

Linked List

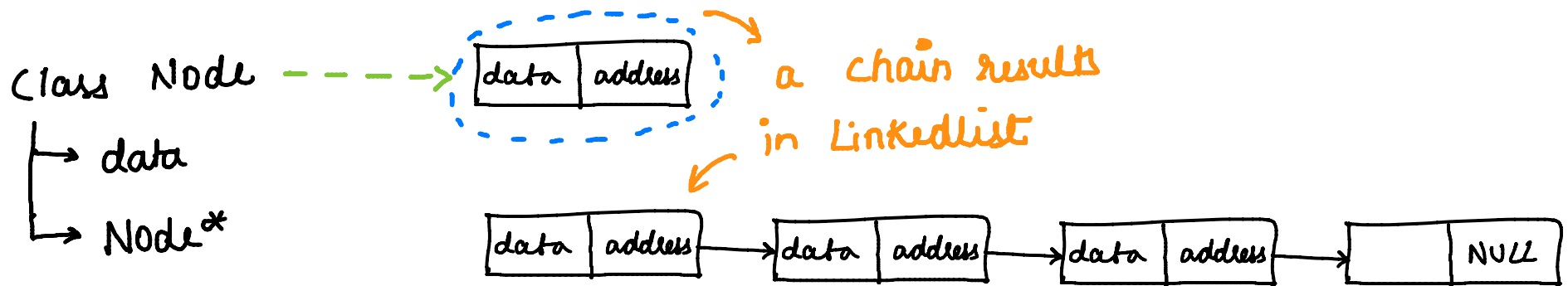
- Karun Karthik

Contents →

0. Introduction
1. Reverse a Linked List
2. Middle of Linked List
3. Delete node in a Linked List
4. Merge two sorted Lists
5. Add two numbers
6. Add two numbers II
7. Linked List Cycle
8. Linked List Cycle II
9. Remove Nth node from End of List
10. Palindrome Linked List
11. Remove duplicates from sorted List
12. Swapping nodes in Linked List
13. Odd Even Linked List
14. Swap Nodes in Pairs
15. Copy list with Random Pointer
16. Reverse Nodes in K-group
17. Design Linked List
18. Sort List

Linked List

LinkedList is linear data structure, which consists of a group of nodes in a sequence.



Advantages

1. Dynamic nature
2. Optimal insertion & deletion
3. Stacks and queues can be easily implemented
4. No memory wastage

Real life Applications

1. Previous & next page in browser
2. Image Viewer

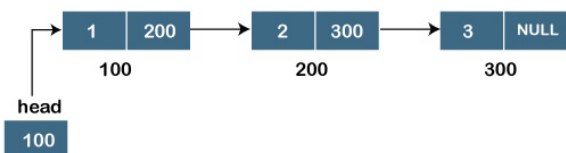
Disadvantages

1. More memory usage due to address pointer.
2. Slow Traversal compared to arrays.
3. No reverse Traversal in singly linked list
4. No random access.

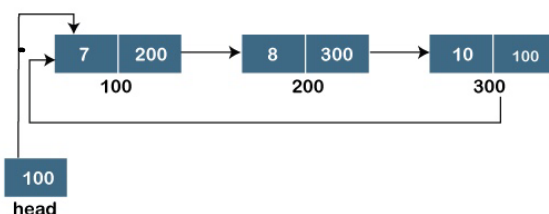
3. Music player

Type

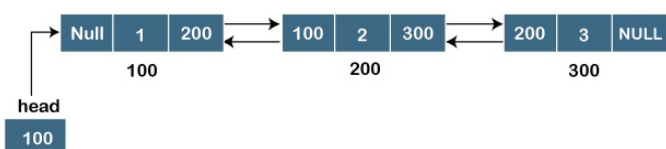
1. Singly linkedlist



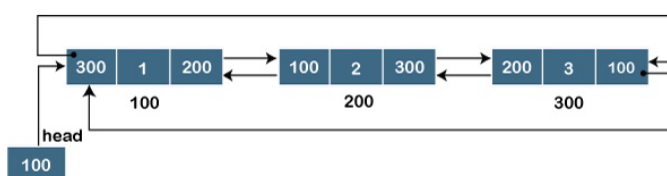
3. Circular LinkedList



2. Doubly linkedlist



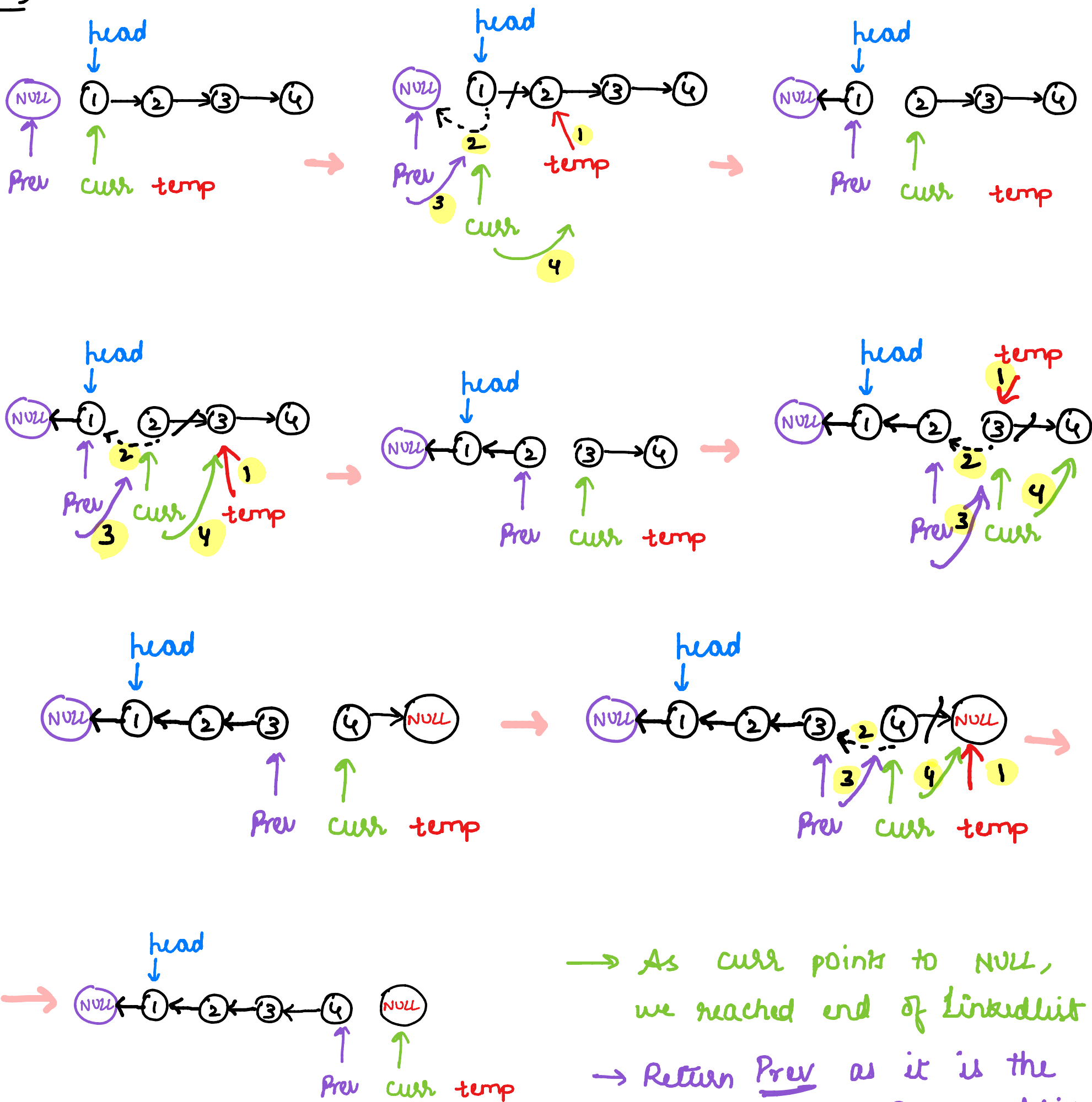
4. Doubly circular linkedlist



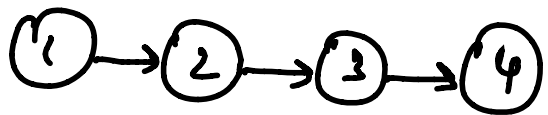
① Reverse a linkedlist → Given a linkedlist, return reversed list.

Eg ① → ② → ③ → ④ ⇒ ④ → ③ → ② → ①

Sol)



Recursive →



curr, prev
(1, NULL):

newNode = 1 → next = 2
1 → next = NULL
call(2, 1)

curr, prev
(2, 1):

newNode = 2 → next = 3
2 → next = 1
call(3, 2)

curr, prev
(3, 2):

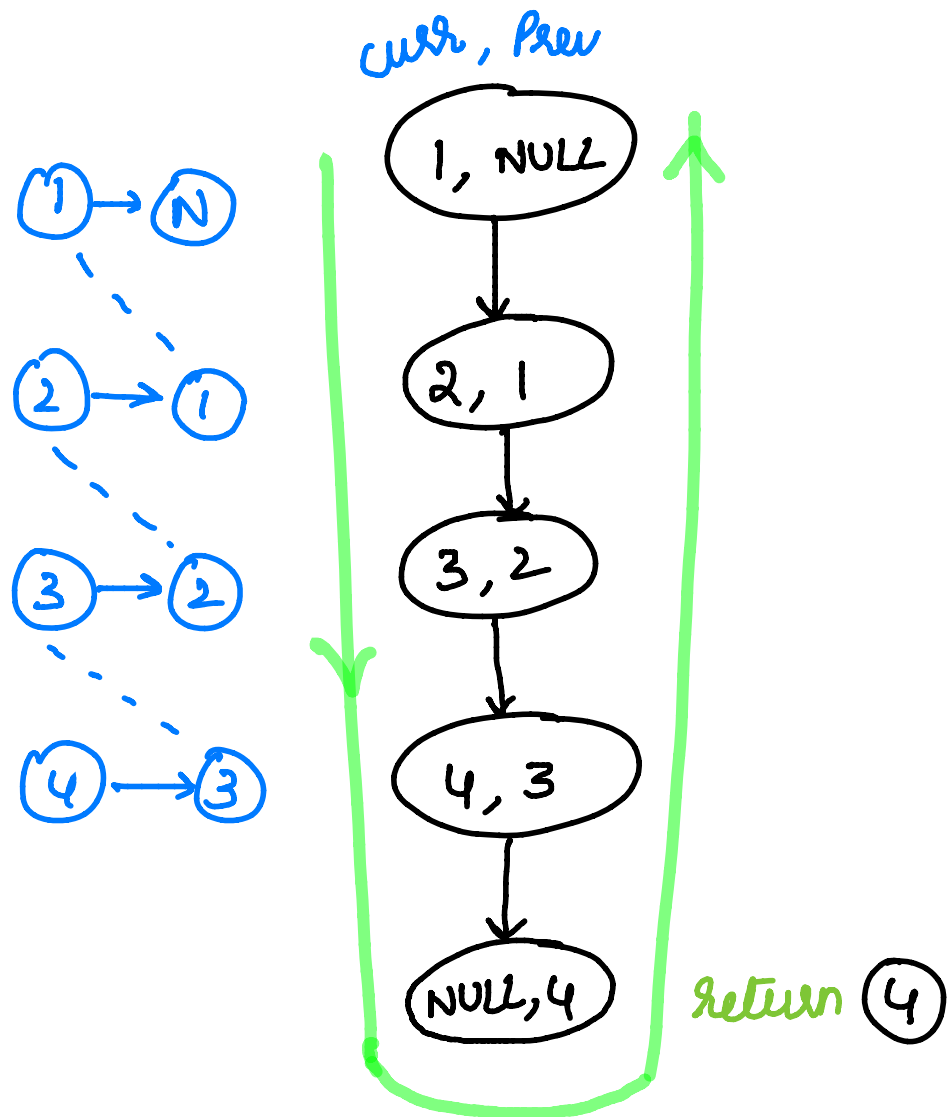
newNode = 3 → next = 4
3 → next = 2
call(4, 3)

curr, prev
(4, 3):

newNode = 4 → next = NULL
4 → next = 3
call(NULL, 4)

curr, prev
(NULL, 4):

as curr == NULL
return prev



func(curr, prev):

if curr == NULL
return prev

newNode = curr → next
curr → next = prev

recursively call newNode & curr as
as curr prev

Code →

$T_c \rightarrow O(n)$

$S_c \rightarrow O(1)$

```
1
2 // Iterative ->
3 class Solution {
4 public:
5     ListNode* reverseList(ListNode* head) {
6         ListNode *prev = NULL, *curr=head, *temp;
7         while(curr){
8             temp = curr->next;
9             curr->next = prev;
10            prev = curr;
11            curr = temp;
12        }
13        return prev;
14    }
15 };
16
17
18 // Recursive ->
19 class Solution {
20 public:
21     ListNode* reverseLinker(ListNode* curr, ListNode* prev) {
22         if(curr==NULL)
23             return prev;
24         ListNode* newNode = curr->next;
25         curr->next = prev;
26         return helper(newNode, curr);
27     }
28
29     ListNode* reverseLinker(ListNode* head) {
30         return helper (head, NULL);
31     }
32 };

```

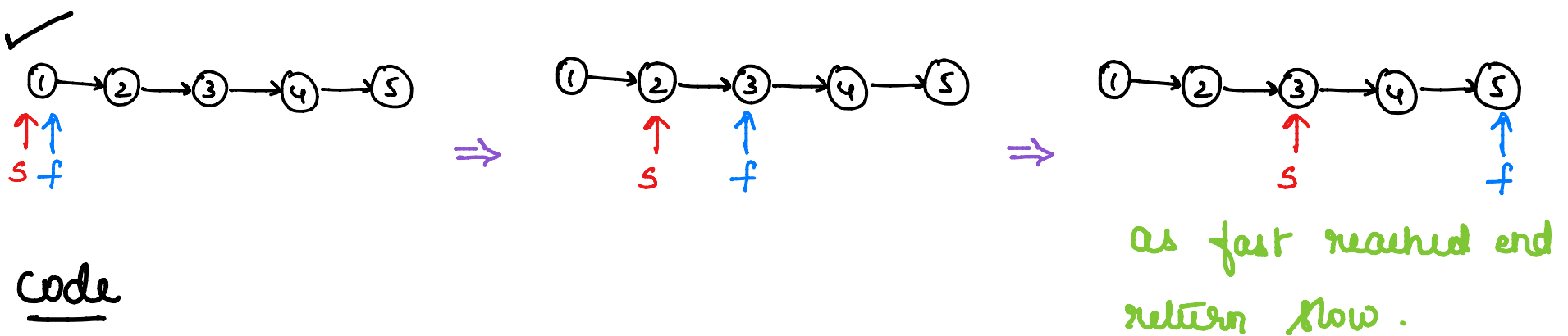
② Middle of Linkedlist → Given the head, return middle node.

