VISVESVARAYA TECHNOLOGICAL UNIVERSITY

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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 MAHESH GOPAL LAMANI **(1BM24CS157)**, 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 2025-26. 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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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.	50
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Course outcomes:

CO1	Apply the concept of linear and nonlinear data structures.
CO2	Analyse 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:

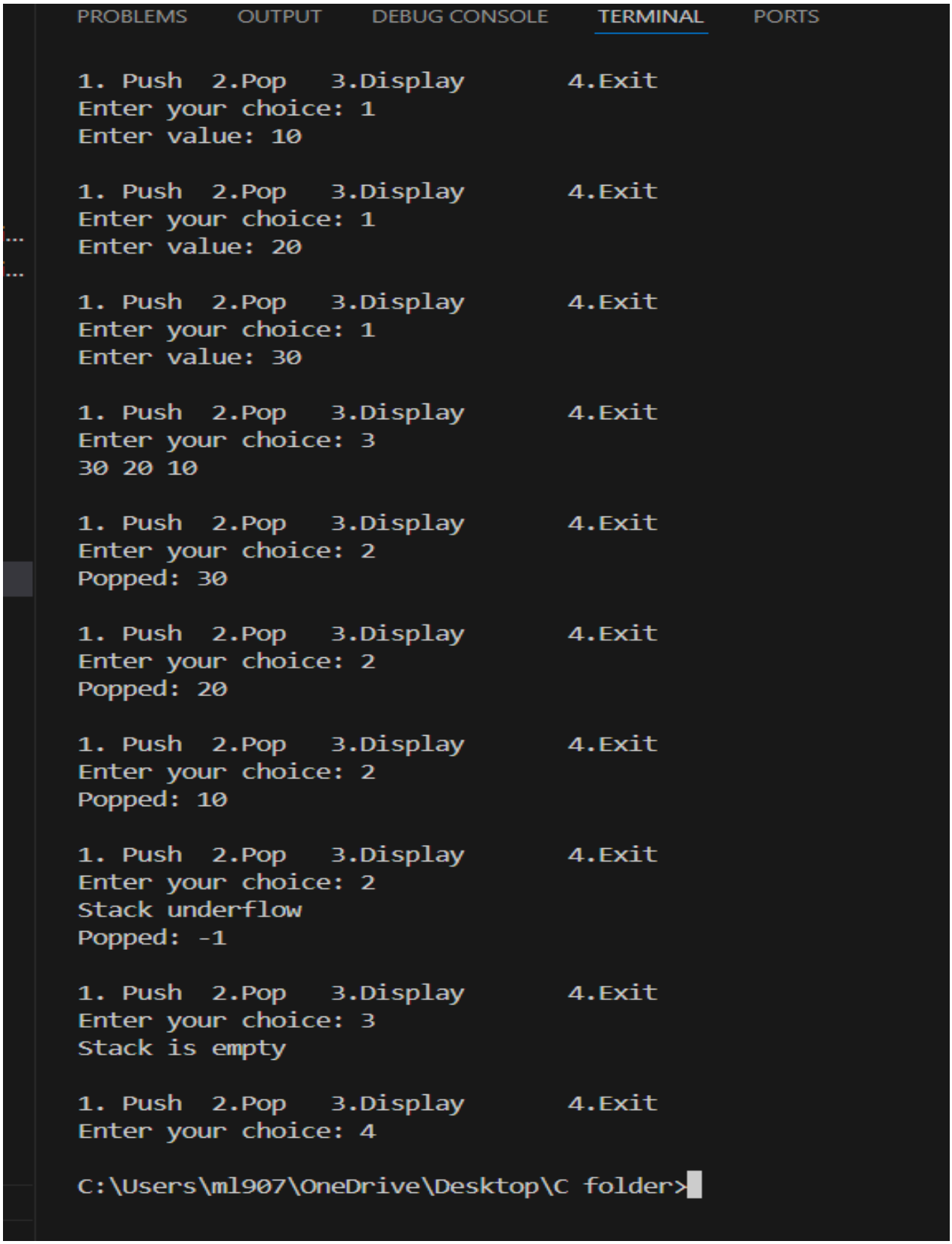
Write a program to simulate the working of stack using an array with the following:
a) Push
b) Pop
c) Display
The program should print appropriate messages for stack overflow, stack underflow.

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

#define MAX 100

typedef struct {
    int arr[MAX];
    int top;
} Stack;

void init(Stack *s) {
    s->top = -1;
}

int isEmpty(Stack *s) {
    return s->top == -1;
}

int isFull(Stack *s) {
    return s->top == MAX - 1;
}

void push(Stack *s, int value) {
    if (isFull(s)) {
        printf("Stack overflow\n");
        return;
    }
    s->arr[++s->top] = value;
}

int pop(Stack *s) {
    if (isEmpty(s)) {
        printf("Stack underflow\n");
        return -1;
    }
    return s->arr[s->top--];
}

int peek(Stack *s) {
    if (isEmpty(s)) {
        printf("Stack is empty\n");
```

```
        return -1;
    }
    return s->arr[s->top];
}

int main(void) {
    Stack s;
    init(&s);

    int choice, value;

    while (1) {
        printf("\n1. Push\n");
        printf("2. Pop\n");
        printf("3. Display\n");
        printf("4. Exit\n");
        printf("Enter choice: ");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                printf("Enter value: ");
                scanf("%d", &value);
                push(&s, value);
                break;

            case 2:
                printf("Popped: %d\n", pop(&s));
                break;

            case 3:
                if (isEmpty(&s)) {
                    printf("Stack is empty\n");
                } else {
                    for (int i = s.top; i >= 0; i--) {
                        printf("%d ", s.arr[i]);
                    }
                    printf("\n");
                }
                break;

            case 4:
                exit(0);

