail=head->next;
    rest_tail->next=head;
    head->next=NULL;
    return rest_head;
}

int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    printList(head);
    head=recRevL(head);
    printList(head);
    return 0;
}
```

OUTPUT :

```
10 20 30

30 20 10
```

Recursive reverse linked list part 2:

```cpp
//In this method a tail recursive solution is discussed to reverse the linked list.
//This method simply follows the iterative solution.

#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    Node *curr=head;
    while (curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

Node *recRevL(Node *curr, Node *prev)
{
    if(curr==NULL)
        return prev;
    Node *next=curr->next;
```



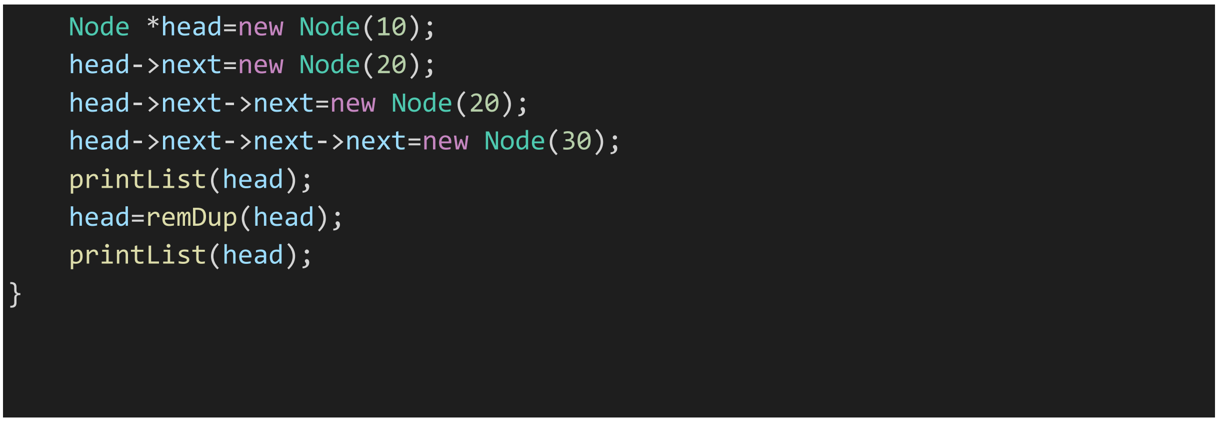
```
    curr->next=prev;
    return recRevL(next,curr);

}

int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    printList(head);
    head=recRevL(head,NULL);
    printList(head);
    return 0;
}
```

OUTPUT :

```
10 20 30

30 20 10
```

Remove duplicate from a sorted singly linked list :

```
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

Node *remDup(Node *head)
{
    Node *curr=head;
    while (curr!=NULL && curr->next!=NULL)
    {
        if(curr->data==curr->next->data)
        {
            Node *temp=curr->next;
            curr->next=curr->next->next;
            delete temp;
        }
        else
            curr=curr->next;
    }
    return head;
}

int main()
{
```



```
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(20);
    head->next->next->next=new Node(30);
    printList(head);
    head=remDup(head);
    printList(head);
}
```

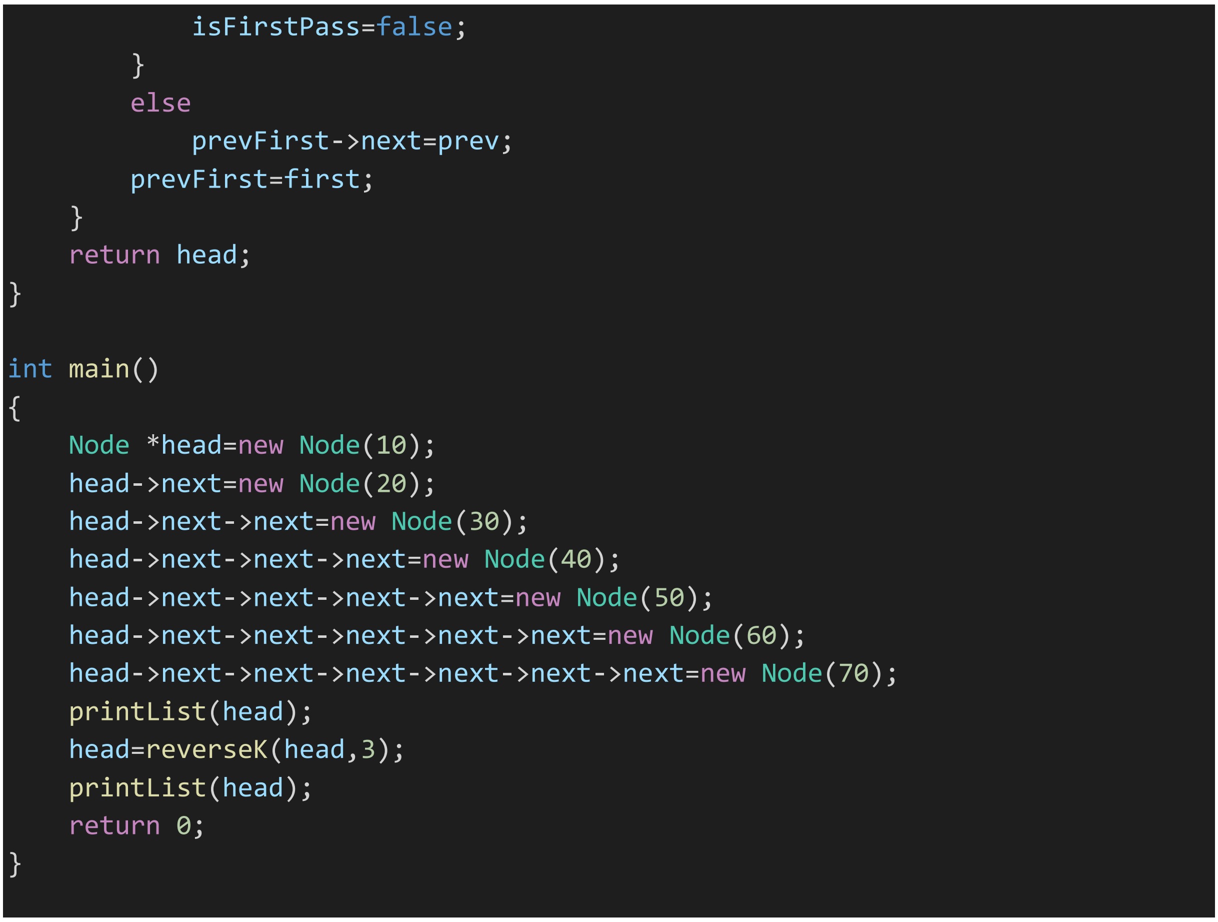
OUTPUT :

```
10 20 20 30

10 20 30
```

Reverse a linked list in a group of size k :

Iterative :

```
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

Node *reverseK(Node *head, int k)
{
    Node *curr=head, *prevFirst=NULL;
    bool isFirstPass=true;
    while (curr!=NULL)
    {
        Node *first=curr,*prev=NULL;
        int count=0;
        while (curr!=NULL && count<k)
        {
            Node *next=curr->next;
            curr->next=prev;
            prev=curr;
            curr=next;
            count++;
        }
        if(isFirstPass)
        {
            head=prev;
```



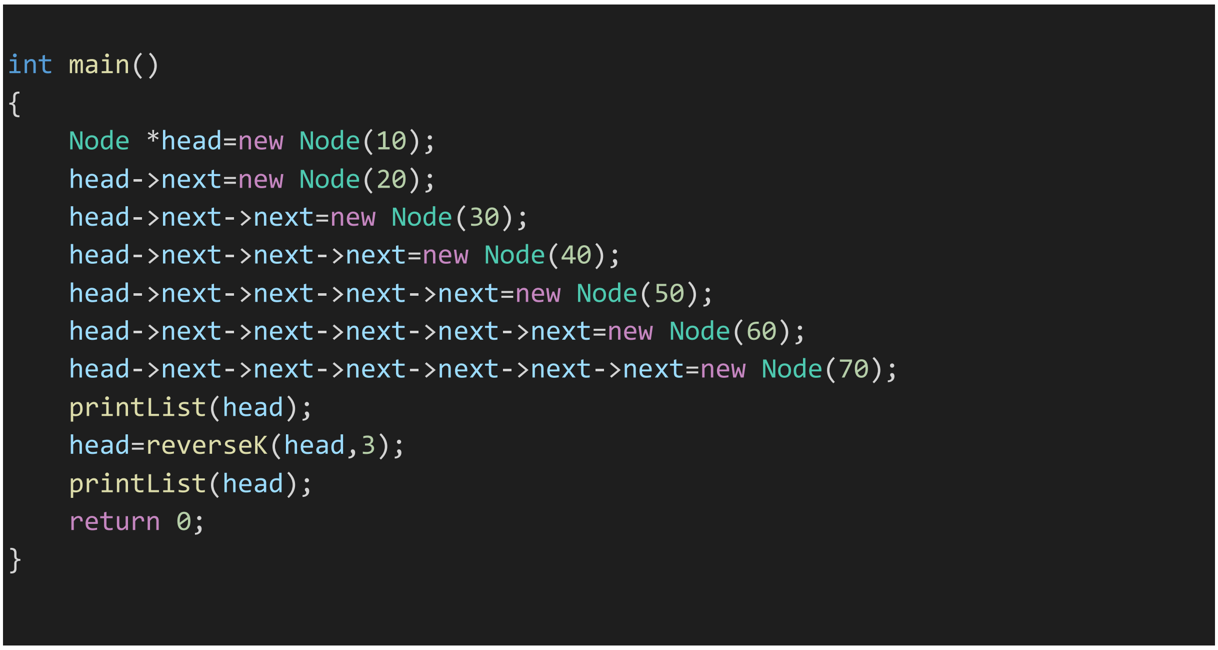
```
            isFirstPass=false;
        }
        else
            prevFirst->next=prev;
        prevFirst=first;
    }
    return head;
}

int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    head->next->next->next=new Node(40);
    head->next->next->next->next=new Node(50);
    head->next->next->next->next->next=new Node(60);
    head->next->next->next->next->next->next=new Node(70);
    printList(head);
    head=reverseK(head,3);
    printList(head);
    return 0;
}
```

OUTPUT :

```
10 20 30 40 50 60 70

30 20 10 60 50 40 70
```

Recursive for reverse a linked list in a group of size k :

```
//time complextity O(n) and auxiliary space n/k
#include<iostream>
using namespace std;

struct Node
{
    int data;
    Node *next;
    Node(int d)
    {
        data=d;
        next=NULL;
    }
};

void printList(Node *head)
{
    Node *curr=head;
    while (curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

Node *reverseK(Node *head, int k)
{
    Node *curr=head, *next=NULL, *prev=NULL;
    int count=0;
    while(curr!=NULL && count<k)
    {
        next=curr->next;
        curr->next=prev;
        prev=curr;
        curr=next;
        count++;
    }
    if(next!=NULL)
    {
        Node *rest_head=reverseK(next,k);
        head->next=rest_head;
    }

    return prev;
}
```



```
int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    head->next->next=new Node(30);
    head->next->next->next=new Node(40);
    head->next->next->next->next=new Node(50);
    head->next->next->next->next->next=new Node(60);
    head->next->next->next->next->next->next=new Node(70);
    printList(head);
    head=reverseK(head,3);
    printList(head);
    return 0;
}
```

OUTPUT :

```
10 20 30 40 50 60 70

30 20 10 60 50 40 70
```

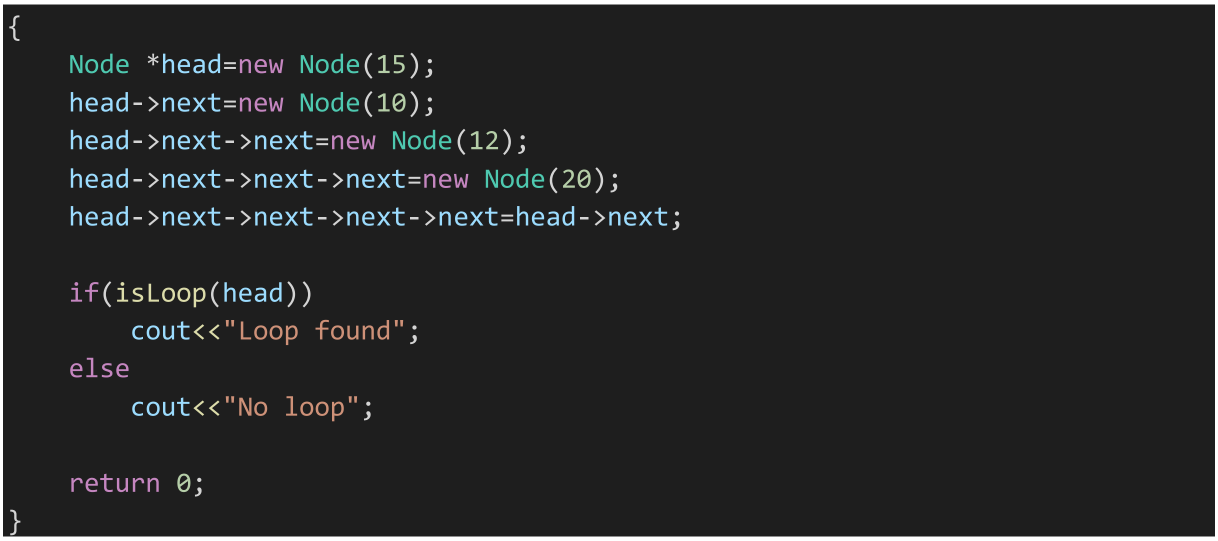
Detect Loop :

the problem of checking whether a linked list contains any loop or not. We would discuss the four methods involved in detecting loops in a linked list, one more efficient than other.

Method 1 : using visited aray

Method 3 : changes refernce/pointer :

```
// the problem of checking whether a linked list contains any loop or not. We would discuss the
// four methods involved in detecting loops in a linked list, one more efficient than other.