Approach 1 → Traverse the list & find no of nodes & return mid

Approach 2 → use 2 pointers → slow (moves by 1) } By time
fast (moves by 2) } fast reaches end, slow points to the mid.

Eg ① → ② → ③ → ④ → ⑤

Res ⇒ ③ → ④ → ⑤



code

```
1 class Solution {
2 public:
3     ListNode* middleNode(ListNode* head) {
4         if(head == NULL)
5             return head;
6         ListNode* slow = head, *fast = head;
7
8         // Traverse the LinkedList
9         while(fast != NULL && fast -> next != NULL)
10        {
11            slow = slow -> next;
12            fast = fast -> next -> next;
13        }
14
15        return slow;
16    }
17 };
```

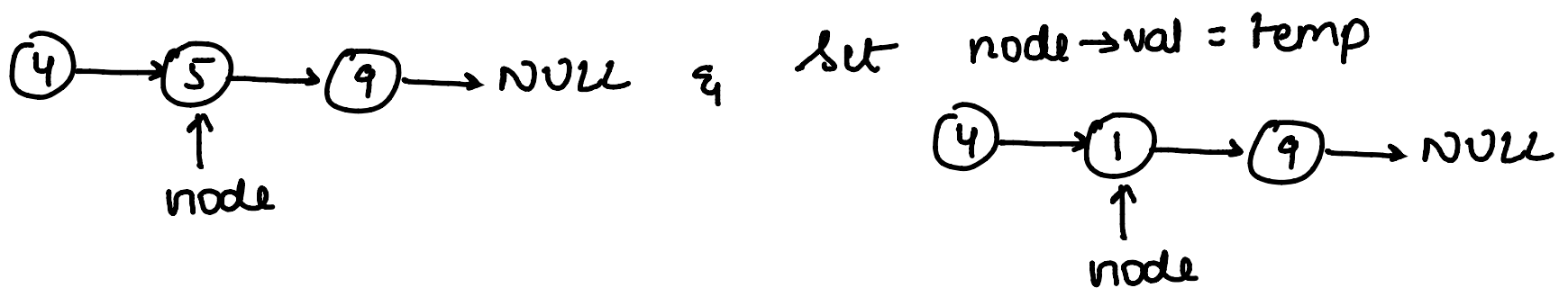
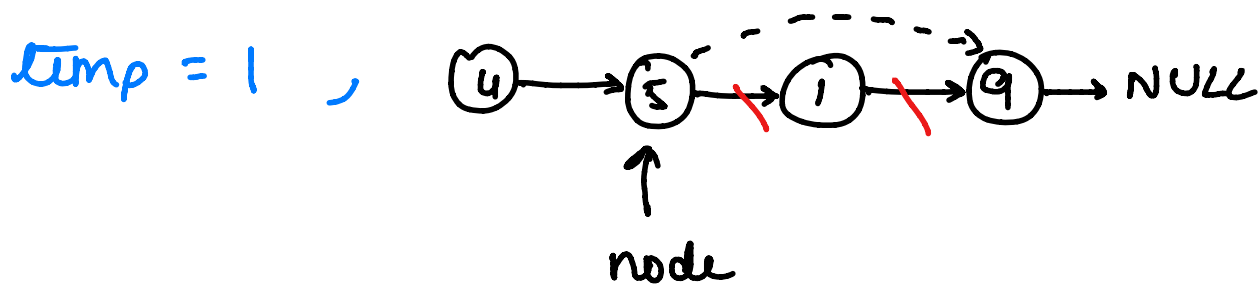
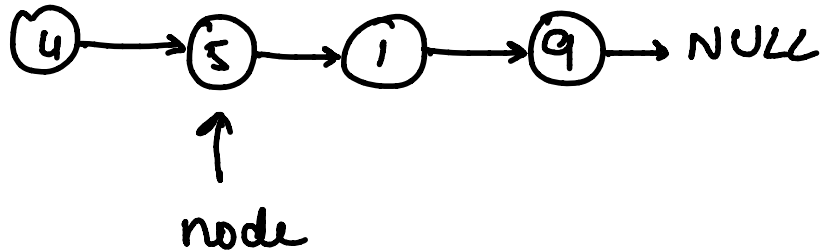
Tc → $O(n)$
Sc → $O(1)$

③ Delete node in a linkedlist →

given a linkedlist's node, delete it.

- copy node's next node's val into a temp variable
- skip the node → next node
- copy the temp variable's value into the node.

Eg

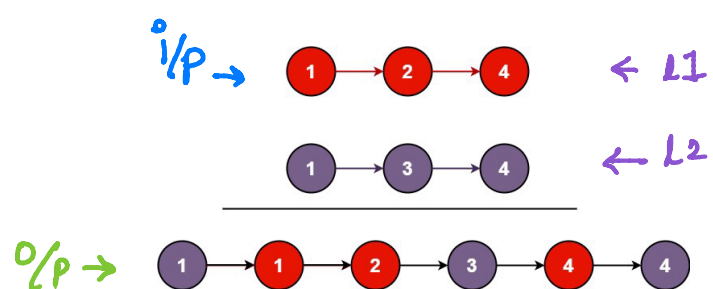


code →

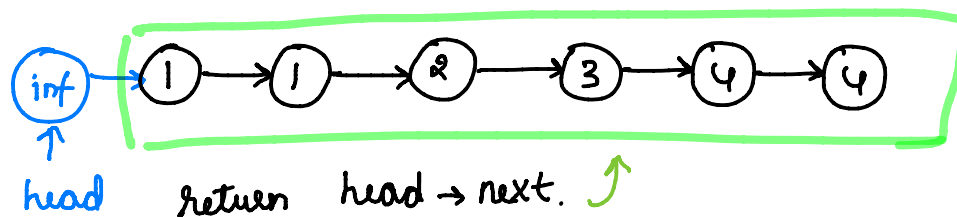
```
1 class Solution {
2 public:
3     void deleteNode(ListNode* node) {
4         int val = node->next->val;
5         node->next = node->next->next;
6         node->val = val;
7     }
8 };
```

Tc → O(1)
Sc → O(1)

④ Merge two sorted lists →



→ Take a dummy node & chain the next node which contains smaller value of L1 & L2



Code →

Tc → $O(m+n)$

Sc → $O(m+n)$

```

1  class Solution {
2  public:
3      ListNode* mergeTwoLists(ListNode* l1, ListNode* l2) {
4
5          if( l1 == NULL ) return l2;
6          if( l2 == NULL ) return l1;
7
8          ListNode* dummy = new ListNode(-101);
9          ListNode* head = dummy;
10
11         // Traverse the lists
12         while( l1 != NULL && l2 != NULL )
13         {
14             if( l1->val < l2->val )
15             {
16                 ListNode* newnode = new ListNode(l1->val);
17                 dummy->next = newnode;
18                 l1 = l1->next;
19             }
20             else
21             {
22                 ListNode* newnode = new ListNode(l2->val);
23                 dummy->next = newnode;
24                 l2 = l2->next;
25             }
26             dummy = dummy->next;
27         }
28
29         /* If a particular list is NULL, the directly chain
30         the other */
31         if(l1!=NULL) dummy->next = l1;
32         if(l2!=NULL) dummy->next = l2;
33
34         return head->next;
35     }
36 };

```

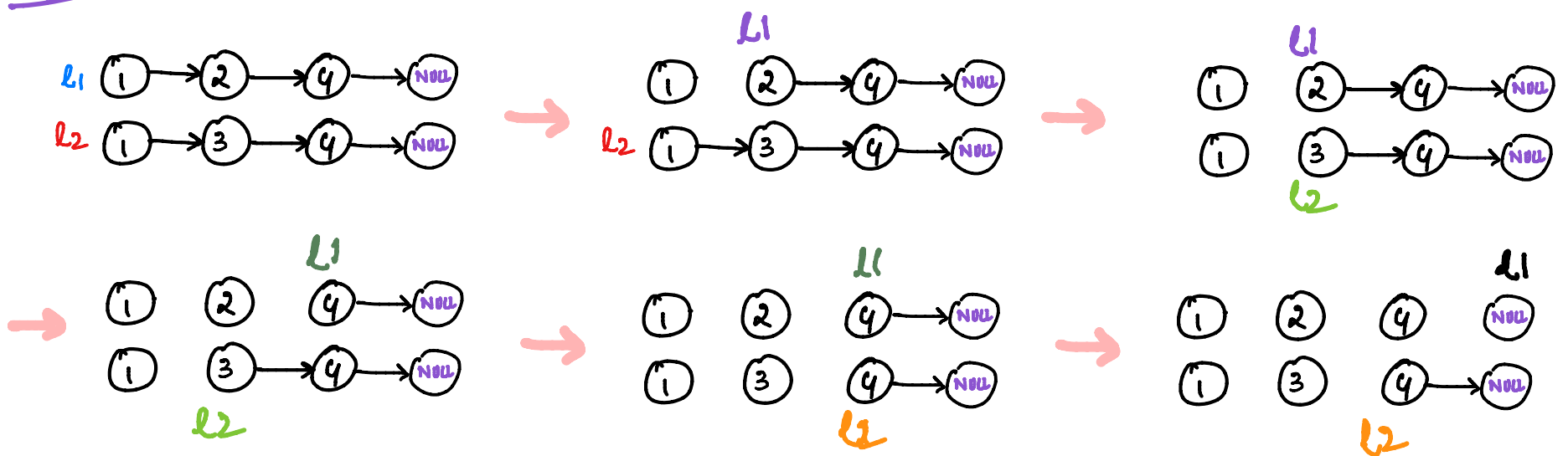
Recursive Code →

```
class Solution {
public:
    ListNode* mergeTwoLists(ListNode* l1, ListNode* l2) {

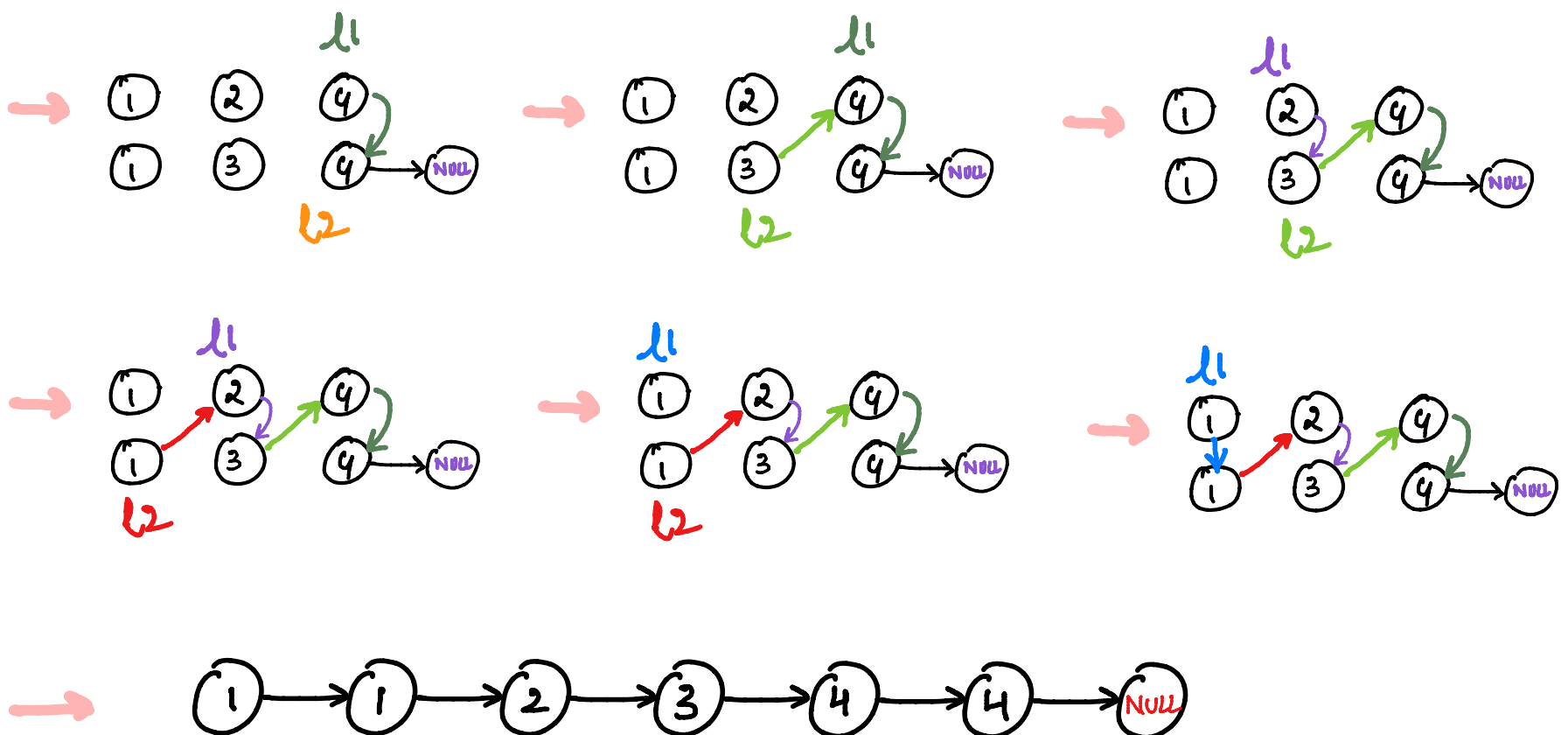
        if (l1 == NULL) return l2;
        if (l2 == NULL) return l1;

        // compare the starting values and link the nodes
        if (l1->val <= l2->val) {
            l1->next = mergeTwoLists(l1->next, l2);
            return l1;
        } else {
            l2->next = mergeTwoLists(l1, l2->next);
            return l2;
        }
    }
};
```

