VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT
On

DATA STRUCTURES (23CS3PCDST)

Submitted by

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in partial fulfillment for the award of the degree of
BACHELOR OF ENGINEERING
in
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B.M.S. COLLEGE OF ENGINEERING
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(Affiliated To Visvesvaraya Technological University, Belgaum)
Department of Computer Science and Engineering

This is to certify that the Lab work entitled **"DATA STRUCTURES"** carried out by NAME **(USN)**, 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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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:

(a) Write a program to swap two numbers using pointers.

```
#include<stdio.h>
void swapping(int*x,int*y);
int main()
{
   int x,y;
   printf("Enter two numbers \n");
   scanf("%d%d",&x,&y);
   printf("The value of x and y before swapping is %d and%d\n",x,y);
   swapping(&x,&y);
   return 0;
}
void swapping(int*x,int*y)
{
   int temp=*x;
   *x=*y;
   *y=temp;
   printf("The value of x and y after swapping is %d and %d",*x,*y);
}
```

Output:

```
Enter two numbers
5 9
The value of x and y before swapping is 5 and9
The value of x and y after swapping is 9 and 5
```

(b) Write a program to demonstrate memory allocation and deallocation in C using malloc , calloc , realloc and free.

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

int main() {
   int *arr1, *arr2;
   int size;

   // Using malloc to allocate memory for an array
   printf("Enter the size of the array: ");
   scanf("%d", &size);

   arr1 = (int *)malloc(size * sizeof(int));
```

```
    if (arr1 == NULL) {
        printf("Memory allocation failed.\n");
        return 1;
    }

    printf("Memory allocated successfully using malloc.\n");

    // Using free to release the allocated memory
    free(arr1);
    printf("Memory freed using free.\n");

    // Using calloc to allocate and initialize memory for an array
    arr2 = (int *)calloc(size, sizeof(int));
    if (arr2 == NULL) {
        printf("Memory allocation failed.\n");
        return 1;
    }

    printf("Memory allocated and initialized to zero using calloc.\n");

    // Using realloc to resize the allocated memory
    int newSize;
    printf("Enter the new size for the array: ");
    scanf("%d", &newSize);

    arr2 = (int *)realloc(arr2, newSize * sizeof(int));
    if (arr2 == NULL) {
        printf("Memory reallocation failed.\n");
        return 1;
    }

    printf("Memory reallocated successfully using realloc.\n");

    // Using free to release the reallocated memory
    free(arr2);
    printf("Memory freed after reallocation using free.\n");

    return 0;
}
```

Output:

```
Enter the size of the array: 3
Memory allocated successfully using malloc.
Memory freed using free.
Memory allocated and initialized to zero using calloc.
Enter the new size for the array: 6
Memory reallocated successfully using realloc.
Memory freed after reallocation using free.
```

(c)Write a program to simulate the working of stack using an array with the following Push , Pop & Display

```
#include <stdio.h>
#include <stdlib.h>
#define SIZE 4
int top = -1;
int inp_array[SIZE];
void push();
void pop();
void show();

void main()
{
   int ch;
   while (1)
   {
      printf("Operations on the stack:\n");
      printf("1.Push the element\n2.Pop the element\n3.Show\n4.End\n");
      printf("Enter the choice:\n ");
      scanf("%d",&ch);

      switch (ch)
      {
      case 1:
         push();
         break;
      case 2:
         pop();
         break;
      case 3:
         show();
         break;
      case 4:
         exit(0);
```

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

void push()
{
    int x;
    if (top == SIZE - 1)
    {
        printf("Overflow\n");
    }
    else
    {
        printf("Enter the element to be added in the stack:\n ");
        scanf("%d", &x);
        top = top + 1;
        inp_array[top] = x;
    }
}
void pop()
{
    if (top == -1)
    {
        printf("Underflow\n");
    }
    else
    {
        printf("Popped element: %d\n", inp_array[top]);
        top = top - 1;
    }
}
void show()
{
    if (top == -1)
    {
        printf("Underflow\n");
    }
    else
    {
        int i;
        printf("Elements in the stack are: \n");
        for (i = top; i >= 0; --i)
            printf("%d\n", inp_array[i]);
    }
}
```

Output:

```
Operations on the stack:
1.Push the element
2.Pop the element
3.Show
4.End
Enter the choice:
1
Enter the element to be added in the stack:
 20
 Operations on the stack:
1.Push the element
2.Pop the element
3.Show
4.End
Enter the choice:
 1
 Enter the element to be added in the stack:
 24
 Operations on the stack:
1.Push the element
2.Pop the element
3.Show
4.End
Enter the choice:
 1
 Enter the element to be added in the stack:
 45
 Operations on the stack:
1.Push the element
2.Pop the element
3.Show
4.End
Enter the choice:
 2
 Popped element: 45
Operations on the stack:
1.Push the element
2.Pop the element
3.Show
4.End
Enter the choice:
 3
 Elements in the stack are:
24
20
Operations on the stack:
1.Push the element
2.Pop the element
3.Show
4.End
Enter the choice:
 4
```

Lab program 2:

(a) Write a program to converts an infix expression to a postfix expression using a stack.

```
#include <stdio.h>
#include <ctype.h>
#define SIZE 50

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

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

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

int pr(char symbol) {
   if (symbol == '^') {
      return (3);
   } else if (symbol == '*' || symbol == '/') {
      return (2);
   } else if (symbol == '+' || symbol == '-') {
      return (1);
   } else {
      return (0);
   }
}

int main() {
   char infix[50], postfix[50], ch, ele;
   int i = 0, k = 0;

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

   push('#');

   while ((ch = infix[i++]) != '\0') {
      if (ch == '(')
         push(ch);
      else if (isalnum(ch))
         postfix[k++] = ch;
      else if (ch == ')') {
         while (stack[top] != '(')
            postfix[k++] = pop();
         ele = pop();
```

```
        } else {
            while (pr(stack[top]) >= pr(ch))
                postfix[k++] = pop();
            push(ch);
        }
    }

    while (stack[top] != '#')
        postfix[k++] = pop();

    postfix[k] = '\0';
    printf("\nPostfix expression = %s\n", postfix);
    return 0;
}
```

Output:

```
Enter the infix expression:A*B+C*D-E
Postfix expression = AB*CD*+E-
```

(b) Write a program to evaluates a postfix expression using a stack.