#include<bits/stdc++.h>
using namespace std;
struct Node{
    int data;
    Node *next;
    Node(int x){
        data=x;
        next=NULL;
    }
};

bool isLoop(Node* head)
{
    Node* temp=new Node(0);
    Node* curr=head;
    while(curr!=NULL){
        if(curr->next==NULL)
            return false;
        if(curr->next==temp)
            return true;

        Node *curr_next=curr->next;
        curr->next=temp;
        curr=curr_next;
    }
    return false;
}

int main()
```



```
{
    Node *head=new Node(15);
    head->next=new Node(10);
    head->next->next=new Node(12);
    head->next->next->next=new Node(20);
    head->next->next->next->next=head->next;

    if(isLoop(head))
        cout<<"Loop found";
    else
        cout<<"No loop";

    return 0;
}
```

OUTPUT :

```
Loop found
```

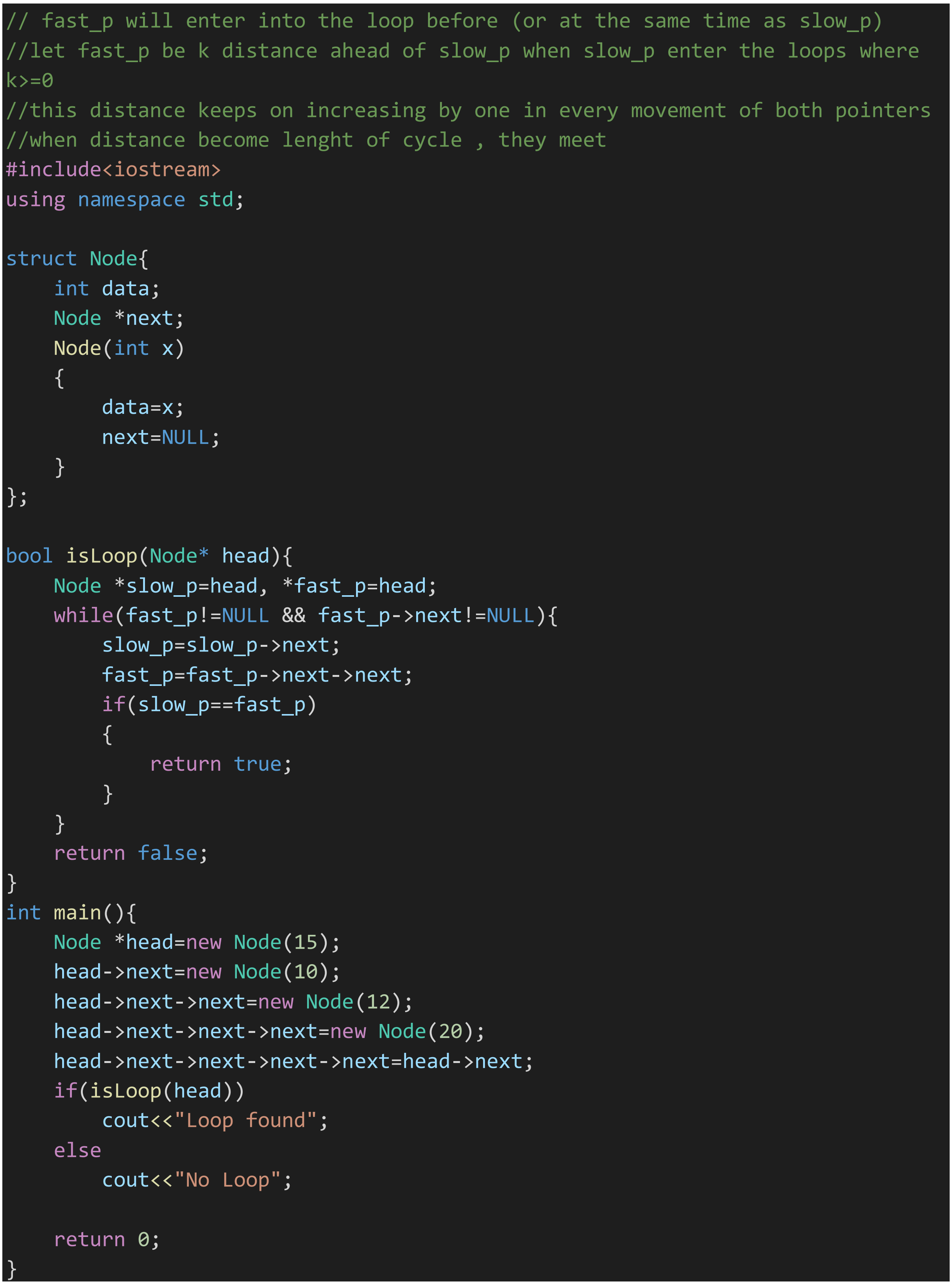
Method 4 : Hashing :

```
#include<bits/stdc++.h>
using namespace std;

struct Node{
    int data;
    Node *next;
    Node(int x)
    {
        data=x;
        next=NULL;
    }
};

bool isLoop(Node *head)
{
    unordered_set<Node*>s;
    for(Node *curr=head;curr!=NULL;curr=curr->next)
    {
        if(s.find(curr)!=s.end())
            return true;
        s.insert(curr);
    }
    return false;
}

int main()
{
    Node *head=new Node(15);
    head->next=new Node(10);
    head->next->next=new Node(12);
    head->next->next->next=new Node(20);
    head->next->next->next->next=head->next;

    if(isLoop(head))
        cout<<"Loop found";
    else
        cout<<"No loop";


    return 0;
}
```

OUTPUT :

Loop found

Detect Loop using Floyd cycle detection :



```
// fast_p will enter into the loop before (or at the same time as slow_p)
//let fast_p be k distance ahead of slow_p when slow_p enter the loops where
k>=0
//this distance keeps on increasing by one in every movement of both pointers
//when distance become lenght of cycle , they meet
#include<iostream>
using namespace std;

struct Node{
    int data;
    Node *next;
    Node(int x)
    {
        data=x;
        next=NULL;
    }
};

bool isLoop(Node* head){
    Node *slow_p=head, *fast_p=head;
    while(fast_p!=NULL && fast_p->next!=NULL){
        slow_p=slow_p->next;
        fast_p=fast_p->next->next;
        if(slow_p==fast_p)
        {
            return true;
        }
    }
    return false;
}
int main(){
    Node *head=new Node(15);
    head->next=new Node(10);
    head->next->next=new Node(12);
    head->next->next->next=new Node(20);
    head->next->next->next->next=head->next;
    if(isLoop(head))
        cout<<"Loop found";
    else
        cout<<"No Loop";

    return 0;
}
```

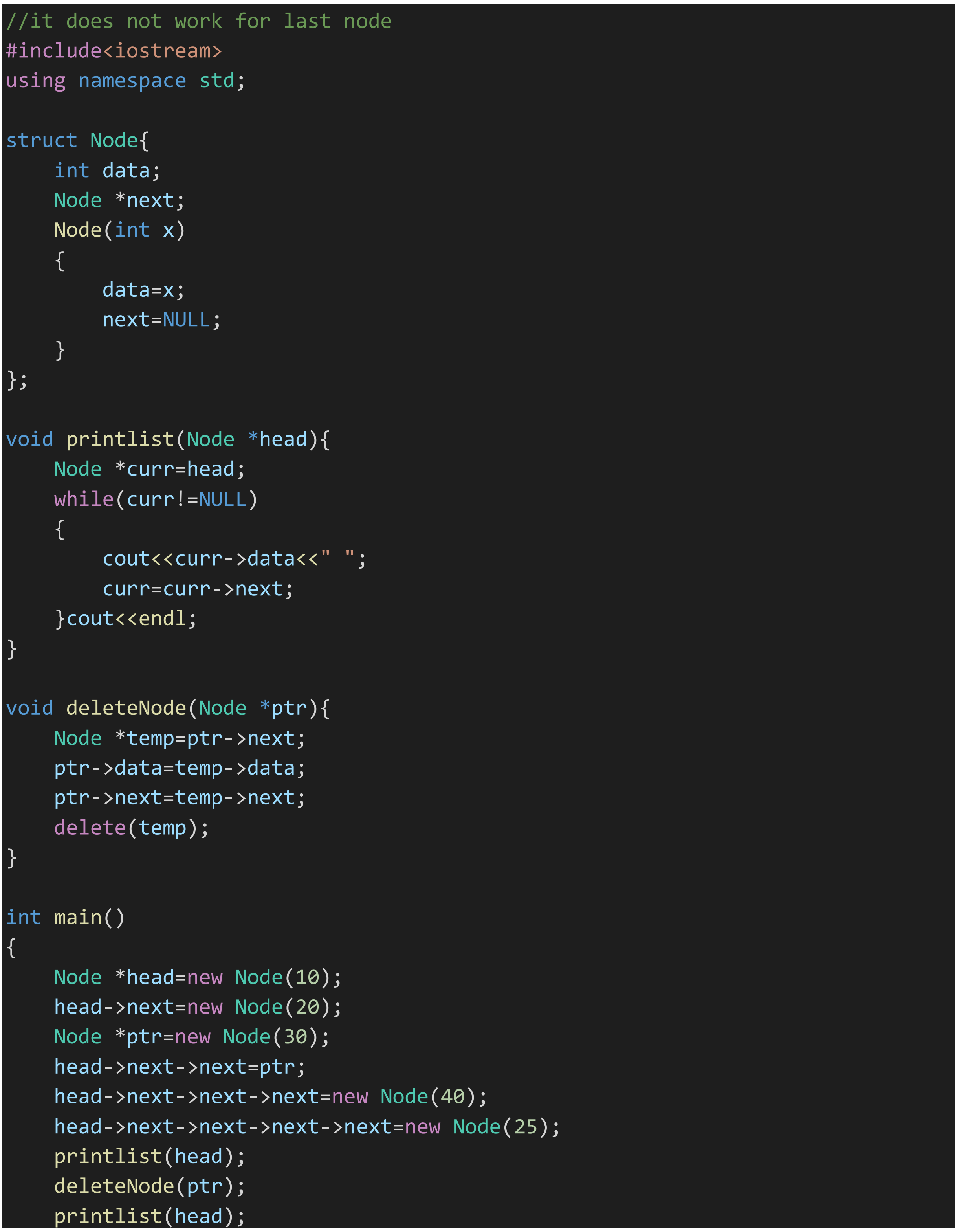
OUTPUT : Loop found

Detect and remove loop in linked list:

```
#include<iostream>
using namespace std;

struct Node{
    int data;
    Node* next;
    Node(int x)
    {
        data=x;
        next=NULL;
    }
};

void detectRemovalLoop(Node* head)
{
    Node *slow=head, *fast=head;
    while(fast!=NULL && fast->next!=NULL)
    {
        slow=slow->next;
        fast=fast->next->next;
        if(slow==fast){
            break;
        }
    }
    if(slow!=fast)
        return;
    slow=head;
    while(slow->next!=fast->next)
    {
        slow=slow->next;
        fast=fast->next;
    }
    fast->next=NULL;
}

int main()
{
    Node *head=new Node(15);
    head->next=new Node(10);
    head->next->next=new Node(12);
    head->next->next->next=new Node(20);
    head->next->next->next->next=head->next;

    detectRemovalLoop(head);
    return 0;
}
```

Delete Node with only pointer given to it :

This is one of the tricky problem asked in an interview where a random address to a node of the linked list is given and the user needs to delete the node of the given address. The address can point to any random node in-between a linked list.



