Experiment 3

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Subject Name: AP Lab - 2 **Subject Code: 22ITP-351**

1. Aim:

To implement the concept of Linked List by solving the problems on LeetCode.

i. Print Linked list
ii. Remove duplicates from a sorted list
iii. Reverse a linked list
iv. Delete middle node of a list
v. Merge two sorted linked list
vi. Remove duplicates from sorted linked lists
vii. Detect a cycle in a linked list
viii. Reverse linked list 2
ix. Rotate a list
x. Merge k sorted lists
xi. Sort List

2. Objective:

- Traverse and display all elements of the linked list.
- Remove consecutive duplicate values to retain unique elements.
- Reverse the order of nodes by modifying pointers.
- Identify and remove the middle node efficiently.
- Combine two sorted lists into a single sorted list.
- Ensure only distinct elements remain in the list.
- Detect if a cycle exists using slow and fast pointer techniques.
- Reverse a specific section of the list between given positions.
- Shift nodes to the right by a given number of positions.
- Efficiently merge multiple sorted lists into one.
- Sort the linked list with an optimal time complexity.

3. Code:

<u>Problem 1: Print linked list</u>

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

class Node {
public:
```

```
    int data;
    Node* next;

    Node(int val) {
        data = val;
        next = nullptr;
    }
};

class Solution {
public:
    // Function to display the elements of a linked list in the same line
    void printList(Node* head) {
        Node* temp = head;
        while (temp != nullptr) {
            cout << temp->data << " ";
            temp = temp->next;
        }
        cout << endl; // Print newline for better readability
    }
};
```

Problem 2: Remove Duplicates from Sorted List

```
class Solution {
public:
    ListNode* deleteDuplicates(ListNode* head) {
        if (!head) return nullptr;

        ListNode* current = head;

        while (current && current->next) { // Ensure current and next exist
            if (current->val == current->next->val) {
                ListNode* temp = current->next;
                current->next = current->next->next;
                delete temp; // Free memory of duplicate node
            } else {
                current = current->next;
            }
        }

        return head;
    }
};
```

Problem 3: Reverse Linked List

```
class Solution {
public:
    ListNode* reverseList(ListNode* head) {
        ListNode* prev = nullptr;
        ListNode* current = head;
        ListNode* next = nullptr;

        while (current != nullptr) {
            next = current->next; // Store the next node
            current->next = prev; // Reverse the link
            prev = current;       // Move prev forward
            current = next;       // Move current forward
        }

    return prev; // New head of the reversed list
  }
};
```

Problem 4: Delete the Middle Node of a Linked List

```
class Solution {
public:
    ListNode* deleteMiddle(ListNode* head) {
         if (!head || !head->next) // If list is empty or has only one node
        return nullptr;
    ListNode *slow = head, *fast = head, *prev = nullptr;
    // Move fast pointer twice as fast as slow pointer
    while (fast && fast->next) {
        prev = slow;
        slow = slow->next;
        fast = fast->next->next;
    }
    // Remove the middle node
    if (prev)
        prev->next = slow->next;
    delete slow; // Free memory
    return head;
    }
};
```

Problem 5: Merge two sorted linked list

```
class Solution {
public:
    ListNode* mergeTwoLists(ListNode* list1, ListNode* list2) {
        if (!list1) return list2;  // If list1 is empty, return list2
```

```
        if (!list2) return list1;  // If list2 is empty, return list1

        ListNode* dummy = new ListNode(-1); // Dummy node for ease of merging
        ListNode* current = dummy;

        while (list1 && list2) {
            if (list1->val <= list2-
            >val) { current->next
            = list1; list1 = list1-
            >next;
          } else {
            current->next = list2;
            list2 = list2->next;
          }
          current = current->next;
        }

        // Attach the remaining nodes of the non-empty list
        current->next = list1 ? list1 : list2;

        return dummy->next; // Return merged list (skip dummy node)
    }
};
```

Problem 6: Remove duplicates from sorted list II

```
class Solution {
public:
    ListNode* deleteDuplicates(ListNode* head) {
        if (!head) return nullptr;

        ListNode* dummy = new ListNode(0, head); // Dummy node before head
        ListNode* prev = dummy; // Pointer to track nodes before duplicate sequence

        while (head) {
            if (head->next && head->val == head->next->val) {
                // Skip all nodes with the same value
                while (head->next && head->val == head->next->val) {
                    head = head->next;
                }
                prev->next = head->next; // Remove all duplicates
            } else {
                prev = prev->next; // Move prev if no duplicate
            }
            head = head->next; // Move head forward
        }

        return dummy->next; // Return new head (skip dummy node)
    }
```

```
};
```

Problem 7: Linked List cycle

```
class Solution {
public:
    bool hasCycle(ListNode *head) {
        if (!head || !head->next) return false; // No cycle if empty or single node