            default:
                printf("Invalid choice\n");
        }
    }

    return 0;
```

}

Output:


PROBLEMS
OUTPUT
DEBUG CONSOLE
TERMINAL
PORTS
1. Push 2.Pop 3.Display 4.Exit
Enter your choice: 1
Enter value: 10
1. Push 2.Pop 3.Display 4.Exit
Enter your choice: 1
Enter value: 20
1. Push 2.Pop 3.Display 4.Exit
Enter your choice: 1
Enter value: 30
1. Push 2.Pop 3.Display 4.Exit
Enter your choice: 3
30 20 10
1. Push 2.Pop 3.Display 4.Exit
Enter your choice: 2
Popped: 30
1. Push 2.Pop 3.Display 4.Exit
Enter your choice: 2
Popped: 20
1. Push 2.Pop 3.Display 4.Exit
Enter your choice: 2
Popped: 10
1. Push 2.Pop 3.Display 4.Exit
Enter your choice: 2
Stack underflow
Popped: -1
1. Push 2.Pop 3.Display 4.Exit
Enter your choice: 3
Stack is empty
1. Push 2.Pop 3.Display 4.Exit
Enter your choice: 4
C:\Users\ml907\OneDrive\Desktop\C folder>

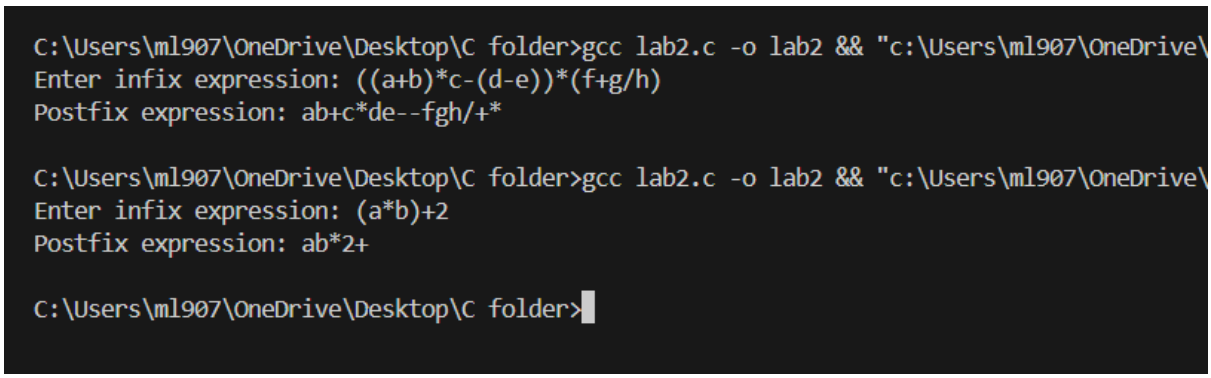
Lab Program 2:

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 <ctype.h>

#define MAX 100

char stack[MAX];
int top = -1;

void push(char ch) {
   stack[++top] = ch;
}

char pop() {
   return stack[top--];
}

char peek() {
   return stack[top];
}

int precedence(char op) {
   if (op == '+' || op == '-')
      return 1;
   if (op == '*' || op == '/')
      return 2;
   return 0;
}

int main() {
   char infix[MAX], postfix[MAX];
   int i, k = 0;

   printf("Enter infix expression: ");
   scanf("%s", infix);

   for (i = 0; infix[i] != '\0'; i++) {
      char ch = infix[i];
```

```
        if (isalnum(ch)) {
            postfix[k++] = ch;
        }
        else if (ch == '(') {
            push(ch);
        }
        else if (ch == ')') {
            while (top != -1 && peek() != '(') {
                postfix[k++] = pop();
            }
            pop();
        }
        else {
            while (top != -1 && precedence(peek()) >= precedence(ch)) {
                postfix[k++] = pop();
            }
            push(ch);
        }
    }

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

    postfix[k] = '\0';

    printf("Postfix expression: %s\n", postfix);

    return 0;
}
```

Output:



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 program should print appropriate messages for queue empty and queue overflow conditions.**

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

#define MAX 3

int queue[MAX];
int front = -1, rear = -1;

void insert()
{
   int value;

   if (rear == MAX - 1)
   {
      printf("Queue overflow\n");
      return;
   }

   printf("Enter value to insert: ");
   scanf("%d", &value);

   if (front == -1)
      front = 0;

   queue[++rear] = value;
}

void delete()
{
   if (front == -1 || front > rear)
   {
      printf("Queue is empty\n");
      return;
   }

   printf("Deleted element: %d\n", queue[front++]);
}

void display()
```

```
{
    if (front == -1 || front > rear)
    {
        printf("Queue is empty\n");
        return;
    }

    printf("Queue elements: ");
    for (int i = front; i <= rear; i++)
    {
        printf("%d ", queue[i]);
    }
    printf("\n");
}

int main()
{
    int choice;

    while (1)
    {
        printf("\n1. Insert\t 2.Delete\t 3.Display\t 4.Exit\n");
        printf("Enter choice: ");
        scanf("%d", &choice);

        switch (choice)
        {
        case 1:
            insert();
            break;

        case 2:
            delete();
            break;

        case 3:
            display();
            break;

        case 4:
            exit(0);

        default:
            printf("Invalid choice\n");
        }
    }
```

```
    return 0;
}
```

Output:

```
C:\Users\ml907\OneDrive\Desktop\C folder>gcc lab3a.c -o lab3a && "c:\Use

1. Insert       2.Delete       3.Display      4.Exit
Enter choice: 1
Enter value to insert: 10

1. Insert       2.Delete       3.Display      4.Exit
Enter choice: 1
Enter value to insert: 20

1. Insert       2.Delete       3.Display      4.Exit
Enter choice: 1
Enter value to insert: 30

1. Insert       2.Delete       3.Display      4.Exit
Enter choice: 1
Queue overflow

1. Insert       2.Delete       3.Display      4.Exit
Enter choice: 3
Queue elements: 10 20 30

1. Insert       2.Delete       3.Display      4.Exit
Enter choice: 2
Deleted element: 10

1. Insert       2.Delete       3.Display      4.Exit
Enter choice: 2
Deleted element: 20

1. Insert       2.Delete       3.Display      4.Exit
Enter choice: 2
Deleted element: 30

1. Insert       2.Delete       3.Display      4.Exit
Enter choice: 4

C:\Users\ml907\OneDrive\Desktop\C folder>
```

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

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

#define MAX 3

int queue[MAX];
int front = -1, rear = -1;

void insert()
{
   int value;

   if ((rear + 1) % MAX == front)
   {
      printf("Queue overflow\n");
      return;
   }

   printf("Enter value to insert: ");
   scanf("%d", &value);

   if (front == -1)
   {
      front = rear = 0;
   }
   else
   {
      rear = (rear + 1) % MAX;
   }

   queue[rear] = value;
}

void delete()
{
   if (front == -1)
   {
      printf("Queue is empty\n");
```

```
        return;
    }

    printf("Deleted element: %d\n", queue[front]);

    if (front == rear)
    {
        front = rear = -1;
    }
    else
    {
        front = (front + 1) % MAX;
    }
}

void display()
{
    if (front == -1)
    {
        printf("Queue is empty\n");
        return;
    }

    printf("Queue elements: ");
    int i = front;
    while (1)
    {
        printf("%d ", queue[i]);
        if (i == rear)
            break;
        i = (i + 1) % MAX;
    }
    printf("\n");
}

int main()
{
    int choice;

    while (1)
    {
        printf("\n1. Insert\t 2.Delete\t 3.Display\t 4.Exit\n");
        printf("Enter choice: ");
```

```
        scanf("%d", &choice);

        switch (choice)
        {
        case 1:
            insert();
            break;

        case 2:
            delete();
            break;

        case 3:
            display();
            break;

        case 4:
            exit(0);

        default:
            printf("Invalid choice\n");
        }
    }

    return 0;
}
```

Output:

```
C:\Users\ml907\OneDrive\Desktop\C folder>gcc lab3b.c -o lab3b && "c:\Us

1. Insert       2.Delete       3.Display      4.Exit
Enter choice: 1
Enter value to insert: 50

1. Insert       2.Delete       3.Display      4.Exit
Enter choice: 1
Enter value to insert: 60

1. Insert       2.Delete       3.Display      4.Exit
Enter choice: 1
Enter value to insert: 70

1. Insert       2.Delete       3.Display      4.Exit
Enter choice: 1
Queue overflow

1. Insert       2.Delete       3.Display      4.Exit
Enter choice: 3
Queue elements: 50 60 70

1. Insert       2.Delete       3.Display      4.Exit
Enter choice: 2
Deleted element: 50

1. Insert       2.Delete       3.Display      4.Exit
Enter choice: 2
Deleted element: 60

1. Insert       2.Delete       3.Display      4.Exit
Enter choice: 2
Deleted element: 70

1. Insert       2.Delete       3.Display      4.Exit
Enter choice: 2
Queue is empty

1. Insert       2.Delete       3.Display      4.Exit
Enter choice: 4

C:\Users\ml907\OneDrive\Desktop\C folder>
```