Dry Run

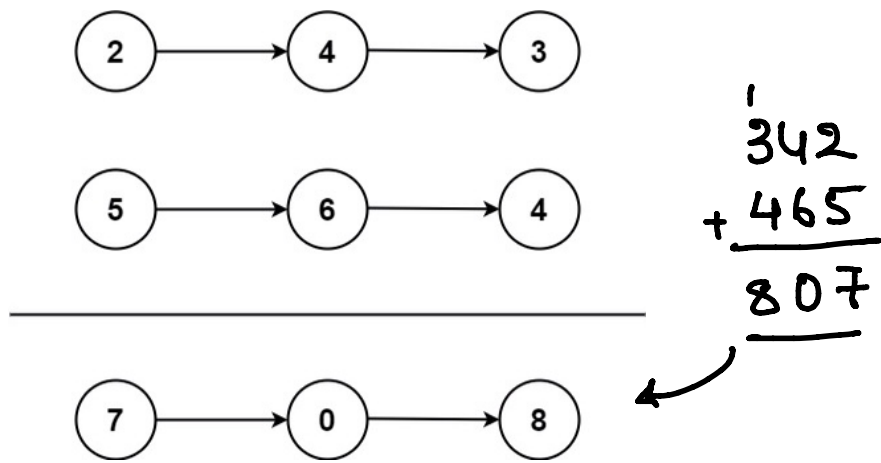


As l_1 is null, return l_2



(5) Add two Numbers

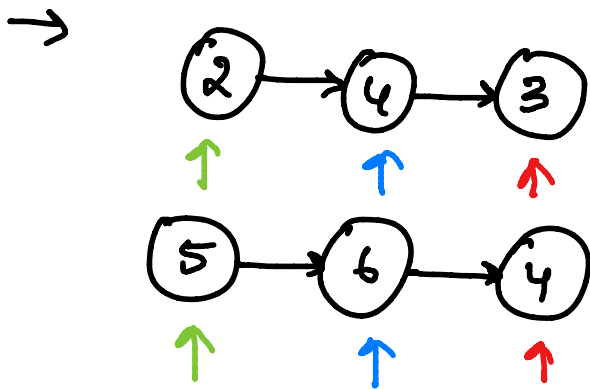
Given 2 lists in reverse order, add them and return the sum.



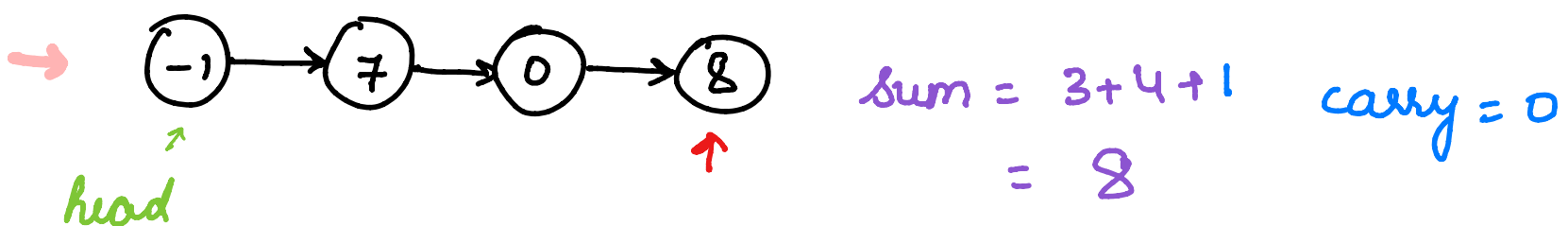
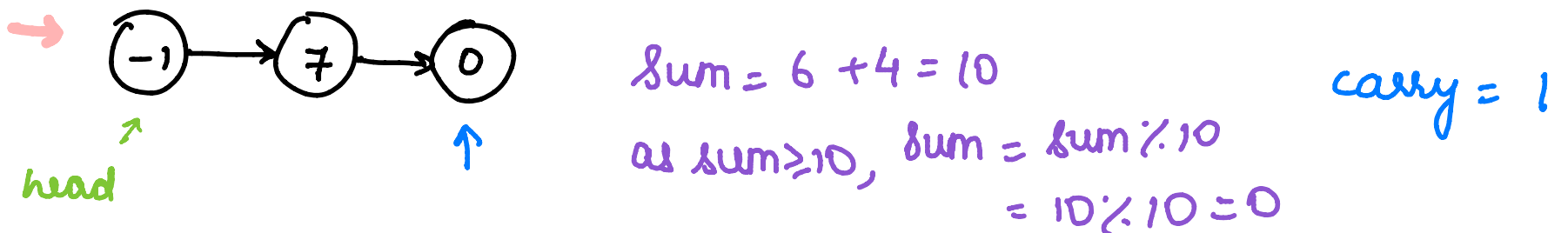
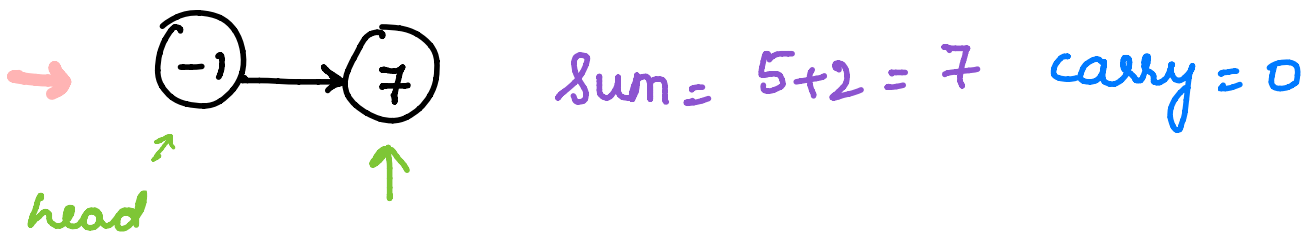
$$Tc \rightarrow O(m+n)$$

$$Sc \rightarrow O(\max(m,n))$$

Initially,



- 1) traverse both list simultaneously & if $sum \geq 10$, then set $carry = 1$
- 2) add both values + carry
- 3) create newNode with this value



code

```
1  class Solution {
2  public:
3
4      ListNode* addTwoNumbers(ListNode* l1, ListNode* l2) {
5
6          ListNode* dummyNode;
7          ListNode* head;
8          dummyNode = head = new ListNode(-1);
9          if(!l1)
10             return l2;
11          if(!l2)
12             return l1;
13
14          int carry = 0;
15
16          while(l1 || l2){
17              int firstVal = l1 ? l1->val : 0;
18              int secondVal = l2 ? l2->val : 0;
19
20              int total = firstVal + secondVal + carry;
21              carry = total / 10;
22              total = total % 10;
23
24              ListNode* newNode = new ListNode(total);
25              dummyNode->next = newNode;
26
27              dummyNode = dummyNode->next;
28
29              l1 = l1 ? l1->next : l1;
30              l2 = l2 ? l2->next : l2;
31          }
32
33          if(carry)
34              dummyNode->next = new ListNode(1);
35
36          return head->next;
37      }
38  };
```

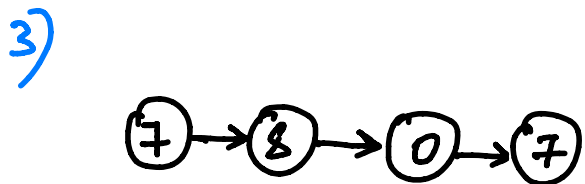
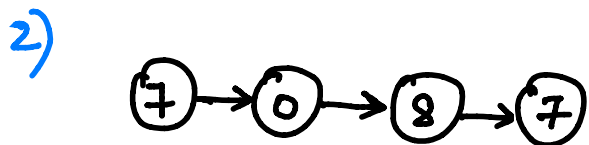
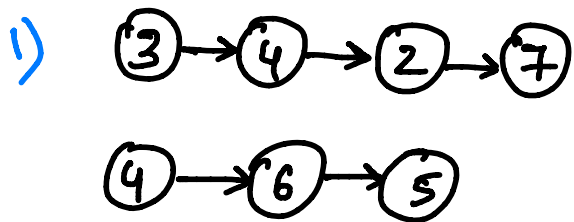
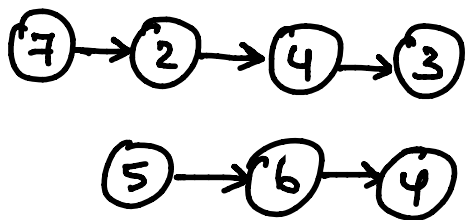
⑥ Add two numbers II

→ Problem solving approach is same as previous problem

→ Points to note :

1. Reverse both the lists
2. Add them
3. Reverse the result

Eg →



Result ↑

Code →

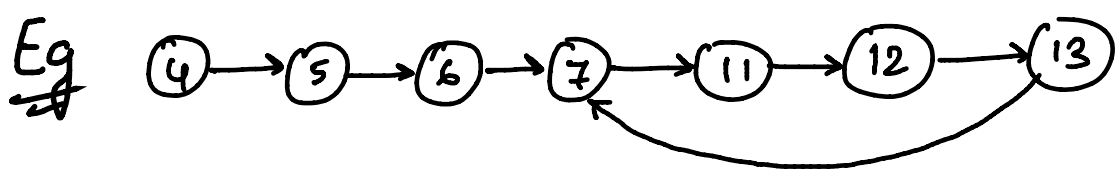
```
1 class Solution {
2 public:
3     ListNode* reverseList(ListNode* head) {
4         ListNode* prev = NULL;
5         ListNode* curr = head;
6         ListNode* temp = NULL;
7         while(curr != NULL)
8         {
9             temp = curr->next;
10            curr->next = prev;
11            prev = curr;
12            curr = temp;
13        }
14        return prev;
15    }
16
17    ListNode* addTwoNumbers(ListNode* l1, ListNode* l2) {
18        l1 = reverseList(l1); // O(n)
19        l2 = reverseList(l2); // O(n)
20        ListNode* dummyNode;
21        ListNode* head;
22        dummyNode = head = new ListNode(-1);
23        if(!l1)
24            return l2;
25        if(!l2)
26            return l1;
27
28        int carry = 0;
29
30        while(l1 || l2){
31            int firstVal = l1 ? l1->val : 0;
32            int secondVal = l2 ? l2->val : 0;
33
34            int total = firstVal + secondVal + carry;
35            carry = total / 10;
36            total = total % 10;
37
38            ListNode* newNode = new ListNode(total);
39            dummyNode->next = newNode;
40
41            dummyNode = dummyNode->next;
42
43            l1 = l1 ? l1->next : l1;
44            l2 = l2 ? l2->next : l2;
45        }
46
47        if(carry)
48            dummyNode->next = new ListNode(1);
49
50        return reverseList(head->next); // O(max(m,n))
51    }
52};
```