        ListNode *slow = head, *fast = head;

        while (fast && fast->next) {
            slow = slow->next;        // Move slow by 1 step
            fast = fast->next->next;  // Move fast by 2 steps

            if (slow == fast) return true; // Cycle detected
        }

        return false; // No cycle
    }
};
```

Problem 8: Reverse Linked list II

```
class Solution {
public:
    ListNode* reverseBetween(ListNode* head, int left, int right) {
        if (!head || left == right) return head; // No need to reverse if empty or one node

        ListNode* dummy = new ListNode(0); // Dummy node before head
        dummy->next = head;
        ListNode* prev = dummy;

        // Move prev to the node just before "left"
        for (int i = 1; i < left; i++) {
            prev = prev->next;
        }

        ListNode* current = prev->next; // First node to be reversed
        ListNode* next = nullptr;

        // Reverse the sublist from left to right
```

```
        for (int i = 0; i < right - left; i++) {
            next = current->next;
            current->next = next->next;
            next->next = prev->next;
            prev->next = next;
        }

        return dummy->next; // Return modified list (skip dummy node)
    }
};
```

Problem 9: Rotate list

```
class Solution {
public:
    ListNode* rotateRight(ListNode* head, int k) {
        if (!head || !head->next || k == 0) return head; // Edge case

        // Step 1: Find the length of the linked list
        int length = 1;
        ListNode* tail = head;
        while (tail->next) {
            tail = tail->next;
            length++;
        }

        // Step 2: Optimize k to prevent unnecessary full rotations
        k = k % length;
        if (k == 0) return head; // No change if k is a multiple of length

        // Step 3: Find the new tail (length - k - 1) and new head (length - k)
        ListNode* newTail = head;
        for (int i = 1; i < length - k; i++) {
            newTail = newTail->next;
        }

        // Step 4: Perform rotation
        ListNode* newHead = newTail->next;
        newTail->next = nullptr; // Break the list
        tail->next = head; // Connect old tail to old head
```

```
        return newHead; // Return new head
    }
};
```

Problem 10: Merge k sorted lists

```
class Solution {
public:
    struct Compare {
        bool operator()(ListNode* a, ListNode* b) {
            return a->val > b->val; // Min-Heap based on node values
        }
    };

    ListNode* mergeKLists(vector<ListNode*>& lists) {
        priority_queue<ListNode*, vector<ListNode*>, Compare> minHeap;

        // Push the first node of each list into the heap
        for (auto list : lists) {
            if (list) minHeap.push(list);
        }

        ListNode* dummy = new ListNode(0); // Dummy node to simplify result list
        ListNode* tail = dummy; // Tail to keep track of merged list

        while (!minHeap.empty()) {
            ListNode* smallest = minHeap.top();
            minHeap.pop();

            tail->next = smallest; // Attach to merged list
            tail = tail->next; // Move tail forward

            if (smallest->next) {
                minHeap.push(smallest->next); // Push next node of extracted list
            }
        }

        return dummy->next; // Return merged list
    }
};
```

Problem 11: Sort List

```
class Solution {
public:
    // Function to merge two sorted linked lists
    ListNode* merge(ListNode* l1, ListNode* l2) {
        if (!l1) return l2;
        if (!l2) return l1;

        ListNode* dummy = new ListNode(0);
        ListNode* tail = dummy;

        while (l1 && l2) {
            if (l1->val < l2->val) {
                tail->next = l1;
                l1 = l1->next;
            } else {
                tail->next = l2;
                l2 = l2->next;
            }
            tail = tail->next;
        }

        if (l1) tail->next = l1;
        if (l2) tail->next = l2;

        return dummy->next;
    }

    // Function to find the middle node and split the list
    ListNode* sortList(ListNode* head) {
        if (!head || !head->next) return head; // Base case

        // Find the middle using slow & fast pointer
        ListNode* slow = head, *fast = head, *prev = nullptr;
        while (fast && fast->next) {
            prev = slow;
            slow = slow->next;
            fast = fast->next->next;
        }
        prev->next = nullptr; // Split the list into two halve
```

```
        // Recursively sort both halves
        ListNode* left = sortList(head);
        ListNode* right = sortList(slow);