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

#define MAX_SIZE 100

// Stack structure
struct Stack {
    int top;
    int items[MAX_SIZE];
};

// Function prototypes
void initialize(struct Stack *s);
void push(struct Stack *s, int value);
int pop(struct Stack *s);
int isOperator(char ch);
int compute(char operator, int operand1, int operand2);
int evaluatePostfix(char postfixExpression[]);

int main() {
    char postfixExpression[MAX_SIZE];

    // Input the postfix expression
```

```
    printf("Enter a postfix expression: ");
    gets(postfixExpression);

    // Evaluate and print the result
    printf("Result: %d\n", evaluatePostfix(postfixExpression));

    return 0;
}

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

void push(struct Stack *s, int value) {
    if (s->top == MAX_SIZE - 1) {
        printf("Stack overflow\n");
        exit(EXIT_FAILURE);
    }
    s->items[++(s->top)] = value;
}

int pop(struct Stack *s) {
    if (s->top == -1) {
        printf("Stack underflow\n");
        exit(EXIT_FAILURE);
    }
    return s->items[(s->top)--];
}

int isOperator(char ch) {
    return (ch == '+' || ch == '-' || ch == '*' || ch == '/');
}

int compute(char operator, int operand1, int operand2) {
    switch (operator) {
    case '+':
        return operand1 + operand2;
    case '-':
        return operand1 - operand2;
    case '*':
        return operand1 * operand2;
    case '/':
        if (operand2 != 0) {
            return operand1 / operand2;
        } else {
            printf("Error: Division by zero\n");
            exit(EXIT_FAILURE);
        }
```

```
    default:
        printf("Error: Invalid operator\n");
        exit(EXIT_FAILURE);
    }
}

int evaluatePostfix(char postfixExpression[]) {
    struct Stack s;
    initialize(&s);

    for (int i = 0; postfixExpression[i] != '\0'; i++) {
        if (isdigit(postfixExpression[i])) {
            // Operand
            push(&s, postfixExpression[i] - '0');
        } else if (isOperator(postfixExpression[i])) {
            // Operator
            int op2 = pop(&s);
            int op1 = pop(&s);
            int result = compute(postfixExpression[i], op1, op2);
            push(&s, result);
        }
        // Ignore other characters
    }

    return pop(&s);
}
```

Output:

```
Enter a postfix expression: 52+83-*4/
Result: 8
```

Lab program 3:

(a) Write a program to simulate the working of a queue of integers using an array. Provide the following operations: Insert, Delete, Display.

```
#include<stdio.h>
#define size 30

int queue[size];
int front=-1;
int rear=-1;

void insert(int a)
{
   if(rear==size-1)
   {
      printf("Queue overflow\n");
      return;
   }
   else
   {
      if(front==-1)
         front=0;
      queue[++rear]=a;
   }
}

void delete()
{
   if(front==-1||front>rear)
   {
      printf("Queue Empty\n");
   }
   else
   {
      front++;
   }
}

void display()
{
   int i;
   if(front==-1)
   {
      printf("Queue Empty\n");
      return;
   }
   printf("Queue:");
   for(i=front;i<=rear;i++)
```

```
    {
        printf("%d ",queue[i]);
    }
}


void main()
{
    int choice;
    int a;
    while(1)
    {
        printf("\n1.Insert\n2.Delete\n3.Display\nChoice:");
        scanf("%d",&choice);

        switch (choice)
        {
        case 1:printf("Enter an element:");
               scanf("%d",&a);
               insert(a);
               display();
               break;

        case 2:delete();
               display();
               break;

        case 3:display();
               break;
        }
    }

}
```

Output:

```
1.Insert
2.Delete
3.Display
Choice:1
Enter an element:24
Queue:24
1.Insert
2.Delete
3.Display
```

```
Choice:1
Enter an element:57
Queue:24 57
1.Insert
2.Delete
3.Display
Choice:1
Enter an element:92
Queue:24 57 92
1.Insert
2.Delete
3.Display
Choice:2
Queue:57 92
1.Insert
2.Delete
3.Display
Choice:3
Queue:57 92
1.Insert
2.Delete
3.Display
Choice:
```

(b) Write a program to simulate the working of a circular queue of integers using an array. Provide the following operations: Insert, Delete & Display.

```
#include<stdio.h>
#define pf printf
#define sf scanf
#define MAX 100
int cq[MAX];
int front=-1,rear=-1;

void enqueue(){
   int data;
   pf("\nEnter the element:");
   sf("%d",&data);

   if(front==-1 && rear==-1){
      front=rear=0;
      cq[rear]=data;
```

```
    }
    else if((rear+1)%MAX==front)
        pf("\nQueue Overflow");
    else{
        rear=(rear+1)%MAX;
        cq[rear]=data;
    }
}
void dequeue()
{
    if(front==-1 && rear==-1){
        pf("\nQueue is empty");
    }
    else if(front==rear){
        front=rear=-1;
    }
    else{
        front=(front+1)%MAX;
    }
}

void display()
{
    int i=front;
    pf("\nThe circular queue is :\n");
    while(i!=rear){
        pf("\t%d",cq[i]);
        i=(i+1)%MAX;
    }
    pf("\t%d",cq[i]);
}
int main()
{
    int ch;
    while(1){
        pf("\n----Enter----\n1.Insertion\n2.Deletion\n3.Display\t");
        sf("%d",&ch);
        switch(ch){
            case 1: enqueue();
                    display();
                    break;
            case 2: dequeue();
                    display();
                    break;
            case 3: display();
                    return 0;

        }
```

```
    }
}
```

Output:

```
----Enter----
1.Insertion
2.Deletion
3.Display   1
Enter the element:22
The circular queue is :
    22
----Enter----
1.Insertion
2.Deletion
3.Display   1
Enter the element:56
The circular queue is :
    22  56
----Enter----
1.Insertion
2.Deletion
3.Display   1
Enter the element:72
The circular queue is :
    22  56  72
----Enter----
1.Insertion
2.Deletion
3.Display   2
The circular queue is :
    56  72
----Enter----
1.Insertion
2.Deletion
3.Display   3
The circular queue is :
    56  72
```

Lab program 4:

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.
c) Display the contents of the linked list.