Lab program 4:

WAP to Implement Singly Linked List with following operations a) Create a linked list. 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, value;
   struct Node *temp, *newNode;

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

   for (int i = 0; i < n; i++)
   {
      newNode = (struct Node *)malloc(sizeof(struct Node));
      printf("Enter data: ");
      scanf("%d", &value);

      newNode->data = value;
      newNode->next = NULL;

      if (head == NULL)
      {
         head = temp = newNode;
      }
      else
      {
         temp->next = newNode;
         temp = newNode;
      }
   }
}

void insertAtBeginning()
```

```
{
   struct Node *newNode;
   int value;

   newNode = (struct Node *)malloc(sizeof(struct Node));
   printf("Enter data: ");
   scanf("%d", &value);

   newNode->data = value;
   newNode->next = head;
   head = newNode;
}

void insertAtEnd()
{
   struct Node *newNode, *temp;
   int value;

   newNode = (struct Node *)malloc(sizeof(struct Node));
   printf("Enter data: ");
   scanf("%d", &value);

   newNode->data = value;
   newNode->next = NULL;

   if (head == NULL)
   {
      head = newNode;
      return;
   }

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

   temp->next = newNode;
}

void insertAtPosition()
{
   struct Node *newNode, *temp;
   int value, pos, i;

   printf("Enter position: ");
   scanf("%d", &pos);
```

```
    if (pos == 1)
    {
        insertAtBeginning();
        return;
    }

    newNode = (struct Node *)malloc(sizeof(struct Node));
    printf("Enter data: ");
    scanf("%d", &value);

    newNode->data = value;

    temp = head;
    for (i = 1; i < pos - 1 && temp != NULL; i++)
    {
        temp = temp->next;
    }

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

    newNode->next = temp->next;
    temp->next = newNode;
}

void display()
{
    struct Node *temp = head;

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

    printf("Linked list: ");
    while (temp != NULL)
    {
        printf("%d -> ", temp->data);
        temp = temp->next;
    }
    printf("NULL\n");
```

```
}

int main()
{
   int choice;

   while (1)
   {
      printf("\n1. Create List\t 2. Insert at Beginning\t 3.Insert at Position\t 4. Insert at End\t
5. Display\t 6. Exit\n");
      printf("Enter choice: ");
      scanf("%d", &choice);

      switch (choice)
      {
      case 1:
         create();
         break;

      case 2:
         insertAtBeginning();
         break;

      case 3:
         insertAtPosition();
         break;

      case 4:
         insertAtEnd();
         break;

      case 5:
         display();
         break;

      case 6:
         exit(0);

      default:
         printf("Invalid choice\n");
      }
   }

   return 0;
}
```

Output:

```
C:\Users\ml907\OneDrive\Desktop\C folder>gcc lab4.c -o lab4 && "c:\Users\ml907\OneDrive\Desktop\C folder\"\lab4

1. Create List   2. Insert at Beginning  3.Insert at Position    4. Insert at End       5. Display     6. Exit
Enter choice: 1
Enter number of nodes: 4
Enter data: 10
Enter data: 20
Enter data: 30
Enter data: 40

1. Create List   2. Insert at Beginning  3.Insert at Position    4. Insert at End       5. Display     6. Exit
Enter choice: 5
Linked list: 10 -> 20 -> 30 -> 40 -> NULL

1. Create List   2. Insert at Beginning  3.Insert at Position    4. Insert at End       5. Display     6. Exit
Enter choice: 2
Enter data: 50

1. Create List   2. Insert at Beginning  3.Insert at Position    4. Insert at End       5. Display     6. Exit
Enter choice: 4
Enter data: 60

1. Create List   2. Insert at Beginning  3.Insert at Position    4. Insert at End       5. Display     6. Exit
Enter choice: 5
Linked list: 50 -> 10 -> 20 -> 30 -> 40 -> 60 -> NULL

1. Create List   2. Insert at Beginning  3.Insert at Position    4. Insert at End       5. Display     6. Exit
Enter choice: 3
Enter position: 3
Enter data: 70

1. Create List   2. Insert at Beginning  3.Insert at Position    4. Insert at End       5. Display     6. Exit
Enter choice: 5
Linked list: 50 -> 10 -> 70 -> 20 -> 30 -> 40 -> 60 -> NULL

1. Create List   2. Insert at Beginning  3.Insert at Position    4. Insert at End       5. Display     6. Exit
Enter choice: 6

C:\Users\ml907\OneDrive\Desktop\C folder>
```

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, value;
   struct Node *temp, *newNode;

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

   for (int i = 0; i < n; i++)
   {
      newNode = (struct Node *)malloc(sizeof(struct Node));
      printf("Enter data: ");
      scanf("%d", &value);

      newNode->data = value;
      newNode->next = NULL;

      if (head == NULL)
      {
         head = temp = newNode;
      }
      else
      {
         temp->next = newNode;
         temp = newNode;
      }
   }
}

void deleteFirst()
{
   struct Node *temp;
```

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

    temp = head;
    head = head->next;
    free(temp);

    printf("First node deleted\n");
}

void deleteLast()
{
    struct Node *temp, *prev;

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

    if (head->next == NULL)
    {
        free(head);
        head = NULL;
        printf("Last node deleted\n");
        return;
    }

    temp = head;
    while (temp->next != NULL)
    {
        prev = temp;
        temp = temp->next;
    }

    prev->next = NULL;
    free(temp);

    printf("Last node deleted\n");
}

void deleteSpecified()
{
    int value;
    struct Node *temp, *prev;

    if (head == NULL)
    {
```

```
        printf("List is empty\n");
        return;
    }

    printf("Enter value to delete: ");
    scanf("%d", &value);

    if (head->data == value)
    {
        deleteFirst();
        return;
    }

    prev = head;
    temp = head->next;

    while (temp != NULL && temp->data != value)
    {
        prev = temp;
        temp = temp->next;
    }

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

    prev->next = temp->next;
    free(temp);

    printf("Specified node deleted\n");
}

void display()
{
    struct Node *temp = head;

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

    printf("Linked list: ");
    while (temp != NULL)
    {
        printf("%d -> ", temp->data);
        temp = temp->next;
    }
    printf("NULL\n");
```

```
}

int main()
{
   int choice;

   while (1)
   {
      printf("\n1. Create List\t 2. Delete First\t 3. Delete Specified\t 4. Delete Last\t 5. Display\t 6.
Exit\n");
      printf("Enter choice: ");
      scanf("%d", &choice);

      switch (choice)
      {
      case 1:
         create();
         break;

      case 2:
         deleteFirst();
         break;

      case 3:
         deleteSpecified();
         break;

      case 4:
         deleteLast();
         break;

      case 5:
         display();
         break;

      case 6:
         exit(0);

      default:
         printf("Invalid choice\n");
      }
   }

   return 0;
}
```

Output:

```
C:\Users\ml907\OneDrive\Desktop\C folder>gcc lab5.c -o lab5 && "c:\Users\ml907\OneDrive\Desktop\C folder\"\lab5

