VISVESVARAYA TECHNOLOGICAL UNIVERSITY

“JnanaSangama”, Belgaum -590014, Karnataka.

LAB REPORT
On

DATA STRUCTURES (23CS3PCDST)

Submitted by

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in partial fulfillment for the award of the degree of
BACHELOR OF ENGINEERING
in
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This is to certify that the Lab work entitled **"DATA STRUCTURES"** carried out by Mohammed Farhaan **(1BM24CS169)**, who is bonafide student of **B. M. S. College of Engineering**. It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visvesvaraya Technological University, Belgaum during the year 2025-2026. The Lab report has been approved as it satisfies the academic requirements in respect of Data structures Lab **- (23CS3PCDST)** work prescribed for the said degree.

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Index Sheet

Course outcomes:

CO1	Apply the concept of linear and nonlinear data structures.
CO2	Analyze data structure operations for a given problem
CO3	Design and develop solutions using the operations of linear and nonlinear data structure for a given specification.
CO4	Conduct practical experiments for demonstrating the operations of different data structures.

Lab program 1:

Write a program to simulate the working of stack using an array with the following:
a) Push
b) Pop
c) Display
The program should print appropriate messages for stack overflow, stack underflow.

```
#include <stdio.h>
#include<stdlib.h>
#define STACK_SIZE 5
void push(int st[],int *top)
{
	int item;
	if(*top==STACK_SIZE-1)
		printf("Stack overflow\n");
	else
	{
		printf("\nEnter an item :");
		scanf("%d",&item);
		(*top)++;
		st[*top]=item;
	}
}
void pop(int st[],int *top)
{
	if(*top==-1)
		printf("Stack underflow\n");
	else
	{
		printf("\n%d item was deleted",st[(*top)--]);
	}
}
void display(int st[],int *top)
{
	int i;
	if(*top==-1)
		printf("Stack is empty\n");
	for(i=0;i<=*top;i++)
		printf("%d\t",st[i]);
}
void main()
{
	int st[10],top=-1, c,val_del;
```

```
	while(1)
	{
		printf("\n1. Push\n2. Pop\n3. Display\n");
		printf("\nEnter your choice :");
		scanf("%d",&c);
		switch(c)
		{
			case 1: push(st,&top);
				break;
			case 2: pop(st,&top);
				break;
			case 3: display(st,&top);
				break;
			default: printf("\nInvalid choice!!!");
				exit(0);
		}
	}
}
```

Output:

```
Enter stack size:2

Stack Operations:
1. Push
2. Pop
3. Display
4. Exit
Enter your choice: 1
Enter the element to push: 1
Pushed 1 onto the stack

Stack Operations:
1. Push
2. Pop
3. Display
4. Exit
Enter your choice: 1
Enter the element to push: 2
Pushed 2 onto the stack

Stack Operations:
1. Push
2. Pop
3. Display
4. Exit
Enter your choice: 3
Stack elements: 1 2
```

```
Stack Operations:
1. Push
2. Pop
3. Display
4. Exit
Enter your choice: 1
Enter the element to push: 3
Stack overflow

Stack Operations:
1. Push
2. Pop
3. Display
4. Exit
Enter your choice: 2
Popped element: 2

Stack Operations:
1. Push
2. Pop
3. Display
4. Exit
Enter your choice: 2
Popped element: 1

Stack Operations:
1. Push
2. Pop
3. Display
4. Exit
Enter your choice: 2
Stack underflow

Stack Operations:
1. Push
2. Pop
3. Display
4. Exit
Enter your choice:
4
Exit
Process returned 0 (0x0)   execution time : 23.870 s
Press any key to continue.
```

Lab program 2:

WAP to convert a given valid parenthesized infix arithmetic expression to postfix expression. The expression consists of single character operands and the binary operators + (plus), - (minus), * (multiply) and / (divide)

```
#include <stdio.h>

#include <string.h>

#include <ctype.h>


char stack[100];

int top = -1;


void push(char c) {

    if (top == 99) {

        printf("Stack overflow\n");

        return;

    }

    stack[++top] = c;

}


int precedence(char op) {

    switch (op) {

        case '+':

        case '-': return 1;

        case '*':

        case '/': return 2;

        case '^': return 3;

        default: return -1;

    }

}
```

```
char pop() {
    if (top == -1) {
        return '0';
    } else {
        return stack[top--];
    }
}

int isOperand(char c) {
    return isalnum(c);
}

int main() {
    char infix[100];
    char postfix[100];

    printf("Enter infix expression: ");
    fgets(infix, sizeof(infix), stdin);
    infix[strcspn(infix, "\n")] = 0;

    int len = strlen(infix);
    int k = 0;

    for (int i = 0; i < len; i++) {
        char c = infix[i];

        if (isOperand(c)) {
```

```
        postfix[k++] = c;
      } else if (c == '(') {
        push(c);
      } else if (c == ')') {
        while (top != -1 && stack[top] != '(')
          postfix[k++] = pop();
        pop();
      } else {
        while (top != -1 && precedence(stack[top]) >= precedence(c)) {
          if (c == '^' && stack[top] == '^') break;
          postfix[k++] = pop();
        }
        push(c);
      }
    }

    while (top != -1) {
      postfix[k++] = pop();
    }

    postfix[k] = '\0';

    printf("Postfix expression: %s\n", postfix);
    return 0;
}
```

Output:

```
C:\Users\Admin\Documents\1bm24cs214\infixtopostfix.exe

Enter infix expression: a+b*(c^d-e)/f)
Postfix expression: abcd^e-*f/+

Process returned 0 (0x0)   execution time : 21.948 s
Press any key to continue.
```

Lab Program 3:

a) **WAP to simulate the working of a queue of integers using an array. Provide the following operations: Insert, Delete, Display The programshould print appropriate messagesfor queue empty and queue overflow conditions**

b) **WAP to simulate the working of a circular queue of integers using an array. Provide the following operations: Insert, Delete & Display The programshould print appropriate messagesfor queue empty and queue overflow conditions**

```
#include<stdio.h>
#define size 2
int front=-1,rear=-1;
int queue[size];
void enque(int value){
   if(rear==size-1)
      printf("queue is full");
   else{
      if(front==-1)
         front=0;
      queue[++rear
      ]=value;
   }
}
void deque(){
   if(front==-1||front>rear)
         printf("queue is empty");
   else
      printf("%d",queue[front++]);
}
void display(){
   if(front==-1)
      printf("queue is empty");
   else{
      for(int i=front;i<=rear;i++)
         printf("%d ",queue[i]);
   }
}
int main(){
   int value,choice;
   while(1){
   printf(" \n1.enque\n 2.deque\n 3.display\n 4.exit\n");
   printf("enter choice:");
   scanf("%d",&choice);
   switch(choice){
   case 1:
      printf("enter value:");
      scanf("%d",&value);
      enque(value);
      break;
   case 2:
```

```
        deque();
        break;
    case 3:
        display();
        break;
    case 4:
        return 0;
    default:
        printf("invalid choice");
    }
    }
}
```