⑦ Linked List Cycle →

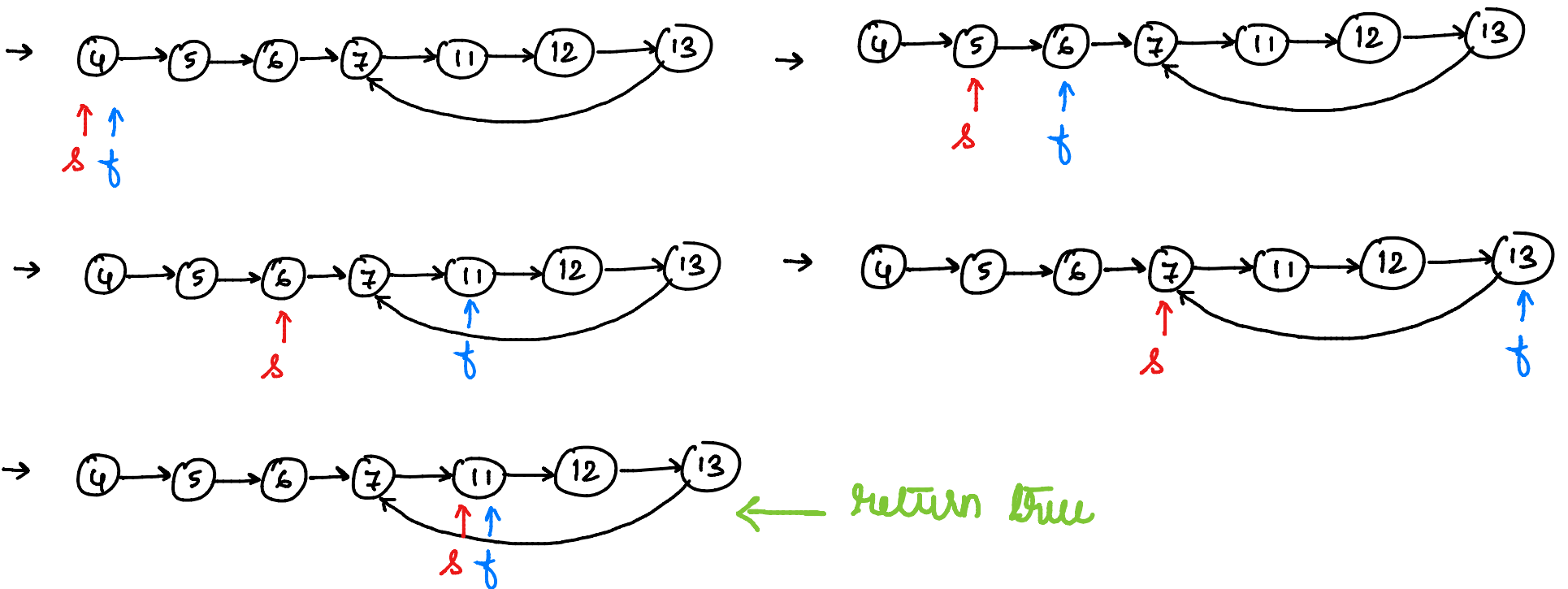
TC → O(n)
SC → O(1)

Approach - 1 → Create a set of nodes & insert every node into it, if already exist then return True else false.

Approach - 2 → using fast & slow pointer TC → O(n) SC → O(1)



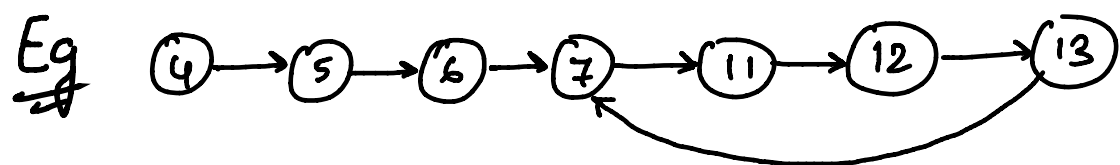
keep iterating till
fast → next && fast → next → next exist.



code →

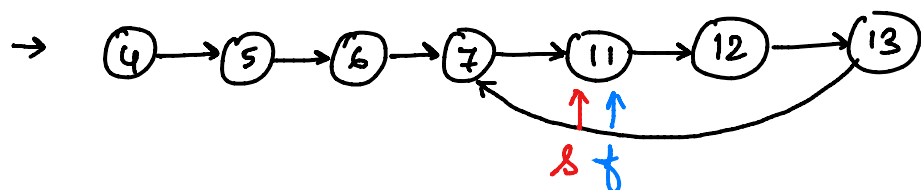
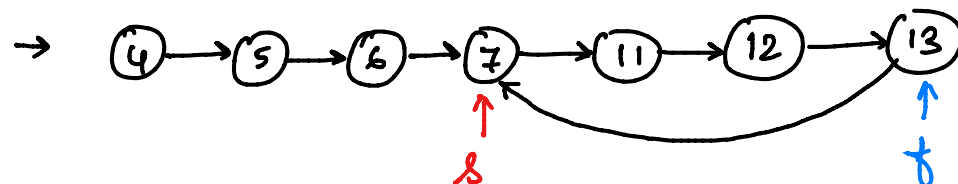
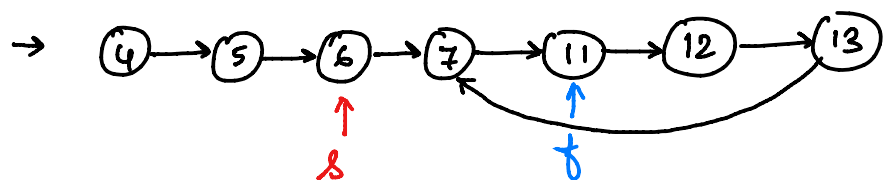
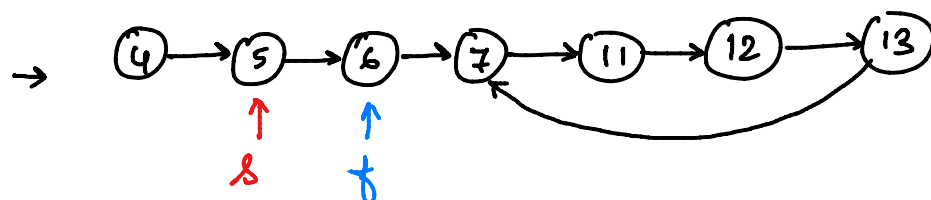
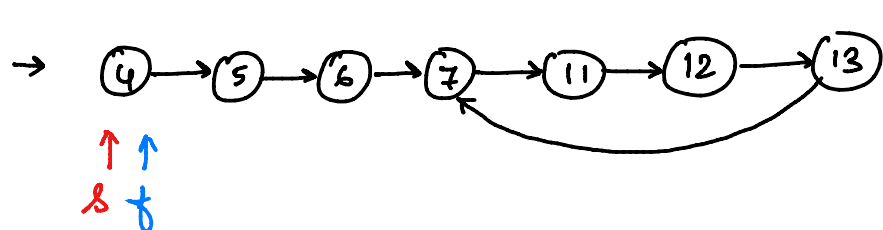
```
1 class Solution {
2 public:
3     bool hasCycle(ListNode *head) {
4         if(head==NULL) return false;
5         ListNode *fast = head, *slow = head;
6         while(fast->next!=NULL && fast->next->next!=NULL)
7         {
8             fast=fast->next->next;
9             slow=slow->next;
10            if(fast==slow) return true;
11        }
12        return false;
13    }
14 };
```

(8) Linked list cycle II $\rightarrow$ return the node where cycle begins.

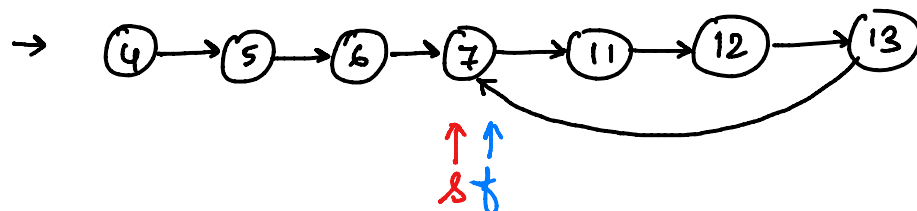
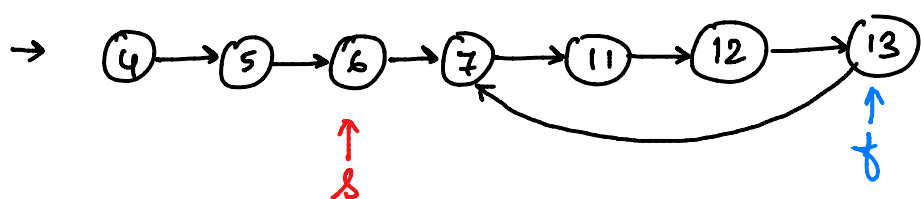
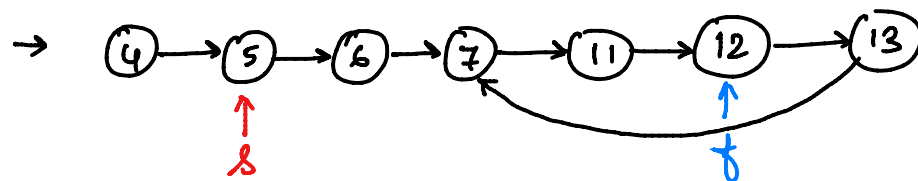
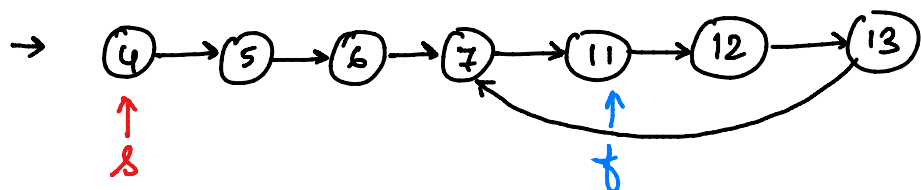


result = 7

keep iterating while fast $\rightarrow$ next && fast $\rightarrow$ next $\rightarrow$ next exist.



$\leftarrow$ once slow == fast, then set slow = head, & move pointers by 1 unit



$\rightarrow$ when slow == fast, it denotes the node where cycle begins.

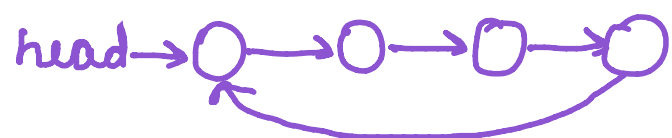
return slow; $\Rightarrow$ 7

code →

```
1  class Solution {
2  public:
3      ListNode *detectCycle(ListNode *head) {
4          if(head==NULL) return NULL;
5          ListNode *fast = head, *slow = head;
6          while(fast->next!=NULL && fast->next->next!=NULL)
7          {
8              fast = fast->next->next;
9              slow = slow->next;
10             if(fast == slow)
11             {
12                 slow = head;
13                 while (slow != fast)
14                 {
15                     slow = slow->next;
16                     fast = fast->next;
17                 }
18                 return slow;
19             }
20         }
21         return NULL;
22     }
23 };
```

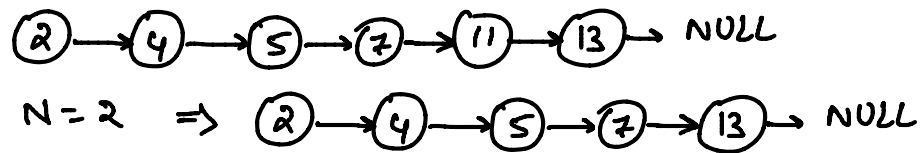
$$T_c \rightarrow O(n) + O(n) = O(2n) = \underline{\underline{O(n)}}$$

* worst case when its a loop



$$S_c \rightarrow O(1)$$

Q) Remove Nth node from End of list



Approach - 1 → find length of list L, delete $L - N + 1$ th node

Approach - 2 → a) Reverse b) Delete Nth node c) Reverse

code →

TC → O(n)

SC → O(1)

```
1 class Solution {
2 public:
3     ListNode* reverseList(ListNode* head) {
4         ListNode *prev = NULL, *curr = head, *temp;
5         while(curr){
6             temp = curr->next;
7             curr->next = prev;
8             prev = curr;
9             curr = temp;
10        }
11        return prev;
12    }
13
14    ListNode* removeNthFromEnd(ListNode* head, int n) {
15        ListNode *dummy = new ListNode(-1);
16        dummy->next = reverseList(head);
17        head = dummy;
18        ListNode *curr = head;
19        ListNode *prev = NULL;
20        // Iteration
21        for(int i=0; i<n; i++){
22            {
23                prev = curr;
24                curr = curr->next;
25            }
26        // Deletion
27        prev->next = curr->next;
28        return reverseList(head->next);
29    }
30 };
```

(10) Palindrome Linked List

Approach - 1 → create a copy of list & reverse it. Compare value by value.
If all are equal **true** else **false**.