        // Merge sorted halves
        return merge(left, right);
    }
};
```

4. Output:

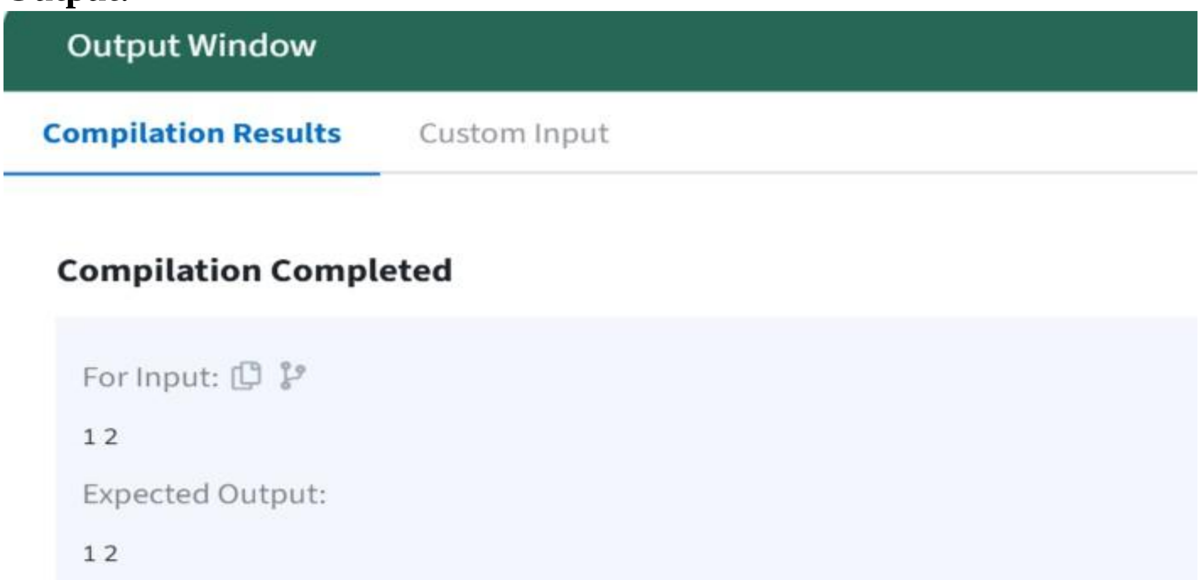

Fig 1. Print linked list

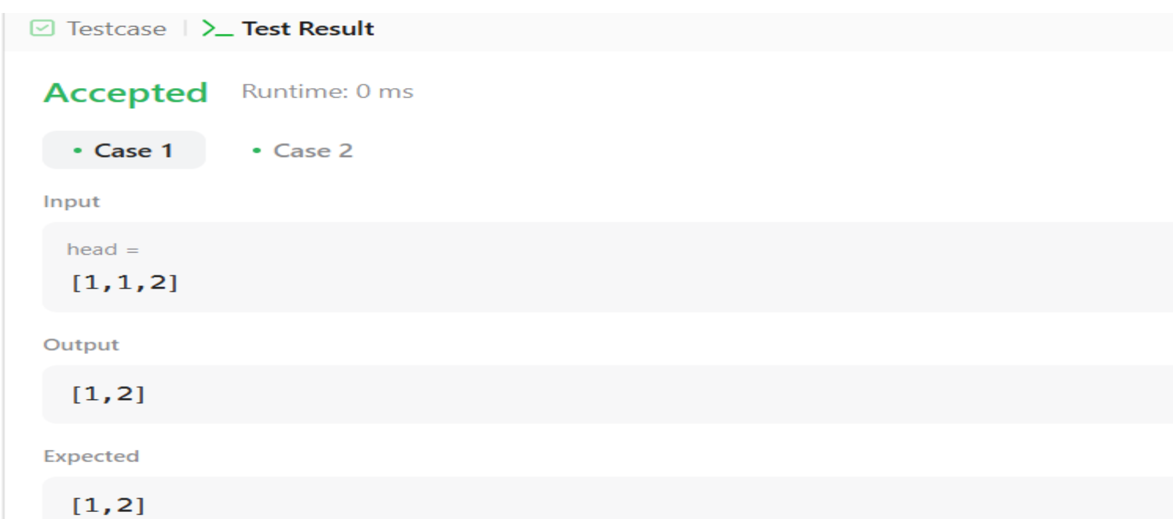

Fig 2. Remove Duplicates from Sorted List

Fig 3. Reverse linked list

Fig 4. Delete the middle node of a list

Accepted Runtime: 0 ms

• Case 1 • Case 2 • Case 3

Input

list1 =

[1,2,4]

list2 =

[1,3,4]

Output

[1,1,2,3,4,4]

Expected

[1,1,2,3,4,4]

Fig 5. Merge two sorted list

Accepted Runtime: 0 ms

• Case 1 • Case 2

Input

head =

[1,2,3,3,4,4,5]

Output

[1,2,5]

Expected

[1,2,5]

Fig 6. Remove duplicates from a list

Accepted Runtime: 3 ms

• Case 1 • Case 2 • Case 3

Input

head =
[3,2,0,-4]

pos =
1

Output

true

Expected

true

Fig 7. Linked list cycle

Accepted Runtime: 0 ms

• Case 1 • Case 2

Input

head =
[1,2,3,4,5]

left =
2

right =
4

Output

[1,4,3,2,5]

Expected

[1,4,3,2,5]

Fig 8. Reverse linked list II

Accepted Runtime: 0 ms