Output:

```
1.enque
 2.deque
 3.display
 4.exit
enter choice:1
enter value:2

1.enque
 2.deque
 3.display
 4.exit
enter choice:1
enter value:2

1.enque
 2.deque
 3.display
 4.exit
enter choice:1
enter value:4
queue is full
1.enque
 2.deque
 3.display
 4.exit
enter choice:3
2 2
1.enque
 2.deque
 3.display
 4.exit
enter choice:2
2
1.enque
 2.deque
 3.display
 4.exit
enter choice:2
2
1.enque
 2.deque
 3.display
 4.exit
enter choice:2
queue is empty
1.enque
 2.deque
 3.display
 4.exit
enter choice:1
enter value:4

1.enque
 2.deque
 3.display
 4.exit
enter choice:3
4
```

```
#include<stdio.h>
#define size 2
int front=-1,rear=-1;
int queue[size];
void enque(int value){
    if((rear+1)%size==front)
        printf("queue is full");
    else{
        if(front==-1)
            front=0;
        rear=(rear+1)%size;
        queue[rear]=value;
    }
}
void deque(){
    if(front==-1)
            printf("queue is empty");
    else{
    printf("%d",queue[front]);
    if(front==rear){
        front=-1;
        rear=-1;
    }
    else
        front=(front+1)%size;
    }
}
void display() {
    if (front == -1) {
        printf("queue is empty");
    } else {
        int i = front;
        while(1){
            printf("%d ", queue[i]);
            if (i == rear)
                break;
            i=(i+1)%size;
    }
}
}
int main(){
    int value,choice;
    while(1){
    printf(" \n1.enque\n 2.deque\n 3.display\n 4.exit\n");
    printf("enter choice:");
    scanf("%d",&choice);
    switch(choice){
    case 1:
        printf("enter value:");
```

```
            scanf("%d",&value);
            enque(value);
            break;
        case 2:
            deque();
            break;
        case 3:
            display();
            break;
        case 4:
            return 0;
        default:
            printf("invalid choice");
        }
        }
}
```

Output:

```
1.enque
 2.deque
 3.display
 4.exit
enter choice:1
enter value:2

1.enque
 2.deque
 3.display
 4.exit
enter choice:1
enter value:3

1.enque
 2.deque
 3.display
 4.exit
enter choice:1
enter value:4
queue is full
1.enque
 2.deque
 3.display
 4.exit
enter choice:3
2 3
1.enque
 2.deque
 3.display
 4.exit
enter choice:2
2
1.enque
 2.deque
 3.display
 4.exit
enter choice:2
3
1.enque
 2.deque
 3.display
 4.exit
enter choice:2
queue is empty
1.enque
 2.deque
 3.display
 4.exit
enter choice:1
enter value:2
queue is full
1.enque
 2.deque
 3.display
 4.exit
enter choice:4

Process returned 0 (0x0)   execution time : 17.852 s
Press any key to continue.
```

Lab Program 4:

WAP to Implement Singly Linked List with following operations a) Createalinkedlist. b) Insertion of a node at first position, at any position and at end of list. Display the contents of the linked list.

```
#include <stdio.h>
#include <stdlib.h>

struct node {
    int data;
    struct node *next;
};

struct node *head = NULL;

void create(int n) {
    struct node *newnode, *temp;
    int val;
    for (int i = 0; i < n; i++) {
        newnode = malloc(sizeof(struct node));
        scanf("%d", &val);
        newnode->data = val;
        newnode->next = NULL;

        if (head == NULL)
            head = newnode;
        else {
            temp = head;
            while (temp->next != NULL)
                temp = temp->next;
            temp->next = newnode;
        }
    }
}

void display() {
    struct node *temp = head;
    if (head == NULL) {
        printf("List is empty\n");
        return;
    }
    while (temp != NULL) {
        printf("%d ", temp->data);
        temp = temp->next;
    }
    printf("\n");
}
```

```
void insert_begin(int val) {
    struct node *newnode = malloc(sizeof(struct node));
    newnode->data = val;
    newnode->next = head;
    head = newnode;
}

void insert_end(int val) {
    struct node *newnode = malloc(sizeof(struct node));
    struct node *temp = head;
    newnode->data = val;
    newnode->next = NULL;

    if (head == NULL)
        head = newnode;
    else {
        while (temp->next != NULL)
            temp = temp->next;
        temp->next = newnode;
    }
}

void insert_pos(int val, int pos) {
    struct node *newnode = malloc(sizeof(struct node));
    newnode->data = val;

    if (pos == 1) {
        newnode->next = head;
        head = newnode;
        return;
    }

    struct node *temp = head;
    for (int i = 1; i < pos - 1 && temp != NULL; i++)
        temp = temp->next;

    if (temp == NULL) {
        printf("Invalid position\n");
        return;
    }

    newnode->next = temp->next;
    temp->next = newnode;
}

int main() {
    int choice, n, val, pos;

    while (1) {
```

```
        printf("\n1.Create\n2.Insert Begin\n3.Insert End\n4.Insert
Position\n5.Display\n6.Exit\n");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                scanf("%d", &n);
                create(n);
                break;
            case 2:
                scanf("%d", &val);
                insert_begin(val);
                break;
            case 3:
                scanf("%d", &val);
                insert_end(val);
                break;
            case 4:
                scanf("%d%d", &val, &pos);
                insert_pos(val, pos);
                break;
            case 5:
                display();
                break;
            case 6:
                exit(0);
        }
    }
}
```

```
1.Create
2.Insert Begin
3.Insert End
4.Insert Position
5.Display
6.Exit
1
3
1
2
3

1.Create
2.Insert Begin
3.Insert End
4.Insert Position
5.Display
6.Exit
5
1 2 3

1.Create
2.Insert Begin
3.Insert End
4.Insert Position
5.Display
6.Exit
2
4
```
Output:

Lab Program 5:

WAP to Implement Singly Linked List with following operations a) Create a linked list. b) Deletion of first element, specified element and last element in the list. c) Display the contents of the linked list

```
#include <stdio.h>
#include <stdlib.h>

struct node {
    int data;
    struct node *next;
};

struct node *head = NULL;

void create(int n) {
    struct node *newnode, *temp;
    int val;
    for (int i = 0; i < n; i++) {
        newnode = malloc(sizeof(struct node));
        scanf("%d", &val);
        newnode->data = val;
        newnode->next = NULL;

        if (head == NULL)
            head = newnode;
        else {
            temp = head;
            while (temp->next != NULL)
                temp = temp->next;
            temp->next = newnode;
        }
    }
}

void display() {
    struct node *temp = head;
    if (head == NULL) {
        printf("List is empty\n");
        return;
    }
    while (temp != NULL) {
        printf("%d ", temp->data);
        temp = temp->next;
    }
    printf("\n");
}
```

```
void delete_begin() {
    if (head == NULL) {
        printf("List is empty\n");
        return;
    }
    struct node *temp = head;
    head = head->next;
    printf("Deleted: %d\n", temp->data);
    free(temp);
}

void delete_end() {
    if (head == NULL) {
        printf("List is empty\n");
        return;
    }
    if (head->next == NULL) {
        printf("Deleted: %d\n", head->data);
        free(head);
        head = NULL;
        return;
    }

    struct node *temp = head, *prev = NULL;
    while (temp->next != NULL) {
        prev = temp;
        temp = temp->next;
    }
    prev->next = NULL;
    printf("Deleted: %d\n", temp->data);
    free(temp);
}

void delete_pos(int pos) {
    if (head == NULL) {
        printf("List is empty\n");
        return;
    }
    if (pos == 1) {
        delete_begin();
        return;
    }

    struct node *temp = head, *prev = NULL;
    for (int i = 1; i < pos && temp != NULL; i++) {
        prev = temp;
        temp = temp->next;
    }
```

```
    if (temp == NULL) {
        printf("Invalid position\n");
        return;
    }

    prev->next = temp->next;
    printf("Deleted: %d\n", temp->data);
    free(temp);
}

int main() {
    int choice, n, pos;

    while (1) {
        printf("\n1.Create\n2.Delete Begin\n3.Delete End\n4.Delete
Position\n5.Display\n6.Exit\n");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                scanf("%d", &n);
                create(n);
                break;
            case 2:
                delete_begin();
                break;
            case 3:
                delete_end();
                break;
            case 4:
                scanf("%d", &pos);
                delete_pos(pos);
                break;
            case 5:
                display();
                break;
            case 6:
                exit(0);
        }
    }
}
```

Output:

```
1.Create
2.Delete Begin
3.Delete End
4.Delete Position
5.Display
6.Exit
1
6
1 2 3 4 5 6

1.Create
2.Delete Begin
3.Delete End
4.Delete Position
5.Display
6.Exit
5
1 2 3 4 5 6

1.Create
2.Delete Begin
3.Delete End
4.Delete Position
5.Display
6.Exit
2
Deleted: 1
```

```
1.Create
2.Delete Begin
3.Delete End
4.Delete Position
5.Display
6.Exit
3
Deleted: 6

1.Create
2.Delete Begin
3.Delete End
4.Delete Position
5.Display
6.Exit
4 2
Deleted: 3

1.Create
2.Delete Begin
3.Delete End
4.Delete Position
5.Display
6.Exit
5
2 4 5
```

Lab program 6:

a) **WAP to Implement Single Link List with following operations: Sort the linked list, Reverse the linked list, Concatenation of two linked lists.**

b) **WAP to Implement Single Link List to simulate Stack & Queue Operations.**

Program a)

```
#include <stdio.h>
#include <stdlib.h>



typedef struct node {
    int val;
    struct node *next;
} node_t;

node_t *create_node(int val) {
    node_t *new_node = (node_t *)malloc(sizeof(node_t));
    if (new_node == NULL)
        return NULL;
    new_node->val = val;
    new_node->next = NULL;
    return new_node;
}

node_t *create_list(int n) {
    node_t *head = NULL, *temp = NULL;
    int val;
    for (int i = 0; i < n; i++) {
        scanf("%d", &val);
        node_t *new_node = create_node(val);
        if (head == NULL) {
            head = new_node;
            temp = head;
        } else {
            temp->next = new_node;
            temp = new_node;
        }
    }
    return head;
}

void print_list(node_t *head) {
    node_t *current = head;
    while (current != NULL) {
```

```
        printf("%d -> ", current->val);
        current = current->next;
    }
    printf("NULL\n");
}

node_t *concatenate_lists(node_t *head1, node_t *head2) {if (head1 == NULL) return head2;
    node_t *current = head1;
    while (current->next != NULL)
        current = current->next;
    current->next = head2;
    return head1;
}

node_t *reverse_list(node_t *head) {
    node_t *prev = NULL, *current = head, *next = NULL;
    while (current != NULL) {
        next = current->next;
        current->next = prev;
        prev = current;
        current = next;
    }
    return prev;
}

node_t *sort_list(node_t *head) {
    int swapped;
    node_t *ptr1;
    node_t *lptr = NULL;

    if (head == NULL)
        return head;



    do {
        swapped = 0;
        ptr1 = head;
        while (ptr1->next != lptr) {
            if (ptr1->val > ptr1->next->val) {
                int temp = ptr1->val;
                ptr1->val = ptr1->next->val;
                ptr1->next->val = temp;
                swapped = 1;
            }
            ptr1 = ptr1->next;
        }
        lptr = ptr1;
    } while (swapped);

    return head;
```

```
}

int main() {
    int n1, n2;
    printf("Enter number of nodes for list 1: ");
    scanf("%d", &n1);
    node_t *head1 = create_list(n1);

    printf("Enter number of nodes for list 2: ");
    scanf("%d", &n2);
    node_t *head2 = create_list(n2);

    printf("List 1: ");
    print_list(head1);
    printf("List 2: ");
    print_list(head2);

    head1 = concatenate_lists(head1, head2);
    printf("After Concatenation: ");
    print_list(head1);

    head1 = reverse_list(head1);
    printf("After Reversal: ");
    print_list(head1);

    head1 = sort_list(head1);
    printf("After Sorting: ");
    print_list(head1);

    return 0;
}
```

Output:

```
Enter number of nodes for list 1: 3
1 2 3
Enter number of nodes for list 2: 3
4 5 6
List 1: 1 -> 2 -> 3 -> NULL
List 2: 4 -> 5 -> 6 -> NULL
After Concatenation: 1 -> 2 -> 3 -> 4 -> 5 -> 6 -> NULL
After Reversal: 6 -> 5 -> 4 -> 3 -> 2 -> 1 -> NULL
After Sorting: 1 -> 2 -> 3 -> 4 -> 5 -> 6 -> NULL
```

Program 6b) STacks

```
#include <stdio.h>
#include <stdlib.h>

typedef struct Node {
    int data;
    struct Node* next;
} Node;

Node* top = NULL;

void push(int data) {
    Node* newNode = (Node*)malloc(sizeof(Node));
    newNode->data = data;
    newNode->next = top;
    top = newNode;
}

int pop() {
    if (top == NULL) {
        printf("Stack empty\n");
        return -1;
    }
    int val = top->data;
    Node* temp = top;
    top = top->next;
    free(temp);
    return val;
}

int peek() {
    if (top == NULL) {
        printf("Stack empty\n");
        return -1;
    }
    return top->data;
}

void display() {
    if (top == NULL) {
        printf("Stack empty\n");
        return;
    }
    Node* temp = top;
    while (temp != NULL) {
        printf("%d ", temp->data);
        temp = temp->next;
    }
    printf("\n");}
```

```
int main() {
    int choice, val;

    while (1) {
        printf("\n1.Push\n2.Pop\n3.Peek\n4.Display\n5.Exit\n");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                scanf("%d", &val);
                push(val);
                break;
            case 2:
                printf("%d\n", pop());
                break;
            case 3:
                printf("%d\n", peek());
                break;
            case 4:
                display();
                break;
            case 5:
                exit(0);
        }
    }
}
```

```
1.Push
2.Pop
3.Peek
4.Display
5.Exit
1
2

1.Push
2.Pop
3.Peek
4.Display
5.Exit
1
4

1.Push
2.Pop
3.Peek
4.Display
5.Exit
1
5

1.Push
2.Pop
3.Peek
4.Display
5.Exit
4
5 4 2
```