1. Create List   2. Delete First        3. Delete Specified     4. Delete Last  5. Display      6. Exit
Enter choice: 1
Enter number of nodes: 6
Enter data: 10
Enter data: 20
Enter data: 30
Enter data: 40
Enter data: 50
Enter data: 60

1. Create List   2. Delete First        3. Delete Specified     4. Delete Last  5. Display      6. Exit
Enter choice: 5
Linked list: 10 -> 20 -> 30 -> 40 -> 50 -> 60 -> NULL

1. Create List   2. Delete First        3. Delete Specified     4. Delete Last  5. Display      6. Exit
Enter choice: 2
First node deleted

1. Create List   2. Delete First        3. Delete Specified     4. Delete Last  5. Display      6. Exit
Enter choice: 4
Last node deleted

1. Create List   2. Delete First        3. Delete Specified     4. Delete Last  5. Display      6. Exit
Enter choice: 5
Linked list: 20 -> 30 -> 40 -> 50 -> NULL

1. Create List   2. Delete First        3. Delete Specified     4. Delete Last  5. Display      6. Exit
Enter choice: 3
Enter value to delete: 40
Specified node deleted

1. Create List   2. Delete First        3. Delete Specified     4. Delete Last  5. Display      6. Exit
Enter choice: 5
Linked list: 20 -> 30 -> 50 -> NULL

1. Create List   2. Delete First        3. Delete Specified     4. Delete Last  5. Display      6. Exit
Enter choice: 6

C:\Users\ml907\OneDrive\Desktop\C folder>
```

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.

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

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

struct Node *head1 = NULL;
struct Node *head2 = NULL;

struct Node *createList()
{
   struct Node *head = NULL, *temp = NULL, *newNode;
   int n, value;

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

   for (int i = 0; i < n; i++)
   {
      newNode = (struct Node *)malloc(sizeof(struct Node));
      printf("Enter data: ");
      scanf("%d", &value);

      newNode->data = value;
      newNode->next = NULL;

      if (head == NULL)
      {
         head = temp = newNode;
      }
      else
      {
         temp->next = newNode;
         temp = newNode;
      }
   }
   return head;
```

```
}

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

   while (head != NULL)
   {
      printf("%d -> ", head->data);
      head = head->next;
   }
   printf("NULL\n");
}

void sortList(struct Node *head)
{
   struct Node *i, *j;
   int temp;

   for (i = head; i != NULL; i = i->next)
   {
      for (j = i->next; j != NULL; j = j->next)
      {
         if (i->data > j->data)
         {
            temp = i->data;
            i->data = j->data;
            j->data = temp;
         }
      }
   }
}

struct Node *reverseList(struct Node *head)
{
   struct Node *prev = NULL, *curr = head, *next = NULL;

   while (curr != NULL)
   {
      next = curr->next;
      curr->next = prev;
```

```
        prev = curr;
        curr = next;
    }
    return prev;
}

struct Node *concatenate(struct Node *head1, struct Node *head2)
{
    struct Node *temp;

    if (head1 == NULL)
        return head2;

    temp = head1;
    while (temp->next != NULL)
    {
        temp = temp->next;
    }

    temp->next = head2;
    return head1;
}

int main()
{
    printf("Create first linked list\n");
    head1 = createList();

    printf("\nCreate second linked list\n");
    head2 = createList();

    printf("\nFirst list:\n");
    display(head1);

    printf("Second list:\n");
    display(head2);

    sortList(head1);
    printf("\nSorted first list:\n");
    display(head1);

    head1 = reverseList(head1);
    printf("\nReversed first list:\n");
    display(head1);
```

```
    head1 = concatenate(head1, head2);
    printf("\nConcatenated list:\n");
    display(head1);

    return 0;
}
```

Output:

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

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

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

struct Node *top = NULL;
struct Node *front = NULL;
struct Node *rear = NULL;

void push()
{
   struct Node *newNode;
   int value;

   newNode = (struct Node *)malloc(sizeof(struct Node));
   printf("Enter value: ");
   scanf("%d", &value);

   newNode->data = value;
   newNode->next = top;
   top = newNode;
}

void pop()
{
   struct Node *temp;

   if (top == NULL)
   {
      printf("Stack is empty\n");
      return;
   }

   temp = top;
   printf("Popped element: %d\n", temp->data);
   top = top->next;
```

```
    free(temp);
}

void displayStack()
{
    struct Node *temp = top;

    if (top == NULL)
    {
        printf("Stack is empty\n");
        return;
    }

    printf("Stack: ");
    while (temp != NULL)
    {
        printf("%d ", temp->data);
        temp = temp->next;
    }
    printf("\n");
}

void enqueue()
{
    struct Node *newNode;
    int value;

    newNode = (struct Node *)malloc(sizeof(struct Node));
    printf("Enter value: ");
    scanf("%d", &value);

    newNode->data = value;
    newNode->next = NULL;

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

```
}

void dequeue()
{
   struct Node *temp;

   if (front == NULL)
   {
      printf("Queue is empty\n");
      return;
   }

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

   if (front == NULL)
      rear = NULL;
}

void displayQueue()
{
   struct Node *temp = front;

   if (front == NULL)
   {
      printf("Queue is empty\n");
      return;
   }

   printf("Queue: ");
   while (temp != NULL)
   {
      printf("%d ", temp->data);
      temp = temp->next;
   }
   printf("\n");
}

int main()
{
   int choice;
```

```
  while (1)
  {
    printf("\n1. Push (Stack)\t 2. Pop (Stack)\t 3. Display Stack\t 4. Enqueue (Queue)\t 5.
Dequeue (Queue)\t 6. Display Queue\t 7. Exit\n");
    printf("Enter choice: ");
    scanf("%d", &choice);

    switch (choice)
    {
    case 1:
      push();
      break;

    case 2:
      pop();
      break;

    case 3:
      displayStack();
      break;

    case 4:
      enqueue();
      break;

    case 5:
      dequeue();
      break;

    case 6:
      displayQueue();
      break;

    case 7:
      exit(0);

    default:
      printf("Invalid choice\n");
    }
  }

  return 0;
```

}

Output:


1. Push (Stack) 2. Pop (Stack) 3. Display Stack 4. Enqueue (Queue) 5. Dequeue (Queue) 6. Display Queue 7. Exit
Enter choice: 1
Enter value: 33
1. Push (Stack) 2. Pop (Stack) 3. Display Stack 4. Enqueue (Queue) 5. Dequeue (Queue) 6. Display Queue 7. Exit
Enter choice: 4
Enter value: 45
1. Push (Stack) 2. Pop (Stack) 3. Display Stack 4. Enqueue (Queue) 5. Dequeue (Queue) 6. Display Queue 7. Exit
Enter choice: 1
Enter value: 18
1. Push (Stack) 2. Pop (Stack) 3. Display Stack 4. Enqueue (Queue) 5. Dequeue (Queue) 6. Display Queue 7. Exit
Enter choice: 3
Stack: 18 33
1. Push (Stack) 2. Pop (Stack) 3. Display Stack 4. Enqueue (Queue) 5. Dequeue (Queue) 6. Display Queue 7. Exit
Enter choice: 1
Enter value: 70
1. Push (Stack) 2. Pop (Stack) 3. Display Stack 4. Enqueue (Queue) 5. Dequeue (Queue) 6. Display Queue 7. Exit
Enter choice: 2
Popped element: 70
1. Push (Stack) 2. Pop (Stack) 3. Display Stack 4. Enqueue (Queue) 5. Dequeue (Queue) 6. Display Queue 7. Exit
Enter choice: 4
Enter value: 99
1. Push (Stack) 2. Pop (Stack) 3. Display Stack 4. Enqueue (Queue) 5. Dequeue (Queue) 6. Display Queue 7. Exit
Enter choice: 4
Enter value: 28
1. Push (Stack) 2. Pop (Stack) 3. Display Stack 4. Enqueue (Queue) 5. Dequeue (Queue) 6. Display Queue 7. Exit
Enter choice: 6
Queue: 45 99 28
1. Push (Stack) 2. Pop (Stack) 3. Display Stack 4. Enqueue (Queue) 5. Dequeue (Queue) 6. Display Queue 7. Exit
Enter choice: 5
Deleted element: 45
1. Push (Stack) 2. Pop (Stack) 3. Display Stack 4. Enqueue (Queue) 5. Dequeue (Queue) 6. Display Queue 7. Exit
Enter choice:

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>

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

struct Node *head = NULL;

void create()
{
   int n, value;
   struct Node *newNode, *temp = NULL;

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

   for (int i = 0; i < n; i++)
   {
      newNode = (struct Node *)malloc(sizeof(struct Node));
      printf("Enter data: ");
      scanf("%d", &value);

      newNode->data = value;
      newNode->prev = NULL;
      newNode->next = NULL;

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

```
            temp = temp->next;

         temp->next = newNode;
         newNode->prev = temp;
      }
   }
}

void insertLeft()
{
   int value, key;
   struct Node *newNode, *temp;

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

   printf("Enter new value: ");
   scanf("%d", &value);
   printf("Insert to the left of node having value: ");
   scanf("%d", &key);

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

   if (temp == NULL)
   {
      printf("Specified node not found\n");
      return;
   }

   newNode = (struct Node *)malloc(sizeof(struct Node));
   newNode->data = value;

   newNode->next = temp;
   newNode->prev = temp->prev;

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

```
        head = newNode;

    temp->prev = newNode;
}

void deleteNode()
{
    int key;
    struct Node *temp;

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

    printf("Enter value to delete: ");
    scanf("%d", &key);

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

    if (temp == NULL)
    {
        printf("Node 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);
    printf("Node deleted\n");
}

void display()
{
```

```
    struct Node *temp = head;

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

    printf("Doubly linked list: ");
    while (temp != NULL)
    {
        printf("%d <-> ", temp->data);
        temp = temp->next;
    }
    printf("NULL\n");
}

int main()
{
    int choice;

    while (1)
    {
        printf("\n1. Create List\t 2. Insert Left\t 3. Delete Node\t 4. Display\t 5. Exit\n");
        printf("Enter choice: ");
        scanf("%d", &choice);

        switch (choice)
        {
        case 1:
            create();
            break;

        case 2:
            insertLeft();
            break;

        case 3:
            deleteNode();
            break;

        case 4:
            display();
```

```
            break;

        case 5:
            exit(0);

        default:
            printf("Invalid choice\n");
        }
    }

    return 0;
}
```

Output:

```
1. Create List   2. Insert Left  3. Delete Node  4. Display     5. Exit
Enter choice: 1
Enter number of nodes: 4
Enter data: 30
Enter data: 60
Enter data: 74
Enter data: 99

1. Create List   2. Insert Left  3. Delete Node  4. Display     5. Exit
Enter choice: 2
Enter new value: 45
Insert to the left of node having value: 74

1. Create List   2. Insert Left  3. Delete Node  4. Display     5. Exit
Enter choice: 4
Doubly linked list: 30 <-> 60 <-> 45 <-> 74 <-> 99 <-> NULL

1. Create List   2. Insert Left  3. Delete Node  4. Display     5. Exit
Enter choice: 2
Enter new value: 68
Insert to the left of node having value: 77
Specified node not found

1. Create List   2. Insert Left  3. Delete Node  4. Display     5. Exit
Enter choice: 3
Enter value to delete: 44
Node not found

1. Create List   2. Insert Left  3. Delete Node  4. Display     5. Exit
Enter choice: 45
Invalid choice

1. Create List   2. Insert Left  3. Delete Node  4. Display     5. Exit
Enter choice: 3
Enter value to delete: 45
Node deleted

1. Create List   2. Insert Left  3. Delete Node  4. Display     5. Exit
Enter choice: 4
Doubly linked list: 30 <-> 60 <-> 74 <-> 99 <-> NULL

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

Lab program 8:

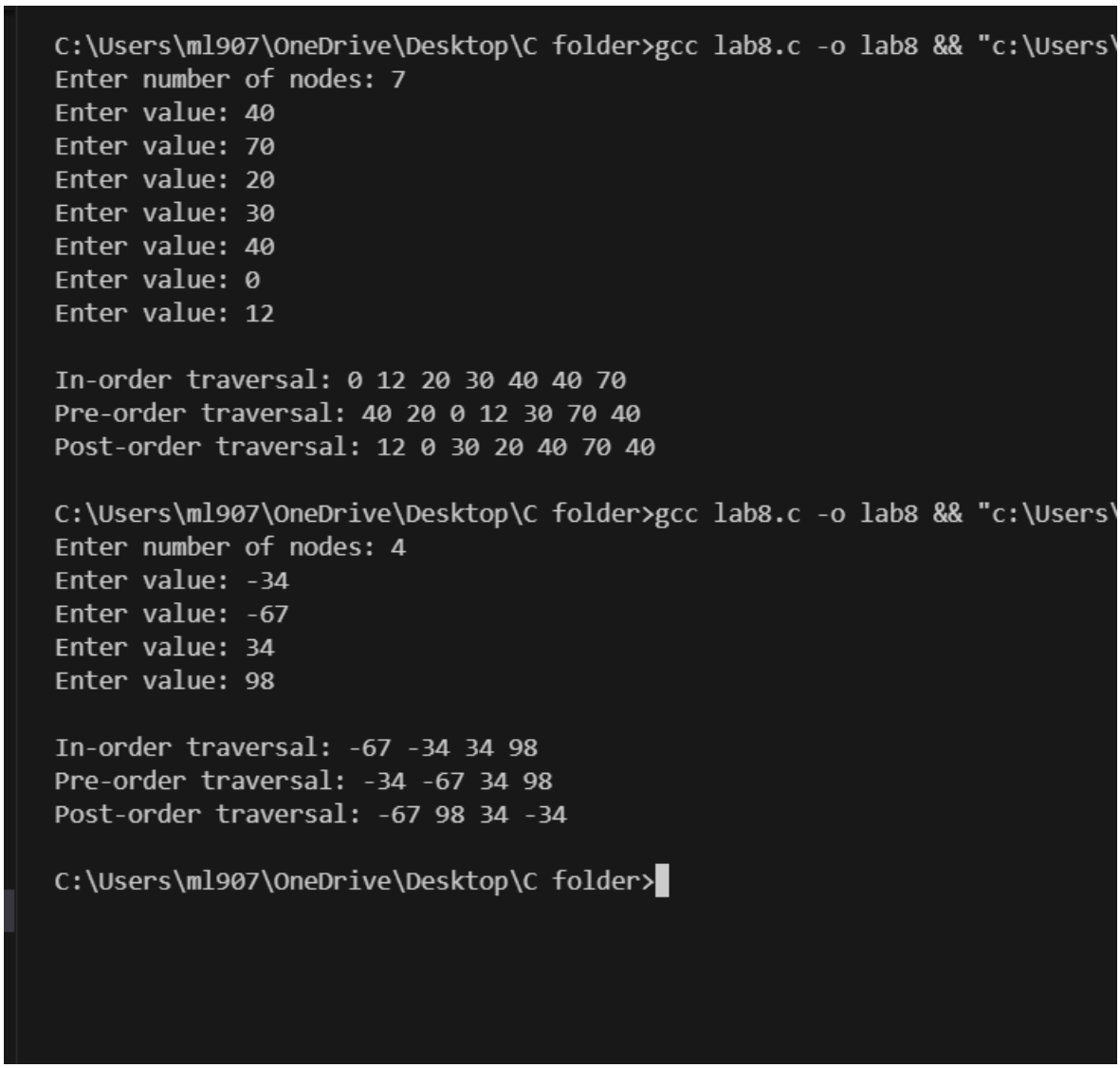
Write a program a) To construct a binary Search tree. b) To traverse the tree using all the methods i.e., in-order, preorder and post order c) To display the elements in the tree.