• Case 1 • Case 2

Input

head =
[1,2,3,4,5]

k =
2

Output

[4,5,1,2,3]

Expected

[4,5,1,2,3]

Fig 9. Rotate list

Accepted Runtime: 0 ms

• Case 1 • Case 2 • Case 3

Input

lists =
[[1,4,5],[1,3,4],[2,6]]

Output

[1,1,2,3,4,4,5,6]

Expected

[1,1,2,3,4,4,5,6]

Fig 10. Merge k sorted list

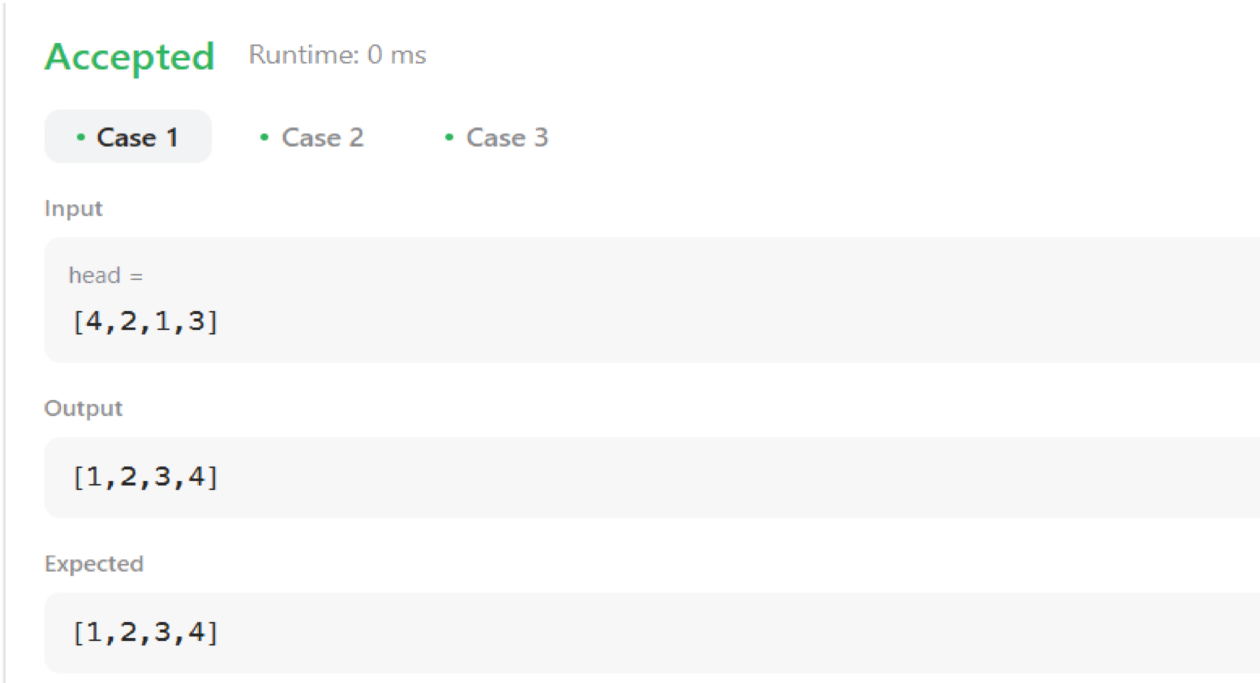

Fig 11. Sort list

5. Learning Outcomes:

- Understand and implement fundamental linked list operations, including traversal, insertion, deletion, and modification.
- Develop efficient algorithms to detect and remove duplicates, reverse a list, and merge multiple sorted lists.
- Apply advanced techniques such as Floyd's cycle detection and merge sort for optimized linked list processing.
- Enhance problem-solving skills by working with pointer manipulation and recursion in linked list-based algorithms.
- Gain hands-on experience in optimizing linked list operations for real-world applications, improving time and space complexity.