Output:

```
1.Push
2.Pop
3.Peek
4.Display
5.Exit
2
5

1.Push
2.Pop
3.Peek
4.Display
5.Exit
3
4

1.Push
2.Pop
3.Peek
4.Display
5.Exit
4
4 2

1.Push
2.Pop
3.Peek
4.Display
5.Exit
5
```

Program 6b) Queue

```
#include <stdio.h>
#include <stdlib.h>

typedef struct Node {
    int data;
    struct Node* next;
} Node;

Node* front = NULL;
Node* rear = NULL;

void enqueue(int data) {
    Node* newNode = (Node*)malloc(sizeof(Node));
    newNode->data = data;
    newNode->next = NULL;

    if (rear == NULL) {
        front = rear = newNode;
    } else {
        rear->next = newNode;
        rear = newNode;
    }
}

int dequeue() {
    if (front == NULL) {
        printf("Queue empty\n");
        return -1;
    }
    int val = front->data;
    Node* temp = front;
    front = front->next;
    if (front == NULL)
        rear = NULL;
    free(temp);
    return val;
}

int peek() {
    if (front == NULL) {
        printf("Queue empty\n");
        return -1;
    }
    return front->data;
}

void display() {
```

```
    if (front == NULL) {
        printf("Queue empty\n");
        return;
    }
    Node* temp = front;
    while (temp != NULL) {
        printf("%d ", temp->data);
        temp = temp->next;
    }
    printf("\n");
}

int main() {
    int choice, val;

    while (1) {
        printf("\n1.Enqueue\n2.Dequeue\n3.Peek\n4.Display\n5.Exit\n");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                scanf("%d", &val);
                enqueue(val); break;
            case 2:
                printf("%d\n", dequeue());
                break;
            case 3:
                printf("%d\n", peek());
                break;
            case 4:
                display();
                break;
            case 5:
                exit(0);
        }
    }
}
```

Output:

```
1.Enqueue
2.Dequeue
3.Peek
4.Display
5.Exit
1
1

1.Enqueue
2.Dequeue
3.Peek
4.Display
5.Exit
1
2

1.Enqueue
2.Dequeue
3.Peek
4.Display
5.Exit
1
3
```

```
1.Enqueue
2.Dequeue
3.Peek
4.Display
5.Exit
2
1

1.Enqueue
2.Dequeue
3.Peek
4.Display
5.Exit
3
2

1.Enqueue
2.Dequeue
3.Peek
4.Display
5.Exit
4
2 3

1.Enqueue
2.Dequeue
3.Peek
4.Display
5.Exit
5
```

Lab program 7:

WAP to Implement doubly link list with primitive operations a) Create a doubly linked list. b) Insert a new node to the left of the node. c) Delete the node based on a specific value d) Display the contents of the list

```
#include <stdio.h>
#include <stdlib.h>

typedef struct Node {
    int data;
    struct Node* prev;
    struct Node* next;
} Node;

Node* head = NULL;

void create(int data) {
    Node* newNode = (Node*)malloc(sizeof(Node));
    newNode->data = data;
    newNode->prev = NULL;
    newNode->next = NULL;

    if (head == NULL) {
        head = newNode;
    } else {
        Node* temp = head;
        while (temp->next != NULL)
            temp = temp->next;
        temp->next = newNode;
        newNode->prev = temp;
    }
}

void insertLeft(int target, int data) {
    if (head == NULL) {
        printf("List empty\n");
        return;
    }

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

    if (temp == NULL) {
        printf("Not found\n");
        return;
    }
```

```
    Node* newNode = (Node*)malloc(sizeof(Node));
    newNode->data = data;
    newNode->next = temp;
    newNode->prev = temp->prev;

    if (temp->prev != NULL)
        temp->prev->next = newNode;
    else
        head = newNode;

    temp->prev = newNode;
}

void deleteNode(int data) {
    if (head == NULL) {
        printf("List empty\n");
        return;
    }

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

    if (temp == NULL) {
        printf("Not found\n");
        return;
    }

    if (temp->prev != NULL)
        temp->prev->next = temp->next;
    else
        head = temp->next;

    if (temp->next != NULL)
        temp->next->prev = temp->prev;

    free(temp);
}

void display() {
    if (head == NULL) {
        printf("List empty\n");
        return;
    }

    Node* temp = head;
    while (temp != NULL) {
        printf("%d ", temp->data);
        temp = temp->next;
```

```
    }
    printf("\n");
}

int main() {
    int choice, val, target;

    while (1) {
        printf("\n1.Create\n2.Insert Left\n3.Delete\n4.Display\n5.Exit\n");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                scanf("%d", &val);
                create(val);
                break;
            case 2:
                scanf("%d%d", &target, &val);
                insertLeft(target, val);
                break;
            case 3:
                scanf("%d", &val);
                deleteNode(val);
                break;
            case 4:
                display();
                break;
            case 5:
                exit(0);
        }
    }
}
```

```
1.Create
2.Insert Left
3.Delete
4.Display
5.Exit
1
1

1.Create
2.Insert Left
3.Delete
4.Display
5.Exit
1
|
2

1.Create
2.Insert Left
3.Delete
4.Display
5.Exit
1
3

1.Create
2.Insert Left
3.Delete
4.Display
```
Output:

```
3.Delete
4.Display
5.Exit
4
1 2 3

1.Create
2.Insert Left
3.Delete
4.Display
5.Exit
3
1

1.Create
2.Insert Left
3.Delete
4.Display
5.Exit
2
3
4

1.Create
2.Insert Left
3.Delete
4.Display
5.Exit
4
2 4 3
```

Lab program 8:

Write a program a) To construct a binary Search tree. b) To traverse the tree using all the methods i.e., in-order, preorder and post order c) To display the elements in the tree.

```
#include <stdio.h>
#include <stdlib.h>

struct Node {
    int data;
    struct Node *left, *right;
};

struct Node* createNode(int data) {
    struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));
    newNode->data = data;
    newNode->left = NULL;
    newNode->right = NULL;
    return newNode;
}

struct Node* insertBST(struct Node* root, int data) {
    if (root == NULL)
        return createNode(data);

    if (data < root->data)
        root->left = insertBST(root->left, data);
    else
        root->right = insertBST(root->right, data);

    return root;
}

void inorder(struct Node* root) {
    if (root == NULL)
        return;
    inorder(root->left);
    printf("%d ", root->data);
    inorder(root->right);
}

void preorder(struct Node* root) {
    if (root == NULL)
        return;
    printf("%d ", root->data);
    preorder(root->left);
    preorder(root->right);
}
```

```
void postorder(struct Node* root) {
    if (root == NULL)
        return;
    postorder(root->left);
    postorder(root->right);
    printf("%d ", root->data);
}

int main() {
    struct Node* root = NULL;
    int n, val, choice;

    while (1) {
        printf("\n1.Insert\n2.Inorder\n3.Preorder\n4.Postorder\n5.Exit\n");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                scanf("%d", &val);
                root = insertBST(root, val);
                break;

            case 2:
                inorder(root);
                printf("\n");
                break;

            case 3:
                preorder(root);
                printf("\n");
                break;

            case 4:
                postorder(root);
                printf("\n");
                break;

            case 5:
                exit(0);
        }
    }
}
```

Output:

```
1.Insert
2.Inorder
3.Preorder
4.Postorder
5.Exit
1
5

1.Insert
2.Inorder
3.Preorder
4.Postorder
5.Exit
1
3

1.Insert
2.Inorder
3.Preorder
4.Postorder
5.Exit
1
2

1.Insert
2.Inorder
3.Preorder
4.Postorder
5.Exit
1
7
1.Insert
2.Inorder
3.Preorder
4.Postorder
5.Exit
1
6

1.Insert
2.Inorder
3.Preorder
4.Postorder
5.Exit
2
2 3 5 6 7

1.Insert
2.Inorder
3.Preorder
4.Postorder
5.Exit
3
5 3 2 7 6

1.Insert
2.Inorder
3.Preorder
4.Postorder
5.Exit
4
2 3 6 7 5
```

Lab program 9:

a) **Write a program to traverse a graph using BFS method.**
b) **Write a program to check whether given graph is connected or not using DFS method.**

```
#include <stdio.h>

int g[100][100], vis[100], n;

int main() {
    int e, u, v, start;
    int q[100], f = 0, r = 0;

    printf("Enter number of nodes and edges: ");
    scanf("%d %d", &n, &e);

    printf("Enter each edge (u v):\n");
    for (int i = 0; i < e; i++) {
        scanf("%d %d", &u, &v);
        g[u][v] = g[v][u] = 1;
    }

    printf("Enter start node: ");
    scanf("%d", &start);

    printf("BFS Order: ");

    q[r++] = start;
    vis[start] = 1;

    while (f < r) {
        u = q[f++];
        printf("%d ", u);
        for (v = 0; v < n; v++) {
            if (g[u][v] && !vis[v]) {
                vis[v] = 1;
                q[r++] = v;
            }
        }
    }

    return 0;
}
```

Output:

```
Enter number of nodes and edges: 5 5
Enter each edge (u v):
0 1
0 2
1 3
1 4
3 4
Enter start node: 0
BFS Order: 0 1 2 3 4
```

```c
#include <stdio.h>

int g[100][100], vis[100], n;

int main() {
    int e, u, v, start;
    int stack[100], top = -1;

    printf("Enter number of nodes and edges: ");
    scanf("%d %d", &n, &e);

    printf("Enter each edge (u v):\n");
    for (int i = 0; i < e; i++) {
        scanf("%d %d", &u, &v);
        g[u][v] = g[v][u] = 1;
    }

    printf("Enter start node: ");
    scanf("%d", &start);

    printf("DFS Order: ");

    stack[++top] = start;

    while (top != -1) {
        u = stack[top--];
        if (!vis[u]) {
            vis[u] = 1;
            printf("%d ", u);
            for (v = n - 1; v >= 0; v--)
                if (g[u][v] && !vis[v])
                    stack[++top] = v;
        }
    }
    return 0;
}
```

Output:

```
Enter number of nodes and edges: 5 5
Enter each edge (u v):
0 1
0 2
1 3
1 4
3 4
Enter start node: 0
DFS Order: 0 1 3 4 2
```

Lab program 10:

Given a File of N employee records with a set K of Keys(4- digit) which uniquely determine the records in file F. Assume that file F is maintained in memory by a Hash Table (HT) of m memory locations with L as the set of memory addresses (2-digit) of locations in HT. Let the keys in K and addresses in L are integers. Design and develop a Program in C that uses Hash function H: K -> L as H(K)=K mod m (remainder method), and implement hashing technique to map a given key K to the address space L. Resolve the collision (if any) using linear probing.

```
#include <stdio.h>

#define M 100

typedef struct {
    int key;
    int used;
} Record;

int hash(int k) {
    return k % M;
}

void insert(Record ht[], int k) {
    int i = hash(k);
    int start = i;
    while (ht[i].used) {
        i = (i + 1) % M;
        if (i == start)
            return;
    }
    ht[i].key = k;
    ht[i].used = 1;
}

int search(Record ht[], int k) {
    int i = hash(k);
    int start = i;
    while (ht[i].used) {
        if (ht[i].key == k)
            return i;
        i = (i + 1) % M;
        if (i == start)
            break;
    }
    return -1;
}

int main() {
```

```
    Record ht[M];
    int n, k, i, pos, choice;

    for (i = 0; i < M; i++)
        ht[i].used = 0;

    printf("Enter number of employee records: ");
    scanf("%d", &n);

    for (i = 0; i < n; i++) {
        printf("Enter 4-digit key: ");
        scanf("%d", &k);
        insert(ht, k);
    }

    do {
        printf("Enter key to search: ");
        scanf("%d", &k);
        pos = search(ht, k);
        if (pos == -1)
            printf("Key not found\n");
        else
            printf("Key found at address %02d\n", pos);

        printf("Search another key? (1-Yes / 0-No): ");
        scanf("%d", &choice);
    } while (choice == 1);

    return 0;
}
```

Output:

```
Enter number of employee records: 5
Enter 4-digit key: 1234
Enter 4-digit key: 2345
Enter 4-digit key: 3456
Enter 4-digit key: 4567
Enter 4-digit key: 5678
Enter key to search: 1235
Key not found
Search another key? (1-Yes / 0-No): 1
Enter key to search: 4567
Key found at address 67
Search another key? (1-Yes / 0-No): 0
```