```
#include<stdio.h>
#include<stdlib.h>
#define pf printf
#define sf scanf

struct node{
   int data;
   struct node *next;
};
struct node *head,*newnode,*temp,*last;


void push()
{
   newnode=(struct node *)malloc(sizeof(struct node));
   pf("Enter the data of the node to be inserted at the beginning:");
   sf("%d",&newnode->data);
   newnode->next=head;
   head=newnode;
   pf("\n---The element %d has been inserted at beg---",newnode->data);
   /*display*/
   pf("\nThe linked list you have created is: \n");
   temp=head;
   while(temp!=NULL)
   {

      pf("%d\t",temp->data);
      temp=temp->next;
   }


}
void append()
{
   newnode=(struct node *)malloc(sizeof(struct node));
   pf("Enter the data of the node 1:");
   sf("%d",&newnode->data);
   newnode->next=NULL;
   temp=head;
   while(temp->next!=NULL)
   {
      temp=temp->next;
```

```
    }
    temp->next=newnode;
    pf("\nThe element %d has been inserted at the end:",newnode->data);

    /*display*/

    pf("The linked list you have created is: \n");
    temp=head;
    while(temp!=NULL)
    {

        pf("%d\t",temp->data);
        temp=temp->next;
    }


}

void insert_pos()
{
    int pos, i=0;
    newnode=(struct node *)malloc(sizeof(struct node));
    pf("Enter the data of the node :");
    sf("%d",&newnode->data);
    pf("\nEnter the pos:");
    sf("%d",&pos);
    temp=last=head;

    for(i=0;i<pos;i++)
    {
        last=temp;
        temp=temp->next;
    }
    last->next=newnode;
    newnode->next=temp;

        pf("The linked list you have created is: \n");
    temp=head;
    while(temp!=NULL)
    {

        pf("%d\t",temp->data);
        temp=temp->next;
    }
}
void display()
{
     pf("The linked list you have created is: \n");
```

```
    temp=head;
    while(temp!=NULL)
    {

        pf("%d\t",temp->data);
        temp=temp->next;
    }
}
int main()
{

   int ch;
   while(1){
      pf("\n\nEnter your choice:\n1.Insert at begining \n2.Insert at End \n3.Insert at a pos
\n4.Display: ");
   sf("%d",&ch);
   switch(ch){
   case 1:
            push();
            break;
    case 2: append();
            break;
    case 3:
            insert_pos();

            break;
    case 4:
            display();
            return 0;
   }
}
```

Output:

```
1.Insert at begining
2.Insert at End
3.Insert at a pos
4.Display: 2
Enter the data of the appending node :6

The element 6 has been inserted at the end:The linked list you have created is:
2       4       6

Enter your choice:
1.Insert at begining
2.Insert at End
3.Insert at a pos
4.Display: 3
Enter the data of the node :0
```

```
Enter the pos:2
The linked list you have created is:
2       4       0       6

Enter your choice:
1.Insert at begining
2.Insert at End
3.Insert at a pos
4.Display: 4
The linked list you have created is:
2       4       0       6
--------------------------------
Process exited after 49.16 seconds with return value 0
Press any key to continue . . .
```

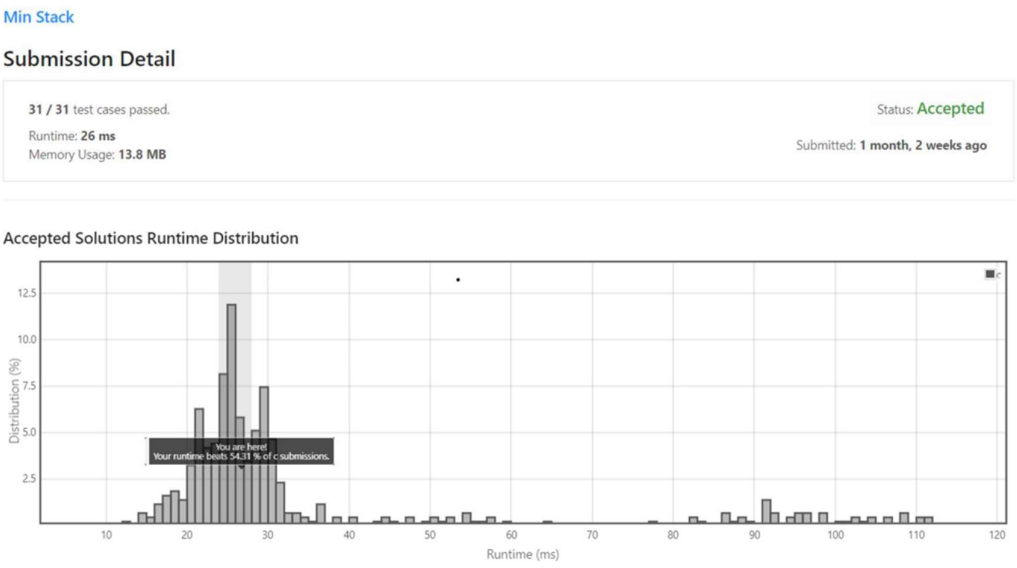
Leetcode Problem-1:

Min Stack Problem