```
//it does not work for last node
#include<iostream>
using namespace std;

struct Node{
    int data;
    Node *next;
    Node(int x)
    {
        data=x;
        next=NULL;
    }
};

void printlist(Node *head){
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }cout<<endl;
}

void deleteNode(Node *ptr){
    Node *temp=ptr->next;
    ptr->data=temp->data;
    ptr->next=temp->next;
    delete(temp);
}

int main()
{
    Node *head=new Node(10);
    head->next=new Node(20);
    Node *ptr=new Node(30);
    head->next->next=ptr;
    head->next->next->next=new Node(40);
    head->next->next->next->next=new Node(25);
    printlist(head);
    deleteNode(ptr);
    printlist(head);
    return 0;
}
```

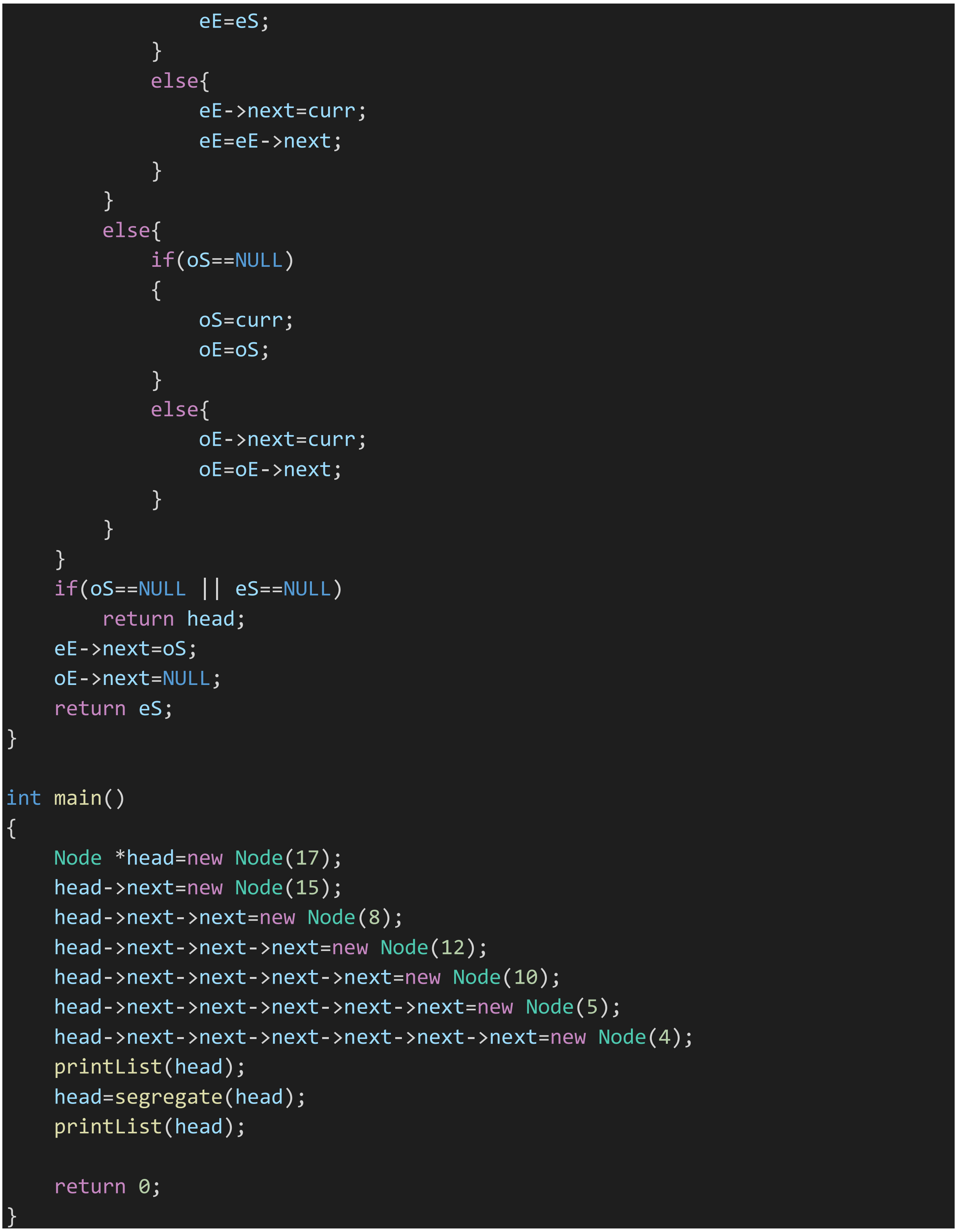
OUTPUT :

10 20 30 40 25

10 20 40 25

Segregate Even odd node in linked list :

```
#include<bits/stdc++.h>
using namespace std;

struct Node{
    int data;
    Node* next;
    Node(int x){
        data=x;
        next=NULL;
    }
};

void printList(Node *head){
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

Node *segregate(Node *head){
    Node *eS=NULL, *eE=NULL, *oS=NULL, *oE=NULL;
    for(Node *curr=head;curr!=NULL;curr=curr->next){
        int x=curr->data;
        if(x%2==0){
            if(eS==NULL)
            {
                eS=curr;
```



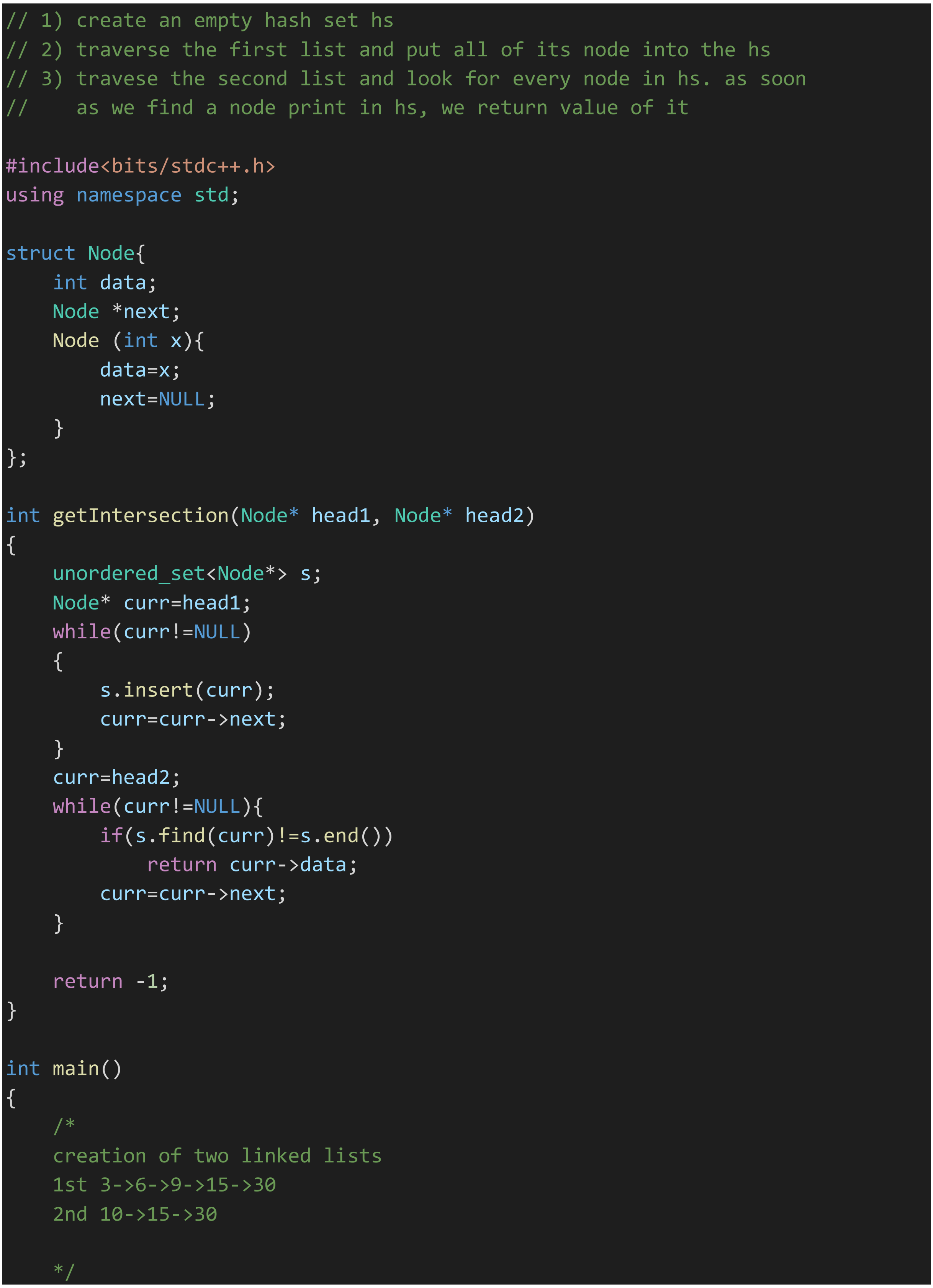
```
                eE=eS;
            }
            else{
                eE->next=curr;
                eE=eE->next;
            }
        }
        else{
            if(oS==NULL)
            {
                oS=curr;
                oE=oS;
            }
            else{
                oE->next=curr;
                oE=oE->next;
            }
        }
    }
    if(oS==NULL || eS==NULL)
        return head;
    eE->next=oS;
    oE->next=NULL;
    return eS;
}

int main()
{
    Node *head=new Node(17);
    head->next=new Node(15);
    head->next->next=new Node(8);
    head->next->next->next=new Node(12);
    head->next->next->next->next=new Node(10);
    head->next->next->next->next->next=new Node(5);
    head->next->next->next->next->next->next=new Node(4);
    printList(head);
    head=segregate(head);
    printList(head);

    return 0;
}
```

OUTPUT :

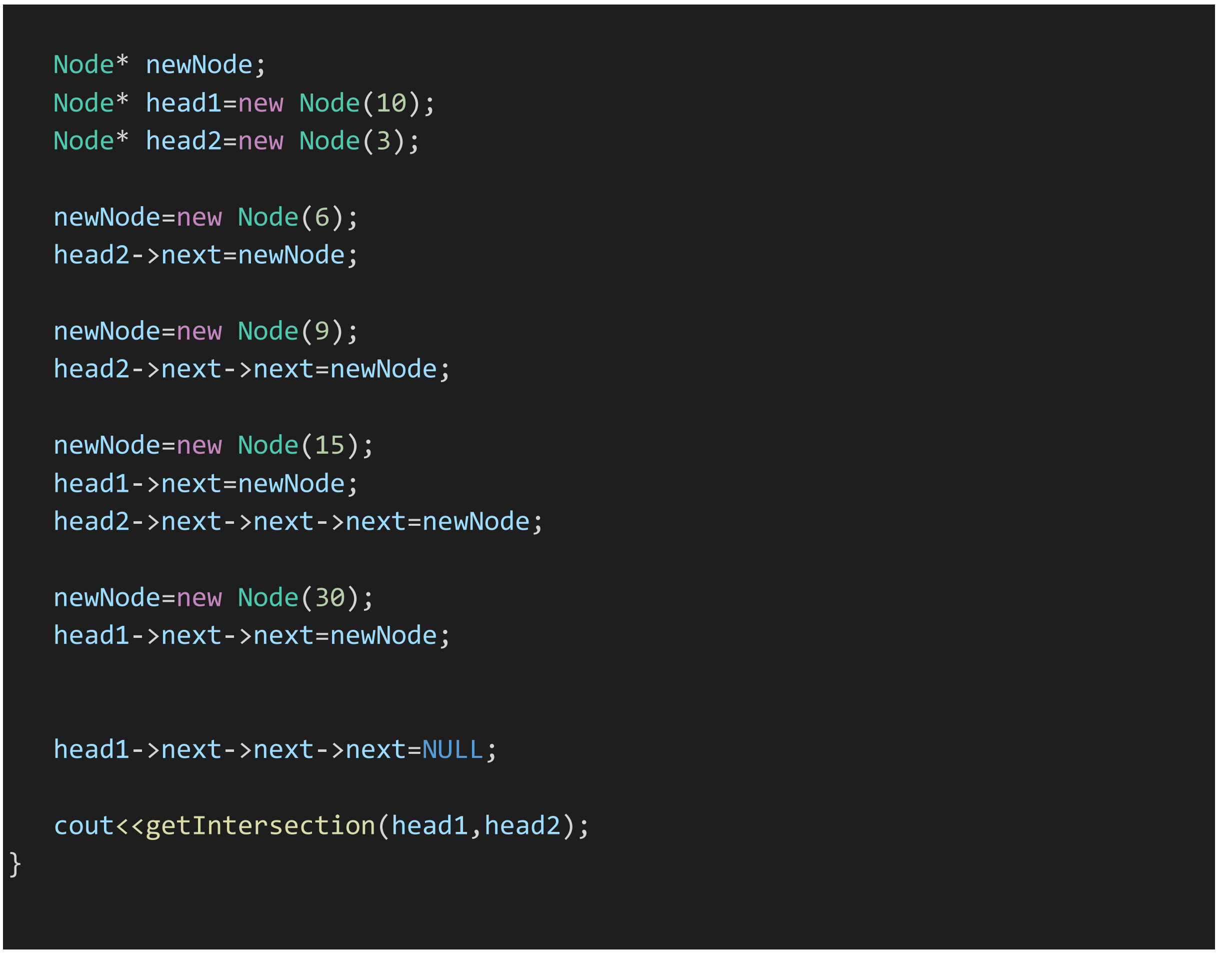
```
17 15 8 12 10 5 4