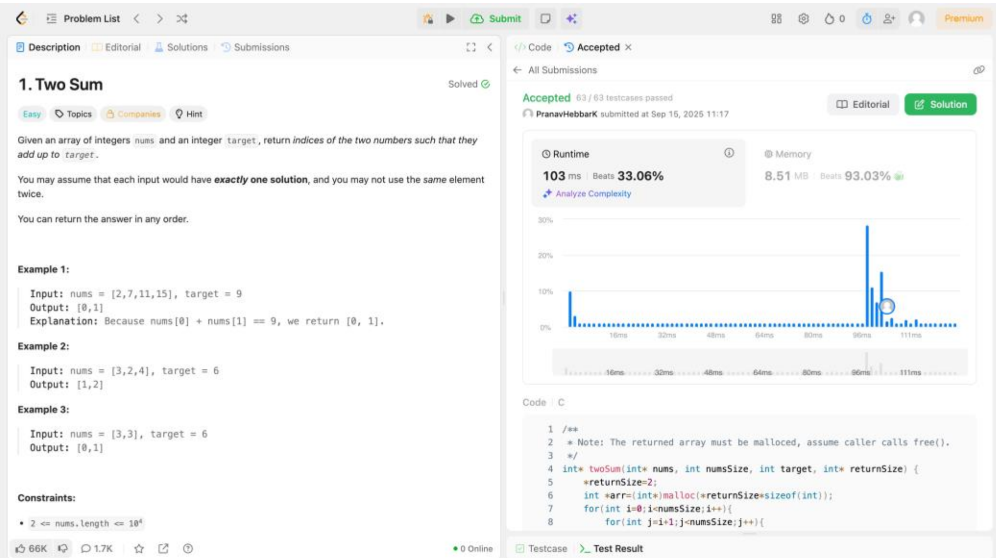
Leetcode Problems:

1) Two Sum

```
/**
 * Note: The returned array must be malloced, assume caller calls free().
 */
int* twoSum(int* nums, int numsSize, int target, int* returnSize) {
    *returnSize=2;
    int *arr=(int*)malloc(*returnSize*sizeof(int));
    for(int i=0;i<numsSize;i++){
        for(int j=i+1;j<numsSize;j++){
            if(nums[i]+nums[j]==target){
                arr[0]=i;
                arr[1]=j;
                return arr;
            }
        }
    }
    *returnSize=0;
    return malloc(sizeof(int)*0);


}
```

Output:

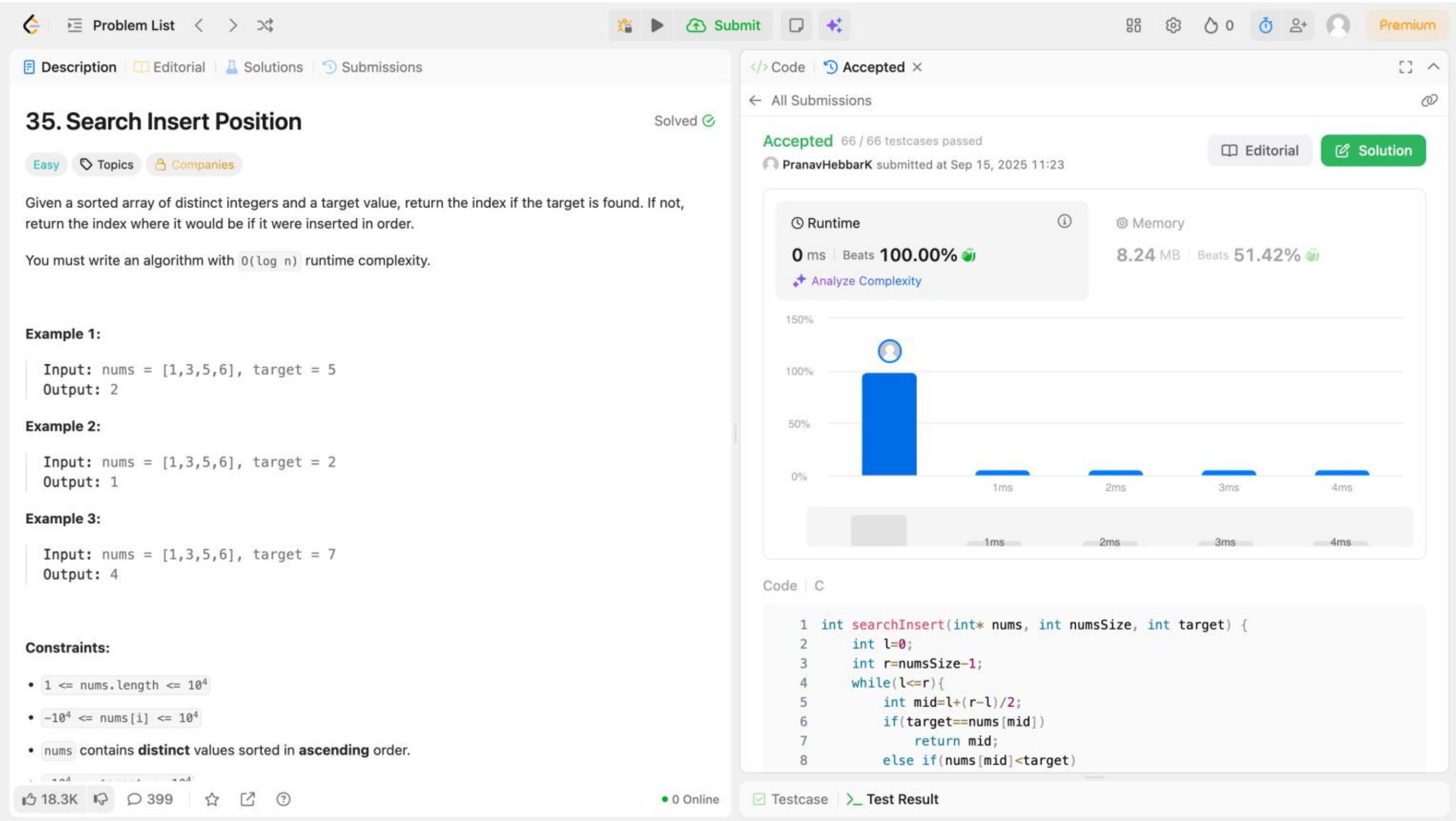


2) Search Insert Position

```c
int searchInsert(int* nums, int numsSize, int target) {
    int l=0;
    int r=numsSize-1;
    while(l<=r){
        int mid=l+(r-l)/2;
        if(target==nums[mid])
            return mid;
        else if(nums[mid]<target)
            l=mid+1;
        else
            r=mid-1;
    }
    return l;

}
```