Approach - 2 → Reach middle node & return the remaining list as new list. Reverse the new list & compare its value by value.

code →

Tc → $O(n)$

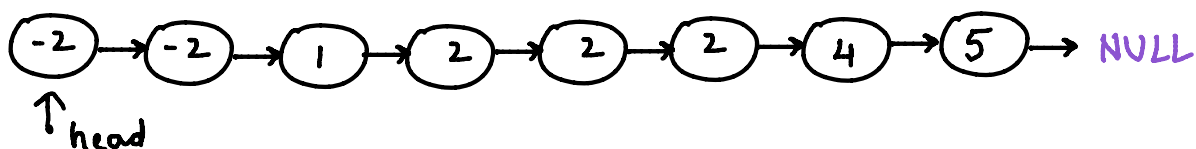
Sc → $O(1)$

```
1  class Solution {
2  public:
3      ListNode* midNode(ListNode* head)
4      {
5          ListNode *fast = head, *slow = head;
6          while(fast->next!=NULL and fast->next->next!=NULL){
7              fast=fast->next->next;
8              slow = slow->next;
9          }
10         return slow;
11     }
12     ListNode* reverseList(ListNode* head) {
13         ListNode *prev = NULL, *curr = head, *temp;
14         while(curr!=NULL)
15         {
16             temp=curr->next;
17             curr->next = prev;
18             prev = curr;
19             curr = temp;
20         }
21         return prev;
22     }
23     bool compare(ListNode* l1, ListNode* l2)
24     {
25         while(l1!=NULL && l2!=NULL)
26         {
27             if(l1->val!=l2->val) return false;
28             l1 = l1->next;
29             l2 = l2->next;
30         }
31         return true;
32     }
33     bool isPalindrome(ListNode* head) {
34         if(head==NULL) return false;
35         if(head->next == NULL) return true;
36         ListNode *mid = midNode(head);
37         ListNode *l2 = mid->next;
38         mid->next = NULL;
39         l2 = reverseList(l2);
40         return compare(head, l2);
41     }
42 };
```

① Remove duplicates from sorted list →

Given a linkedlist, return linkedlist without duplicates.

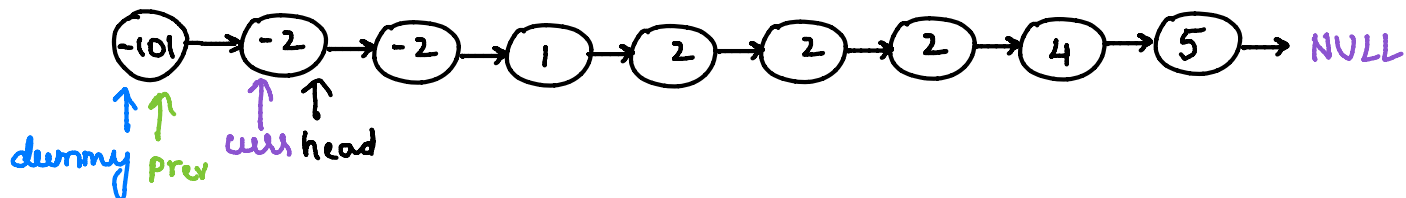
Ex



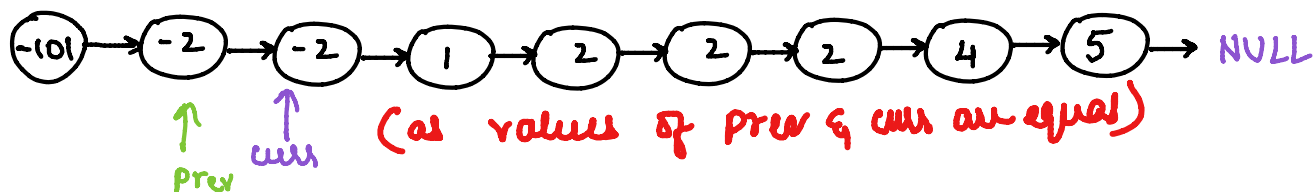
⇒

any out of range value

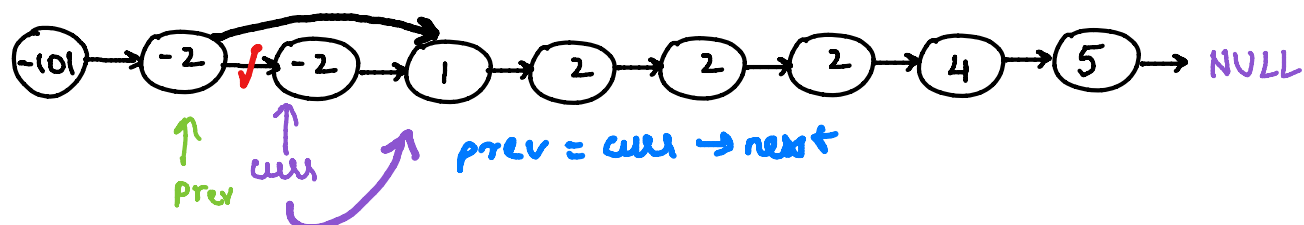
1)



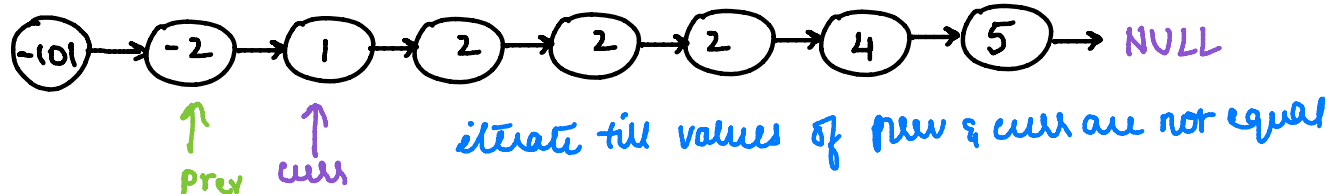
2)



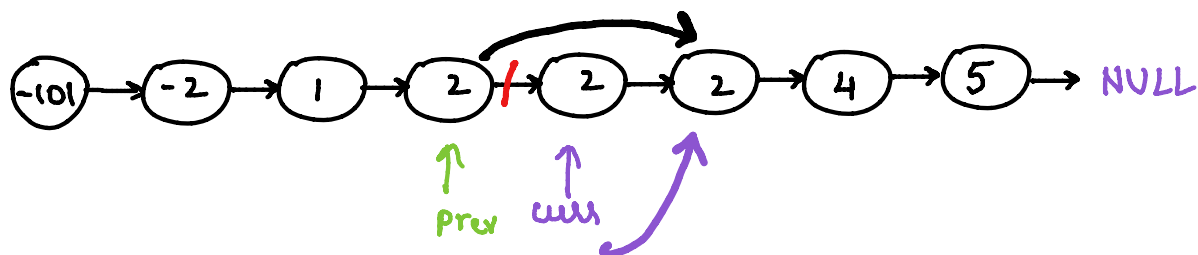
3)



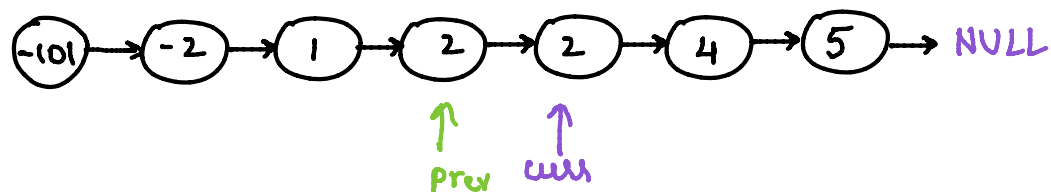
4)



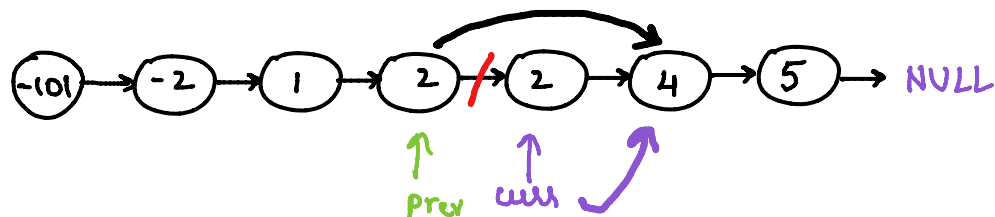
5)



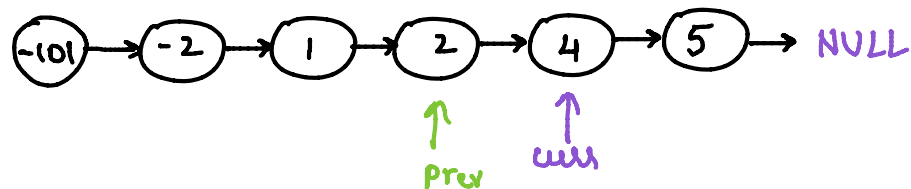
6)



7)



8)



code →

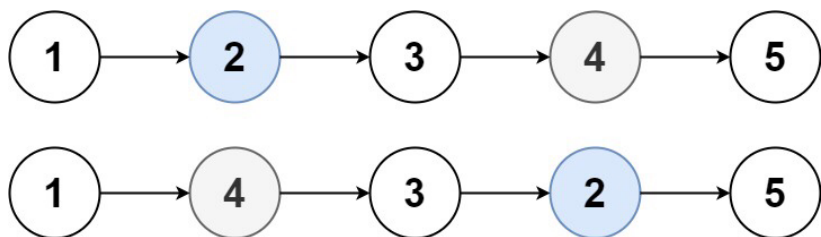
```
1  class Solution {
2  public:
3      ListNode* deleteDuplicates(ListNode* head) {
4          ListNode* dummy = new ListNode(101);
5          dummy->next = head;
6          ListNode* curr = head;
7          ListNode* prev = dummy;
8          while(curr!=NULL)
9          {
10             if(curr->val==prev->val){
11                 prev->next = curr->next;
12                 curr = curr->next;
13             } else {
14                 prev = curr;
15                 curr = curr->next;
16             }
17         }
18         return dummy->next;
19     }
20 };
21
22
23 // Another approach
24
25 ListNode* deleteDuplicates(ListNode* head) {
26     if(head==NULL || head->next==NULL) return head;
27     ListNode *curr = head;
28     while(curr->next!=NULL){
29         if(curr->val == curr->next->val){
30             curr->next = curr->next->next;
31         } else {
32             curr = curr->next;
33         }
34     }
35     return head;
36 }
```

$T_c \rightarrow O(n)$

$S_c \rightarrow O(1)$

(12) Swapping Nodes in Linked list →

Eg:

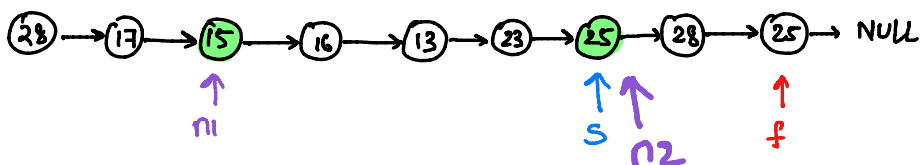
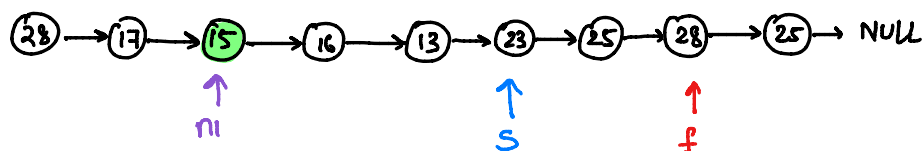
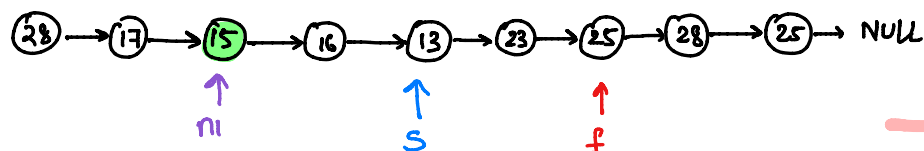
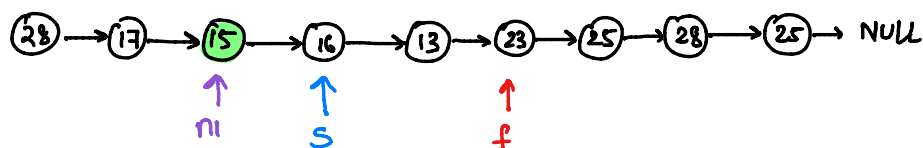
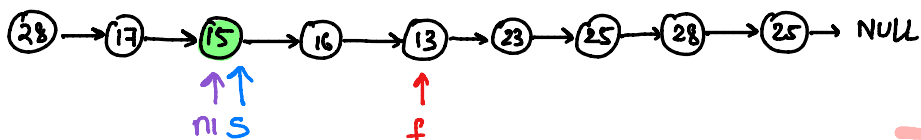
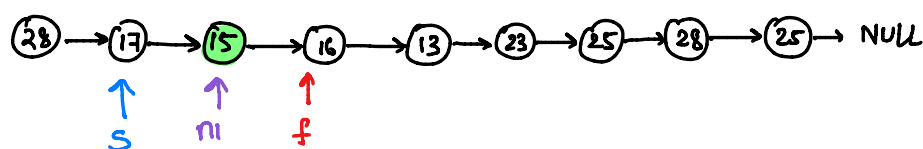
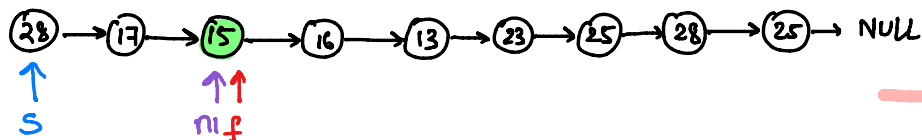
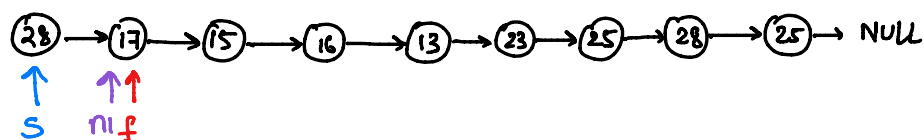
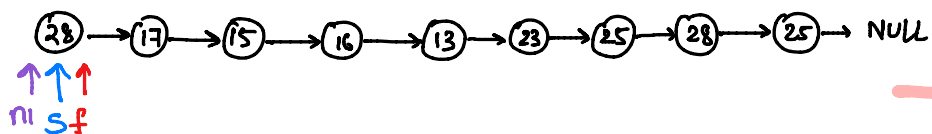


$k=2$

Given a linkedlist swap k^{th} node from both ends.