```
#include<stdio.h>
#include<stdlib.h>
typedef struct
{
   int value;
   int min;
} StackNode;
typedef struct
{
   StackNode *array;
   int capacity;
   int top;
}MinStack;
MinStack* minStackCreate()
{
   MinStack* stack=(MinStack*)malloc(sizeof(MinStack));
   stack->capacity = 10;
   stack->array = (StackNode*)malloc(stack->capacity * sizeof(StackNode));
   stack->top = -1;
   return stack;
 }
void minStackPush(MinStack* obj, int val)
{
   if (obj->top == obj->capacity - 1)
   {
      obj->capacity *= 2;
      obj->array =(StackNode*)realloc(obj->array,obj->capacity*size(StackNode));
   }
   StackNode newNode;
```

```
    newNode.value = val;
    newNode.min = (obj->top == -1) ? val : (val < obj->array[obj->top].min) ? val : obj-
>array[obj->top].min;
    obj->array[++(obj->top)] = newNode;
}
void minStackPop(MinStack* obj)
{
    if (obj->top != -1)
    {
        obj->top--;
    }
}
int minStackTop(MinStack* obj)
{
    if (obj->top != -1)
    {
         return obj->array[obj->top].value;
    }
     return -1;
}
int minStackGetMin(MinStack* obj)
{
    if (obj->top != -1)
    {
        return obj->array[obj->top].min;
    }
    return -1;
}
void minStackFree(MinStack* obj)
{
    free(obj->array);
    free(obj);
}
```

Output:



Lab program 5:

1.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.

```
#include<stdio.h>
#include<stdlib.h>
#define pf printf
#define sf scanf

struct node{
   int data;
   struct node *next;
};
struct node *head,*newnode,*temp,*temp1;


void create()
{
   newnode=(struct node *)malloc(sizeof(struct node));
   pf("Enter the data of the node to be inserted at the beginning:");
   sf("%d",&newnode->data);
   newnode->next=head;
   head=newnode;
   pf("\n---The element %d has been inserted at beg---",newnode->data);
   /*display*/
   pf("\nThe linked list you have created is: \n");
   temp=head;
   while(temp!=NULL)
   {

      pf("%d\t",temp->data);
      temp=temp->next;
   }
}

void delete_at_beg(){
   temp=head;
   if(head==NULL){
      pf("\nThe linked list is empty");
   }
   else if(head->next==NULL)
   {
      head=NULL;
      pf("\nThe only node is deleted, the list is now empty")  ;
   }
   else{
```

```
        head=temp->next;
        free(temp);
    }
}
void delete_at_end()
{
        if(head==NULL)
    {
        pf("\nThe linked list is empty");
    }
    else if(head->next==NULL)
    {
        head=NULL;
        pf("\nThe only node is deleted, the list is now empty")  ;
    }
    else
        {
            temp=head;
        while(temp->next!=NULL)
        {
                temp1=temp;
                temp=temp->next;

        }
        temp1->next=NULL;
        free(temp);
}
}

void delete_atpos()
{
    temp=head;
    int pos,i;


    if(head==NULL){
        pf("\nThe linked list is empty");
    }
    else if(head->next==NULL)
    {
        head=NULL;
        pf("\nThe only node is deleted, the list is now empty");
    }
    else{
        pf("\nEnter the position of element to be deleted:");
        sf("%d",&pos);

    for(i=1;i<pos;i++)
    {
```

```
        temp1=temp;
        temp=temp->next;
        if(temp==NULL){
            pf("\nThere are less than %d elements in the list",pos);
            return 0;
            }
    }
    temp1->next=temp->next;
    free(temp);
    }

}

void display()
{
     pf("The linked list you have created is: \n");
    temp=head;
    while(temp!=NULL)
    {
        pf("%d\t",temp->data);
        temp=temp->next;
    }


}

int main()
{
    int ch;
    while(1)
    {
         pf("\n----Menu----\n 1.Create\n2.Delete_at_beg\n3.delete at end\n4.Delete at
pos\n5.Display: ");
        sf("%d",&ch);
    switch(ch)
    {
    case 1:create();
            break;
    case 2:delete_at_beg();
            break;
    case 3:delete_at_end();
            break;
    case 4:delete_atpos();
            break;
    case 5: display();
           return 0;
        }
    }
}
```

Output:

```
---The element 80 has been inserted at beg---
The linked list you have created is:
80      60      40      20
----Menu----
 1.Create
2.Delete_at_beg
3.delete at end
4.Delete at pos
5.Display: 2

----Menu----
 1.Create
2.Delete_at_beg
3.delete at end
4.Delete at pos
5.Display: 3

----Menu----
 1.Create
2.Delete_at_beg
3.delete at end
4.Delete at pos
5.Display: 4

Enter the position of element to be deleted:2

----Menu----
 1.Create
2.Delete_at_beg
3.delete at end
4.Delete at pos
5.Display: 5
The linked list you have created is:
60
--------------------------------
Process exited after 48.74 seconds with return value 0
Press any key to continue . . .
```

Leetcode Problem-2:

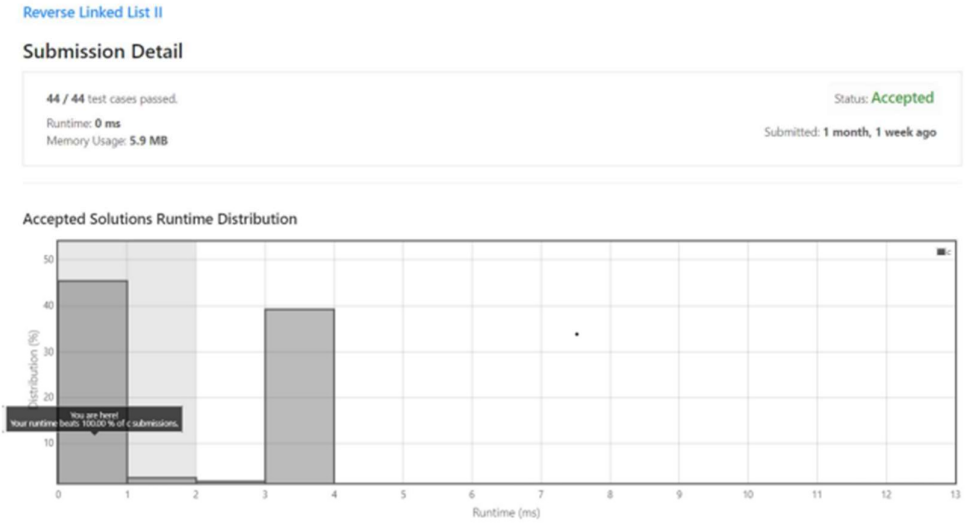
Reversal Linked List-II

```
/**
 * Definition for singly-linked list.
 * struct ListNode {
 * int val;
 * struct ListNode *next;
```

```
 * };
 */
struct ListNode* reverseBetween(struct ListNode* head, int left, int right) {
if (head == NULL) return NULL;
if (left == right) return head;
struct ListNode* prev = NULL;
struct ListNode* curr = head;
int index = 1;
while (index < left)
{
   prev = curr;
   curr = curr->next;
   index++;
 }
struct ListNode* leftMinusOneNode = prev;
struct ListNode* leftNode = curr;
struct ListNode* next = NULL;
while (left <= right)
{
   next = curr->next;
   curr->next = prev;
   prev = curr;
   curr = next;
   left++;
}
if (leftMinusOneNode == NULL) // means head changes
head = prev;
else
leftMinusOneNode->next = prev;
```

```
leftNode->next = curr;
return head;
}
```

Output:



Lab program 6:

(a) Write a program 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;
};

typedef struct Node Node;

Node *createNode(int value)
{
   Node *newNode=(Node*)malloc(sizeof(Node));
   newNode->data=value;
   newNode->next=NULL;
   return newNode;

}

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

Node *sortList(Node *head)
{
   if(head==NULL || head->next==NULL)
   {
      return head;
   }


   int swapped;
   Node *temp;
   Node *end=NULL;

   do
   {
```

```
        swapped=0;
        temp=head;
        while(temp->next !=end)
        {
           if(temp->data > temp->next->data)
           {
              int tempData=temp->data;
              temp->data=temp->next->data;
              temp->next->data=tempData;
              swapped=1;

           }
           temp=temp->next;
        }
        end=temp;
    }while(swapped);

    return head;
}

Node *reverseList(Node *head)
{
    Node *prev=NULL;
    Node *current=head;
    Node *nextNode=NULL;

    while(current!=NULL)
    {
       nextNode=current->next;
       current->next=prev;
       prev=current;
       current=nextNode;
    }
    return prev;

}

Node *concatenatedLists(Node *list1,Node *list2)
{

    if(list1==NULL)
    {
      return list2;
    }

    Node *temp=list1;
    while(temp->next!=NULL)
```

```
    {
        temp=temp->next;
    }
    temp->next=list2;
    return list1;

}

int main()
{
    Node *list1=createNode(3);
    list1->next=createNode(1);
    list1->next->next=createNode(4);

    Node *list2=createNode(2);
    list2->next=createNode(5);

    printf("Original list 1:");
    displayList(list1);

    printf("Original list 2:");
    displayList(list2);

    list1=sortList(list1);
    printf("Sorted list 1:");
    displayList(list1);

    list1=reverseList(list1);
    printf("Reversed list 1:");
    displayList(list1);

    Node *Concatenated= concatenatedLists(list1,list2);
    printf("Concatenated List:");
    displayList(Concatenated);
    return 0;
}
```

Output:

```
Original list 1:3->1->4->NULL
Original list 2:2->5->NULL
Sorted list 1:1->3->4->NULL
Reversed list 1:4->3->1->NULL
Concatenated List:4->3->1->2->5->NULL
```

(b) Write a program to Implement Single Link List to simulate Stack & Queue Operations.

Stack Implementation

```
#include<stdio.h>
#include<stdlib.h>
#define pf printf
#define sf scanf

struct node{
   int data;
   struct node *next;
};
struct node *head,*newnode,*temp,*temp1;


void push()
{
   newnode=(struct node *)malloc(sizeof(struct node));
   pf("Enter the data to be pushed into the stack:");
   sf("%d",&newnode->data);
   newnode->next=head;
   head=newnode;

}
 void display()
 {
    pf("\nThe stack you have created is:\n");
    temp=head;
    while(temp!=NULL)
   {
      pf("%d\n",temp->data);
      temp=temp->next;
   }
}

void pop()
{
   if(head==NULL)
      pf("\nThe stack is empty");
   else
   {
      temp=head;
      head=temp->next;
      free(temp);
   }
 }

 int main()
```

```
{
int ch;

while(1)
  {
     pf("\n1.Push\n2.Pop\n3.Display\n4.Exit Menu\nChoice:");
    sf("%d",&ch);

switch(ch)
     {
  case 1: push();
          display();
          break;
  case 2: pop();
          display();
          break;
  case 3: display();
          break;
  case 4: return 0;
  default:
          pf("\nInvalid input--try again\n\n\n");
     }
  }
}
```

Output:

```
1.Push
2.Pop
3.Display
4.Exit Menu
Choice:1
Enter the data to be pushed into the stack:20
The stack you have created is:
20

1.Push
2.Pop
3.Display
4.Exit Menu
Choice:1
Enter the data to be pushed into the stack:45
The stack you have created is:
45
20
```

```
1.Push
2.Pop
3.Display
4.Exit Menu
Choice:1
Enter the data to be pushed into the stack:37
The stack you have created is:
37
45
20

1.Push
2.Pop
3.Display
4.Exit Menu
Choice:2
The stack you have created is:
45
20

1.Push
2.Pop
3.Display
4.Exit Menu
Choice:4
```

Queue Implementation

```
#include<stdio.h>
#include<stdlib.h>
#define pf printf
#define sf scanf

struct node{
   int data;
   struct node *next;
};
struct node *head,*newnode,*temp,*temp1;


void pushqueue()
{
   newnode=(struct node *)malloc(sizeof(struct node));
   pf("Enter the data to be pushed into the queue:");
   sf("%d",&newnode->data);
```

```
   newnode->next=head;
   head=newnode;

}
 void display()
 {
    pf("\nThe queue you have created is:\n");
    temp=head;
    while(temp!=NULL)
   {
      pf("\t%d",temp->data);
      temp=temp->next;
   }
}

void popqueue()
{
   if(head==NULL)
      pf("\nThe queue is empty");
   else
   {
      temp=temp1=head;
      while(temp->next!=NULL)
          {
          temp1=temp;
          temp=temp->next;
          }
      temp1->next=NULL;
      free(temp);
   }
 }

 int main()
 {
 int ch;

 while(1)
   {
       pf("\n1.Push\n2.Pop\n3.Display\n4.Exit Menu\nChoice:");
          sf("%d",&ch);

 switch(ch)
       {
   case 1: pushqueue();
          display();
          break;
   case 2: popqueue();
          display();
```

```
            break;
    case 3: display();
            break;
    case 4: return 0;
    default:
            pf("\nInvalid input--try again\n\n\n");
        }
    }
}
```

Output:

```
1.Push
2.Pop
3.Display
4.Exit Menu
Choice:1
Enter the data to be pushed into the queue:35
The queue you have created is:
    35
1.Push
2.Pop
3.Display
4.Exit Menu
Choice:1
Enter the data to be pushed into the queue:89
The queue you have created is:
    89  35
1.Push
2.Pop
3.Display
4.Exit Menu
Choice:1
Enter the data to be pushed into the queue:76
The queue you have created is:
    76  89  35
1.Push
2.Pop
3.Display
4.Exit Menu
Choice:2
The queue you have created is:
    76  89
```

```
1.Push
2.Pop
3.Display
4.Exit Menu
Choice:4
```

Lab program 7:

1.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

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

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

struct Node* createNode(int data)
{
   struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));
   if (newNode == NULL)
   {
      printf("Memory allocation failed\n");
      exit(1);
   }
   newNode->data = data;
   newNode->prev = NULL;
   newNode->next = NULL;
   return newNode;
}

void insertNodeToLeft(struct Node* head, struct Node* target, int data)
{
   struct Node* newNode = createNode(data);
   if (target->prev != NULL)
   {
      target->prev->next = newNode;
      newNode->prev = target->prev;
   }
   else
   {
      head = newNode;
   }
   newNode->next = target;
   target->prev = newNode;
}

void deleteNode(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\n", value);
}

void displayList(struct Node* head)
{
    printf("Doubly Linked List: ");
    while (head != NULL)
    {
        printf("%d <-> ", head->data);
        head = head->next;
    }
    printf("NULL\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;

    displayList(head);

    insertNodeToLeft(head, head->next, 10);
```

```
    printf("After insertion:\n");
    displayList(head);

    deleteNode(head, 2);
    printf("After deletion:\n");
    displayList(head);

    return 0;
}
```

Output:

```
Doubly Linked List: 1 <-> 2 <-> 3 <-> NULL
After insertion:
Doubly Linked List: 1 <-> 10 <-> 2 <-> 3 <-> NULL
After deletion:
Doubly Linked List: 1 <-> 10 <-> 3 <-> NULL
```

Leetcode Problem-3:

Split Linked List in Parts

```
/**
* Definition for singly-linked list.
* struct ListNode {
* int val;
* struct ListNode *next;
* };
*/
/**
 * Note: The returned array must be malloced, assume caller calls free().
*/ 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:

Split Linked List in Parts

Submission Detail

43 / 43 test cases passed.

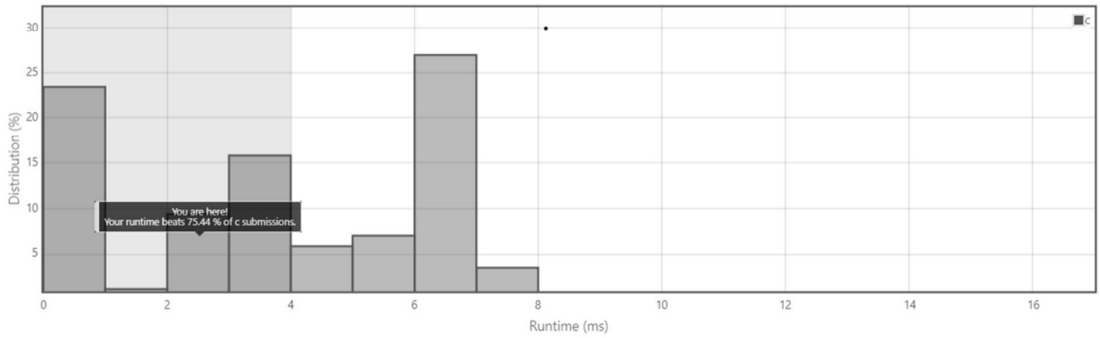
Runtime: **2 ms**

Memory Usage: **6.2 MB**

Status: Accepted

Submitted: **1 month ago**

Accepted Solutions Runtime Distribution



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>

typedef struct BST
{
   int data;
   struct BST *left;
   struct BST *right;
}node;

node *create()
{
   node *temp;
   printf("Enter data:\n");
   temp=(node*)malloc(sizeof(node));
   scanf("%d",&temp->data);
   temp->left=temp->right=NULL;
   return temp;
}

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

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

void postorder(node *root)
{
   if(root!=NULL)
```

```
    {
        postorder(root->left);
        postorder(root->right);
        printf("%d  ",root->data);
    }
}

void insert(node *root,node *temp)
{
    if(temp->data<root->data)
    {
        if (root->left!=NULL)
            insert(root->left,temp);
        else
            root->left=temp;
    }
    else if (temp->data>root->data)
    {
        if (root->right!=NULL)
            insert(root->right,temp);
        else
            root->right=temp;
    }
    else
    {
        printf("Ignoring duplicate data %d\n",temp->data);
    }
}

int main()
{
    char ch;
    int choice;
    node *root=NULL,*temp;
    do
    {
        temp=create();
        if(root==NULL)
            root=temp;
        else
            insert(root,temp);
        printf("\nDo you want to continue? (y/n): ");
        getchar();
        scanf("%c",&ch);
    }
    while(ch=='y'|ch=='Y');

    printf("Choose traversal type\n");
    printf("1.Preorder traversal\n");
    printf("2.Postorder traversal\n");
```

```
    printf("3.Inorder traversal\n");
    printf("Enter your choose(1-3)\n");
    scanf("%d",&choice);

    switch(choice){
        case 1:
            printf("\nBST in preorder traversal\n");
            preorder(root);
            break;
        case 2:
            printf("\nBST in postorder traversal\n");
            postorder(root);
            break;
        case 3:
            printf("BST in inorder traversal\n");
            inorder(root);
            break;
        default:
            printf("Invalid choice");
    }
    return 0;
}
```

Output:

```
Enter data:
15
Do you want to continue? (y/n): y
Enter data:
5
Do you want to continue? (y/n): y
Enter data:
20
Do you want to continue? (y/n): y
Enter data:
37
Do you want to continue? (y/n): y
Enter data:
24
Do you want to continue? (y/n): y
Enter data:
3
Do you want to continue? (y/n): n
```

```
Choose traversal type
1.Preorder traversal
2.Postorder traversal
3.Inorder traversal
Enter your choose(1-3)
2

BST in postorder traversal
3  5  24  37  20  15
```

Leetcode Problem-4:

Rotate List

```
/**
* Definition for singly-linked list.
* struct ListNode {
* int val;
* struct ListNode *next;
* };
*/
struct ListNode* rotateRight(struct ListNode* head, int k) {
   if (head == NULL || head->next == NULL || k == 0)
      return head;
   int len = 1;
   struct ListNode *tail = head;
   while (tail->next != NULL) {
      tail = tail->next;
      len++;
   }
   k = k % len;
   if (k == 0)
   return head;
   struct ListNode *p = head;
   for (int i = 0; i < len - k - 1; i++) {
      p = p->next;
    }
   tail->next = head;
   head = p->next
   p->next = NULL;
   return head;
}
```

Output:

Rotate List

Submission Detail

232 / 232 test cases passed.

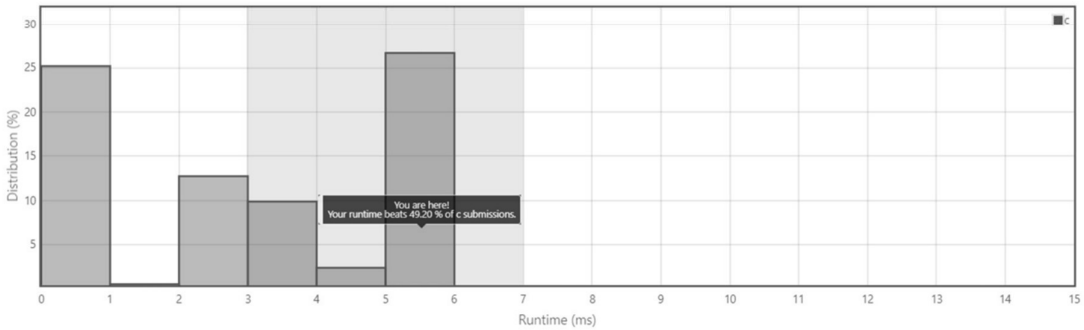
Status: Accepted

Runtime: **5 ms**

Memory Usage: **6.1 MB**

Submitted: **2 weeks, 3 days ago**

Accepted Solutions Runtime Distribution



Lab program 9:

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

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

#define MAX_SIZE 100

{
   int items[MAX_SIZE];
   int front;
   int rear;
};

struct Queue* createQueue()
{
   struct Queue* queue = (struct Queue*)malloc(sizeof(struct Queue));
   queue->front = -1;
   queue->rear = -1;
   return queue;
}

int isEmpty(struct Queue* queue)
{
   if (queue->rear == -1)
      return 1;
   else
      return 0;
}

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("Queue is empty");
      item = -1;
```

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

struct Graph
{
    int vertices;
    int** adjMatrix;
};

struct Graph* createGraph(int vertices)
{
    struct Graph* graph = (struct Graph*)malloc(sizeof(struct Graph));
    graph->vertices = vertices;

    graph->adjMatrix = (int*)malloc(vertices * sizeof(int));
    for (int i = 0; i < vertices; i++)
    {
        graph->adjMatrix[i] = (int*)malloc(vertices * sizeof(int));
        for (int j = 0; j < vertices; j++)
            graph->adjMatrix[i][j] = 0;
    }
    return graph;
}

void addEdge(struct Graph* graph, int src, int dest)
{
    graph->adjMatrix[src][dest] = 1;
    graph->adjMatrix[dest][src] = 1; // Uncomment if the graph is undirected
}

// Breadth First Search traversal
void BFS(struct Graph* graph, int startVertex)
{
    int visited[MAX_SIZE] = {0}; // Initialize all vertices as not visited
    struct Queue* queue = createQueue();

    visited[startVertex] = 1;
    enqueue(queue, startVertex);

    printf("Breadth First Search Traversal: ");
```

```
    while (!isEmpty(queue))
    {
        int currentVertex = dequeue(queue);
        printf("%d ", currentVertex);

        for (int i = 0; i < graph->vertices; i++)
        {
            if (graph->adjMatrix[currentVertex][i] == 1 && visited[i] == 0)
            {
                visited[i] = 1;
                enqueue(queue, i);
            }
        }
    }
    printf("\n");
}

int main()
{
    int vertices, edges, src, dest;

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

    struct Graph* graph = createGraph(vertices);

    printf("Enter the number of edges: ");
    scanf("%d", &edges);

    for (int i = 0; i < edges; i++)
    {
        printf("Enter edge %d (source destination): ", i + 1);
        scanf("%d%d", &src, &dest);
        addEdge(graph, src, dest);
    }

    int startVertex;
    printf("Enter the starting vertex for BFS: ");
    scanf("%d", &startVertex);

    BFS(graph, startVertex);

    return 0;
}
```

Output:

```
Enter the number of vertices: 4
Enter the number of edges: 4
Enter edge 1 (source destination): 0 1
Enter edge 2 (source destination): 0 2
Enter edge 3 (source destination): 1 3
Enter edge 4 (source destination): 2 3
Enter the starting vertex for BFS: 2
Breadth First Search Traversal: 2 0 3 1
```

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

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

#define MAX_SIZE 100

// Graph implementation
struct Graph
{
   int vertices;
   int** adjMatrix;
};

// Create a graph with 'vertices' number of vertices
struct Graph* createGraph(int vertices)
{
   struct Graph* graph = (struct Graph*)malloc(sizeof(struct Graph));
   graph->vertices = vertices;

   graph->adjMatrix = (int*)malloc(vertices * sizeof(int));
   for (int i = 0; i < vertices; i++)
   {
      graph->adjMatrix[i] = (int*)malloc(vertices * sizeof(int));
      for (int j = 0; j < vertices; j++)
         graph->adjMatrix[i][j] = 0;
   }
   return graph;
}

// Add an edge to the graph
void addEdge(struct Graph* graph, int src, int dest)
{
   graph->adjMatrix[src][dest] = 1;
   graph->adjMatrix[dest][src] = 1; // Uncomment if the graph is undirected
}
```

```
// Depth First Search traversal
void DFS(struct Graph* graph, int startVertex, int visited[])
{
    visited[startVertex] = 1;

    for (int i = 0; i < graph->vertices; i++)
    {
        if (graph->adjMatrix[startVertex][i] == 1 && visited[i] == 0)
            DFS(graph, i, visited);
    }
}

// Check if the graph is connected
int isConnected(struct Graph* graph)
{
    int* visited = (int*)malloc(graph->vertices * sizeof(int));

    for (int i = 0; i < graph->vertices; i++)
        visited[i] = 0;

    DFS(graph, 0, visited);

    for (int i = 0; i < graph->vertices; i++)
    {
        if (visited[i] == 0)
            return 0; // Graph is not connected
    }
    return 1; // Graph is connected
}

int main()
{
    int vertices, edges, src, dest;

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

    struct Graph* graph = createGraph(vertices);

    printf("Enter the number of edges: ");
    scanf("%d", &edges);

    for (int i = 0; i < edges; i++)
    {
        printf("Enter edge %d (source destination): ", i + 1);
        scanf("%d%d", &src, &dest);
        addEdge(graph, src, dest);
    }
```

```
    if (isConnected(graph))
        printf("The graph is connected.\n");
    else
        printf("The graph is not connected.\n");

    return 0;
}
```

Output:

```
Enter the number of vertices: 4
Enter the number of edges: 4
Enter edge 1 (source destination): 0 1
Enter edge 2 (source destination): 1 2
Enter edge 3 (source destination): 2 3
Enter edge 4 (source destination): 3 1
The graph is connected.
```

HackerRank Problem

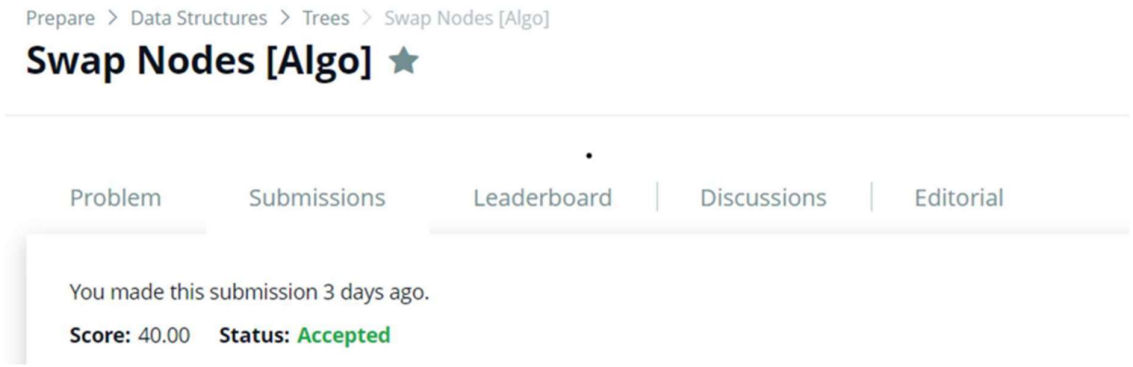
Swap Nodes

```
#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 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 TABLE_SIZE 10

int hashFunction(int key) {
   return key % TABLE_SIZE;
}

void insertValue(int hashTable[], int key) {
   int i = 0;
   int hkey = hashFunction(key);
   int index;
   do {
      index = (hkey + i) % TABLE_SIZE;
      if (hashTable[index] == -1) {
         hashTable[index] = key;
         printf("Inserted key %d at index %d\n", key, index);
         return;
      }
      i++;
   } while (i < TABLE_SIZE);
   printf("Unable to insert key %d. Hash table is full.\n", key);
}

int searchValue(int hashTable[], int key) {
   int i = 0;
   int hkey = hashFunction(key);
   int index;
   do {
      index = (hkey + i) % TABLE_SIZE;
      if (hashTable[index] == key) {
         printf("Key %d found at index %d\n", key, index);
         return index;
      }
      i++;
```

```
    } while (i < TABLE_SIZE);
    printf("Key %d not found in hash table.\n", key);
    return -1;
}

int main() {
    int hashTable[TABLE_SIZE];
    for (int i = 0; i < TABLE_SIZE; i++) {
        hashTable[i] = -1;
    }
    insertValue(hashTable, 1234);
    insertValue(hashTable, 5678);
    insertValue(hashTable, 9876);
    searchValue(hashTable, 5678);
    searchValue(hashTable, 1111);
    return 0;
}
```

Output:

```
Inserted key 1234 at index 4
Inserted key 5678 at index 8
Inserted key 9876 at index 6
Key 5678 found at index 8
Key 1111 not found in hash table.

Process returned 0 (0x0)   execution time : 0.074 s
Press any key to continue.
```