8 12 10 4 17 15 5
```

Intersection of Two linked list :

Method 1 : hashing :



```
// 1) create an empty hash set hs
// 2) traverse the first list and put all of its node into the hs
// 3) travese the second list and look for every node in hs. as soon
//    as we find a node print in hs, we return value of it

#include<bits/stdc++.h>
using namespace std;

struct Node{
    int data;
    Node *next;
    Node (int x){
        data=x;
        next=NULL;
    }
};

int getIntersection(Node* head1, Node* head2)
{
    unordered_set<Node*> s;
    Node* curr=head1;
    while(curr!=NULL)
    {
        s.insert(curr);
        curr=curr->next;
    }
    curr=head2;
    while(curr!=NULL){
        if(s.find(curr)!=s.end())
            return curr->data;
        curr=curr->next;
    }

    return -1;
}

int main()
{
    /*
    creation of two linked lists
    1st 3->6->9->15->30
    2nd 10->15->30

    */
```

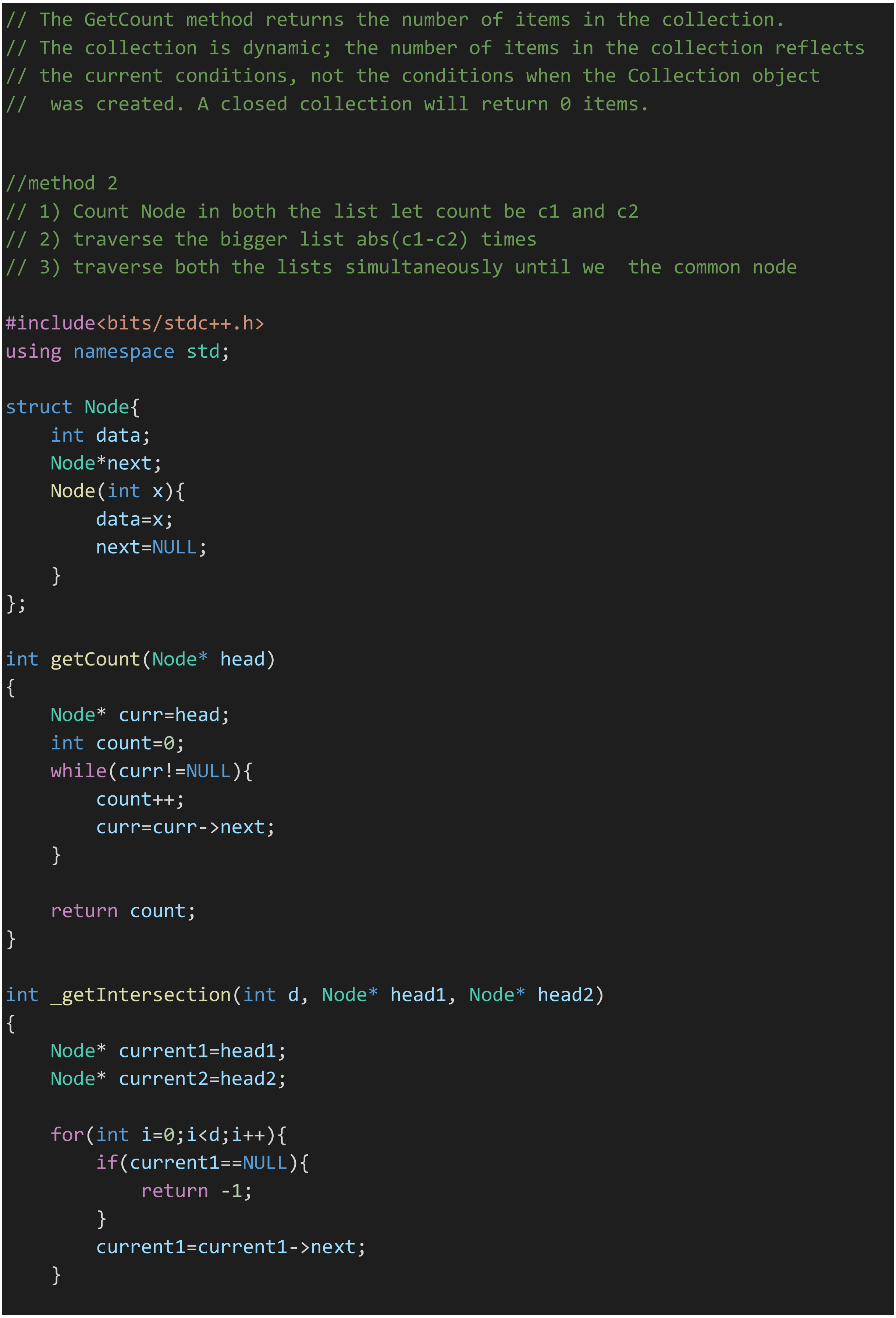


```
    Node* newNode;
    Node* head1=new Node(10);
    Node* head2=new Node(3);

    newNode=new Node(6);
    head2->next=newNode;

    newNode=new Node(9);
    head2->next->next=newNode;

    newNode=new Node(15);
    head1->next=newNode;
    head2->next->next->next=newNode;

    newNode=new Node(30);
    head1->next->next=newNode;


    head1->next->next->next=NULL;

    cout<<getIntersection(head1,head2);
}
```

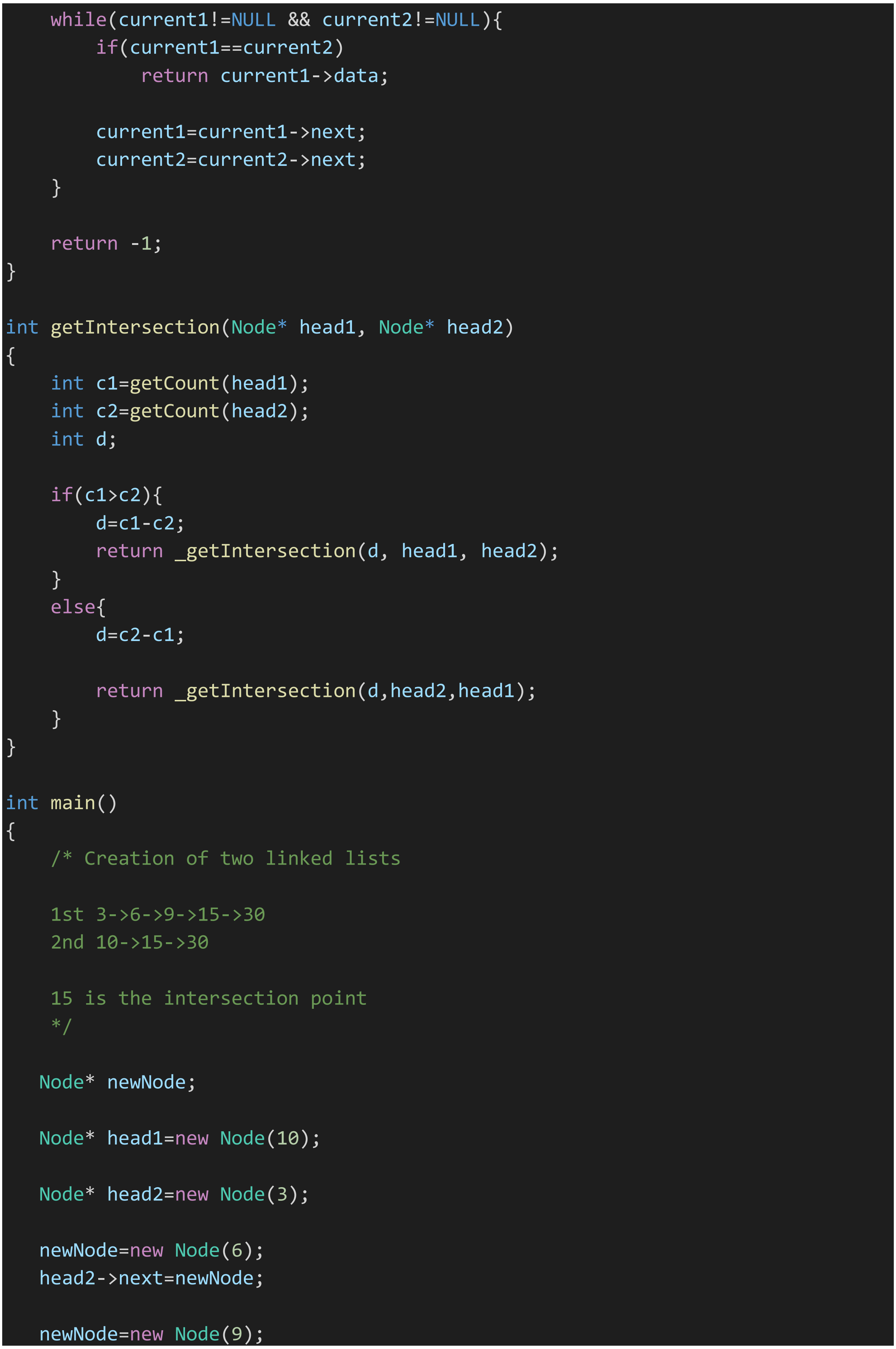
OUTPUT :

15

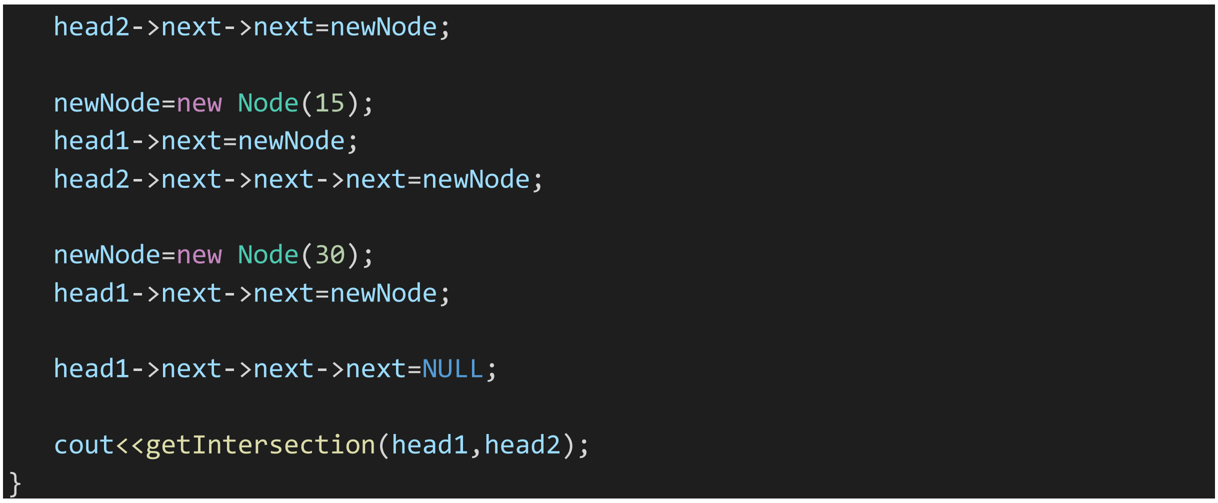
Method 2 :



```
// The GetCount method returns the number of items in the collection.
// The collection is dynamic; the number of items in the collection reflects
// the current conditions, not the conditions when the Collection object
//  was created. A closed collection will return 0 items.


//method 2
// 1) Count Node in both the list let count be c1 and c2
// 2) traverse the bigger list abs(c1-c2) times
// 3) traverse both the lists simultaneously until we  the common node

#include<bits/stdc++.h>
using namespace std;

struct Node{
    int data;
    Node*next;
    Node(int x){
        data=x;
        next=NULL;
    }
};

int getCount(Node* head)
{
    Node* curr=head;
    int count=0;
    while(curr!=NULL){
        count++;
        curr=curr->next;
    }

    return count;
}

int _getIntersection(int d, Node* head1, Node* head2)
{
    Node* current1=head1;
    Node* current2=head2;

    for(int i=0;i<d;i++){
        if(current1==NULL){
            return -1;
        }
        current1=current1->next;
    }
```



```
    while(current1!=NULL && current2!=NULL){
        if(current1==current2)
            return current1->data;

        current1=current1->next;
        current2=current2->next;
    }

    return -1;
}

int getIntersection(Node* head1, Node* head2)
{
    int c1=getCount(head1);
    int c2=getCount(head2);
    int d;

    if(c1>c2){
        d=c1-c2;
        return _getIntersection(d, head1, head2);
    }
    else{
        d=c2-c1;

        return _getIntersection(d,head2,head1);
    }
}

int main()
{
    /* Creation of two linked lists

    1st 3->6->9->15->30
    2nd 10->15->30

    15 is the intersection point
    */

   Node* newNode;

   Node* head1=new Node(10);

   Node* head2=new Node(3);

   newNode=new Node(6);
   head2->next=newNode;

   newNode=new Node(9);
```



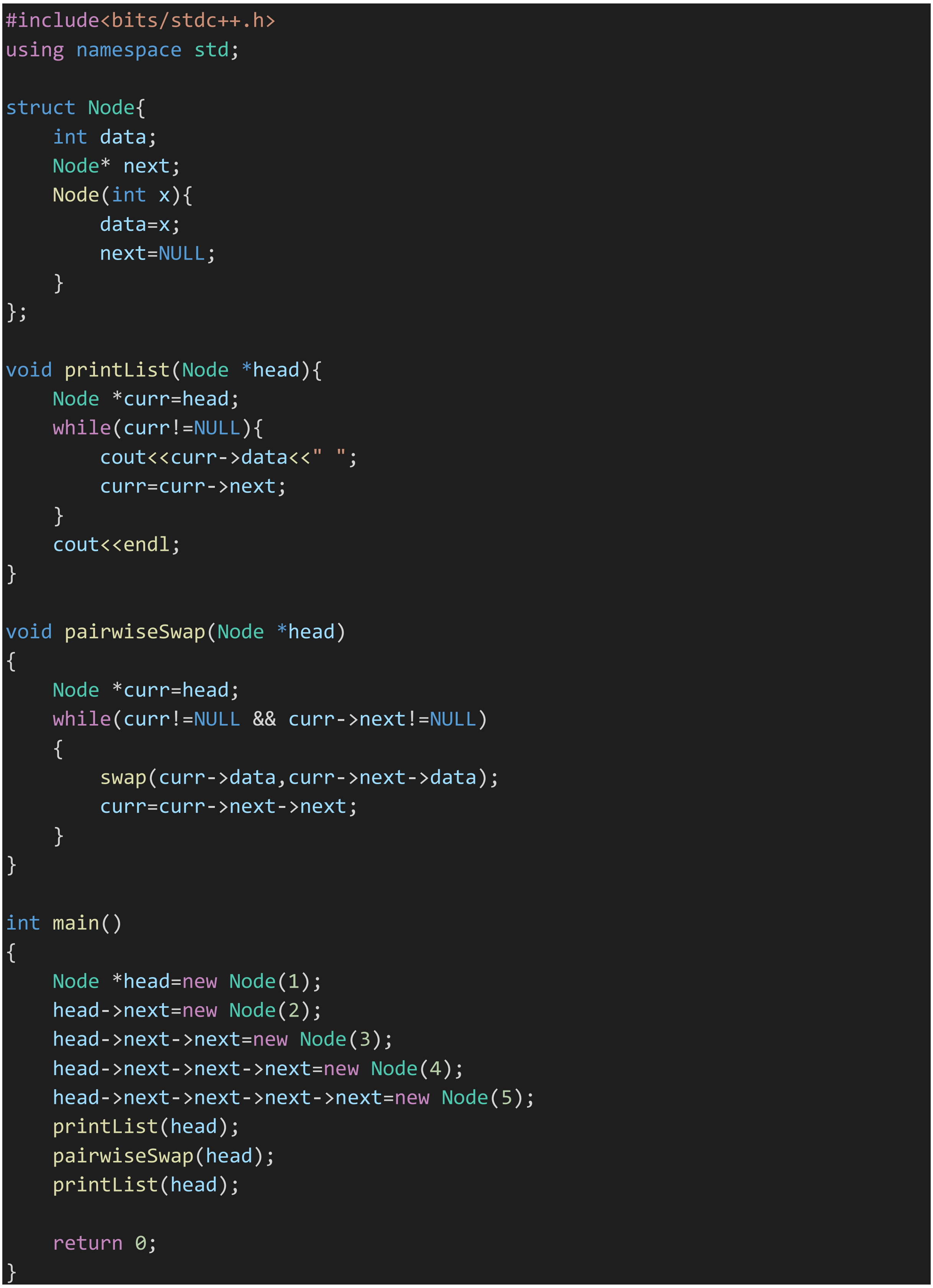
```
    head2->next->next=newNode;

    newNode=new Node(15);
    head1->next=newNode;
    head2->next->next->next=newNode;

    newNode=new Node(30);
    head1->next->next=newNode;

    head1->next->next->next=NULL;

    cout<<getIntersection(head1,head2);
}
```

OUTPUT :

```
15
```

Pairwise swapped linked list :

Method 1 : swapping data:



```
#include<bits/stdc++.h>
using namespace std;

struct Node{
    int data;
    Node* next;
    Node(int x){
        data=x;
        next=NULL;
    }
};

void printList(Node *head){
    Node *curr=head;
    while(curr!=NULL){
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

void pairwiseSwap(Node *head)
{
    Node *curr=head;
    while(curr!=NULL && curr->next!=NULL)
    {
        swap(curr->data,curr->next->data);
        curr=curr->next->next;
    }
}

int main()
{
    Node *head=new Node(1);
    head->next=new Node(2);
    head->next->next=new Node(3);
    head->next->next->next=new Node(4);
    head->next->next->next->next=new Node(5);
    printList(head);
    pairwiseSwap(head);
    printList(head);

    return 0;
}
```

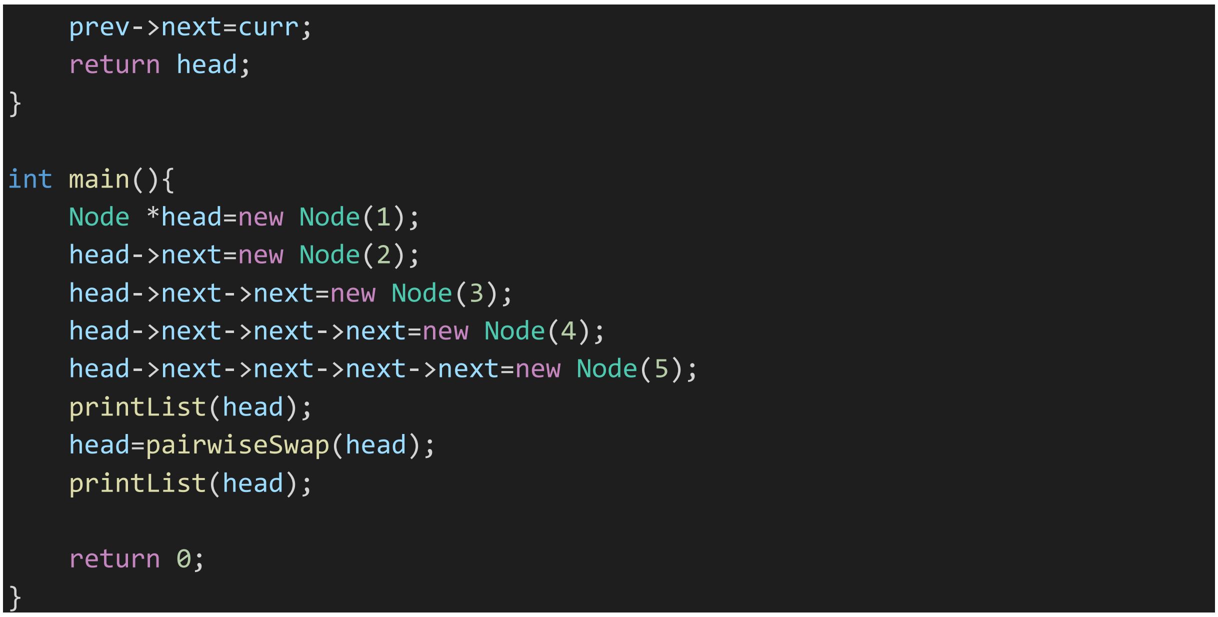
OUTPUT :

1 2 3 4 5

2 1 4 3 5

Method 2 : changing pointer/ reference :

```
#include<bits/stdc++.h>
using namespace std;

struct Node{
    int data;
    Node* next;
    Node(int x){
        data=x;
        next=NULL;
    }
};

void printList(Node *head){
    Node *curr=head;
    while(curr!=NULL)
    {
        cout<<curr->data<<" ";
        curr=curr->next;
    }cout<<endl;
}

Node *pairwiseSwap(Node *head){
    if(head==NULL || head->next==NULL)
        return head;

    Node *curr=head->next->next;
    Node *prev=head;
    head=head->next;
    head->next=prev;
    while(curr!=NULL && curr->next!=NULL)
    {
        prev->next=curr->next;
        prev=curr;
        Node *next=curr->next->next;
        curr->next->next=curr;
        curr=next;
    }
```



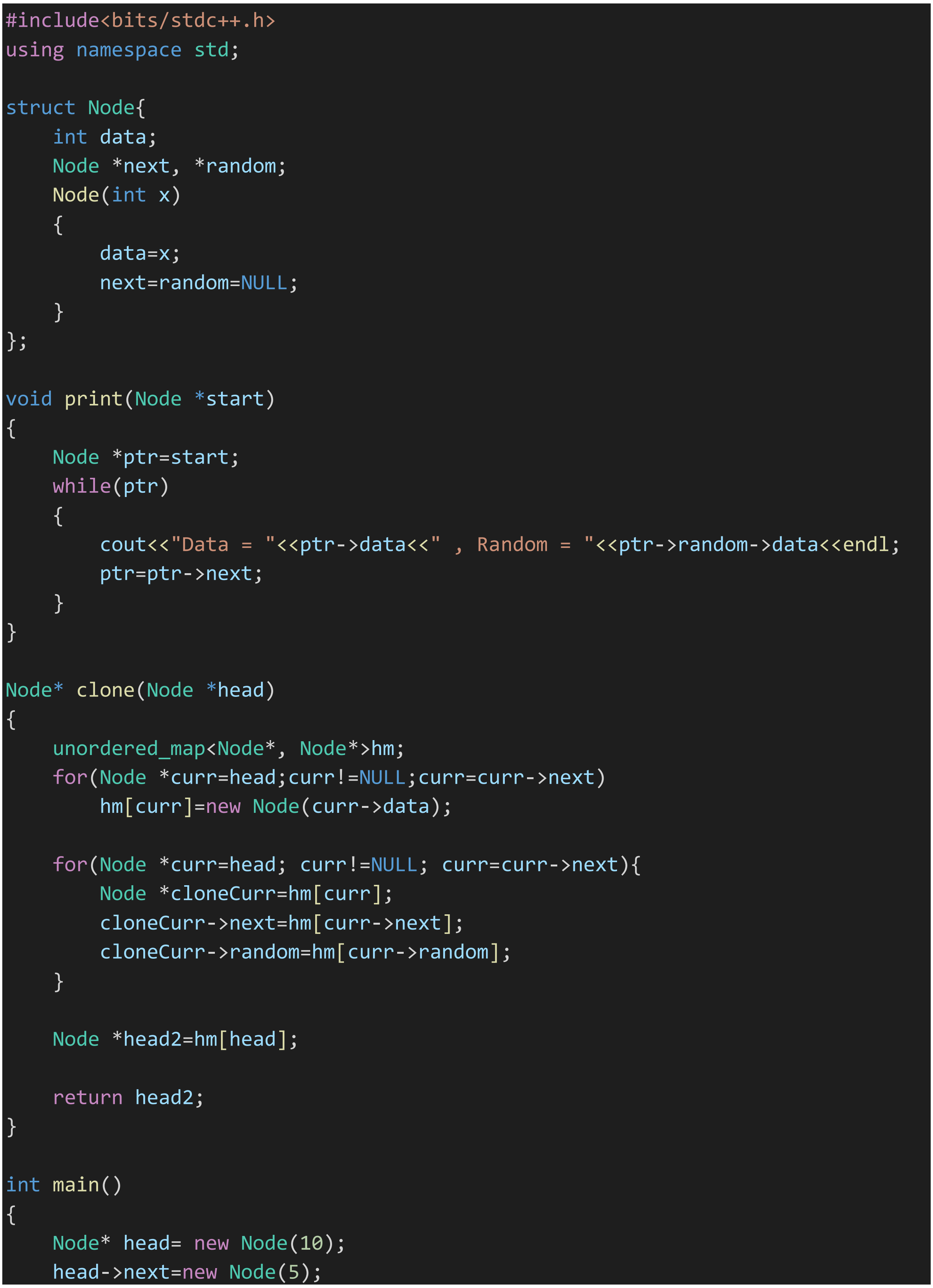
```
    prev->next=curr;
    return head;
}

int main(){
    Node *head=new Node(1);
    head->next=new Node(2);
    head->next->next=new Node(3);
    head->next->next->next=new Node(4);
    head->next->next->next->next=new Node(5);
    printList(head);
    head=pairwiseSwap(head);
    printList(head);

    return 0;
}
```

OUTPUT :

```
1 2 3 4 5

2 1 4 3 5
```

Clone a Linked List Using Random Pointer :

Method 1 : Hashing :



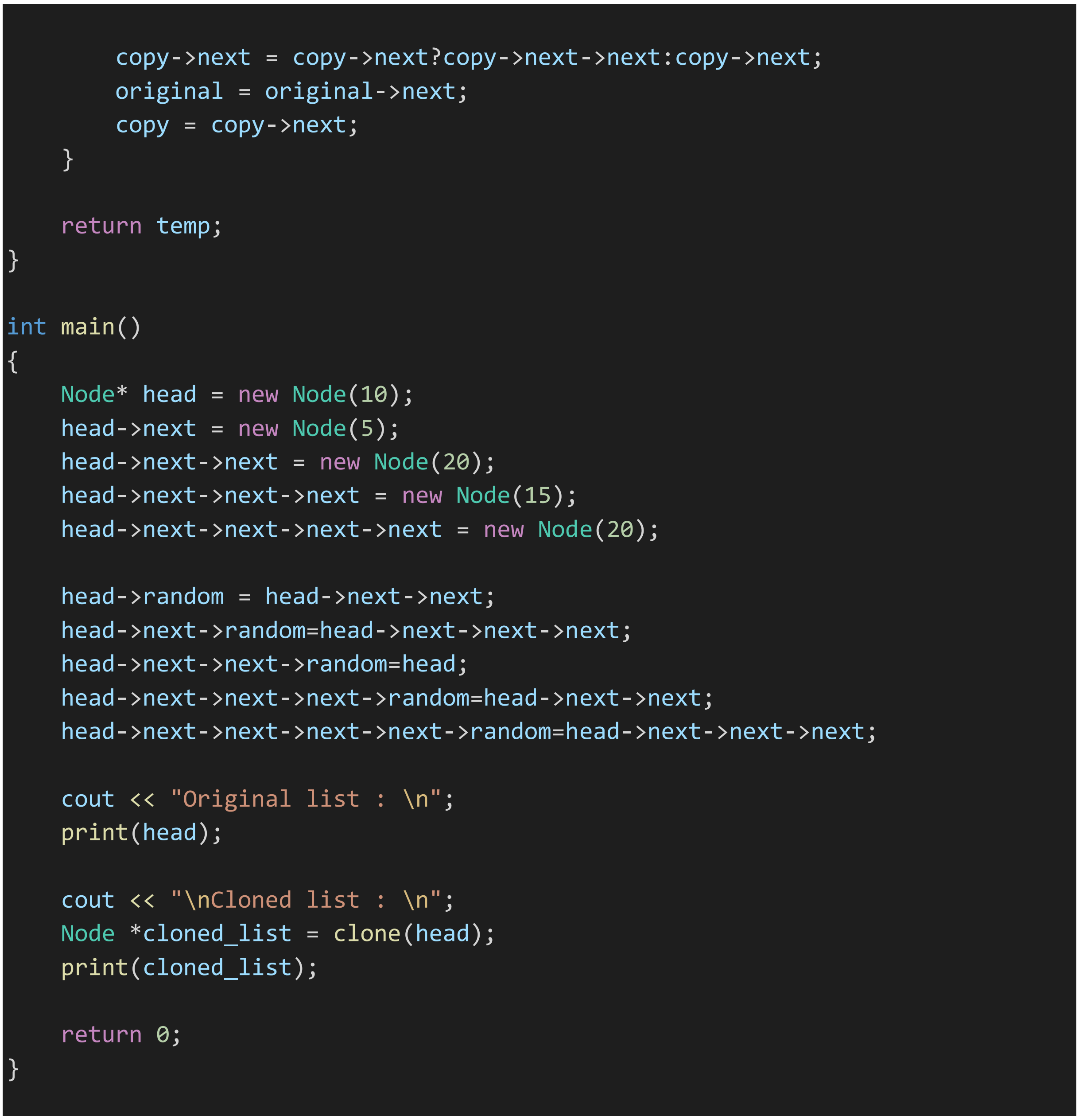
```
#include<bits/stdc++.h>
using namespace std;

struct Node{
    int data;
    Node *next, *random;
    Node(int x)
    {
        data=x;
        next=random=NULL;
    }
};

void print(Node *start)
{
    Node *ptr=start;
    while(ptr)
    {
        cout<<"Data = "<<ptr->data<<" , Random = "<<ptr->random->data<<endl;
        ptr=ptr->next;
    }
}

Node* clone(Node *head)
{
    unordered_map<Node*, Node*>hm;
    for(Node *curr=head;curr!=NULL;curr=curr->next)
        hm[curr]=new Node(curr->data);

    for(Node *curr=head; curr!=NULL; curr=curr->next){
        Node *cloneCurr=hm[curr];
        cloneCurr->next=hm[curr->next];
        cloneCurr->random=hm[curr->random];
    }

    Node *head2=hm[head];

    return head2;
}

int main()
{
    Node* head= new Node(10);
    head->next=new Node(5);
    head->next->next=new Node(20);
    head->next->next->next=new Node(15);
    head->next->next->next->next=new Node(20);

    head->random=head->next->next;
    head->next->random=head->next->next->next;
    head->next->next->random=head;
    head->next->next->next->random=head->next->next;
    head->next->next->next->next->random=head->next->next->next;


    cout<<" Original List : \n";
    print(head);

    cout<< "\nCloned List : \n";
    Node *cloned_list=clone(head);
    print(cloned_list);

    return 0;
}
```

OUTPUT :

```
Original List :

Data = 10 , Random = 20

Data = 5 , Random = 15

Data = 20 , Random = 10

Data = 15 , Random = 20

Data = 20 , Random = 15


Cloned List :

Data = 10 , Random = 20

Data = 5 , Random = 15

Data = 20 , Random = 10

Data = 15 , Random = 20

Data = 20 , Random = 15
```

Method 2:

```
#include <bits/stdc++.h>
using namespace std;

struct Node
{
    int data;
    Node *next,*random;
    Node(int x)
    {
        data = x;
        next = random = NULL;
    }
};

void print(Node *start)
{
    Node *ptr = start;
    while (ptr)
    {
        cout << "Data = " << ptr->data << ", Random  = "<< ptr->random->data
<< endl;
        ptr = ptr->next;
    }
}

Node* clone(Node *head)
{
    Node *next,*temp;
    for(Node *curr=head;curr!=NULL;){
        next=curr->next;
        curr->next=new Node(curr->data);
        curr->next->next=next;
        curr=next;
    }
    for(Node *curr=head;curr!=NULL;curr=curr->next->next){
        curr->next->random=(curr->random!=NULL)?(curr->random->next):NULL;
    }

     Node* original = head, *copy = head->next;

    temp = copy;

    while (original && copy)
    {
        original->next =
         original->next? original->next->next : original->next;
```

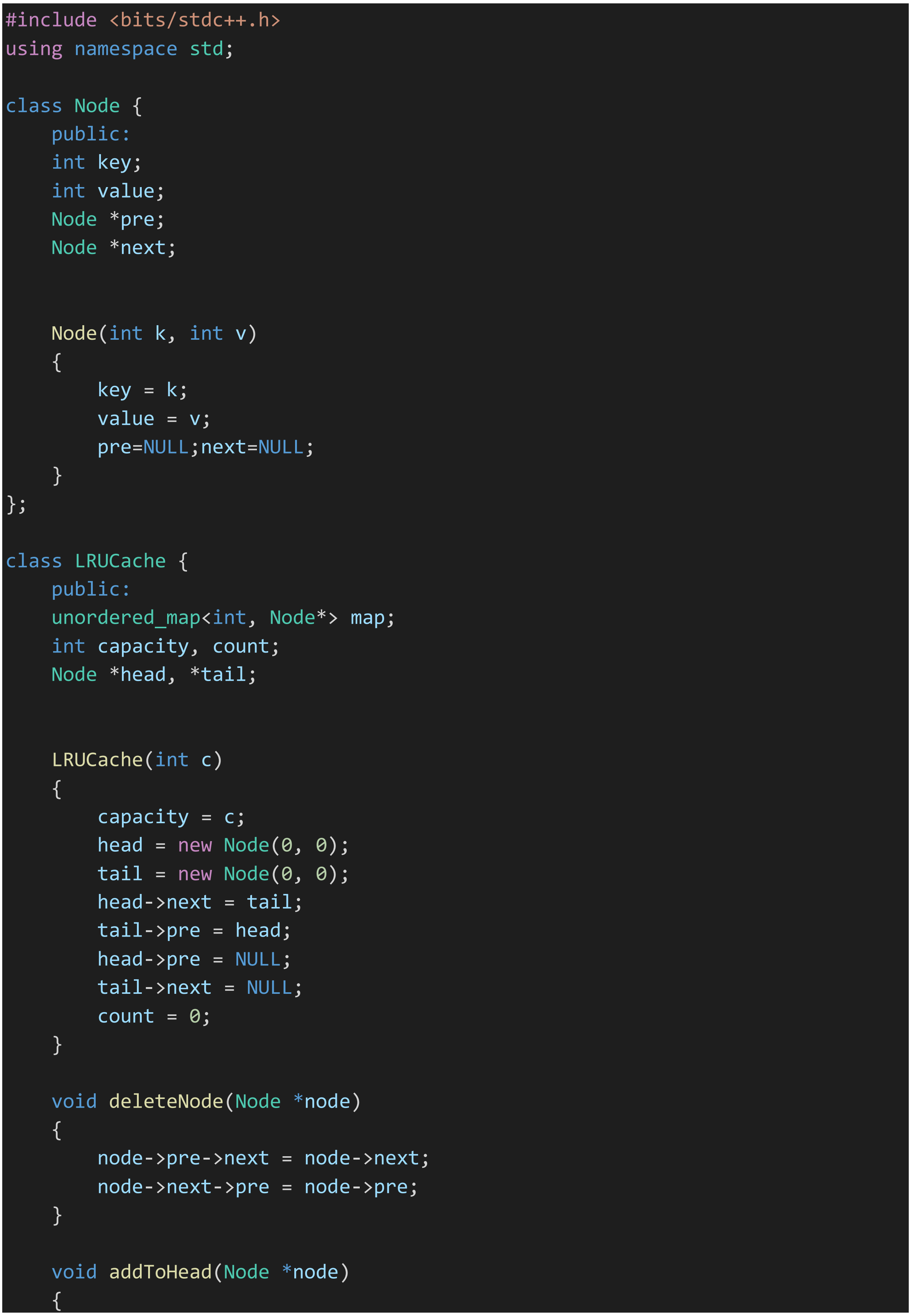


```
        copy->next = copy->next?copy->next->next:copy->next;
        original = original->next;
        copy = copy->next;
    }

    return temp;
}

int main()
{
    Node* head = new Node(10);
    head->next = new Node(5);
    head->next->next = new Node(20);
    head->next->next->next = new Node(15);
    head->next->next->next->next = new Node(20);

    head->random = head->next->next;
    head->next->random=head->next->next->next;
    head->next->next->random=head;
    head->next->next->next->random=head->next->next;
    head->next->next->next->next->random=head->next->next->next;

    cout << "Original list : \n";
    print(head);

    cout << "\nCloned list : \n";
    Node *cloned_list = clone(head);
    print(cloned_list);

    return 0;
}
```

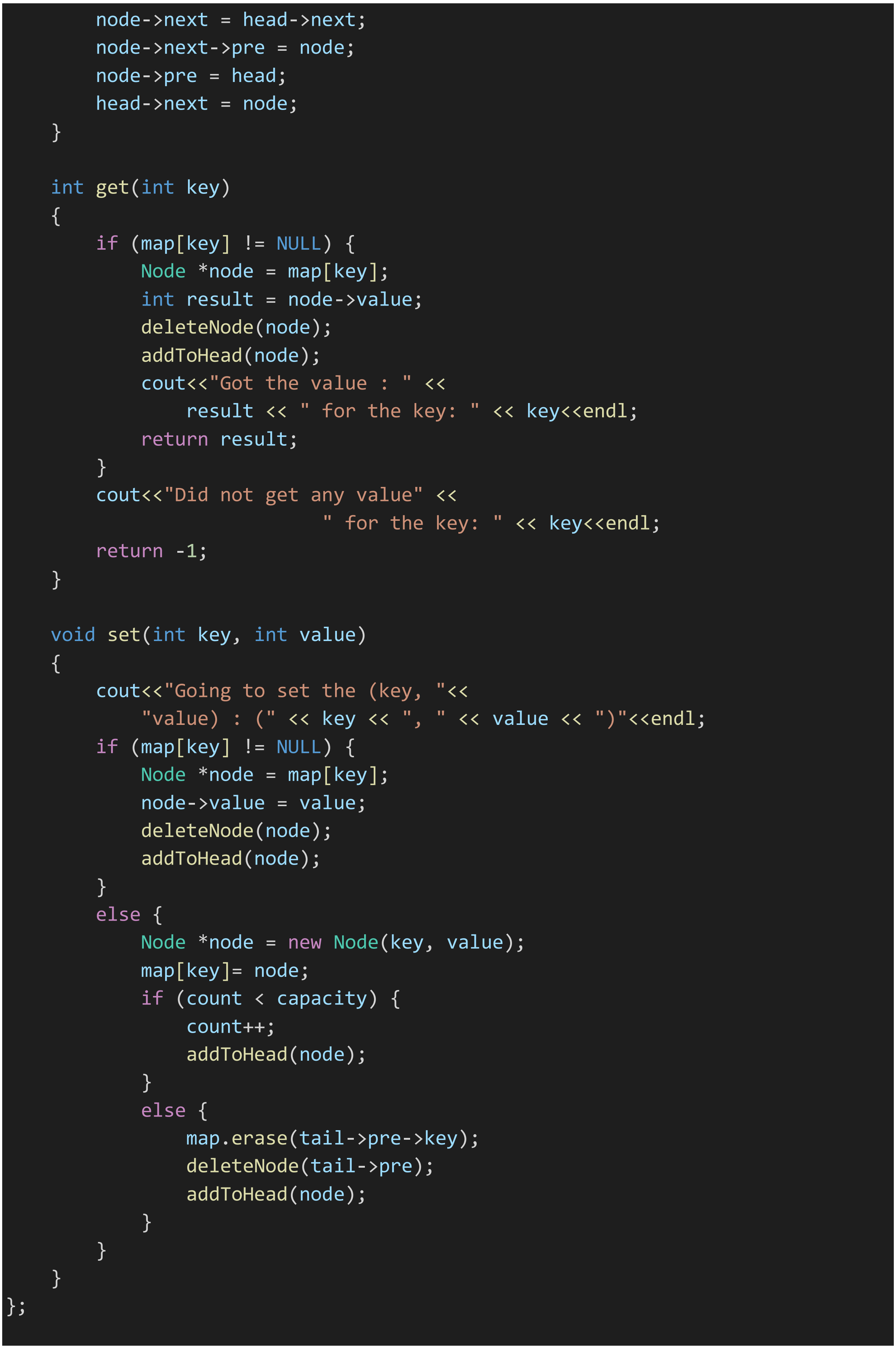
OUTPUT:

```
Original list :

Data = 10, Random  = 20

Data = 5, Random  = 15

Data = 20, Random  = 10

Data = 15, Random  = 20
Data = 20, Random  = 15


Cloned list :

Data = 10, Random  = 20

Data = 5, Random  = 15

Data = 20, Random  = 10

Data = 15, Random  = 20

Data = 20, Random  = 15
```

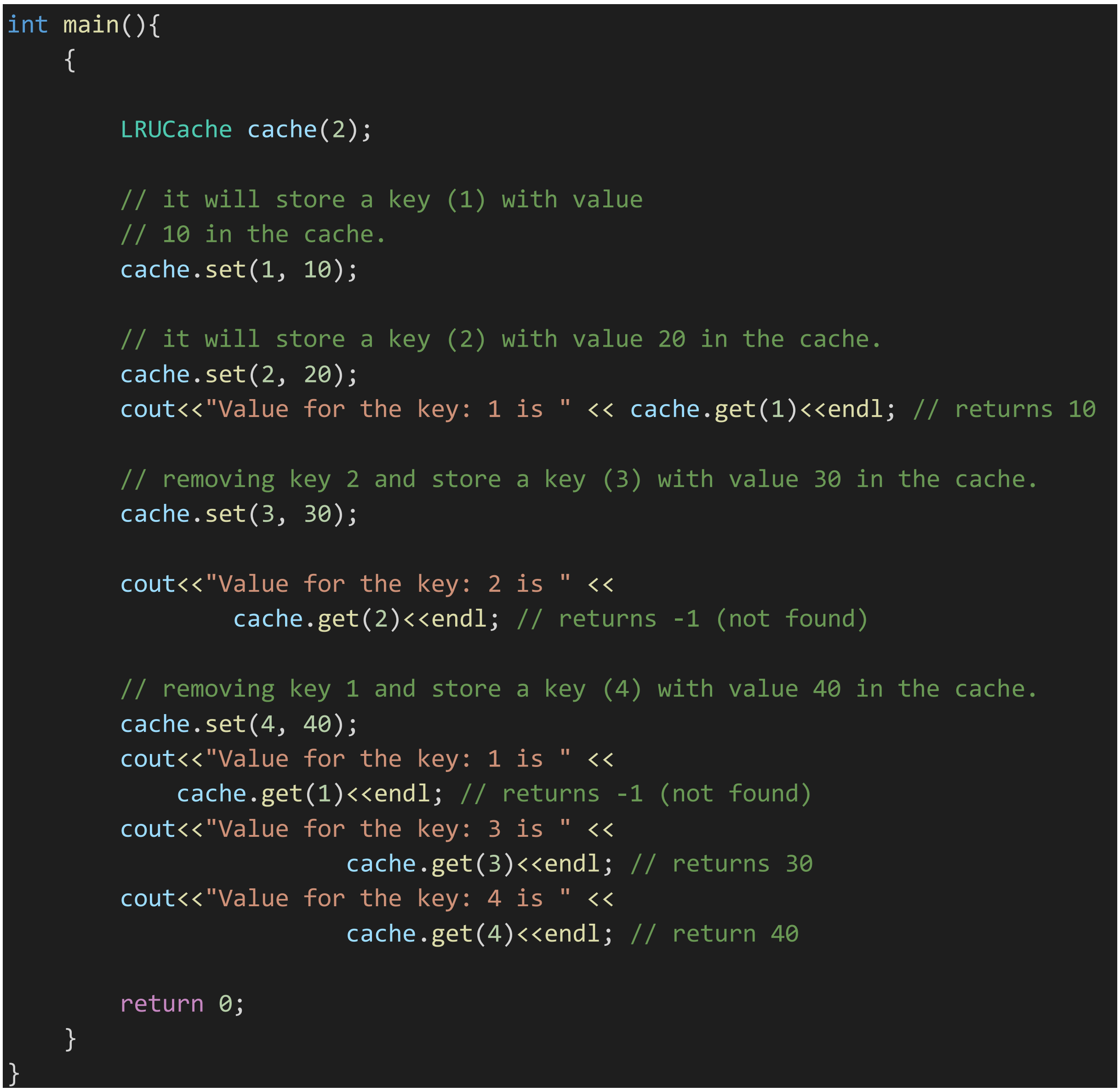
LRU cache design efficient :



```
#include <bits/stdc++.h>
using namespace std;

class Node {
    public:
    int key;
    int value;
    Node *pre;
    Node *next;


    Node(int k, int v)
    {
        key = k;
        value = v;
        pre=NULL;next=NULL;
    }
};

class LRUCache {
    public:
    unordered_map<int, Node*> map;
    int capacity, count;
    Node *head, *tail;


    LRUCache(int c)
    {
        capacity = c;
        head = new Node(0, 0);
        tail = new Node(0, 0);
        head->next = tail;
        tail->pre = head;
        head->pre = NULL;
        tail->next = NULL;
        count = 0;
    }

    void deleteNode(Node *node)
    {
        node->pre->next = node->next;
        node->next->pre = node->pre;
    }

    void addToHead(Node *node)
    {
```



```
        node->next = head->next;
        node->next->pre = node;
        node->pre = head;
        head->next = node;
    }

    int get(int key)
    {
        if (map[key] != NULL) {
            Node *node = map[key];
            int result = node->value;
            deleteNode(node);
            addToHead(node);
            cout<<"Got the value : " <<
                result << " for the key: " << key<<endl;
            return result;
        }
        cout<<"Did not get any value" <<
                            " for the key: " << key<<endl;
        return -1;
    }

    void set(int key, int value)
    {
        cout<<"Going to set the (key, "<<
            "value) : (" << key << ", " << value << ")"<<endl;
        if (map[key] != NULL) {
            Node *node = map[key];
            node->value = value;
            deleteNode(node);
            addToHead(node);
        }
        else {
            Node *node = new Node(key, value);
            map[key]= node;
            if (count < capacity) {
                count++;
                addToHead(node);
            }
            else {
                map.erase(tail->pre->key);
                deleteNode(tail->pre);
                addToHead(node);
            }
        }
    }
};
```



```
int main(){
    {

        LRUCache cache(2);

        // it will store a key (1) with value
        // 10 in the cache.
        cache.set(1, 10);

        // it will store a key (2) with value 20 in the cache.
        cache.set(2, 20);
        cout<<"Value for the key: 1 is " << cache.get(1)<<endl; // returns 10

        // removing key 2 and store a key (3) with value 30 in the cache.
        cache.set(3, 30);

        cout<<"Value for the key: 2 is " <<
                cache.get(2)<<endl; // returns -1 (not found)

        // removing key 1 and store a key (4) with value 40 in the cache.
        cache.set(4, 40);
        cout<<"Value for the key: 1 is " <<
            cache.get(1)<<endl; // returns -1 (not found)
        cout<<"Value for the key: 3 is " <<
                        cache.get(3)<<endl; // returns 30
        cout<<"Value for the key: 4 is " <<
                        cache.get(4)<<endl; // return 40

        return 0;
    }
}
```

OUTPUT :

Going to set the (key, value) : (1, 10)

Going to set the (key, value) : (2, 20)

Value for the key: 1 is Got the value : 10 for the key: 1

10

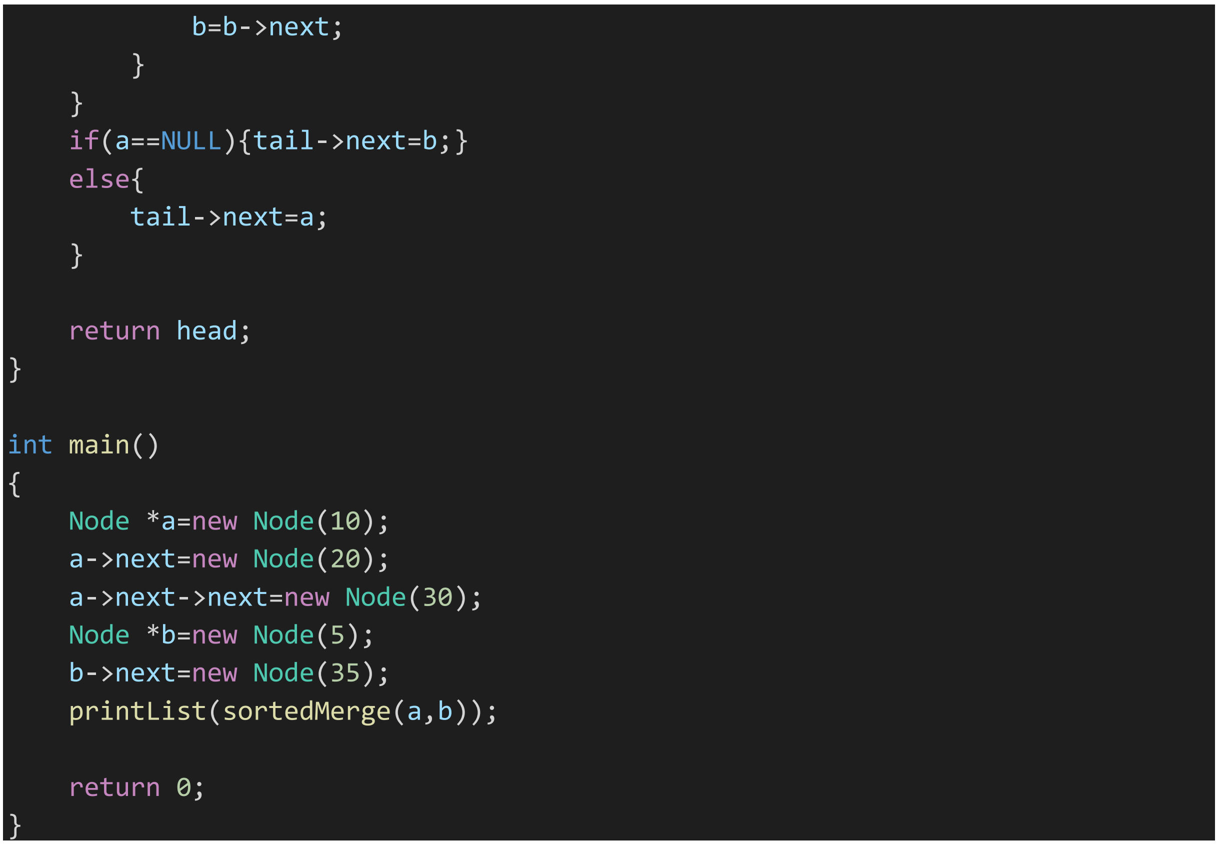
Going to set the (key, value) : (3, 30)