Eg

* for $k-1$ times iterate f & mark $n1$, then iterate s & f till f is not NULL, once null mark s as $n2$.
(as it is 1 indexed) $\swarrow$
swap($n1, n2$)



($f \rightarrow \text{next} == \text{NULL}$, so s is $n2$)

swap(13, 25)



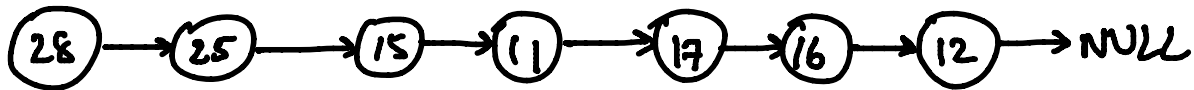
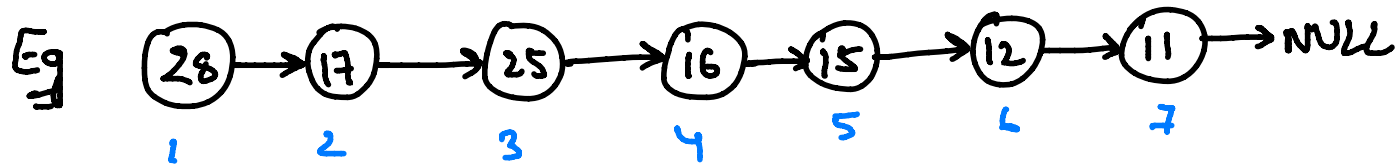
code →

```
1 class Solution {
2 public:
3     ListNode* swapNodes(ListNode* head, int k) {
4         ListNode *slow = head, *fast = head, *n1 = head;
5         // finding n1
6         for(int i=0; i<k-1; i++){
7             fast = fast->next;
8             n1 = fast;
9         }
10        // finding n2 (i.e slow)
11        while(fast->next!=NULL){
12            fast = fast->next;
13            slow = slow->next;
14        }
15        // swapping
16        int n1_val = n1->val;
17        n1->val = slow->val;
18        slow->val = n1_val;
19        return head;
20    }
21 };
```

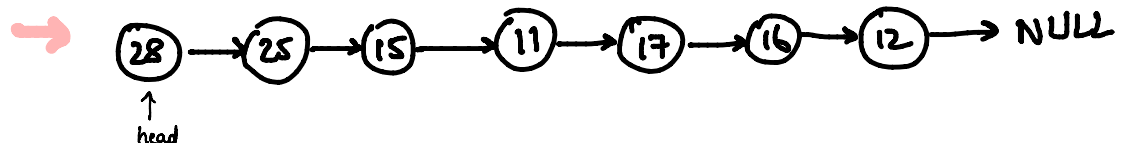
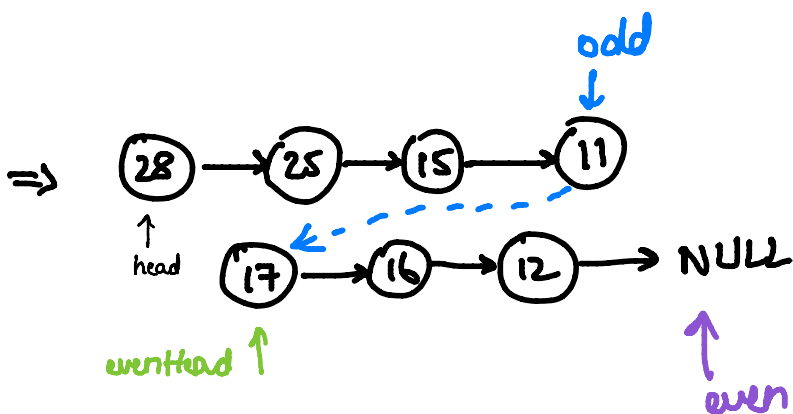
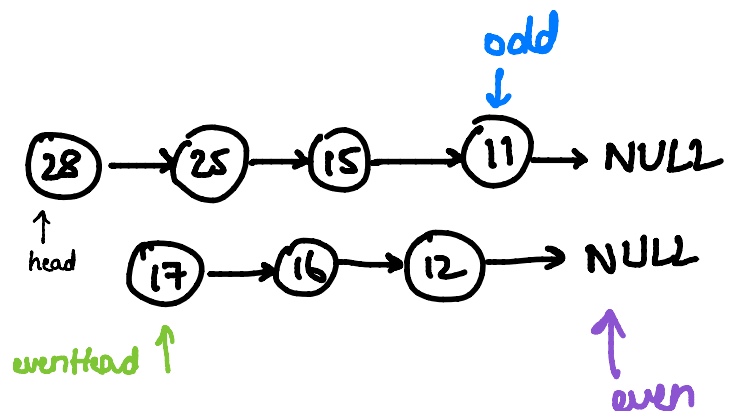
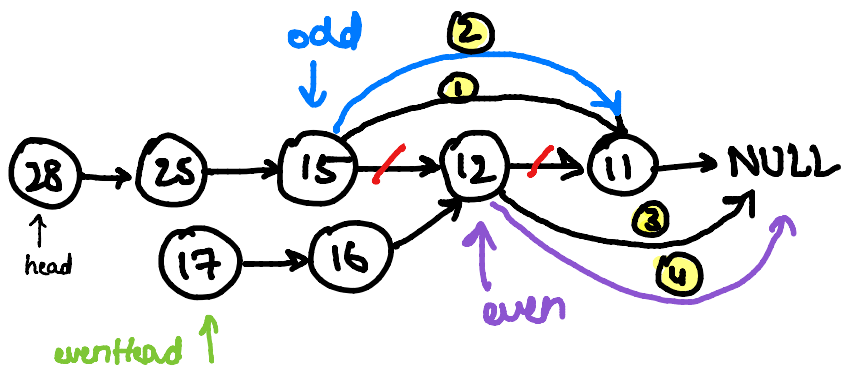
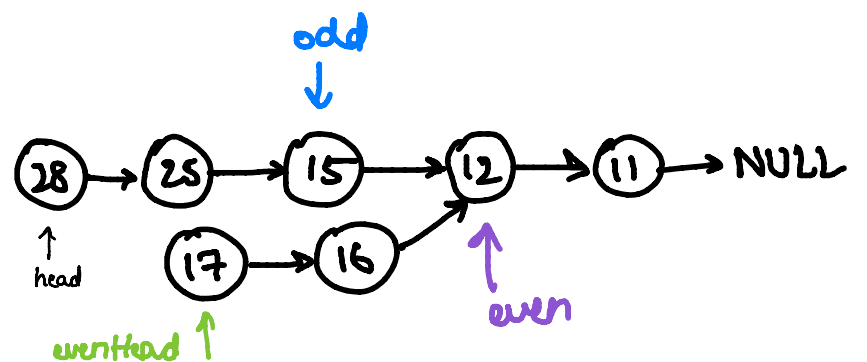
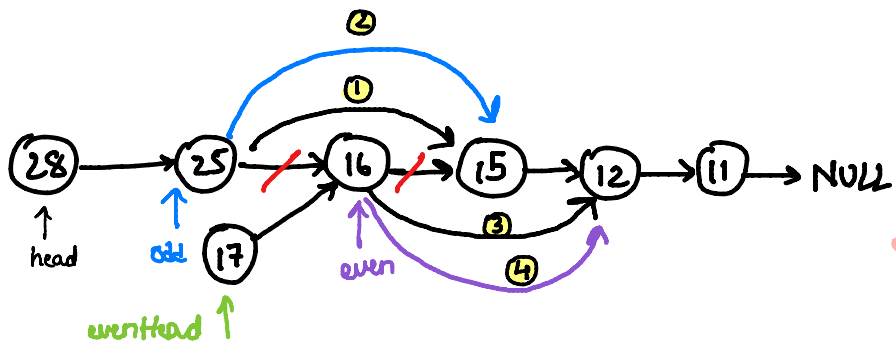
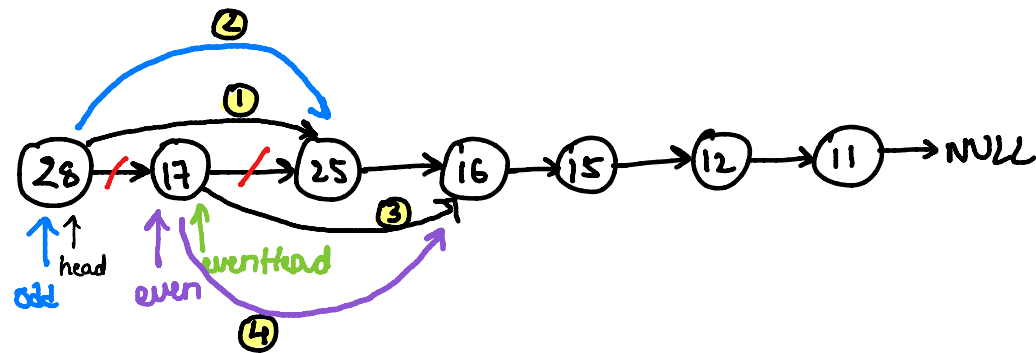
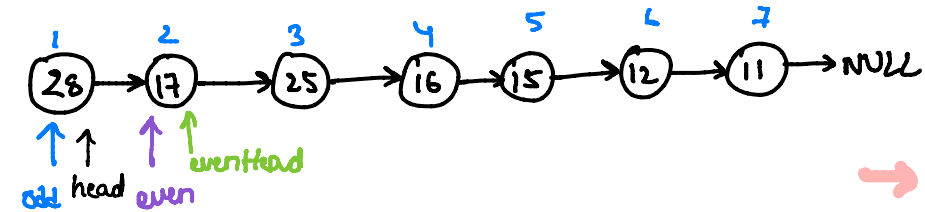
$Tc \rightarrow O(n)$
 $Sc \rightarrow O(1)$

13) Odd Even Linked List →

Given a linkedlist group all odd indices nodes followed by even nodes



⇒



odd → next = evenhead

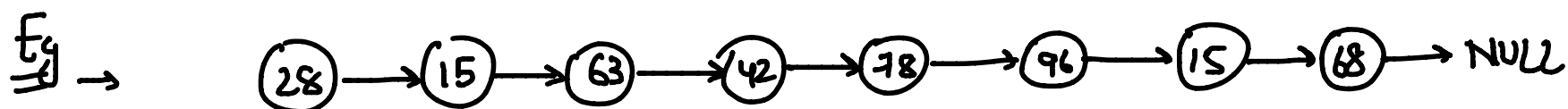
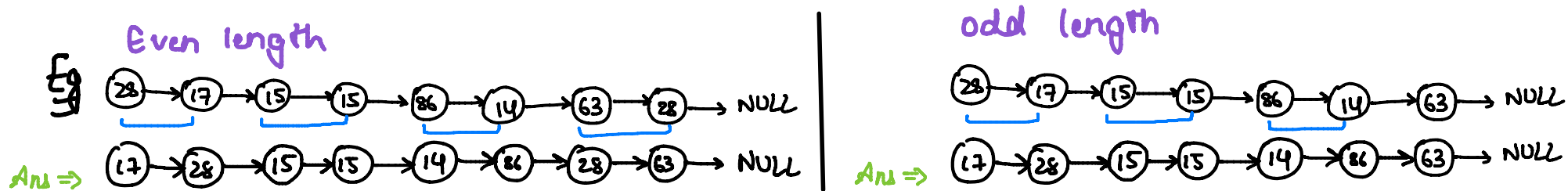
code →

```
1  class Solution {
2  public:
3      ListNode* oddEvenList(ListNode* head) {
4          if(!head) return NULL;
5
6          ListNode *even = head->next;
7          ListNode *odd = head;
8          ListNode *evenHead = even;
9
10         while(even && even->next){
11             odd->next=even->next;
12             odd=odd->next;
13             even->next=odd->next;
14             even=even->next;
15         }
16
17         // like odd and even lists
18         odd->next = evenHead;
19         return head;
20     }
21 };
```

