Experiment 3

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Semester: 6th Date of Performance:05.02.25

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:

Problem 1: Print linked list class

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

Problem 2: Remove Duplicates from Sorted List

```
class Solution { public:
    ListNode* deleteDuplicates(ListNode* head)
       { if(!head) return nullptr;
       ListNode*current=head; while(current-
       >next){
          if(current->val==current->next->val){
             ListNode*temp=current->next; current-
             >next=current->next->next; delete temp;
          }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; current-
       >next=prev; prev=current;
       current=next;
       }
       return prev;
```

```
    }
};
```

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:

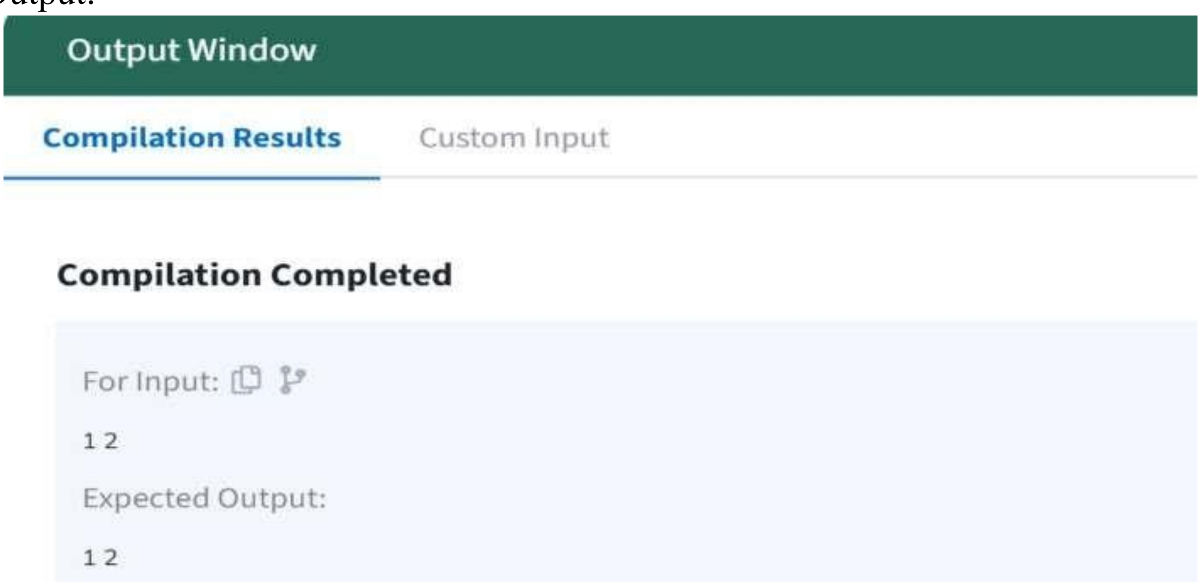

Fig 1. Print linked list

Fig 2. Remove Duplicates from Sorted List

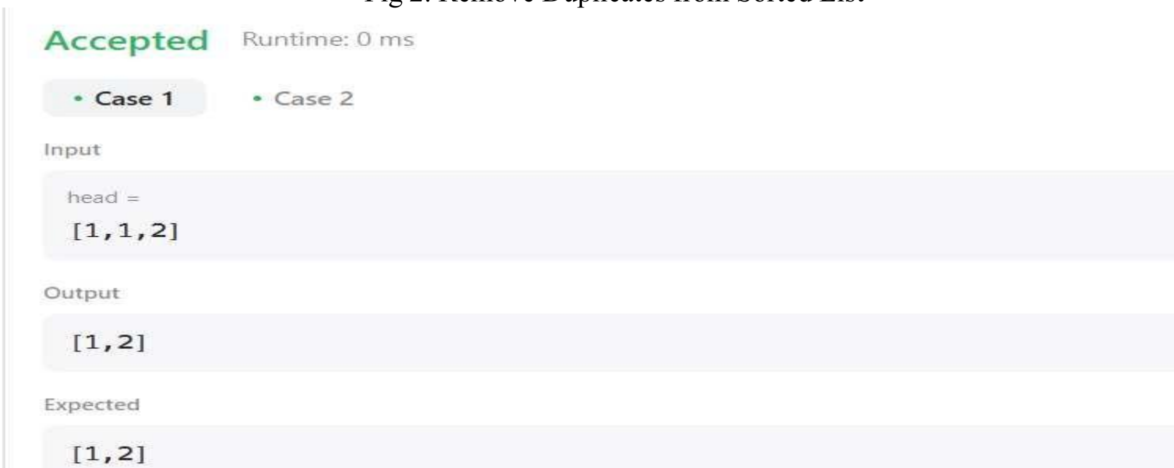

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Fig 3. Reverse linked list

Accepted Runtime: 0 ms

• Case 1 • Case 2 • Case 3

Input

head =

[1,3,4,7,1,2,6]

Output

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

Expected

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

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

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]

k =
2

Output

[4,5,1,2,3]

Expected

[4,5,1,2,3]

Fig 9. Rotate list

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.