```
Value for the key: 2 is Did not get any value for the key: 2

-1

Going to set the (key, value) : (4, 40)

Value for the key: 1 is Did not get any value for the key: 1

-1

Value for the key: 3 is Got the value : 30 for the key: 3

30

Value for the key: 4 is Got the value : 40 for the key: 4

40
```

Merged Two Sorted Linked List :

A O(m+n) time and O(1) auxiliary space solution is discussed

```
#include<bits/stdc++.h>
using namespace std;

struct Node{
    int data;
    Node* next;
    Node(int x)
    {
        data=x;
        next=NULL;
    }
};

void printList(Node *head){
    Node *curr=head;
    while(curr!=NULL){
        cout<<curr->data<<" ";
        curr=curr->next;
    }
    cout<<endl;
}

Node *sortedMerge(Node *a, Node *b){
    if(a==NULL)return b;
    if(b==NULL)return a;
    Node *head=NULL, *tail=NULL;
    if(a->data<=b->data){
        head=tail=a;
        a=a->next;
    }
    else{
        head=tail=b;
        b=b->next;
    }

    while(a!=NULL && b!=NULL){
        if(a->data<=b->data){
            tail->next=a;
            tail=a;
            a=a->next;
        }
        else{
            tail->next=b;
            tail=b;
```



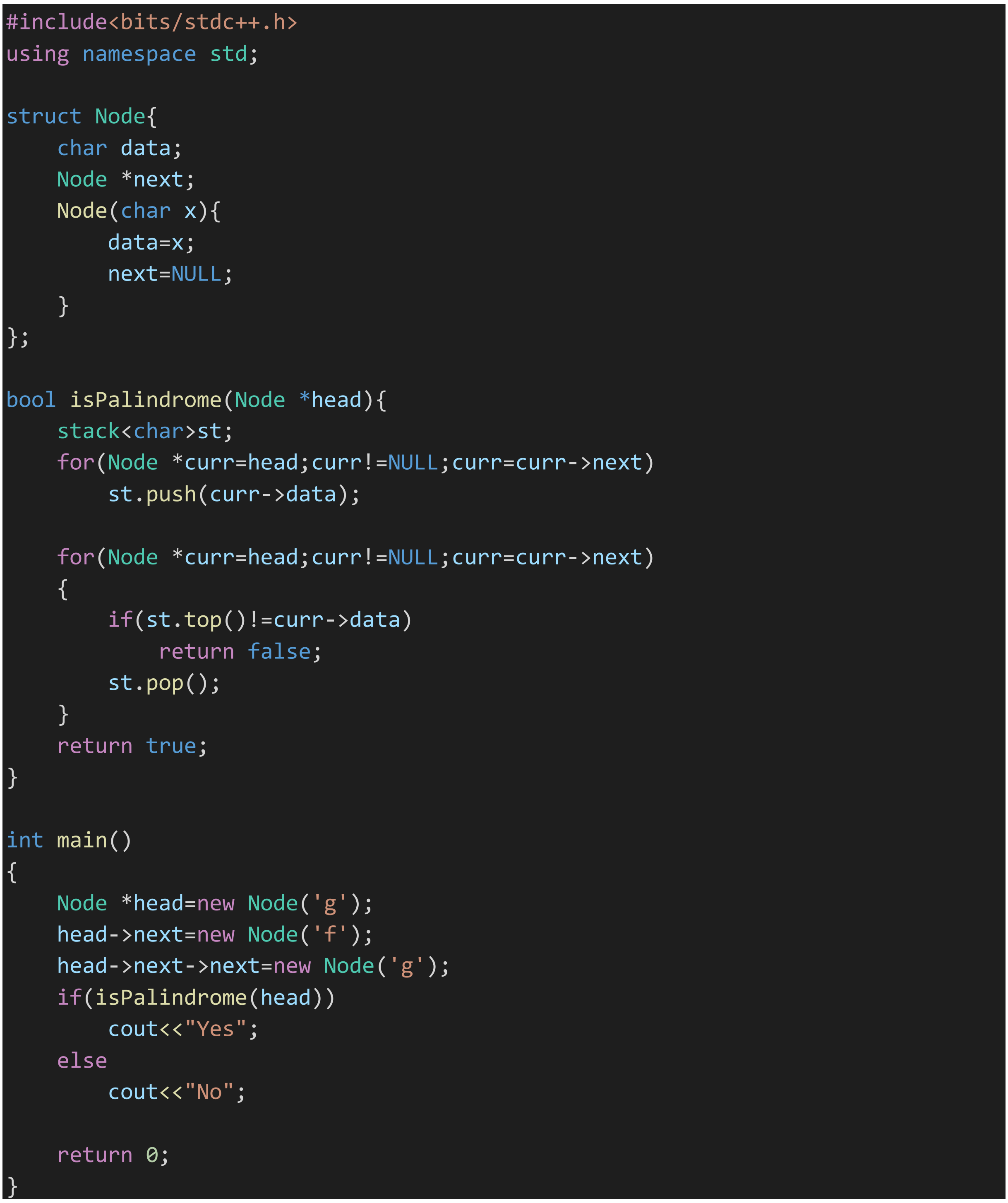
```
            b=b->next;
        }
    }
    if(a==NULL){tail->next=b;}
    else{
        tail->next=a;
    }

    return head;
}

int main()
{
    Node *a=new Node(10);
    a->next=new Node(20);
    a->next->next=new Node(30);
    Node *b=new Node(5);
    b->next=new Node(35);
    printList(sortedMerge(a,b));

    return 0;
}
```

OUTPUT :

```
5 10 20 30 35
```

Merged Two Sorted Linked List :

Using stack naive:

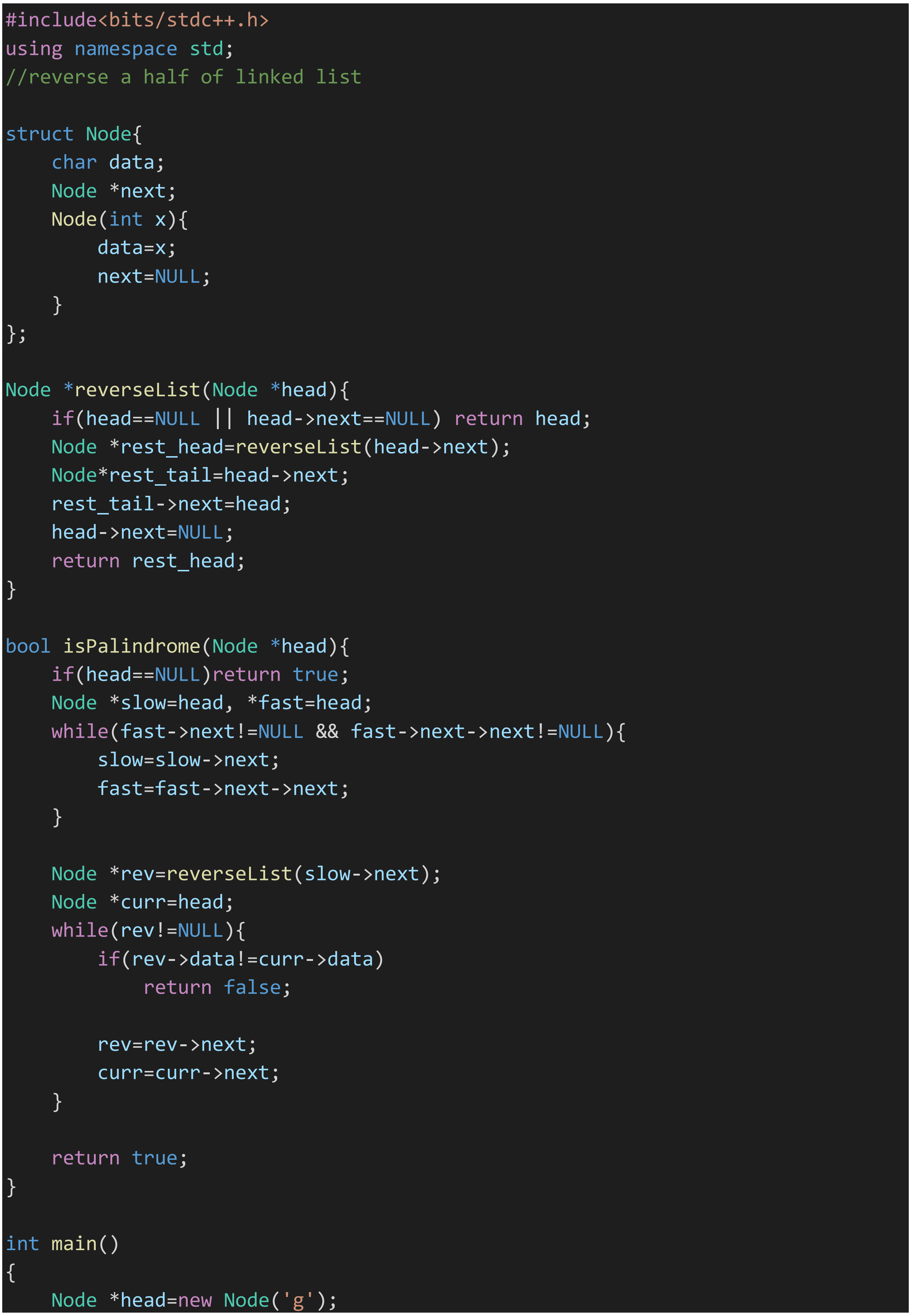


```
#include<bits/stdc++.h>
using namespace std;

struct Node{
    char data;
    Node *next;
    Node(char x){
        data=x;
        next=NULL;
    }
};

bool isPalindrome(Node *head){
    stack<char>st;
    for(Node *curr=head;curr!=NULL;curr=curr->next)
        st.push(curr->data);

    for(Node *curr=head;curr!=NULL;curr=curr->next)
    {
        if(st.top()!=curr->data)
            return false;
        st.pop();
    }
    return true;
}

int main()
{
    Node *head=new Node('g');
    head->next=new Node('f');
    head->next->next=new Node('g');
    if(isPalindrome(head))
        cout<<"Yes";
    else
        cout<<"No";

    return 0;
}
```

OUTPUT :

Yes

Efficient :



```
#include<bits/stdc++.h>
using namespace std;
//reverse a half of linked list

struct Node{
    char data;
    Node *next;
    Node(int x){
        data=x;
        next=NULL;
    }
};

Node *reverseList(Node *head){
    if(head==NULL || head->next==NULL) return head;
    Node *rest_head=reverseList(head->next);
    Node*rest_tail=head->next;
    rest_tail->next=head;
    head->next=NULL;
    return rest_head;
}

bool isPalindrome(Node *head){
    if(head==NULL)return true;
    Node *slow=head, *fast=head;
    while(fast->next!=NULL && fast->next->next!=NULL){
        slow=slow->next;
        fast=fast->next->next;
    }

    Node *rev=reverseList(slow->next);
    Node *curr=head;
    while(rev!=NULL){
        if(rev->data!=curr->data)
            return false;

        rev=rev->next;
        curr=curr->next;
    }

    return true;
}

int main()
{
    Node *head=new Node('g');
    head->next=new Node('f');
    head->next->next=new Node('g');
    if(isPalindrome(head))
        cout<<"Yes";
    else
        cout<<"No";

    return 0;
}
```

OUTPUT :

```
Yes
```