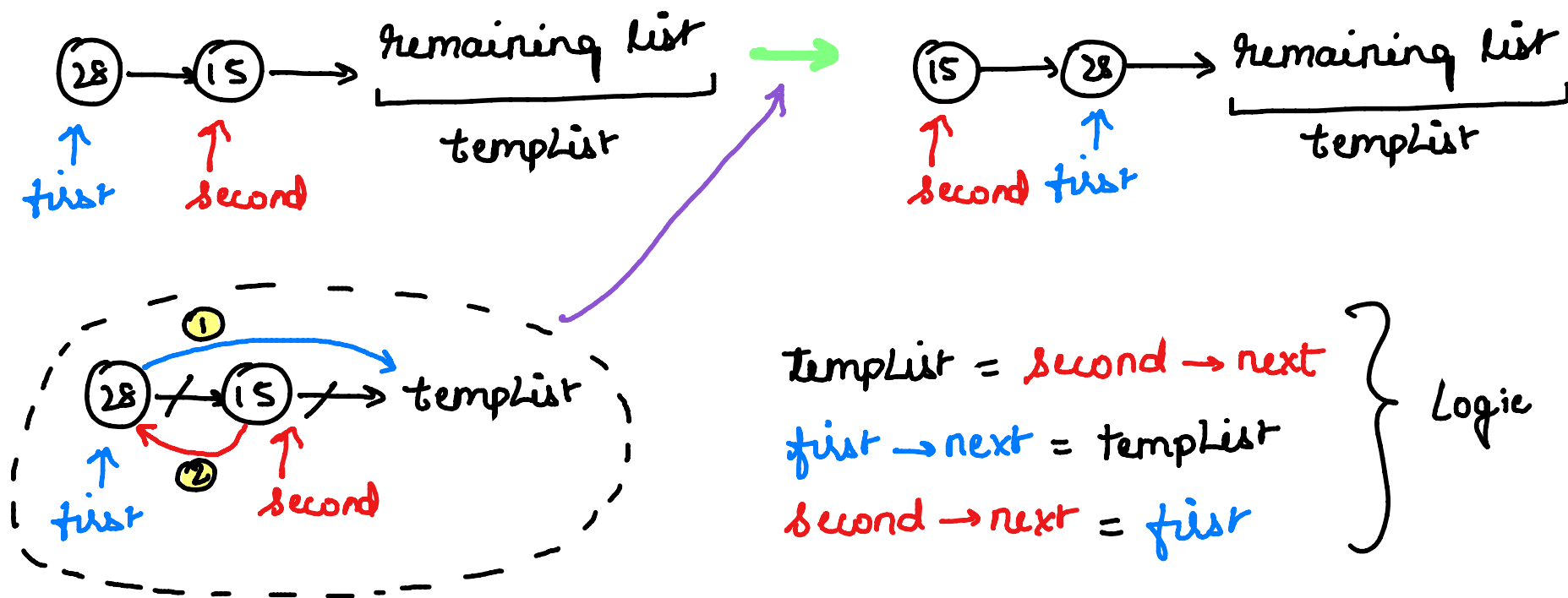
$TC \rightarrow O(n)$

$SC \rightarrow O(1)$

(14) Swap Nodes in Pairs → Given a linkedlist swap adjacent nodes.



Consider for 1st pair,



Solve recursively for all pairs.

Code →

```

1 class Solution {
2 public:
3     ListNode* SwapAdjacentNodes(ListNode* head)
4     {
5         if(head==NULL || head->next==NULL) return head;
6         ListNode *first = head;
7         ListNode *second = head->next;
8         // start logic
9         ListNode *tempList = SwapAdjacentNodes(second->next);
10        first->next = tempList;
11        second->next = first;
12        return second;
13    }
14    ListNode* swapPairs(ListNode* head) {
15        return SwapAdjacentNodes(head);
16    }
17 };

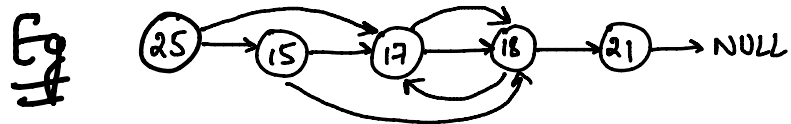
```

Tc → $O(N)$

Sc → $O(1)$

Recursive
stack → $O(N/2)$
 $\approx O(N)$

15) Copy list with random pointer → given a list, clone & return.



→ In 1st iteration create the list without random pointer & also maintain hashmap for mapping nodes pointed by random pointer

→ In 2nd iteration use **map** to link nodes pointed by random pointer

mp

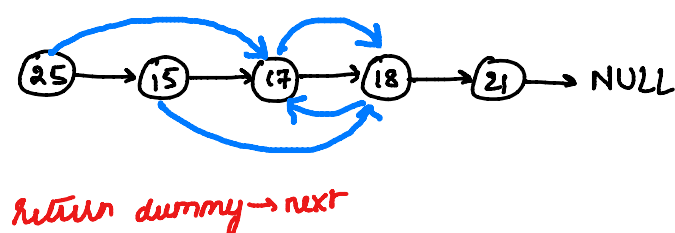
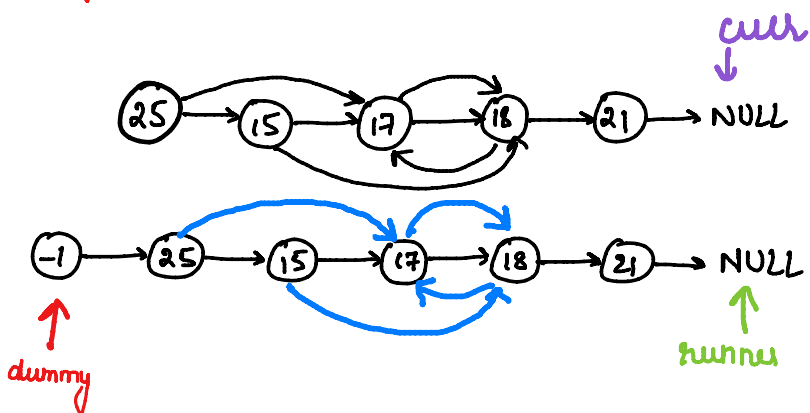
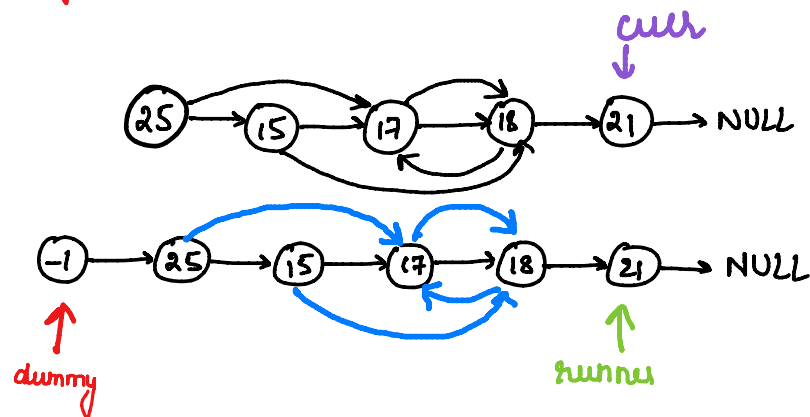
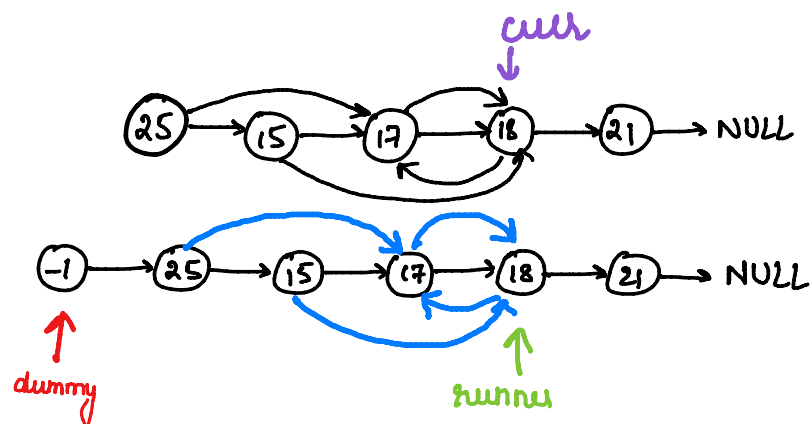
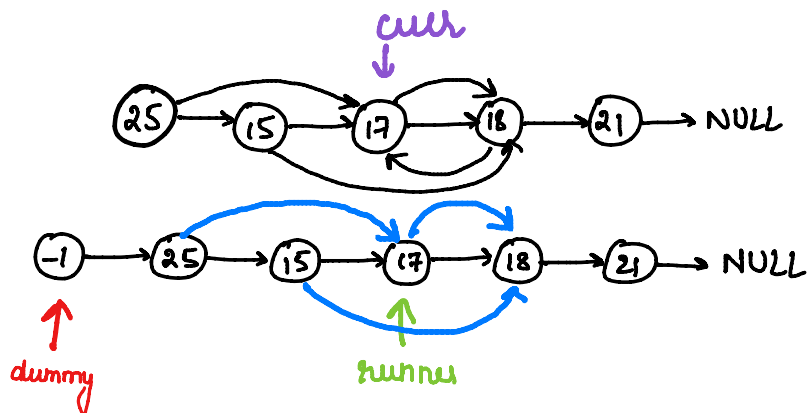
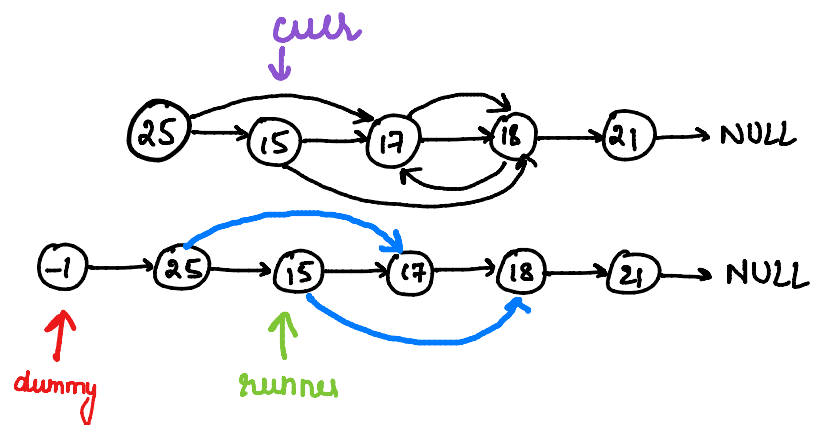
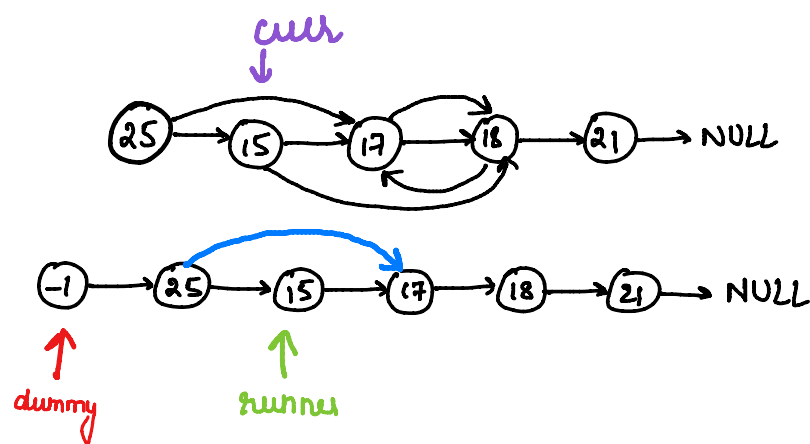
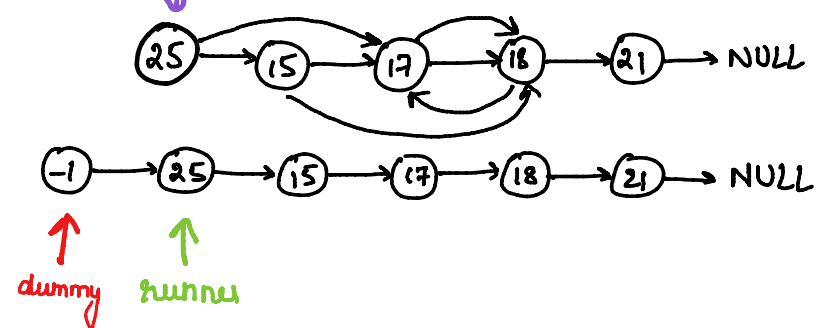
25	25
15	15
17	17
18	18
21	21
NULL	NULL

Old New

After 1st iteration →



⇒ cur (iterate till cur is not null)



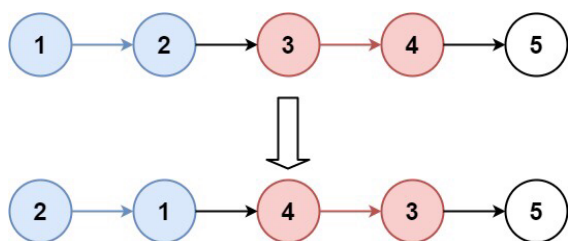
Code →

TC → $O(n)$

SC → $O(n)$

```
1  class Solution {
2  public:
3      Node* copyRandomList(Node* head) {
4
5          unordered_map<Node*, Node*> mp;
6          Node *dummy = new Node(100001);
7          Node *runner = dummy, *curr = head;
8
9          // initial iteration
10         while(curr != NULL){
11             Node *newNode = new Node(curr->val);
12             runner->next = newNode;
13             mp[curr] = newNode;
14             curr = curr->next;
15             runner = runner->next;
16         }
17
18         // setting starting points in both lists
19         curr = head;
20         runner = dummy->next;
21
22         // setting the random pointers
23         while(curr != NULL){
24             if(curr->random != NULL)
25                 runner->random = mp[curr->random];
26             runner = runner->next;
27             curr = curr->next;
28         }
29
30         return dummy->next;
31     }
32 };
```

(1b) Reverse Nodes in K-Group



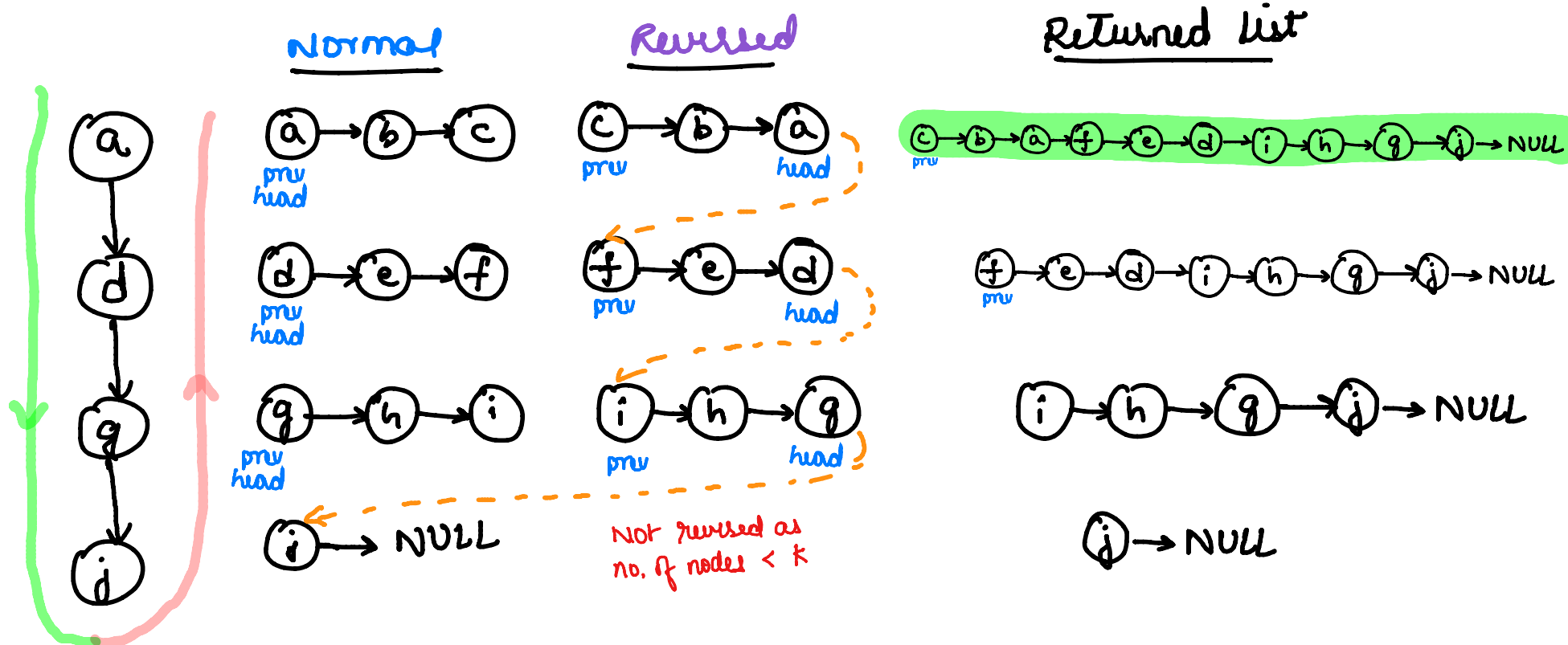
$K=2$

Given a linkedlist & K, return a list with reversed nodes by K-groups.

Eg. $a \rightarrow b \rightarrow c \rightarrow d \rightarrow e \rightarrow f \rightarrow g \rightarrow h \rightarrow i \rightarrow j \rightarrow \text{NULL}$

$k=3$

Res $\Rightarrow c \rightarrow b \rightarrow a \rightarrow f \rightarrow e \rightarrow d \rightarrow i \rightarrow h \rightarrow g \rightarrow j \rightarrow \text{NULL}$



* Consider the case of $f \rightarrow e \rightarrow d$, then $tempList = i \rightarrow h \rightarrow g$
linking would happen as $head \rightarrow next = tempList$ & this list
would become $tempList$ to $c \rightarrow b \rightarrow a$

code →

$T_c \rightarrow O(n)$
 $S_c \rightarrow O(1)$

```
1  class Solution {
2  public:
3      ListNode* reverseList(ListNode* head)
4      {
5          ListNode *prev = NULL, *curr = head, *temp;
6          while (curr!=NULL)
7          {
8              temp = curr->next;
9              curr->next = prev;
10             prev = curr;
11             curr = temp;
12         }
13         return prev;
14     }
15
16     ListNode* reverseInGroups(ListNode* head, int k)
17     {
18         ListNode *curr = head;
19         int currlen = 1;
20         if(head == NULL) return head;
21         while(curr->next!=NULL && currlen<k ){
22             curr=curr->next;
23             currlen+=1;
24         }
25         if(currlen<k) return head;
26         ListNode *tempNode = curr->next;
27         curr->next = NULL;
28
29         // start linking
30         ListNode *tempList = reverseInGroups(tempNode,k);
31         ListNode *prev = reverseList(head);
32         head->next = tempList;
33         return prev;
34     }
35
36     ListNode* reverseKGroup(ListNode* head, int k) {
37         return reverseInGroups(head,k);
38     }
39 };
```

⑦ Design linked list → Implementation of Doubly Linked list

code →

```
class Node{
public:
    int val;
    Node* prev;
    Node* next;
    Node(int val){
        this->val=val;
        prev = nullptr;
        next = nullptr;
    }
};
class MyLinkedList {
public:
    Node *head;
    Node *tail;
    MyLinkedList(){
        head = nullptr;
        tail = nullptr;
    }

    int get(int index){
        if(head == NULL) return -1;
        Node *temp = head;
        int count = 0;
        while(temp!=NULL){
            temp=temp->next;
            count++;
        }
        if(index>=count) return -1;
        temp = head;
        while(temp != NULL && index>0){
            temp=temp->next;
            index--;
        }
        return temp->val;
    }

    void addAtHead(int val){
        Node *newNode = new Node(val);
        if(head == NULL){
            head = newNode;
            tail = newNode;
        } else {
            newNode->next = head;
            head->prev = newNode;
            head = newNode;
        }
    }

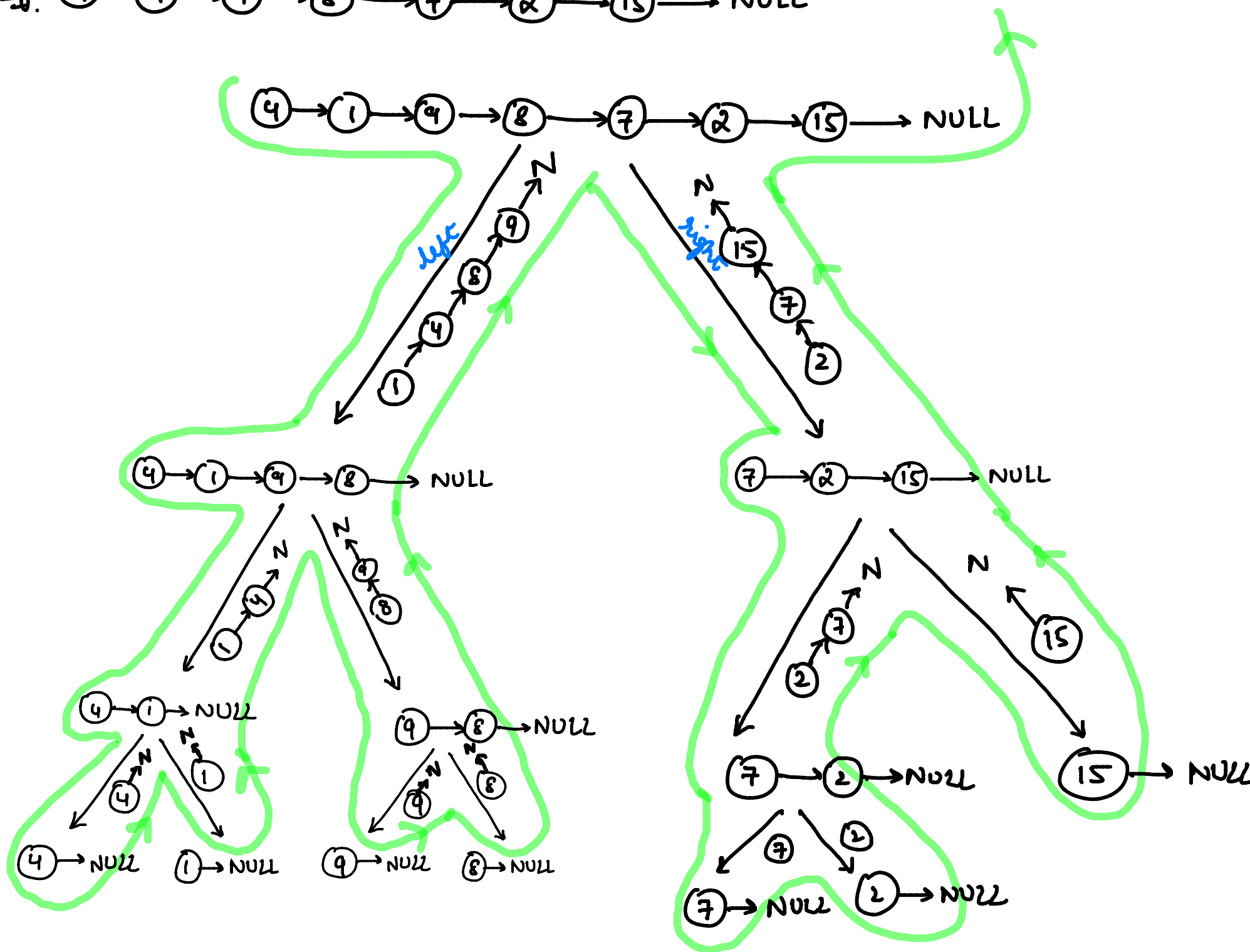
    void addAtTail(int val){
        Node *temp = head;
        if(head == NULL){
            Node *newNode = new Node(val);
            head = newNode;
            tail = newNode;
            return;
        }
        while(temp->next!=NULL){
            temp = temp->next;
        }
        Node *newNode = new Node(val);
        temp->next = newNode;
        newNode->prev = temp;
        tail = newNode;
    }
};
```

```
void addAtIndex(int index, int val){
    Node *temp = head;
    int count = 0;
    while(temp != NULL){
        temp = temp->next;
        count++;
    }
    if(index>count) return ;
    if(index==0){
        addAtHead(val);
        return;
    } else if(count == index){
        addAtTail(val);
        return;
    } else {
        temp = head;
        while(temp != NULL && index>0){
            temp = temp->next;
            index--;
        }
        Node* newNode = new Node(val);
        Node* temp2 = temp->prev;
        temp->prev->next = newNode;
        temp->prev = newNode;
        newNode->prev = temp2;
        newNode->next = temp;
    }
}

void deleteAtIndex(int index) {
    Node* temp = head;
    int count = 0;
    while(temp != NULL){
        temp=temp->next;
        count++;
    }
    if(index>=count) return;
    if(count==1 && index==0){
        head = NULL;
        return;
    } else if(count-1 == index){
        tail = tail->prev;
        tail->next = NULL;
        return;
    } else {
        if(index==0){
            head->next->prev = NULL;
            head = head->next;
            return;
        }
        temp=head;
        while(temp!=NULL && index>0){
            temp = temp->next;
            index--;
        }
        Node* temp2 = temp->next;
        temp->prev->next = temp2;
        temp->next->prev = temp->prev;
    }
};
```

18) Sort List → By following Merge Sort.

Ex. 4 → 1 → 9 → 8 → 7 → 2 → 15 → NULL



In the last step while returning from both branches we have,

left = 1 → 4 → 8 → 9 → NULL & right = 2 → 7 → 15 → NULL

so create dummy node & merge, i.e. -1 → 1 → 2 → 4 → 7 → 8 → 9 → 15 → NULL

return dummy → next, 1 → 2 → 4 → 7 → 8 → 9 → 15 → NULL

* The same happens at every intermediate merge

code →

$T_c \rightarrow O(m+n)$

$S_c \rightarrow O(n)$

```
1  class Solution {
2  public:
3      ListNode* merge(ListNode* l1, ListNode* l2) {
4          ListNode *dummy = new ListNode(-1);
5          ListNode *curr = dummy;
6          while(l1 && l2){
7              if(l1->val < l2->val){
8                  curr->next = l1;
9                  l1 = l1->next;
10             } else {
11                 curr->next = l2;
12                 l2 = l2->next;
13             }
14             curr = curr->next;
15         }
16         if(l1) curr->next = l1;
17         if(l2) curr->next = l2;
18
19         return dummy->next;
20     }
21
22     ListNode* sortList(ListNode* head) {
23         if(!head || !head->next) return head;
24
25         ListNode *slow = head;
26         ListNode *fast = head->next;
27         while(fast && fast->next) {
28             slow = slow->next;
29             fast = fast->next->next;
30         }
31         // dividing the lists into 2 parts
32         fast = slow->next;
33         slow->next = NULL;
34
35         // sort & merge
36         head = sortList(head);
37         fast = sortList(fast);
38         return merge(head, fast);
39     }
40 };
```

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