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
COMPUTER SCIENCE AND ENGINEERING

B.M.S. COLLEGE OF ENGINEERING
(Autonomous Institution under VTU)
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Department of Computer Science and Engineering

This is to certify that the Lab work entitled **"DATA STRUCTURES"** carried out by PREETHI NARASIMHAN **(1BM22CS207)**, who is a 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 2023-24. 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:

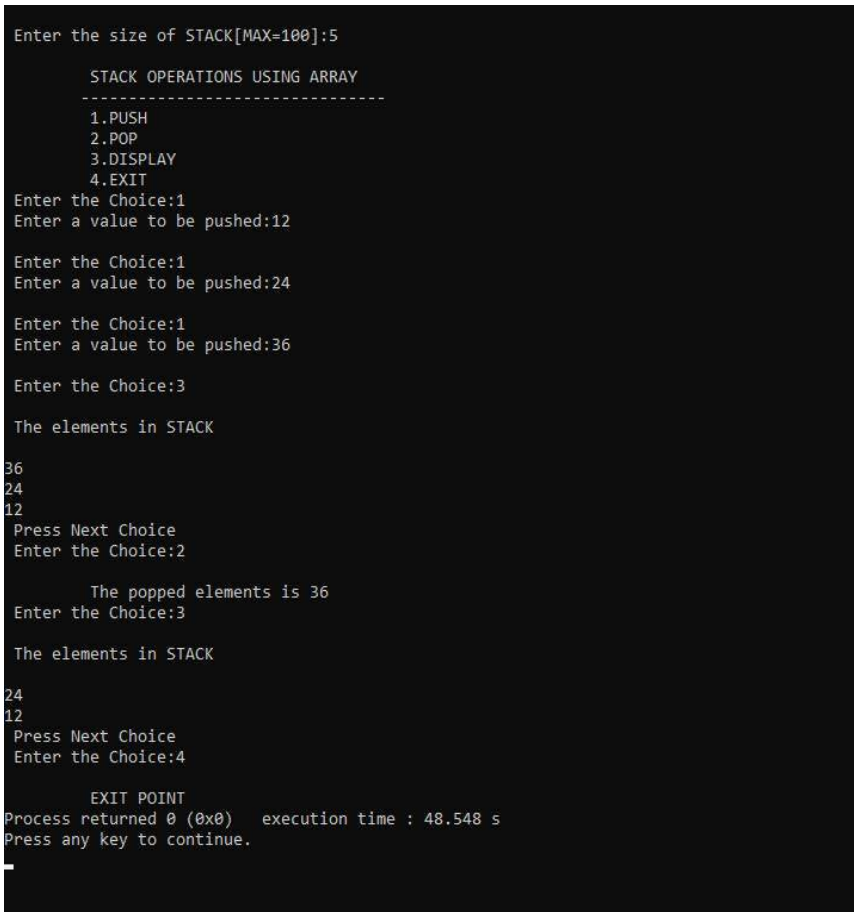
Write a program to simulate the working of stack using an array with the following:
a) Push
b) Pop
c) Display
The program should print appropriate messages for stack overflow, stack underflow.

Code:

```
#include <stdio.h>
#include<stdlib.h>
void push(int st[],int *top)
{
	int item;
	if(*top==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]);
}
int main()
{
	int st[10],top=-1, c,val_del;
	int SIZE;
	printf("Enter the size of STACK[MAX=100]\n");
	scanf("%d",&SIZE);
	printf("STACK OPERATIONS USING ARRAYS\n");
	printf("-----------------------------------------------------\n");
	printf("1. PUSH\n2. POP\n3. DISPLAY\n4.EXIT");
```

```
        do
        {
                printf("\nEnter the choice :");
                scanf("%d",&c);
                switch(c)
                {
                        case 1: push(st,&top);
                                break;
                        case 2: pop(st,&top);
                                break;
                        case 3: display(st,&top);
                                break;
                        case 4: printf("\n EXIT POINT");
                                break;
                        default: printf("\nPlease enter a valid choice (1/2/3/4) ");

                }
        }while(choice!=4);
return 0;
}
```

Output:



Lab Program 2:

2a) Write a program 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).

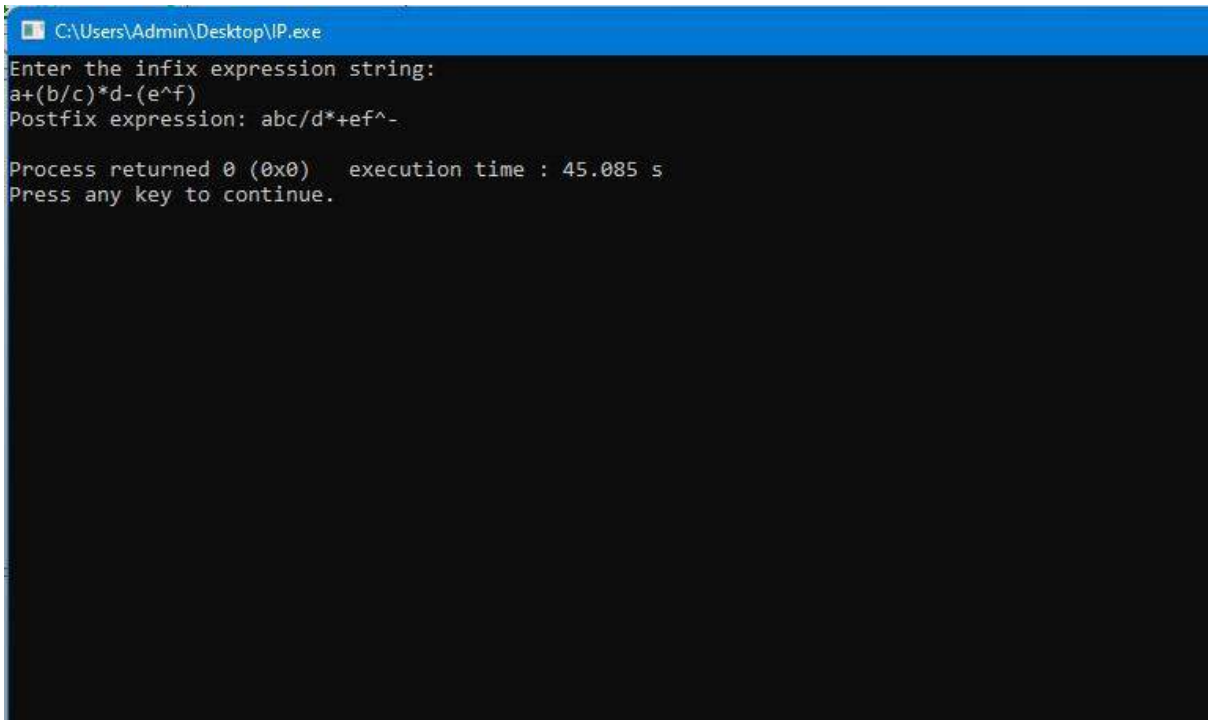
Code:

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

#define MAX 20

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

int prec(char c) {
   if (c == '^')
      return 5;
   else if (c == '/')
      return 4;
   else if (c == '*')
      return 3;
   else if (c == '+')
      return 2;
   else if (c == '-')
      return 1;
   else
      return -1;
}

int isEmpty() {
   return top == -1;
}

int isFull() {
   return top == MAX - 1;
}

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

char pop() {
   if (isEmpty()) {
      printf("Stack is empty\n");
      return -1;
   }
   else
```

```
    {
        char ch = s[top];
        top--;
        return ch;
    }
}

void push(char opr) {
    if (isFull()) {
        printf("Stack is full\n");
    } else {
        top = top + 1;
        s[top] = opr;
    }
}

void infixToPostfix(char infix[], char postfix[]) {
    int i, j;
    char ch;
    for (i = 0, j = 0; i < strlen(infix); i++) {
        ch = infix[i];
        if ((ch >= '0' && ch <= '9') || (ch >= 'A' && ch <= 'Z') || (ch >= 'a' && ch <= 'z')) {
            postfix[j++] = ch;
        } else if (ch == '(') {
            push(ch);
        } else if (ch == ')') {
            while (!isEmpty() && peek() != '(') {
                postfix[j++] = pop();
            }
            if (!isEmpty() && peek() != '(') {
                printf("Invalid expression\n");
                return;
            } else {
                pop();
            }
        } else {
            while (!isEmpty() && prec(ch) <= prec(peek())) {
                postfix[j++] = pop();
            }
            push(ch);
        }
    }

    while (!isEmpty()) {
        postfix[j++] = pop();
    }

    postfix[j] = '\0'; // Null-terminate the postfix expression
}
```

```
int main() {
    char infix[20], postfix[20];
    printf("Enter the infix expression string: \n");
    scanf("%s", infix);
    infixToPostfix(infix, postfix);
    printf("Postfix expression: %s\n", postfix);
    return 0;
}
```

Output:



2b) Write a Leetcode program to implement minstack.

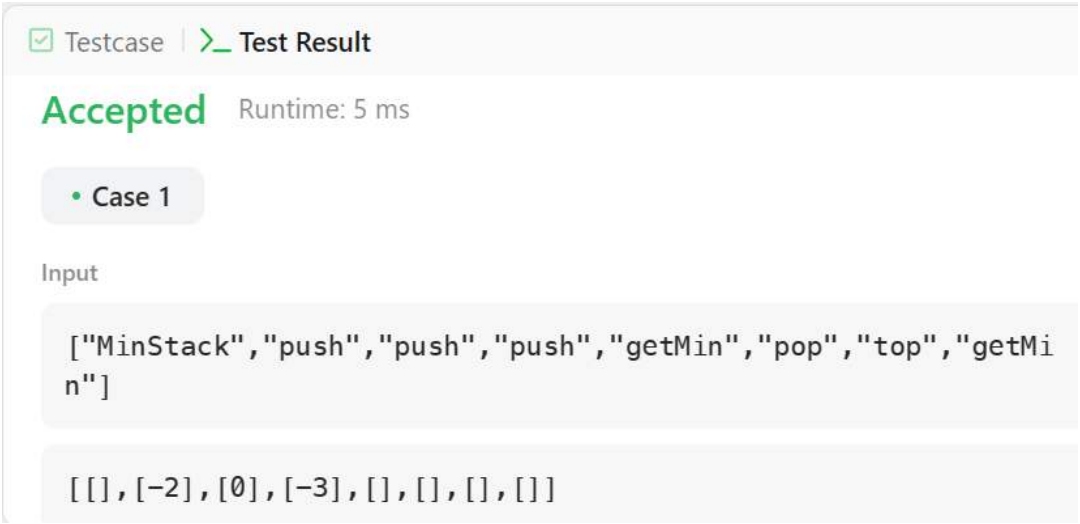
Code:

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

typedef struct MinStackNode
{
    int val;
    struct MinStackNode* next;
} MinStackNode;

typedef struct
{
    MinStackNode* top;
    int min;
```

```
} MinStack;

MinStack* minStackCreate()
{
    MinStack* stack = (MinStack*)malloc(sizeof(MinStack));
    stack->top = NULL;
    stack->min = __INT_MAX__;
    return stack;
}

void minStackPush(MinStack* obj, int val)
{
    MinStackNode* newNode = (MinStackNode*)malloc(sizeof(MinStackNode));
    newNode->val = val;
    newNode->next = obj->top;
    obj->top = newNode;
    if (val < obj->min)
        obj->min = val;
}

void minStackPop(MinStack* obj)
{
    if (obj->top == NULL)
        return;
    MinStackNode* temp = obj->top;
    obj->top = obj->top->next;
    if (temp->val == obj->min) {
        // Recalculate min if necessary
        MinStackNode* current = obj->top;
        obj->min = __INT_MAX__;
        while (current != NULL) {
            if (current->val < obj->min)
                obj->min = current->val;
            current = current->next;
        }
    }
    free(temp);
}

int minStackTop(MinStack* obj)
{
    if (obj->top == NULL)
        return -1; // Stack is empty
    return obj->top->val;
}

int minStackGetMin(MinStack* obj)
{
    return obj->min;
}
```

```
void minStackFree(MinStack* obj)
{
    while (obj->top != NULL) {
        MinStackNode* temp = obj->top;
        obj->top = obj->top->next;
        free(temp);
    }
    free(obj);
}

int main(int argc, char *argv[])
{
    // Test your MinStack implementation here
    MinStack* obj = minStackCreate();

    minStackPush(obj, -2);
    minStackPush(obj, 0);
    minStackPush(obj, -3);
    printf("getMin: %d\n", minStackGetMin(obj)); // return -3
    minStackPop(obj);
    printf("top: %d\n", minStackTop(obj));       // return 0
    printf("getMin: %d\n", minStackGetMin(obj)); // return -2
    minStackFree(obj);
    return 0;
}
```

Output:



Output

```
[null,null,null,null,-3,null,0,-2]
```

Expected

```
[null,null,null,null,-3,null,0,-2]
```

Lab Program 3:

3a) Write a program 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.

Code:

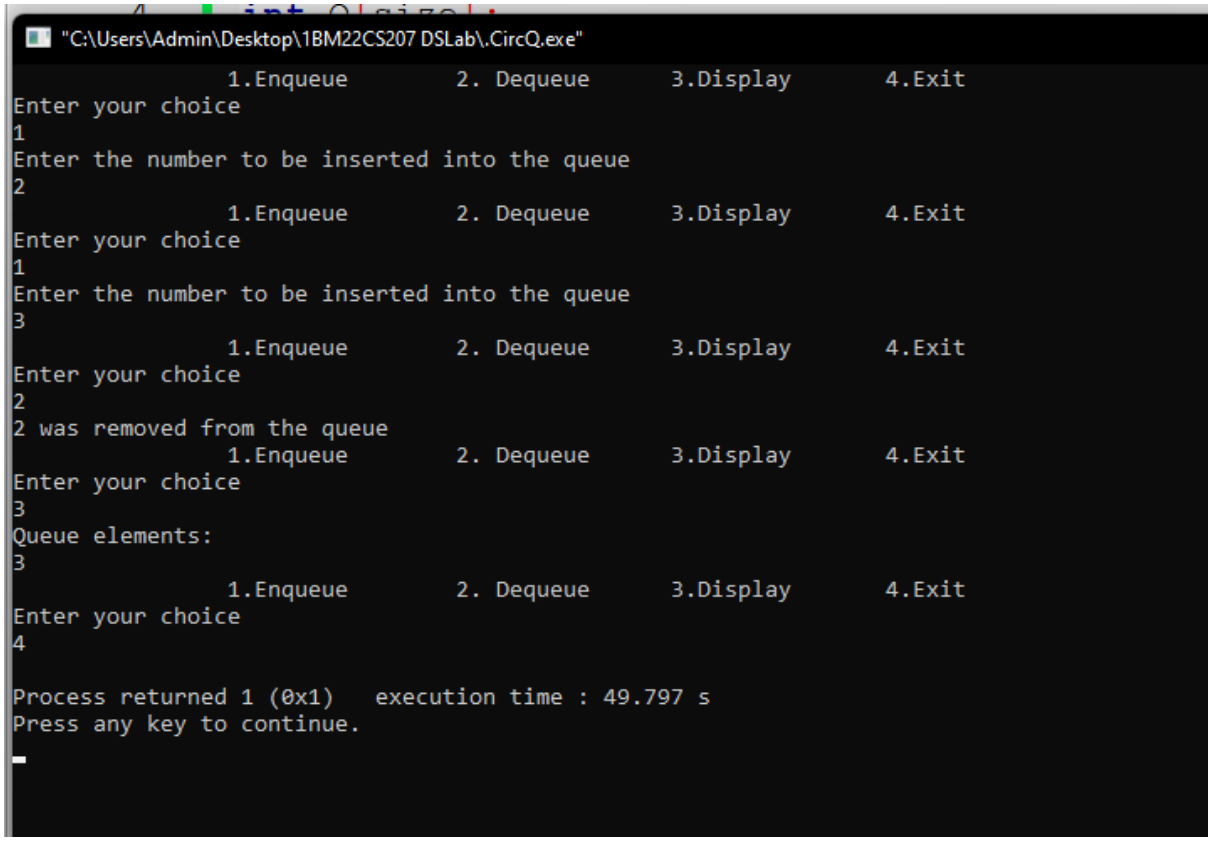
```
#include<stdio.h>
#include<stdlib.h>
#define size 3
int Q[size];
int rear=-1;
int front=-1;
int IsFull()
{
   if(front==(rear+1)%size)
   {
      return 0;
   }
   else
   {
      return -1;
   }
}
int IsEmpty()
{
   if(front==-1 && rear==-1)
   {
      return 0;
   }
   else
```

```
    {
        return -1;
    }
}
void Enqueue(int x)
{
    int item;
    if(IsFull()==0)
    {
        printf("Queue overflow \n");
        return;
    }
    else
    {
        if(IsEmpty()==0)
        {
            front=0;
            rear=0;
        }
        else
        {
          rear=(rear+1)%size;
        }
        Q[rear]=x;
    }
}
int Dequeue()
{
    int x;
    if(IsEmpty()==0)
    {
        printf("Queue underflow \n");
    }
    else
    {
        if(front==rear)
        {
            x=Q[front];
            front=-1;
            rear=-1;
```

```
        }
        else
        {
            x=Q[front];
            front=(front+1)%size;
        }
        return x;
    }
}
void Display()
{
    int i;
    if(IsEmpty()==0)
    {
        printf("Queue is empty \n");
    }
    else
    {
        printf("Queue elements:\n");
        for(i=front; i!=rear; i=(i+1)%size)
        {
            printf("%d \n",Q[i]);
        }
        printf("%d \n",Q[i]);
    }
}
void main()
{
    int choice,x,b;
    while(1)
    {
        printf("1.Enqueue, 2.Dequeue, 3.Display, 4.exit \n");
        printf("Enter your choice:");
        scanf("%d", &choice);
        switch(choice)
        {
        case 1:
            printf("Enter the number to be inserted \n");
            scanf("%d", &x);
            Enqueue(x);
```

```
            break;
        case 2:
            b=Dequeue();
            printf("%d was removed from the queue \n",b);
            break;
        case 3:
            Display();
            break;
        case 4:
            exit(1);
        default:
            printf("Invalid choice \n");

        }
    }
}
```

Output:



3b) Write a program to simulate the working of a circular queue of integers using an array. Provide the following operations: Insert, Delete and Display. The program should print appropriate messages for queue empty and queue overflow conditions.

Code:

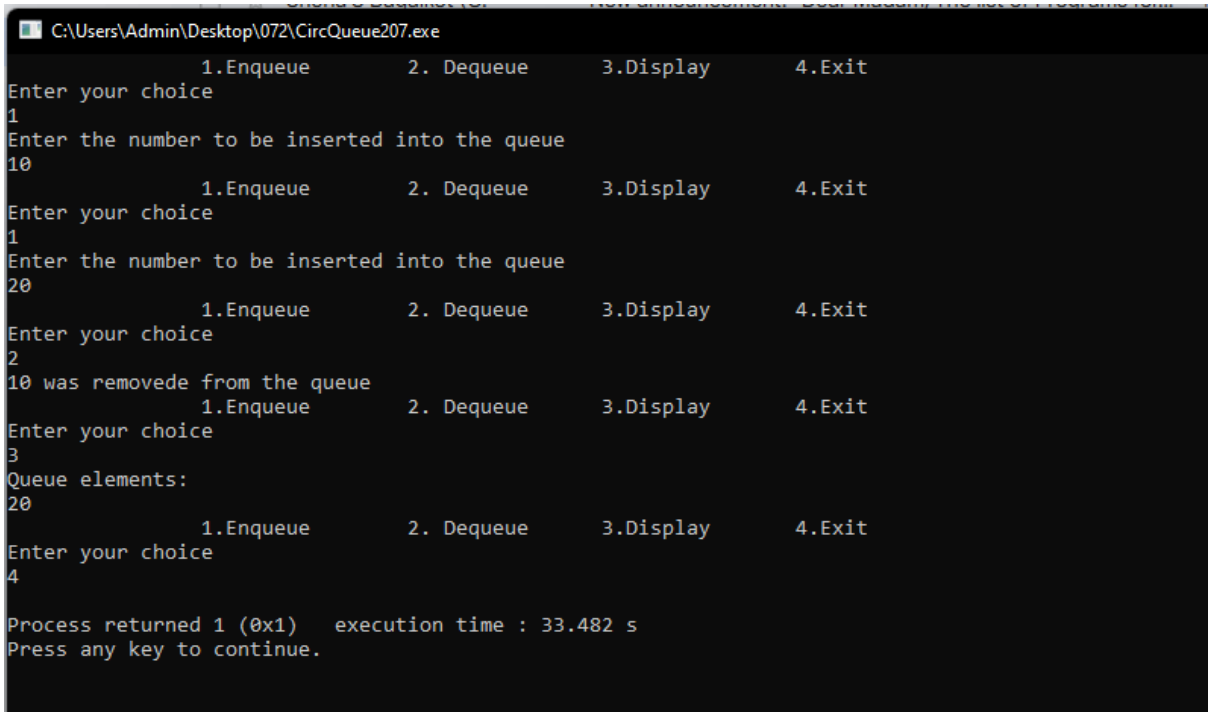
```
#include <stdio.h>
#include <stdlib.h>
#define size 50
int Q[size];
int rear=-1;
int front=-1;
int IsFull()
{
   if(front==(rear+1)%size)
   {
      return 0;
   }
   else
   {
      return -1;
   }
}
int IsEmpty()
{
   if(front==-1&&rear==-1)
   {
      return 0;
   }
   else
   {
      return -1;
   }
}
void Enqueue(int x)
{
   int item;
   if(IsFull()==0)
   {
```

```
        printf("Queue Overflow\n");
    }
    else
    {
        if(IsEmpty()==0)
        {
            front=0;
            rear=0;
        }
        else
        {
            rear=(rear+1)%size;
        }
        Q[rear]=x;
    }
}
int Dequeue()
{
    int x;
    if(IsEmpty()==0)
    {
        printf("Queue underflow\n");
    }
    else
    {
        if(front==rear)
        {
            x=Q[front];
            front=-1;
            rear=-1;
        }
        else
        {
            x=Q[front];
            front=(front+1)%size;
        }
        return x;
    }
}
void Display()
```

```
{
   int i;
   if(IsEmpty()==0)
   {
      printf("Queue is empty\n");
   }
   else
   {
      printf("Queue elements:\n");
      for(i=front;i!=rear;i=(i+1)%size)
      {
         printf("%d\n",Q[i]);
      }
      printf("%d \n",Q[i]);
   }
}
void main()
{
   int choice,x,b;
   while(1)
   {
      printf("\t\t1.Enqueue\t 2. Dequeue\t 3.Display\t 4.Exit\n");
      printf("Enter your choice\n");
      scanf("%d",&choice);
      switch(choice)
      {
      case 1:
         printf("Enter the number to be inserted into the queue\n");
         scanf("%d",&x);
         Enqueue(x);
         break;
      case 2:
         b=Dequeue();
         printf("%d was removed from the queue\n",b);
         break;
      case 3:
         Display();
         break;
      case 4:
         exit(1);
```

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

Output:



Lab Program 4:

4a) Write a program 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.

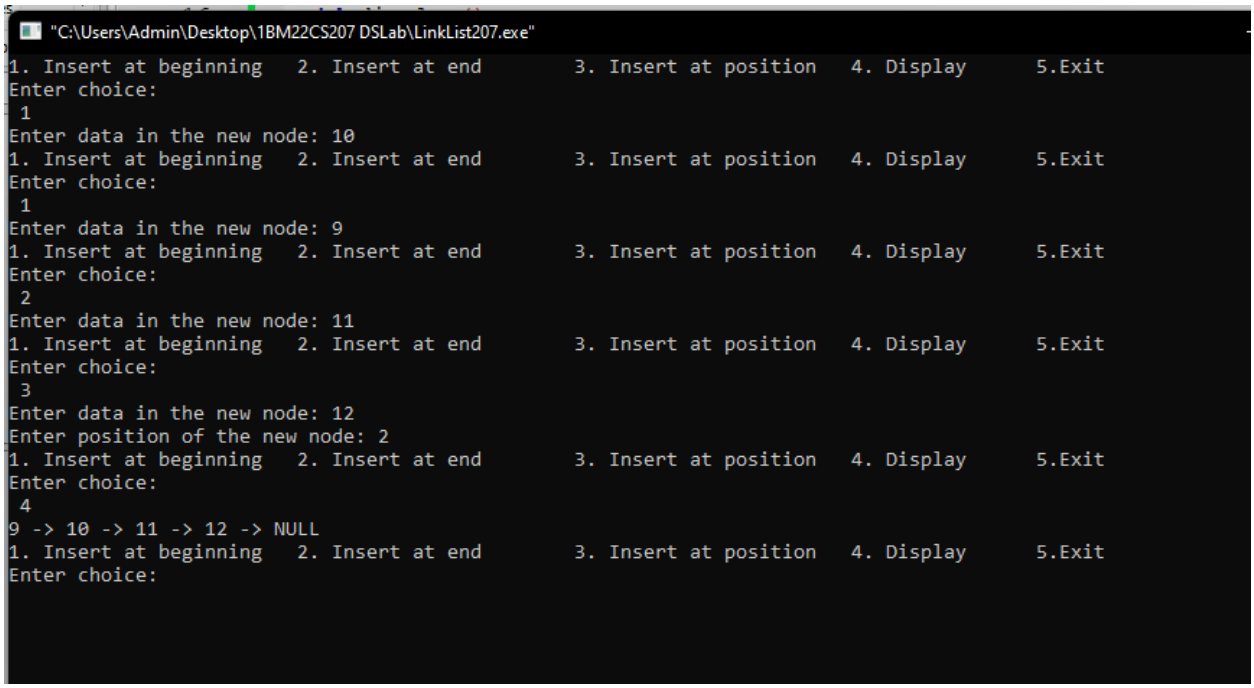
Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <conio.h>
typedef struct Node
 {
   int data;
   struct Node* next;
 } Node;
Node* head = NULL;
void push();
void append();
void insert();
void display();
void main()
{
   int choice;
   while (1) {
      printf("1. Insert at beginning\t 2. Insert at end\t 3. Insert at position\t 4. Display\t
5.Exit\t\n");
      printf("Enter choice: \n ");
      scanf("%d", &choice);
      switch (choice)
      {
         case 1:
            push();
            break;
         case 2:
            append();
            break;
         case 3:
            insert();
```

```
            break;
        case 4:
            display();
            break;
        default:
            printf("Exiting the program");
      }
   }
}

void push()
 {
   Node* temp = (Node*)malloc(sizeof(Node));
   int new_data;
   printf("Enter data in the new node: ");
   scanf("%d", &new_data);
   temp->data = new_data;
   temp->next = head;
   head = temp;
}

void append()
 {
   Node* temp = (Node*)malloc(sizeof(Node));
   int new_data;
   printf("Enter data in the new node: ");
   scanf("%d", &new_data);
   temp->data = new_data;
   temp->next = NULL;
   if (head == NULL) {
      head = temp;
      return;
   }
   Node* temp1 = head;
   while (temp1->next != NULL) {
      temp1 = temp1->next;
   }
   temp1->next = temp;
}
```

```
void insert() {
   Node* temp = (Node*)malloc(sizeof(Node));
   int new_data, pos;
   printf("Enter data in the new node: ");
   scanf("%d", &new_data);
   printf("Enter position of the new node: ");
   scanf("%d", &pos);
   temp->data = new_data;
   temp->next = NULL;
   if (pos == 0) {
      temp->next = head;
      head = temp;
      return;
   }
   Node* temp1 = head;
   while (pos--) {
      temp1 = temp1->next;
   }
   Node* temp2 = temp1->next;
   temp->next = temp2;
   temp1->next = temp;
}

void display()
{
   Node* temp1 = head;
   while (temp1 != NULL) {
      printf("%d -> ", temp1->data);
      temp1 = temp1->next;
   }
   printf("NULL\n");
}
```

Output:



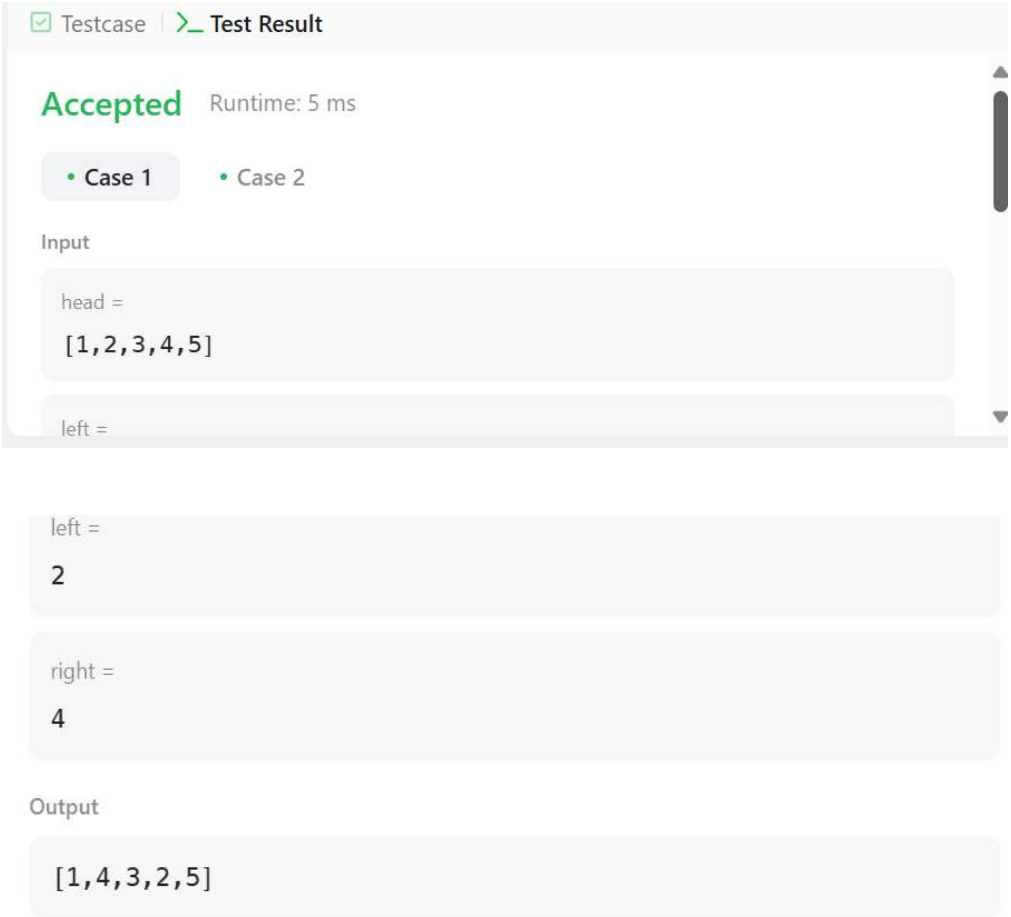
4b) Write a Leetcode program to reverse a Linked List.

Code:

```
struct ListNode* reverseBetween(struct ListNode* head, int left, int right)
{
    if (head == NULL || left == right) {
        return head;
    }
    struct ListNode* dummy = (struct ListNode*)malloc(sizeof(struct ListNode));
    dummy->next = head;
    struct ListNode* pre = dummy;
    // Move to the node just before the left position
    for (int i = 1; i < left; ++i)
   {
        pre = pre->next;
    }
    // Reverse the nodes from left to right
    struct ListNode* current = pre->next;
    struct ListNode* next = NULL;
```

```
    struct ListNode* prev = NULL;
    for (int i = 0; i <= right - left; ++i) {
        next = current->next;
        current->next = prev;
        prev = current;
        current = next;
    }
    // Connect the reversed portion back to the original list
    pre->next->next = current;
    pre->next = prev;
    struct ListNode* result = dummy->next;
    free(dummy);
    return result;
}
```

Output:



Lab Program 5:

5a) Write a program 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.

Code:

```
#include<stdio.h>
#include<stdlib.h>
struct node{
int data;
struct node*next;
};
void display();
void insert_begin();
void insert_end();
void insert_pos();
void begin_delete();
struct node *head=NULL;
void display()
{

   printf("elements are :\n");
        struct node *ptr;
        if(head==NULL)
        {
        printf("list is empty");
        return;



        }
```

```
        else{
        ptr=head;
        while(ptr !=NULL)
        {
        printf("%d\n", ptr->data);
        ptr=ptr->next;
        }
        }
}
void insert_begin()
{
        struct node*temp;
        temp =(struct node*)malloc(sizeof(struct node));
        printf("enter the value to be inserted\n");
        scanf("%d",&temp->data);
        temp->next=NULL;
        if(head==NULL)
        head=temp;
        else{
      temp->next=head;
        head=temp;
        }
}
void insert_end()
{
        struct node *temp,*ptr;
        temp=(struct node*)malloc(sizeof(struct node));
        printf("enter the value to be inserted \n");
        scanf("%d",&temp->data);
   temp->next=NULL;
        if(head==NULL)
        {
```

```
            head=temp;
            }
            else
            {
            ptr=head;
            while(ptr->next != NULL)
            {
            ptr=ptr->next;
            }
        ptr->next=temp;
            }
}
void insert_pos()
{

            int pos,i;
            struct node*temp,*ptr;
            printf("enter the position");
    scanf("%d",&pos);
            temp=(struct node*)malloc(sizeof(struct node));
            printf("enter the value to be inserted\n");
    scanf("%d",&temp->data);
    temp->next=NULL;
            if(pos==0)
            {

        temp->next=head;
            head=temp;

            }
            else
```

```
        {

        for(i=0, ptr=head; i<pos-1;i++)
        {

        ptr=ptr->next;
        }
    temp->next=ptr->next;
    ptr->next=temp;
        }
}

void begin_delete()
{
        struct node *ptr;
        if(head == NULL)
        {
    printf("\nList is empty\n");
        }
        else
        {
        ptr = head;
        head = ptr->next;
        free(ptr);
         printf("\nNode deleted from the begining ...\n");
        }
}

void last_delete()
{
        struct node *ptr,*ptr1;
        if(head == NULL)
```

```
        {
    printf("\nlist is empty");
        }
        else if(head -> next == NULL)
        {
        head = NULL;
        free(head);
    printf("\nOnly node of the list deleted ...\n");
        }
        else
        {
        ptr = head;
    while(ptr->next != NULL)
        {
        ptr1 = ptr;
        ptr = ptr ->next;
        }
        ptr1->next = NULL;
        free(ptr);
    printf("\nDeleted Node from the last ...\n");
        }
}

void random_delete()
{
        struct node *ptr,*ptr1;
        int loc,i;
        printf("\n Enter the location of the node after which you want to perform deletion \n");
        scanf("%d",&loc);
        ptr=head;
        for(i=0;i<loc;i++)
        {
```

```
        ptr1 = ptr;
        ptr = ptr->next;

        if(ptr == NULL)
        {
        printf("\nCan't delete");
        return;
        }
        }
        ptr1 ->next = ptr ->next;
        free(ptr);
        printf("\nDeleted node %d ",loc+1);
}

void main()
{
        int choice;
        while(1)
        {

        printf("\n 1.to insert at the beginning\n"
        " 2.to insert at the end\n "
          "3.to insert at the position\n "
          "4.to display\n "
          "5.delete from beginning\n"
          "6.delete from end\n"
          "7.random delete\n"
          "8.exit\n");
         printf("enter you choice:\n");
      scanf("%d",&choice);
        switch(choice)
        {
```

```
        case 1: insert_begin();
                break;
        case 2: insert_end();
                break;
        case 3: insert_pos();
                break;
        case 4: display();
                break;
        case 5: begin_delete();
                break;
        case 6: last_delete();
                break;
        case 7: random_delete();
                break;
        case 8: exit(0);
                break;
        default: printf("invalid choice\n");
                break;
        }
        }
}
```

Output:

```
 1.to insert at the beginning
 2.to insert at the end
 3.to insert at the position
 4.to display
 5.delete from beginning
6.delete from end
7.random delete
8.exit
enter you choice:
1
enter the value to be inserted
2

 1.to insert at the beginning
 2.to insert at the end
 3.to insert at the position
 4.to display
 5.delete from beginning
6.delete from end
7.random delete
8.exit
enter you choice:
1
enter the value to be inserted
3

 1.to insert at the beginning
 2.to insert at the end
 3.to insert at the position
 4.to display
 5.delete from beginning
6.delete from end
7.random delete
8.exit
enter you choice:
2
enter the value to be inserted
5

 1.to insert at the beginning
```

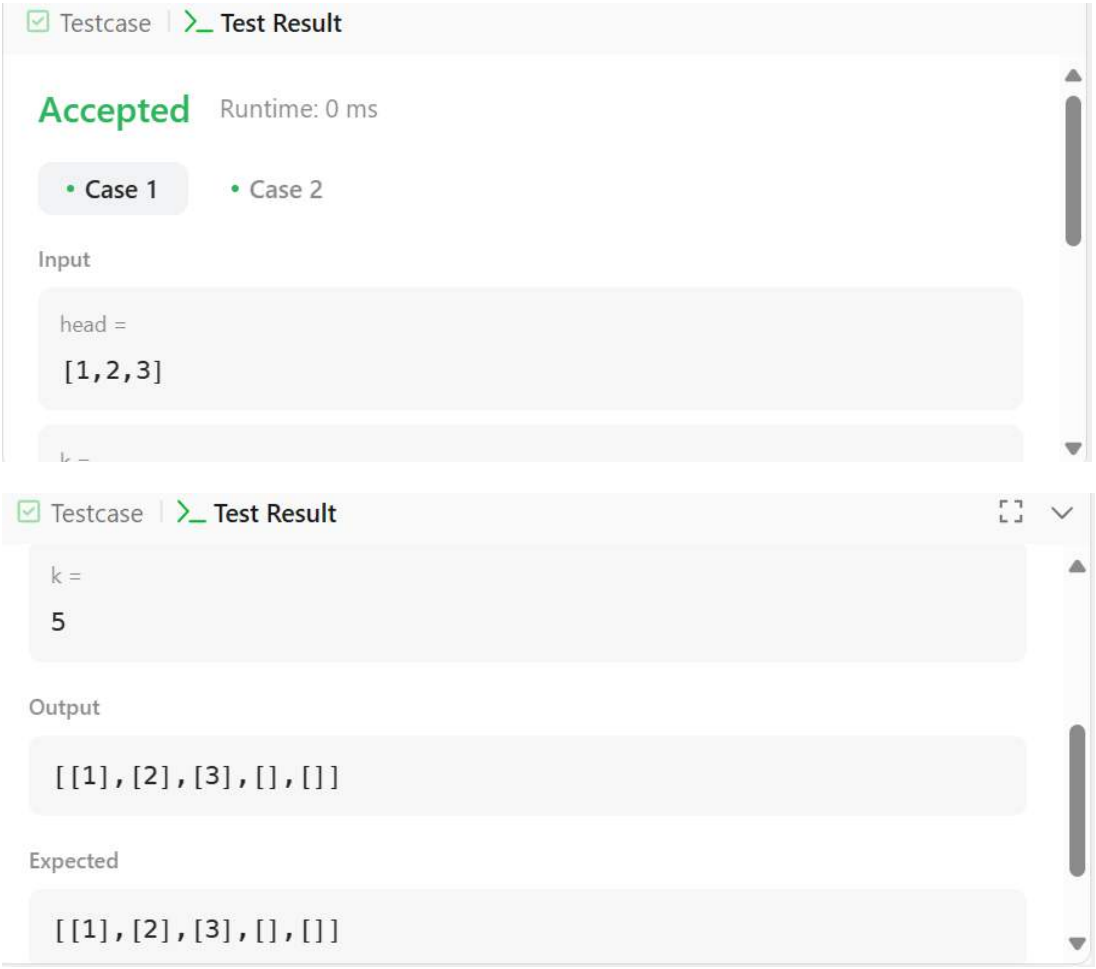
5b) Leetcode Program to split a Linked List into parts.

Code:

```
 int getLength(struct ListNode* head)
{
    int length = 0;
    while (head != NULL) {
        length++;
        head = head->next;
    }
```

```
    return length;
}


    struct ListNode** splitListToParts(struct ListNode* head, int k, int* returnSize)
{
    int length = getLength(head);
    int partSize = length / k;
    int remainder = length % k;

    struct ListNode** result = (struct ListNode**)malloc(k * sizeof(struct ListNode*));
    *returnSize = k;

    for (int i = 0; i < k; i++) {
        int currentPartSize = partSize + (i < remainder ? 1 : 0);

        if (currentPartSize == 0) {
            result[i] = NULL;
        } else {
            result[i] = head;
            for (int j = 0; j < currentPartSize - 1; j++) {
                head = head->next;
            }

            struct ListNode* temp = head->next;
            head->next = NULL;
            head = temp;
        }
    }

    return result;
}
```

Output:



Lab Program 6:

6a) Write a program to Implement Single Link List with following operations: Sort the linked list, Reverse the linked list, Concatenation of two linked lists.

Code:

```
 #include <stdio.h>
#include <stdlib.h>
struct Node {
        int data;
        struct Node* next;
};
```

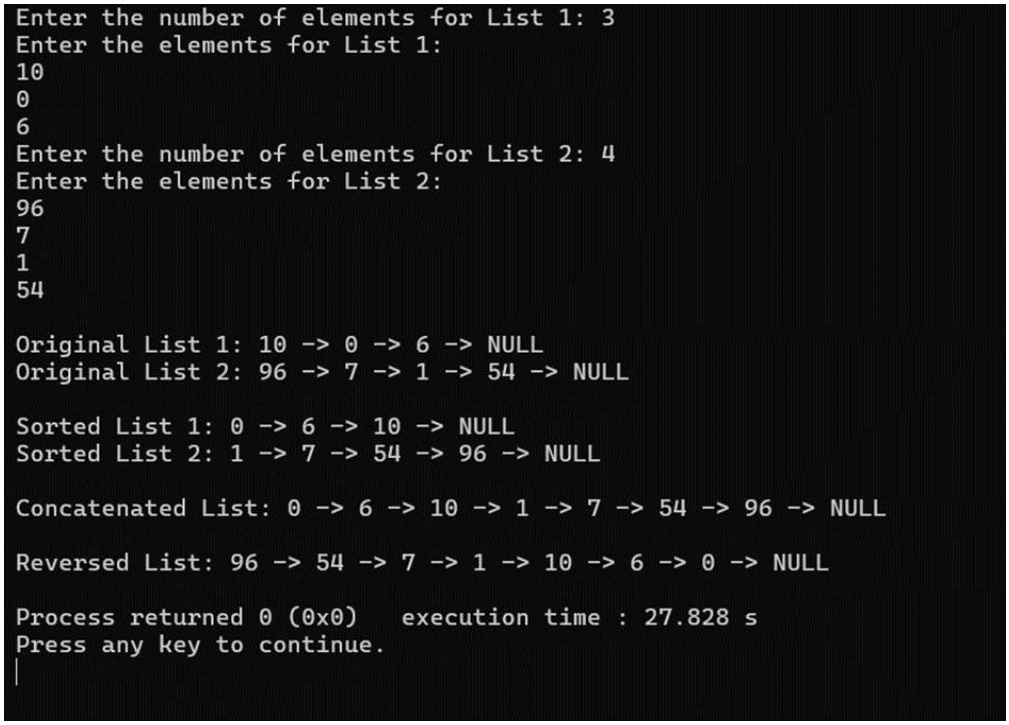
```
void append(struct Node** head_ref, int new_data)
{
        struct Node* new_node = (struct Node*)malloc(sizeof(struct Node));
        struct Node* last = *head_ref;
        new_node->data = new_data;
        new_node->next = NULL;
        if (*head_ref == NULL) {
        *head_ref = new_node;
        return;
        }
        while (last->next != NULL) {
        last = last->next;
        }
        last->next = new_node;
}

void printList(struct Node* node) {
        while (node != NULL) {
      printf("%d -> ", node->data);
        node = node->next;
        }
   printf("NULL\n");
}

void sortList(struct Node** head_ref)
{
        if (*head_ref == NULL) {
        return;
        }
        int swapped, temp;
        struct Node* ptr1;
```

```
        struct Node* lptr = NULL;
        do {
        swapped = 0;
        ptr1 = *head_ref;
        while (ptr1->next != lptr) {
        if (ptr1->data > ptr1->next->data) {
                temp = ptr1->data;
           ptr1->data = ptr1->next->data;
           ptr1->next->data = temp;
           swapped = 1;
        }
        ptr1 = ptr1->next;
        }
        lptr = ptr1;
        } while (swapped);
}

void reverseList(struct Node** head_ref) {
        struct Node* prev = NULL;
        struct Node* current = *head_ref;
        struct Node* next = NULL;
        while (current != NULL)
        {
        next = current->next;
        current->next = prev;
        prev = current;
        current = next;
        }
        *head_ref = prev;
}

void concatenateLists(struct Node** head1, struct Node* head2) {
```

```
        if (*head1 == NULL) {
        *head1 = head2;
        return;
        }

        struct Node* temp = *head1;
        while (temp->next != NULL) {
        temp = temp->next;
        }
        temp->next = head2;
}
int main() {
        struct Node* list1 = NULL;
        struct Node* list2 = NULL;
        int n, data;
        printf("Enter the number of elements for List 1: ");
        scanf("%d", &n);
        printf("Enter the elements for List 1:\n");
        for (int i = 0; i < n; ++i)
        {
                scanf("%d", &data);
                append(&list1, data);
        }
        printf("Enter the number of elements for List 2: ");
         scanf("%d", &n);
        printf("Enter the elements for List 2:\n");
        for (int i = 0; i < n; ++i)
        {
                scanf("%d", &data);
                append(&list2, data);
        }
   printf("\nOriginal List 1: ");
```

```
    printList(list1);
    printf("Original List 2: ");
    printList(list2);
    sortList(&list1);
    sortList(&list2);
    printf("\nSorted List 1: ");
    printList(list1);
    printf("Sorted List 2: ");
    printList(list2);
    concatenateLists(&list1, list2);
    printf("\nConcatenated List: ");
    printList(list1);
    reverseList(&list1);
    printf("\nReversed List: ");
    printList(list1);
    return 0;
}
```

Output:



6b) Write a program to implement Single Link List to simulate Stack and Queue Operations.

Code:

Stack using linked list:

```
#include <stdio.h>
#include <stdlib.h>
void push();
void pop();
void display();
struct node
{
int val;
struct node *next;
};
struct node *head;

void main ()
{
        int choice=0;
   printf("\nStack operations using linked list\n");
        while(choice != 4)
        {
      printf("\n\nChoose one from the below options...\n");
      printf("\n1.Push\n2.Pop\n3.Show\n4.Exit");
      printf("\n Enter your choice \n");
      scanf("%d",&choice);
      switch(choice)
        {
        case 1:
        {
           push();
                break;
        }
        case 2:
        {
```

```
                pop();
                break;
        }
        case 3:
        {
           display();
                break;
        }
        case 4:
        {
           printf("Exiting....");
                break;
        }
        default:
        {
           printf("Please Enter valid choice ");
        }
        };
}
}
void push ()
{
        int val;
        struct node *ptr = (struct node*)malloc(sizeof(struct node));
        if(ptr == NULL)
        {
      printf("Not able to push the element");
        }
        else
        {
      printf("Enter the value");
      scanf("%d",&val);
        if(head==NULL)
        {
        ptr->val = val;
        ptr -> next = NULL;
        head=ptr;
        }
        else
        {
```

```
            ptr->val = val;
            ptr->next = head;
            head=ptr;

            }
        printf("Item pushed");

            }
}

void pop()
{
            int item;
            struct node *ptr;
            if (head == NULL)
            {
        printf("Underflow");
            }
            else
            {
            item = head->val;
            ptr = head;
            head = head->next;
            free(ptr);
        printf("Item popped");

            }
}
void display()
{
            int i;
            struct node *ptr;
            ptr=head;
            if(ptr == NULL)
            {
        printf("Stack is empty\n");
            }
            else
            {
        printf("Printing Stack elements \n");
```

```
        while(ptr!=NULL)
            {
            printf("%d\n",ptr->val);
            ptr = ptr->next;
            }
            }
}
```

Output:

```
Stack operations using linked list


Chose one from the below options...

1.Push
2.Pop
3.Show
4.Exit
 Enter your choice
1
Enter the value23
Item pushed

Chose one from the below options...

1.Push
2.Pop
3.Show
4.Exit
 Enter your choice
1
Enter the value45
Item pushed

Chose one from the below options...

1.Push
2.Pop
3.Show
4.Exit
 Enter your choice
1
Enter the value75
Item pushed

Chose one from the below options...

1.Push
2.Pop
```

Queue using linked list:

```
#include<stdio.h>
#include<stdlib.h>
struct node
{
        int data;
        struct node *next;
};
struct node *front;
struct node *rear;
void insert();
void delete();
void display();
void main ()
{
        int choice;
        while(choice != 4)
        {
            printf("\nQueue operation using linked list\n");
            printf("\n1.insert an element\n2.Delete an element\n3.Display the
        queue\n4.Exit\n");
            printf("\nEnter your choice ");
            scanf("%d",& choice);
            switch(choice)
            {
               case 1: insert();
                       break;
               case 2: delete();
                       break;
               case 3: display();
                       break;
               case 4: exit(0);
                       break;
               default: printf("\nEnter valid choice??\n");
               }
        }
}
void insert()
{
```

```
        struct node *ptr;
        int item;

        ptr = (struct node *) malloc (sizeof(struct node));
        if(ptr == NULL)
        {
        printf("\nOVERFLOW\n");
        return;
        }
        else
        {
        printf("\nEnter value?\n");
        scanf("%d",&item);
        ptr -> data = item;
        if(front == NULL)
        {
        front = ptr;
        rear = ptr;
        front -> next = NULL;
        rear -> next = NULL;
        }
        else
        {
        rear -> next = ptr;
        rear = ptr;
        rear->next = NULL;
        }
        }
}
void delete ()
{
        struct node *ptr;
        if(front == NULL)
        {
        printf("\nUNDERFLOW\n");
        return;
        }
        else
        {
        ptr = front;
```

```
            front = front -> next;
            free(ptr);
            }
}
void display()
{
            struct node *ptr;
            ptr = front;
            if(front == NULL)
            {
        printf("\nEmpty queue\n");
            }
            else
            {   printf("\nprinting values .....\n");
            while(ptr != NULL)
            {
            printf("\n%d\n",ptr -> data);
            ptr = ptr -> next;
            }
            }
}
```

Output:

```
Queue operation using linked list

1.insert an element
2.Delete an element
3.Display the queue
4.Exit

Enter your choice 2

Queue operation using linked list

1.insert an element
2.Delete an element
3.Display the queue
4.Exit

Enter your choice 2

Queue operation using linked list

1.insert an element
2.Delete an element
3.Display the queue
4.Exit

Enter your choice 3

printing values .....

54

76

100

Queue operation using linked list

1.insert an element
2.Delete an element
3.Display the queue
4.Exit
```

Lab Program 7:

7a) Write a program 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.

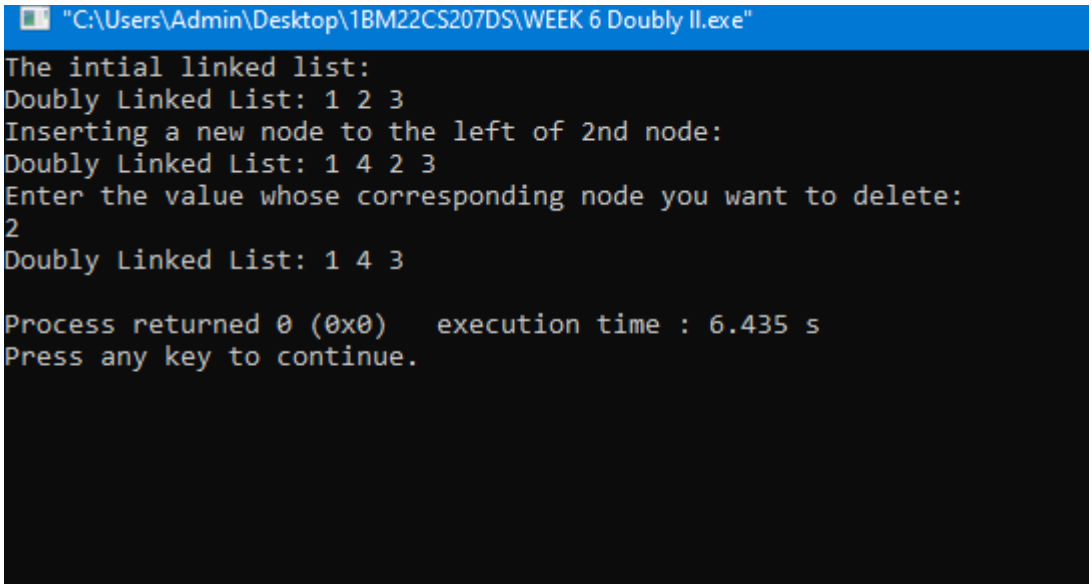
Code:

```
#include <stdio.h>
#include <stdlib.h>
struct Node
{
    int data;
    struct Node* prev;
    struct Node* next;
};

// Function to create a new node
struct Node* createNode(int value) {
    struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));
    if (newNode == NULL) {
        printf("Memory allocation failed!\n");
        exit(1);
    }
    newNode->data = value;
    newNode->prev = NULL;
    newNode->next = NULL;
    return newNode;
}

// Function to insert a new node to the left of the given node
void insertNodeToLeft(struct Node** head, struct Node* targetNode, int value)
{
    struct Node* newNode = createNode(value);
    if (targetNode->prev != NULL) {
```

```
        targetNode->prev->next = newNode;
        newNode->prev = targetNode->prev;
    }
    else
    {
        *head = newNode;
    }
    newNode->next = targetNode;
    targetNode->prev = newNode;
}

void deleteNodeByValue(struct Node** head, int value)
{
    struct Node* current = *head;
    while (current != NULL)
    {
        if (current->data == value)
        {
            if (current->prev != NULL)
            {
                current->prev->next = current->next;
            }
            else
            {
                *head = current->next;
            }
            if (current->next != NULL)
            {
                current->next->prev = current->prev;
            }
            free(current);
            return;
        }
        current = current->next;
    }
    printf("Node with value %d not found in the list.\n", value);
}
```

```
void displayList(struct Node* head)
{
      printf("Doubly Linked List: ");
      while (head != NULL)
   {
       printf("%d ", head->data);
       head = head->next;
   }
   printf("\n");
}
int main()
{
   struct Node* head = NULL;
   head = createNode(1);
   head->next = createNode(2);
   head->next->prev = head;
   head->next->next = createNode(3);
   head->next->next->prev = head->next;
   // Displaying the initial list
   printf("The intial linked list:\n");
   displayList(head);
   printf("Inserting a new node to the left of 2nd node:\n");
   insertNodeToLeft(&head, head->next, 4);
   displayList(head);
   int value;
   printf("Enter the value whose corresponding node you want to delete:\n");
   scanf("%d",&value);
   deleteNodeByValue(&head,value);
   displayList(head);
   return 0;
}
```

Output:



7b) Leetcode program to rotate a linked list.

Code:

```
struct ListNode* rotateRight(struct ListNode* head, int k)
{
    struct ListNode *temp = head;
    if (head == NULL) return NULL;
    if (head->next == NULL) return head;
    if (k == 0) return head;
    int size = 1;
    for(; temp->next != NULL; temp=temp->next, size++);
    k %= size;
    if (k == 0) return head;
    temp->next = head;
    struct ListNode *temp1 = head;
    for(int i = 0; i < (size-k-1); temp1 = temp1->next, i++);
    head = temp1->next;
    temp1->next = NULL;
    return head;
}
```

Output:

Lab Program 8:

8a) 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.

Code:

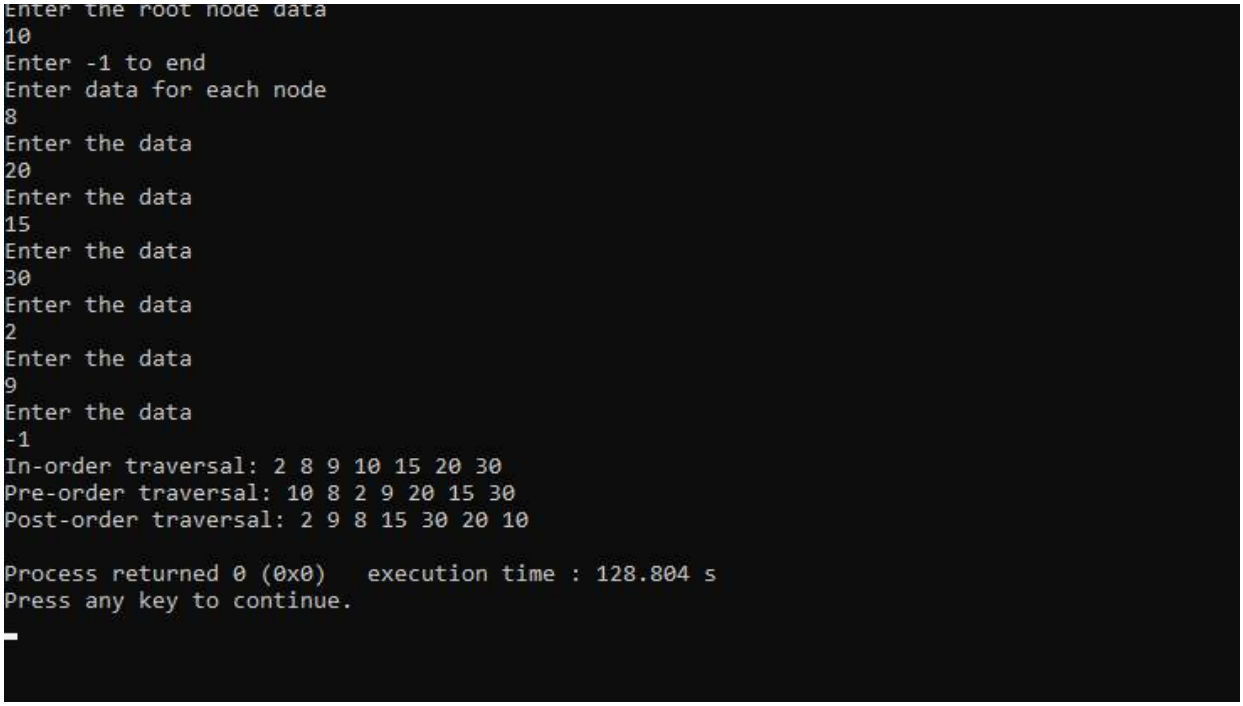
```
#include <stdio.h>
#include <stdlib.h>
struct TreeNode {
    int data;
    struct TreeNode* left;
    struct TreeNode* right;
};
struct TreeNode* createNode(int data)
{
```

```
    struct TreeNode* newNode = (struct TreeNode*)malloc(sizeof(struct TreeNode));
    newNode->data = data;
    newNode->left = NULL;
    newNode->right = NULL;
    return newNode;
}

struct TreeNode* insert(struct TreeNode* root, int data)
{
    if (root == NULL)
        return createNode(data);

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

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

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

void postorderTraversal(struct TreeNode* root)
```

```
{
   if (root != NULL)
   {
       postorderTraversal(root->left);
       postorderTraversal(root->right);
       printf("%d ", root->data);
    }
}

void display(struct TreeNode* root)
{
   printf("In-order traversal: ");
   inorderTraversal(root);
   printf("\nPre-order traversal: ");
   preorderTraversal(root);
   printf("\nPost-order traversal: ");
   postorderTraversal(root);
   printf("\n");
}

int main()
{
   struct TreeNode* root = NULL;
   int num_root;
   int num;
   // Constructing the binary search tree
   printf("Enter the root node data\n");
   scanf("%d",&num_root);
   root = insert(root, num_root);
   printf("Enter -1 to end\n");
   printf("Enter data for each node\n");
   scanf("%d",&num);
   while(num!=-1)
   {
      insert(root,num);
      printf("Enter the data\n");
      scanf("%d",&num);
   }
   // Displaying the elements in the binary search tree
   display(root);
```

```
    return 0;
}
```

Output:



8b) Hackerrank program to swap nodes of a binary search tree at a level.

Code:

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

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

Node* createNode(int data)
{
```

```
    Node* newNode = (Node*)malloc(sizeof(Node));
    newNode->data = data;
    newNode->left = NULL;
    newNode->right = NULL;
    return newNode;
}

void inOrderTraversal(Node* root, int* result, int* index)
{
    if (root == NULL) return;
    inOrderTraversal(root->left, result, index);
    result[(*index)++] = root->data;
    inOrderTraversal(root->right, result, index);
}

void swapAtLevel(Node* root, int k, int level)
{
    if (root == NULL) return;
    if (level % k == 0)
   {
        Node* temp = root->left;
        root->left = root->right;
        root->right = temp;
    }
    swapAtLevel(root->left, k, level + 1);
    swapAtLevel(root->right, k, level + 1);
}

int** swapNodes(int indexes_rows, int indexes_columns, int** indexes, int queries_count,
 int* queries, int* result_rows, int* result_columns)
{
    // Build the tree
    Node** nodes = (Node*)malloc((indexes_rows + 1) * sizeof(Node));
    for (int i = 1; i <= indexes_rows; i++)
   {
        nodes[i] = createNode(i);
    }

    for (int i = 0; i < indexes_rows; i++)
   {
```

```
        int leftIndex = indexes[i][0];
        int rightIndex = indexes[i][1];
        if (leftIndex != -1) nodes[i + 1]->left = nodes[leftIndex];
        if (rightIndex != -1) nodes[i + 1]->right = nodes[rightIndex];
    }

    // Perform swaps and store results
    int** result = (int*)malloc(queries_count * sizeof(int));
    *result_rows = queries_count;
    *result_columns = indexes_rows;
     for (int i = 0; i < queries_count; i++)
    {
        swapAtLevel(nodes[1], queries[i], 1);
        int* traversalResult = (int*)malloc(indexes_rows * sizeof(int));
        int index = 0;
        inOrderTraversal(nodes[1], traversalResult, &index);
        result[i] = traversalResult;
    }

    free(nodes);
    return result;
}

int main()
{
            int n;
            scanf("%d", &n);
            int** indexes = malloc(n * sizeof(int*));
            for (int i = 0; i < n; i++)
            {
                indexes[i] = malloc(2 * sizeof(int));
                scanf("%d %d", &indexes[i][0], &indexes[i][1]);
            }
            int queries_count;
            scanf("%d", &queries_count);

            int* queries = malloc(queries_count * sizeof(int));
            for (int i = 0; i < queries_count; i++)
            {
                scanf("%d", &queries[i]);
```

```
    }
    int result_rows;
    int result_columns;
    int** result = swapNodes(n, 2, indexes, queries_count, queries, &result_rows,
    &result_columns);

    for (int i = 0; i < result_rows; i++)
    {
        for (int j = 0; j < result_columns; j++)
       {
            printf("%d ", result[i][j]);
        }
        printf("\n");
        free(result[i]); // Free memory allocated for each row
    }
    free(result); // Free memory allocated for the result array

    // Free memory allocated for indexes and queries arrays
    for (int i = 0; i < n; i++) {
        free(indexes[i]);
    }
    free(indexes);
    free(queries);
    return 0;
}
```

Output:

Lab Program 9:

9a) Write a program to traverse a graph using BFS method.

Code:

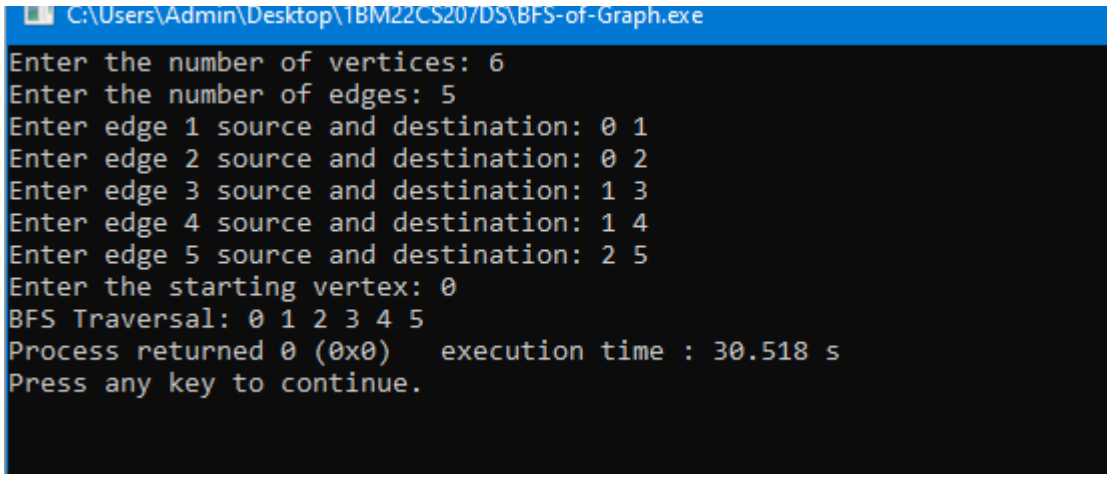
```
#include <stdio.h>
#include <stdbool.h>
#define MAX_SIZE 100
struct Queue {
    int items[MAX_SIZE];
    int front;
    int rear;
};

// Graph structure
struct Graph
{
```

```
    int vertices;
    bool adjMatrix[MAX_SIZE][MAX_SIZE];
};
struct Queue* createQueue()
{
    struct Queue* queue = (struct Queue*)malloc(sizeof(struct Queue));
    queue->front = -1;
    queue->rear = -1;
    return queue;
}

bool isEmpty(struct Queue* queue)
{
    if (queue->rear == -1)
        return true;
    else
        return false;
}

void enqueue(struct Queue* queue, int value)
{
    if (queue->rear == MAX_SIZE - 1)
        printf("\nQueue is full!");
    else
   {
        if (queue->front == -1)
            queue->front = 0;
        queue->rear++;
        queue->items[queue->rear] = value;
    }
}

int dequeue(struct Queue* queue)
{
    int item;
    if (isEmpty(queue))
    {
        printf("\nQueue is empty!");
        item = -1;
    }
```

```
    else
    {
        item = queue->items[queue->front];
        queue->front++;
        if (queue->front > queue->rear)
        {
            queue->front = queue->rear = -1;
        }
    }
    return item;
}

void createGraph(struct Graph* graph, int vertices)
{
    graph->vertices = vertices;
    for (int i = 0; i < vertices; i++)
    {
        for (int j = 0; j < vertices; j++)
        {
            graph->adjMatrix[i][j] = false;
        }
    }
}

void addEdge(struct Graph* graph, int src, int dest)
{
    graph->adjMatrix[src][dest] = true;
    graph->adjMatrix[dest][src] = true;
}

// Function to perform BFS traversal
void BFS(struct Graph* graph, int startVertex)
{
    bool visited[MAX_SIZE] = {false};
    struct Queue* queue = createQueue();
    visited[startVertex] = true;
    enqueue(queue, startVertex);
    while (!isEmpty(queue))
   {
        int currentVertex = dequeue(queue);
```

```
        printf("%d ", currentVertex);

        for (int i = 0; i < graph->vertices; i++)
        {
            if (graph->adjMatrix[currentVertex][i] && !visited[i])
            {
                visited[i] = true;
                enqueue(queue, i);
            }
        }
    }
}


int main()
{
    struct Graph graph;
    int vertices, edges, startVertex;
    printf("Enter the number of vertices: ");
    scanf("%d", &vertices);
    createGraph(&graph, vertices);
    printf("Enter the number of edges: ");
    scanf("%d", &edges);
    for (int i = 0; i < edges; i++)
    {
        int src, dest;
        printf("Enter edge %d source and destination: ", i+1);
        scanf("%d %d", &src, &dest);
        addEdge(&graph, src, dest);
    }

    printf("Enter the starting vertex: ");
    scanf("%d", &startVertex);
    printf("BFS Traversal: ");
    BFS(&graph, startVertex);
    return 0;
}
```

Output:



9b) Write a program to check whether given graph is connected or not using DFS method.

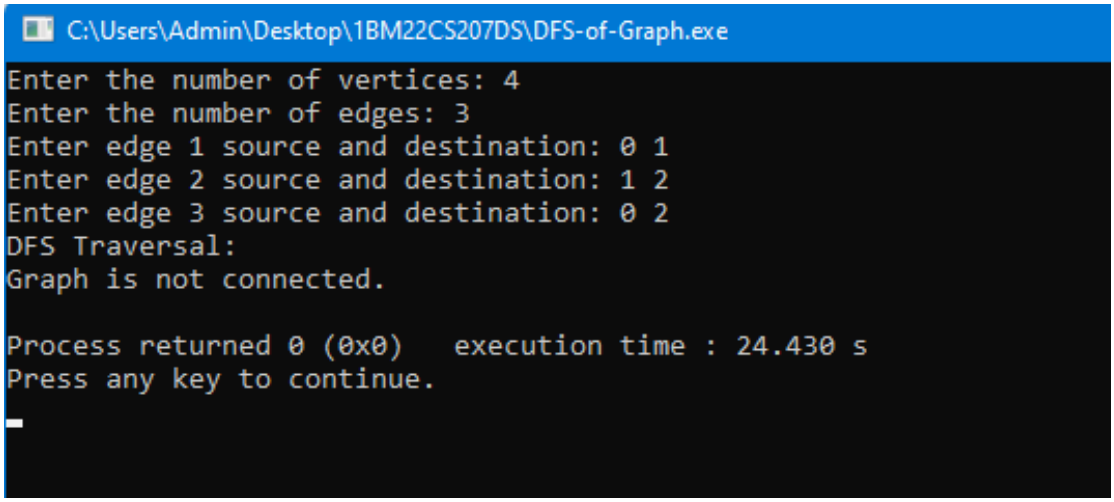
Code:

```
#include <stdio.h>
#include <stdbool.h>
#define MAX_SIZE 100

// Graph structure
struct Graph {
   int vertices;
   bool adjMatrix[MAX_SIZE][MAX_SIZE];
   bool visited[MAX_SIZE];
};

void createGraph(struct Graph* graph, int vertices)
{
    graph->vertices = vertices;

    for (int i = 0; i < vertices; i++)
    {
      graph->visited[i] = false;
      for (int j = 0; j < vertices; j++)
      {
          graph->adjMatrix[i][j] = false;
       }
   }
}
```

```
void addEdge(struct Graph* graph, int src, int dest)
{
   graph->adjMatrix[src][dest] = true;
   graph->adjMatrix[dest][src] = true;
}

// Function to perform DFS traversal
void DFS(struct Graph* graph, int vertex, int* count)
{
    (*count)++;
    graph->visited[vertex] = true;
    for (int i = 0; i < graph->vertices; i++)
   {
        if (graph->adjMatrix[vertex][i] && !graph->visited[i])
       {
           DFS(graph, i, count);
       }
   }
}

int main()
{
              struct Graph graph;
              int vertices, edges;
              printf("Enter the number of vertices: ");
              scanf("%d", &vertices);
              createGraph(&graph, vertices);
              printf("Enter the number of edges: ");
              scanf("%d", &edges);

              for (int i = 0; i < edges; i++)
              {
                  int src, dest;
                  printf("Enter edge %d source and destination: ", i+1);
                  scanf("%d %d", &src, &dest);
                  addEdge(&graph, src, dest);
              }
              int count = 0;
              printf("DFS Traversal: ");
              DFS(&graph, 0, &count); // Starting DFS from vertex 0
              if (count == vertices)
                  printf("\nGraph is connected.\n");
              else
                  printf("\nGraph is not connected.\n");
```

```
    return 0;
}
```

Output:



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.

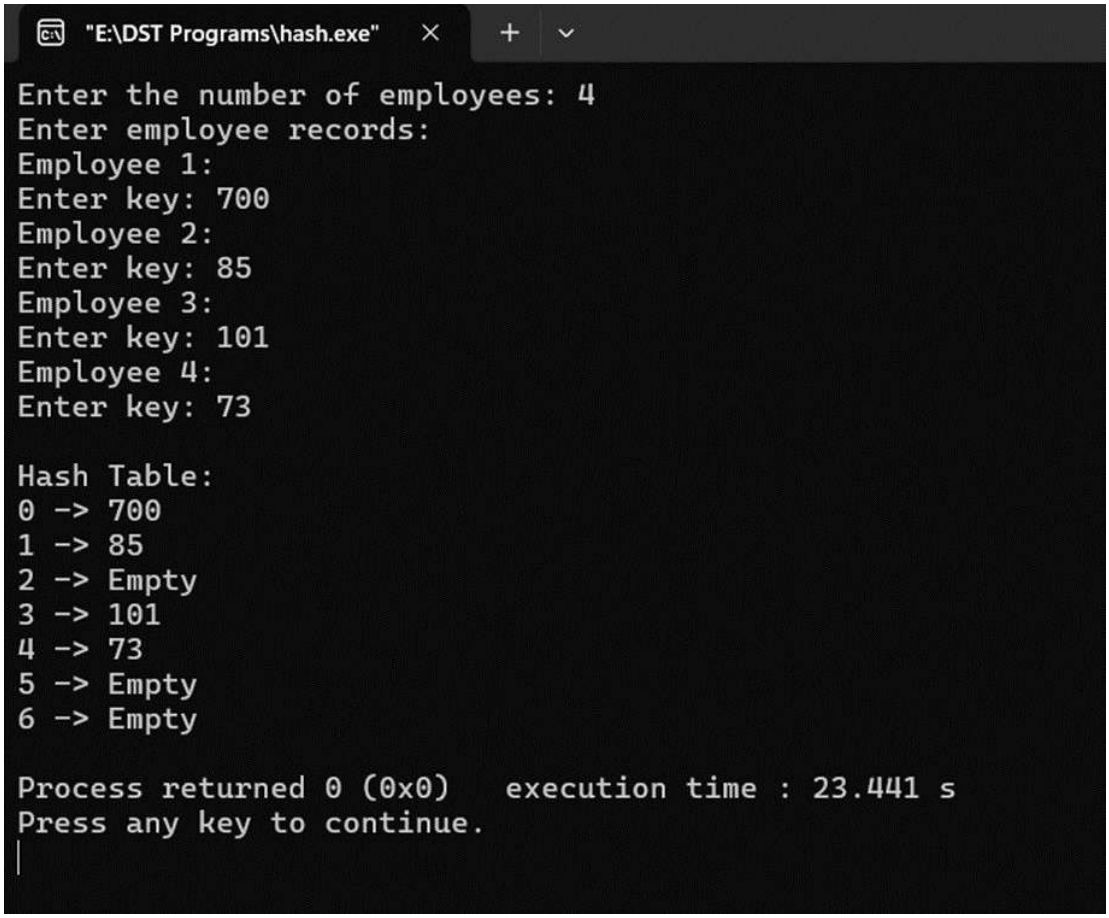
Code:

```
#include <stdio.h>
#include <stdlib.h>
#define MAX_EMPLOYEES 100 // Maximum number of employees
#define HASH_TABLE_SIZE 7 // Size of the hash table

// Structure for employee record
struct Employee {
    int key; // 4-digit key
    // Other employee details can be added here
```

```
};

// Function prototypes
int hashFunction(int key);
void insertEmployee(struct Employee employees[], int hashTable[], struct Employee emp);
void displayHashTable(int hashTable[]);

int main()
{
	struct Employee employees[MAX_EMPLOYEES]; // Array to hold employee records
	int hashTable[HASH_TABLE_SIZE] = {0}; // Hash table initialized with 0
	int n, m, i;
	// Input the number of employees
	printf("Enter the number of employees: ");
	scanf("%d", &n);

	// Input employee records
	printf("Enter employee records:\n");
	for (i = 0; i < n; ++i)
	{
		printf("Employee %d:\n", i + 1);
		printf("Enter key: ");
		scanf("%d", &employees[i].key);
		// Additional details can be input here
		insertEmployee(employees, hashTable, employees[i]);
	 }

	// Display the hash table
	 printf("\nHash Table:\n");
	 displayHashTable(hashTable);
	return 0;
}

// Hash function: H(K) = K mod m
int hashFunction(int key)
{
	return key % HASH_TABLE_SIZE;
}

// Function to insert an employee into the hash table
```

```
void insertEmployee(struct Employee employees[], int hashTable[], struct Employee emp)
{
        int index = hashFunction(emp.key);
        // Linear probing to resolve collisions
        while (hashTable[index] != 0)
        {
                index = (index + 1) % HASH_TABLE_SIZE;
        }
        // Insert the employee key into the hash table
        hashTable[index] = emp.key;
}

// Function to display the hash table
void displayHashTable(int hashTable[])
{
        int i;
        for (i = 0; i < HASH_TABLE_SIZE; ++i) {
      printf("%d -> ", i);
        if (hashTable[i] == 0) {
        printf("Empty\n");
        } else {
        printf("%d\n", hashTable[i]);
        }
        }
}
```

Output:


"E:\DST Programs\hash.exe"
Enter the number of employees: 4
Enter employee records:
Employee 1:
Enter key: 700
Employee 2:
Enter key: 85
Employee 3:
Enter key: 101
Employee 4:
Enter key: 73
Hash Table:
0 -> 700
1 -> 85
2 -> Empty
3 -> 101
4 -> 73
5 -> Empty
6 -> Empty
Process returned 0 (0x0) execution time : 23.441 s
Press any key to continue.