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

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

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

struct Node *insert(struct Node *root, int value)
{
   if (root == NULL)
      return createNode(value);

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

   return root;
}

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

```
        inorder(root->right);
    }
}

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

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

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

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

    for (int i = 0; i < n; i++)
    {
        printf("Enter value: ");
        scanf("%d", &value);
        root = insert(root, value);
    }

    printf("\nIn-order traversal: ");
    inorder(root);

    printf("\nPre-order traversal: ");
```

```
    preorder(root);

    printf("\nPost-order traversal: ");
    postorder(root);

    printf("\n");

    return 0;
}
```

Output:



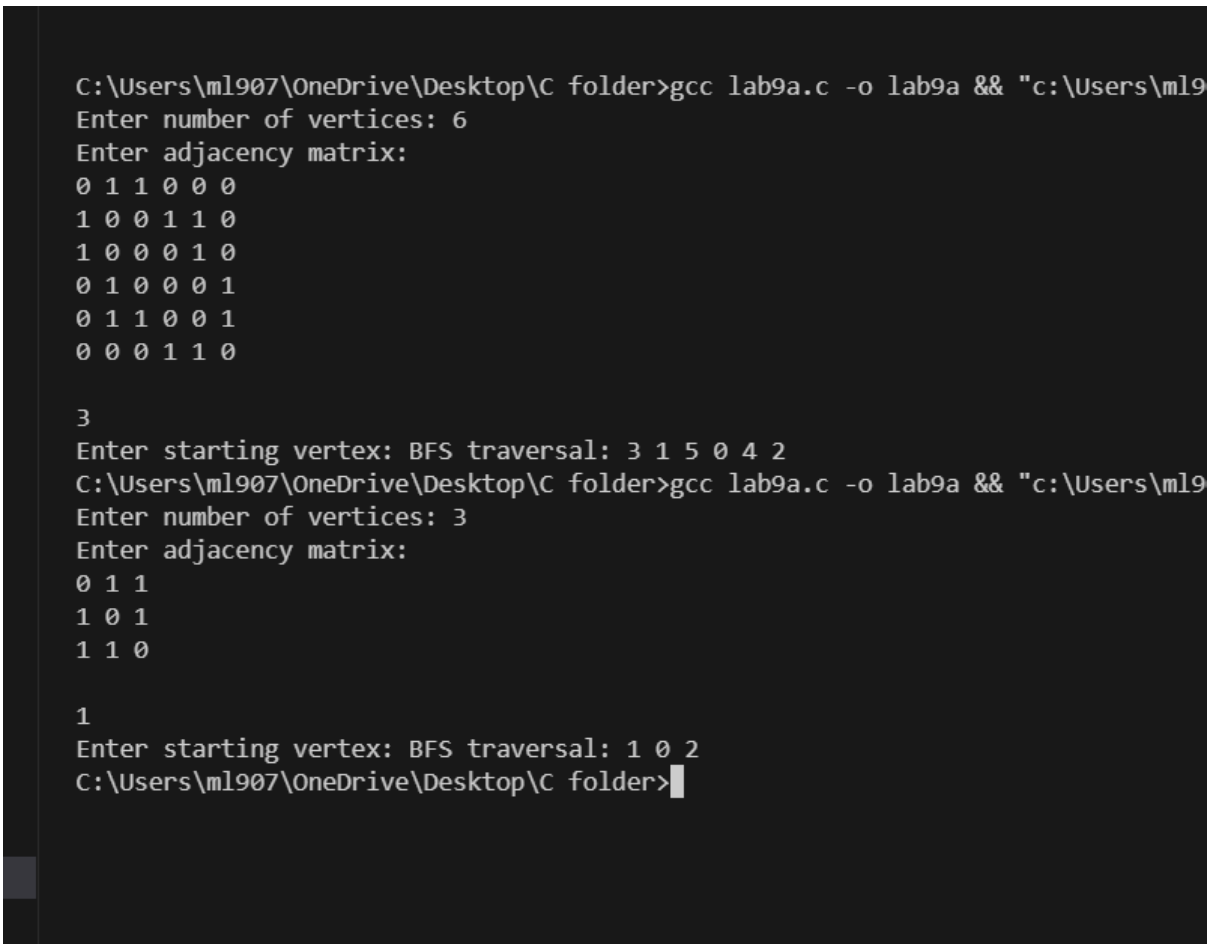
Lab Program 9:

a) Write a program to traverse a graph using BFS method.

```
#include <stdio.h>

#define MAX 10

int adj[MAX][MAX];
int visited[MAX];
int queue[MAX];
int front = 0, rear = -1;
int n;

void bfs(int start) {
   int i, v;

   queue[++rear] = start;
   visited[start] = 1;

   while (front <= rear) {
      v = queue[front++];
      printf("%d ", v);

      for (i = 0; i < n; i++) {
         if (adj[v][i] == 1 && visited[i] == 0) {
            queue[++rear] = i;
            visited[i] = 1;
         }
      }
   }
}

int main() {
   int start;

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

   printf("Enter adjacency matrix:\n");
   for (int i = 0; i < n; i++) {
      for (int j = 0; j < n; j++) {
         scanf("%d", &adj[i][j]);
      }
   }
```

```
    for (int i = 0; i < n; i++)
        visited[i] = 0;

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

    printf("BFS traversal: ");
    bfs(start);

    return 0;
}
```

Output:



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

```
#include <stdio.h>

#define MAX 10

int adj[MAX][MAX];
int visited[MAX];
int n;

void dfs(int v) {
   visited[v] = 1;

   for (int i = 0; i < n; i++) {
      if (adj[v][i] == 1 && visited[i] == 0) {
         dfs(i);
      }
   }
}

int main() {
   int i, j;
   int connected = 1;

   printf("Enter number of vertices: ");
   fflush(stdout);
   scanf("%d", &n);

   printf("Enter adjacency matrix:\n");
   fflush(stdout);
   for (i = 0; i < n; i++) {
      for (j = 0; j < n; j++) {
         scanf("%d", &adj[i][j]);
      }
   }

   for (i = 0; i < n; i++)
      visited[i] = 0;

   dfs(0);

   for (i = 0; i < n; i++) {
      if (visited[i] == 0) {
         connected = 0;
```

```
            break;
        }
    }

    if (connected)
        printf("Graph is CONNECTED\n");
    else
        printf("Graph is NOT CONNECTED\n");

    return 0;
}
```

Output:

```
C:\Users\ml907\OneDrive\Desktop\C folder>gcc lab9b.c -o lab9b && "c:\Users\ml907\OneDrive\Desktop\C folder\"\lab9b
Enter number of vertices: 4
Enter adjacency matrix:
0 1 1 0
1 0 0 1
1 0 0 1
0 1 1 0
Graph is CONNECTED

C:\Users\ml907\OneDrive\Desktop\C folder>gcc lab9b.c -o lab9b && "c:\Users\ml907\OneDrive\Desktop\C folder\"\lab9b
Enter number of vertices: 4
Enter adjacency matrix:
0 1 0 0
1 0 0 0
0 0 0 1
0 0 1 0
Graph is NOT CONNECTED

C:\Users\ml907\OneDrive\Desktop\C folder>gcc lab9b.c -o lab9b && "c:\Users\ml907\OneDrive\Desktop\C folder\"\lab9b
Enter number of vertices: 5
Enter adjacency matrix:
0 1 1 0 0
1 0 0 1 1
1 0 0 0 1
0 1 0 0 0
0 1 1 0 0
Graph is CONNECTED

C:\Users\ml907\OneDrive\Desktop\C folder>gcc lab9b.c -o lab9b && "c:\Users\ml907\OneDrive\Desktop\C folder\"\lab9b
Enter number of vertices: 3
Enter adjacency matrix:
0 1 1
1 0 1
1 1 0
Graph is CONNECTED

C:\Users\ml907\OneDrive\Desktop\C folder>
```

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 MAX 100

int hashTable[MAX];
int m;

void initialize()
{
   for (int i = 0; i < m; i++)
      hashTable[i] = -1;
}

void insert(int key)
{
   int index = key % m;
   int start = index;

   while (hashTable[index] != -1)
   {
      index = (index + 1) % m;
      if (index == start)
      {
         printf("Hash table is full\n");
         return;
      }
   }

   hashTable[index] = key;
   printf("Key %d inserted at address %d\n", key, index);
}

void display()
```

```
{
   printf("\nHash Table:\n");
   for (int i = 0; i < m; i++)
   {
      if (hashTable[i] != -1)
         printf("Address %d : %d\n", i, hashTable[i]);
      else
         printf("Address %d : Empty\n", i);
   }
}

int main()
{
   int n, key;

   printf("Enter number of memory locations (m): ");
   scanf("%d", &m);

   initialize();

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

   for (int i = 0; i < n; i++)
   {
      printf("Enter key: ");
      scanf("%d", &key);
      insert(key);
   }

   display();

   return 0;
}
```

Output:

```
C:\Users\ml907\OneDrive\Desktop\C folder>gcc lab10.
Enter number of memory locations (m): 10
Enter number of keys: 6
Enter key: 1234
Key 1234 inserted at address 4
Enter key: 2356
Key 2356 inserted at address 6
Enter key: 2354
Key 2354 inserted at address 5
Enter key: 9867
Key 9867 inserted at address 7
Enter key: 3433
Key 3433 inserted at address 3
Enter key: 1111
Key 1111 inserted at address 1

Hash Table:
Address 0 : Empty
Address 1 : 1111
Address 2 : Empty
Address 3 : 3433
Address 4 : 1234
Address 5 : 2354
Address 6 : 2356
Address 7 : 9867
Address 8 : Empty
Address 9 : Empty
```

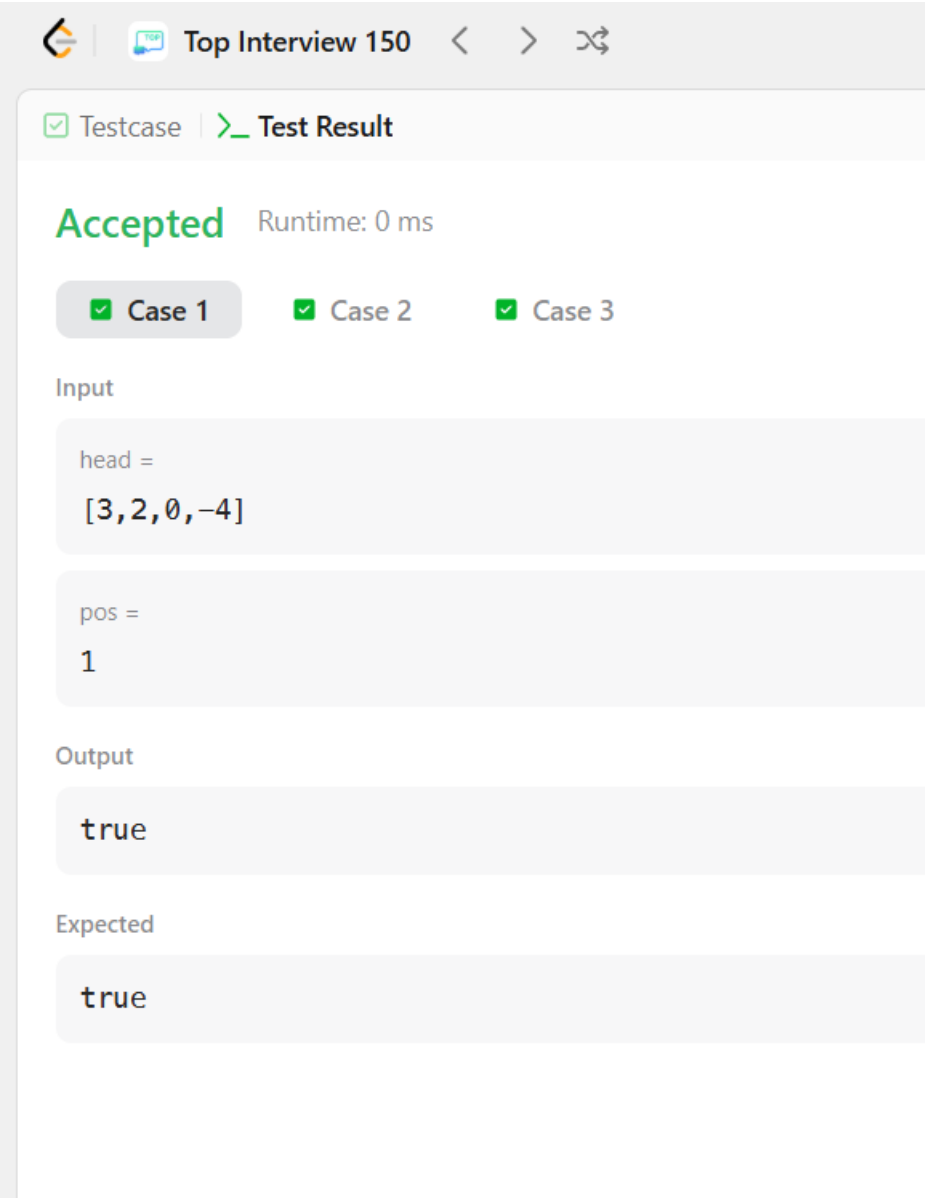
```
C:\Users\ml907\OneDrive\Desktop\C folder>gcc lab
Enter number of memory locations (m): 5
Enter number of keys: 6
Enter key: 2235
Key 2235 inserted at address 0
Enter key: 1234
Key 1234 inserted at address 4
Enter key: 5655
Key 5655 inserted at address 1
Enter key: 1986
Key 1986 inserted at address 2
Enter key: 2005
Key 2005 inserted at address 3
Enter key: 1888
Hash table is full

Hash Table:
Address 0 : 2235
Address 1 : 5655
Address 2 : 1986
Address 3 : 2005
Address 4 : 1234
```

Leet code programs:

141. Linked List Cycle

```
bool hasCycle(struct ListNode *head) {
    if(head==NULL || head->next==NULL)return false;
   struct ListNode* slow = head;
   struct ListNode* fast = head->next;
   while(fast!=NULL && fast->next!=NULL){
    slow = slow->next;
    fast = fast->next->next;
    if(slow==fast) return true;
   }

   return false;
}
```

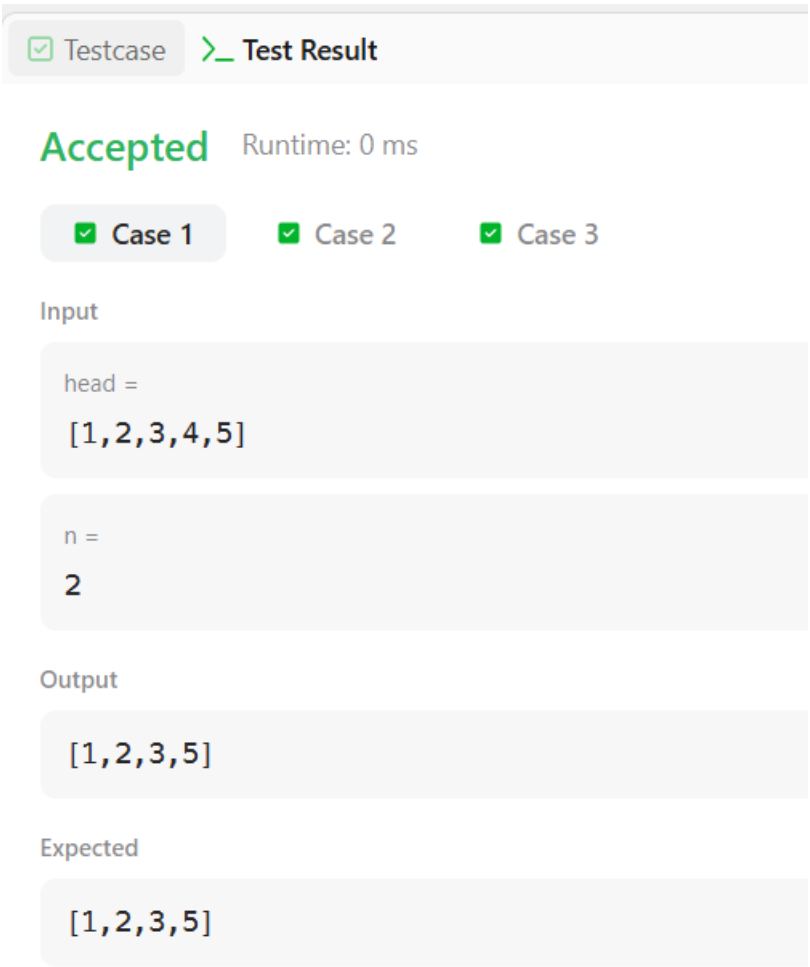
Test cases:


Top Interview 150
Testcase
Test Result
Accepted
Runtime: 0 ms
Case 1
Case 2
Case 3
Input
head =
[3,2,0,-4]
pos =
1
Output
true
Expected
true

19. Remove Nth Node From End of List

```
struct ListNode* removeNthFromEnd(struct ListNode* head, int n) {
    int len = 0;
    struct ListNode* temp = head;
    if(head->next==NULL) return NULL;
    while(temp!=NULL){
        len++;
        temp = temp->next;
    }
    int x= len-n;
    temp=head;
    if(x==0)head = head->next;
    for(int i=1;i<x;i++){
        temp = temp->next;
    }
    if(temp->next->next!=NULL)
        temp->next = temp->next->next;
    else temp->next=NULL;
        return head;
}
```

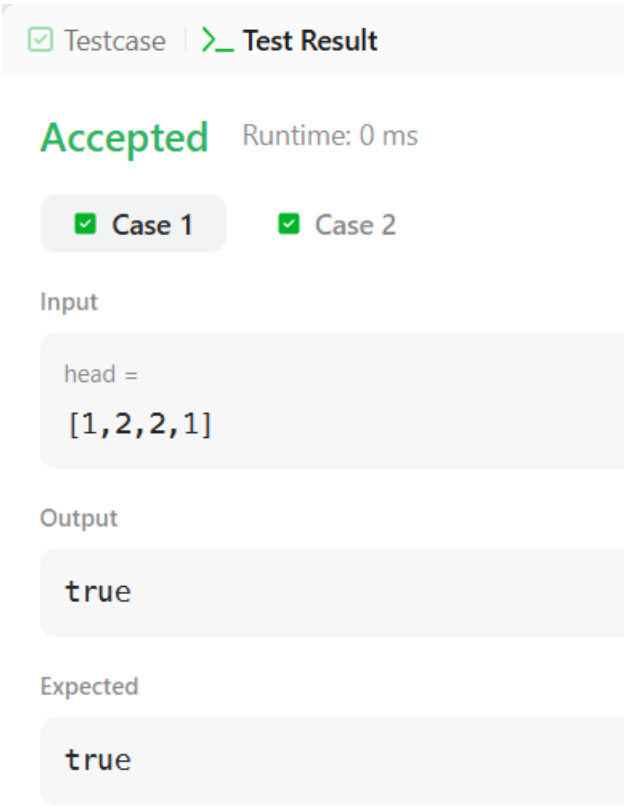
Test case:


Testcase
Test Result
Accepted
Runtime: 0 ms
Case 1
Case 2
Case 3
Input
head =
[1,2,3,4,5]
n =
2
Output
[1,2,3,5]
Expected
[1,2,3,5]

234. Palindrome Linked List

```
bool isPalindrome(struct ListNode* head) {
    int arr[100000];
    int n=0;
    struct ListNode* temp = head;
    while(temp!=NULL){
        arr[n++]=temp->val;
        temp = temp->next;
    }
    int i=0, j=n-1;
    while(i<j){
        if(arr[i]!=arr[j]){
            return false;
        }
            i++;
            j--;
    }
    return true;
}
```

Test case:


Testcase
Test Result
Accepted
Runtime: 0 ms
Case 1
Case 2
Input
head =
[1,2,2,1]
Output
true
Expected
true

1971. Find if Path Exists in Graph

```
#include <stdbool.h>
#include <stdlib.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 = (int **)malloc(n * sizeof(int *));
    int *adjSize = (int *)calloc(n, sizeof(int));
    bool *visited = (bool *)calloc(n, sizeof(bool));

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

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

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

    dfs(source, adj, adjSize, visited);

    return visited[destination];
}
```

Test case:


Testcase
Test Result
Accepted
Runtime: 0 ms
Case 1
Case 2
Input
n =
3
edges =
[[0,1],[1,2],[2,0]]
source =
0
destination =
2
Output
true
Expected
true