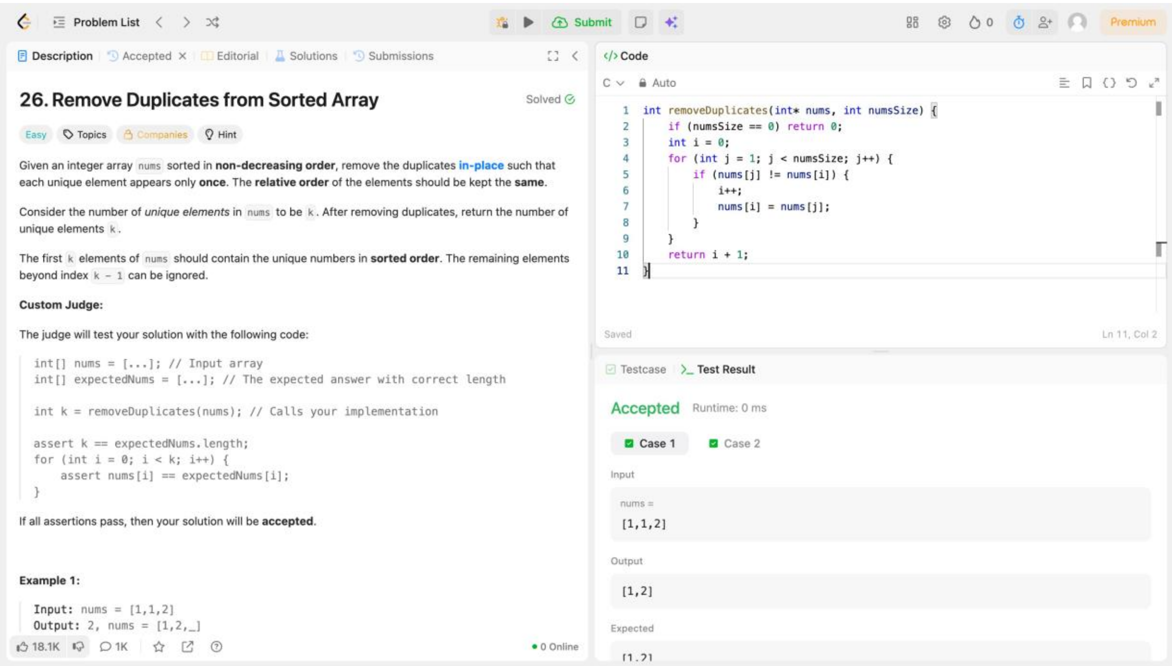
Output :



3) Remove Duplicates from Sorted Array

```c
int removeDuplicates(int* nums, int numsSize) {
    if (numsSize == 0) return 0;
    int i = 0;
    for (int j = 1; j < numsSize; j++) {
        if (nums[j] != nums[i]) {
            i++;
            nums[i] = nums[j];
        }
    }
    return i + 1;
}
```

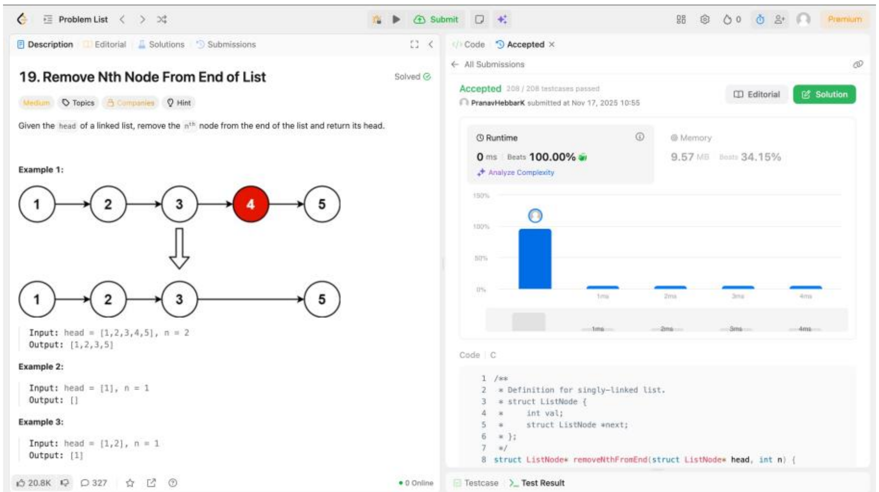
Output:



4) Remove Nth Node From End of List

```c
/**
 * Definition for singly-linked list.
 * struct ListNode {
 *     int val;
 *     struct ListNode *next;
 * };
 */
struct ListNode* removeNthFromEnd(struct ListNode* head,
int n) {
    if(!head || !head->next)
        return NULL;
    struct ListNode* fast=head;
    struct ListNode* slow=head;
    while(n--){
        fast=fast->next;
    }
    if(!fast){
        struct ListNode* temp=head;
        head=head->next;
        free(temp);
        return head;
    }
    while(fast->next){
        fast=fast->next;
        slow=slow->next;
    }
    struct ListNode* curr=slow->next;
    slow->next=slow->next->next;
    free(curr);
    return head;
}
```

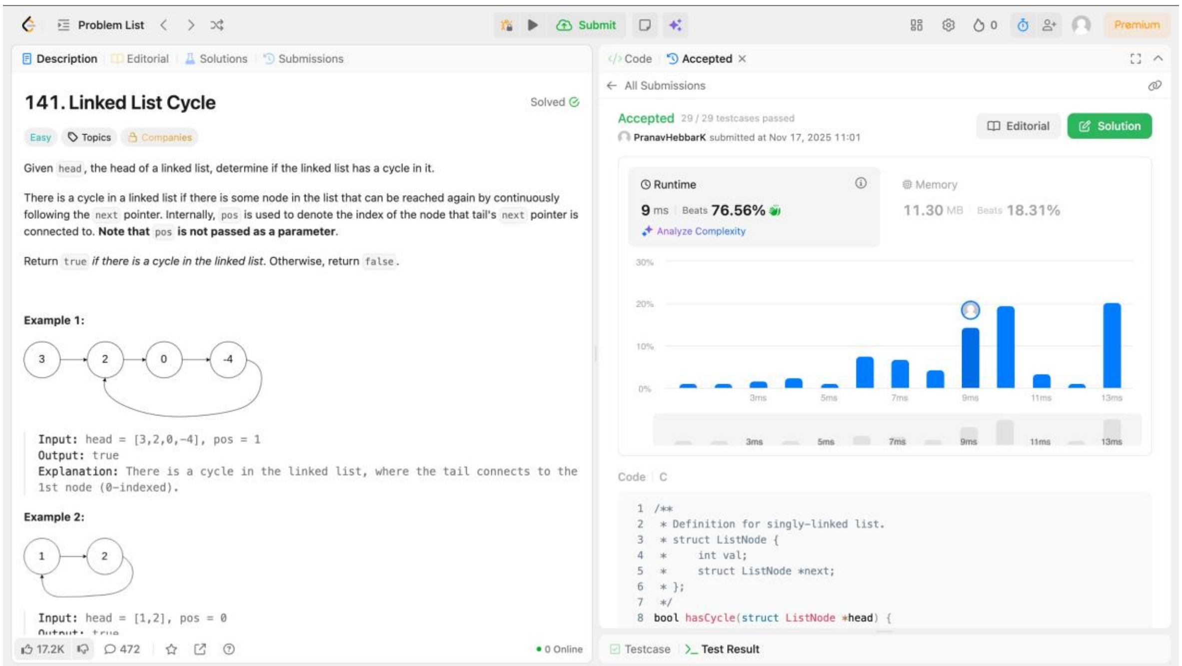
Output:



5) Linked List Cycle

```c
/**
 * Definition for singly-linked list.
 * struct ListNode {
 *     int val;
 *     struct ListNode *next;
 * };
 */
bool hasCycle(struct ListNode *head) {
    struct ListNode* fast=head;
    struct ListNode* slow=head;
    while(fast && fast->next){
        fast=fast->next->next;
        slow=slow->next;
        if(fast==slow)
            return true;
    }
    return false;
}
```

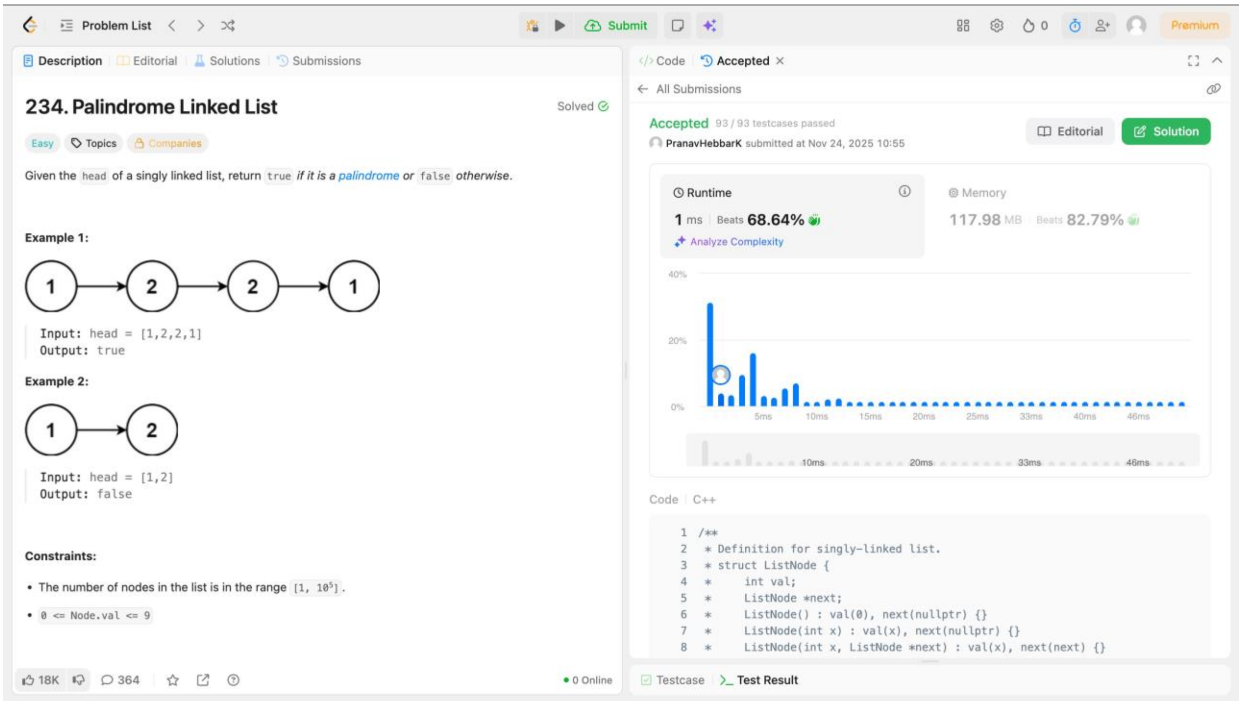
Output:



6) Palindrome Linked List

```
/**
 * Definition for singly-linked list.
 * struct ListNode {
 *     int val;
 *     ListNode *next;
 *     ListNode() : val(0), next(nullptr) {}
 *     ListNode(int x) : val(x), next(nullptr) {}
 *     ListNode(int x, ListNode *next) : val(x),
next(next) {}
 * };
 */
class Solution {
public:
    bool isPalindrome(ListNode* head) {
        struct ListNode* slow=head;
        struct ListNode* fast=head;
        while(fast && fast->next){
            fast=fast->next->next;
            slow=slow->next;
        }
        if(fast)
            slow=slow->next;
        ListNode* prev=NULL;
        while(slow){
            struct ListNode* temp=slow->next;
            slow->next=prev;
            prev=slow;
            slow=temp;
        }
        struct ListNode* a=head;
        struct ListNode* b=prev;
        while(b){
            if(a->val==b->val){
                a=a->next;
                b=b->next;
            }
            else
                return false;
        }
        return true;
    }
};
```

Output:


Problem List
Submit
Premium
Description
Editorial
Solutions
Submissions
234. Palindrome Linked List
Solved
Easy
Topics
Companies
Given the head of a singly linked list, return true if it is a palindrome or false otherwise.
Example 1:
Input: head = [1,2,2,1]
Output: true
Example 2:
Input: head = [1,2]
Output: false
Constraints:
The number of nodes in the list is in the range [1, 10^5].
0 <= Node.val <= 9
18K
364
0 Online
Code
Accepted
All Submissions
Accepted 93 / 93 testcases passed
PranavHebbarK submitted at Nov 24, 2025 10:55
Editorial
Solution
Runtime
1 ms Beats 68.64%
Analyze Complexity
Memory
117.98 MB Beats 82.79%
Code C++
/**
* Definition for singly-linked list.
* struct ListNode {
* int val;
* ListNode *next;
* ListNode() : val(0), next(nullptr) {}
* ListNode(int x) : val(x), next(nullptr) {}
* ListNode(int x, ListNode *next) : val(x), next(next) {}
Testcase
Test Result

7) Find if Path Exists in Graph

```
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>

void dfs(int node, int **adj, int *adjSize, bool
*visited) {
    visited[node] = true;
    for (int i = 0; i < adjSize[node]; i++) {
        int next = adj[node][i];
        if (!visited[next]) {
            dfs(next, adj, adjSize, visited);
        }
    }
}

bool validPath(int n, int** edges, int edgesSize, int*
edgesColSize, int source, int destination){
    int **adj = malloc(n * sizeof(int*));
    int *adjSize = calloc(n, sizeof(int));

    for (int i = 0; i < edgesSize; i++) {
        adjSize[edges[i][0]]++;
        adjSize[edges[i][1]]++;
    }

    for (int i = 0; i < n; i++) {
        adj[i] = malloc(adjSize[i] * sizeof(int));
        adjSize[i] = 0;
    }

    for (int i = 0; i < edgesSize; i++) {
        int u = edges[i][0], v = edges[i][1];
        adj[u][adjSize[u]++] = v;
        adj[v][adjSize[v]++] = u;
    }

    bool *visited = calloc(n, sizeof(bool));
    dfs(source, adj, adjSize, visited);

    bool result = visited[destination];

    for (int i = 0; i < n; i++) free(adj[i]);
    free(adj);
    free(adjSize);
```

```
    free(visited);

    return result;
}
```

Output: