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
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This is to certify that the Lab work entitled **“DATA STRUCTURES”** carried out by S GAJANANA NAYAK **(1BM22CS227)**, 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 202324. The Lab report has been approved as it satisfies the academic requirements in respect of Data structures Lab **- (23CS3PCDST) work** prescribed for the said degree.

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Index Sheet

Course outcomes:

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

Lab program 1:

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

```
#include <stdio.h>
#include <stdlib.h>
#define 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
    {
        printf("Elements in the stack are: \n");
        for (int i = top; i >= 0; --i)
            printf("%d\n", inp_array[i]);
    }
}
```

Output:

```
C:\Users\Admin\Desktop\1BM22CS227\DS\stackimplementation.exe
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:
 4
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:
 5
Operations on the stack:
1.Push the element
2.Pop the element
3.Show
4.End
Enter the choice:
 2
Popped element: 5
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:
4
Operations on the stack:
1.Push the element
2.Pop the element
3.Show
4.End
Enter the choice:
 4

Process returned 0 (0x0)   execution time : 12.759 s
Press any key to continue.
```

Lab program 2:

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

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

#define SIZE 100

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

void push(char);
char pop();
int precedence(char);
void infixToPostfix(char infix[], char postfix[]);

void push(char item) {
    if (top == MAX - 1) {
        printf("Overflow!\n");
    } else {
        top++;
        stack[top] = item;
    }
}

char pop() {
    if (top == -1) {
        printf("Underflow!\n");
    } else {
        char popped = stack[top];
        top--;
        return popped;
    }
}

int precedence(char symbol) {
    if (symbol == '^') {
        return 3;
    } else if (symbol == '*' || symbol == '/') {
```

```
        return 2;
    } else if (symbol == '+' || symbol == '-') {
        return 1;
    } else {
        return -1;
    }
}

void infixToPostfix(char infix[], char postfix[]) {
    int i = 0, j = 0;
    char symbol, temp;

    push('#');

    while ((symbol = infix[i++]) != '\0') {
        if (symbol == '(') {
            push(symbol);
        } else if (isalnum(symbol)) {
            postfix[j++] = symbol;
        } else if (symbol == ')') {
            while (stack[top] != '(') {
                postfix[j++] = pop();
            }
            temp = pop(); // Remove '(' from the stack
        } else {
            while (precedence(stack[top]) >= precedence(symbol)) {
                postfix[j++] = pop();
            }
            push(symbol);
        }
    }

    while (stack[top] != '#') {
        postfix[j++] = pop();
    }

    postfix[j] = '\0';
}

int main() {
    char infix[MAX], postfix[MAX];

    printf("Enter a valid parenthesized infix expression: ");
```

```
    scanf("%s", infix);

    infixToPostfix(infix, postfix);

    printf("The postfix exp is: %s\n", postfix);
    return 0;
}
```

Output:

```
Enter a valid parenthesized infix expression:
a*b+c*d-e
The postfix exp is: ab*cd**+e-

Process returned 0 (0x0)   execution time : 20.804 s
Press any key to continue.
```

Lab program 3:

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

```
#include<stdio.h>
#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()
{
    if(front==-1)
    {
        printf("Queue Empty\n");
        return;
    }
    printf("Queue:");
    for(int 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:7
Queue:7
1.Insert
2.Delete
3.Display
Choice:1
Enter an element:8
Queue:7 8
1.Insert
2.Delete
3.Display
Choice:2
Queue:8
1.Insert
2.Delete
3.Display
Choice:3
Queue:8
```

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

```
#include<stdio.h>
#define size 5

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


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

void dequeue()
{
   if(front==-1)
   {
      printf("Queue Empty\n");
   }
   else
   {
      int a=queue[front];
      if(front==rear)
      {
         front=-1;
         rear=-1;

      }
      else
      {
```

```
            front=(front+1)%size;

        }
        printf("Deleted element=%d\n",a);
        return(a);
    }
}

void display()
{
    if(front==-1)
    {
        printf("Queue Empty\n");
        return;
    }
    else
    {
        int i;
        printf("\nFront=%d", front);
        printf("\nItems=");
        for(i=front;i!=rear;i=(i+1)%size)
        {
            printf("%d",queue[i]);
        }
        printf("%d",queue[i]);
        printf("\nRear=%d",rear);
    }
}


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);
               enqueue(a);
               display();
               break;
```

```
        case 2:dequeue();
               display();
               break;

        case 3:display();
               break;
        }
    }

}
```

Output:

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

Front=0
Items=2
Rear=0
1.Insert
2.Delete
3.Display
Choice:1
Enter an element:3

Front=0
Items=23
Rear=1
1.Insert
2.Delete
3.Display
Choice:1
Enter an element:4

Front=0
Items=234
Rear=2
1.Insert
2.Delete
3.Display
Choice:2
Deleted element=2

Front=1
Items=34
Rear=2
```

Lab program 4:

WAP to Implement Singly Linked List with following operations

a) Create a linked list.
b) Insertion of a node at first position, at any position and at end of list.
Display the contents of the linked list.

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

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


struct Node *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->next = NULL;
   return newNode;
}


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

   struct Node *temp = head;
   printf("Linked List:\n ");
   while (temp != NULL)
   {
      printf("%d -> ", temp->data);
```

```
        temp = temp->next;
    }
    printf("NULL\n");
}


struct Node *insertatbeginning(struct Node *head, int value)
{
    struct Node *newNode = createNode(value);
    newNode->next = head;
    return newNode;
}

void insertatend(struct Node *head, int value)
{
    struct Node *newNode = createNode(value);
    struct Node *temp = head;

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

    temp->next = newNode;
}

void insertatposition(struct Node *head, int position, int value)
{
    struct Node *newNode = createNode(value);
    struct Node *temp = head;
    int count = 1;

    while (temp != NULL && count < position - 1)
    {
        temp = temp->next;
        count++;
    }

    if (temp == NULL)
    {
        printf("Position out of range.\n");
        free(newNode);
        return;
    }

    newNode->next = temp->next;
```

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


int main()
{
    struct Node *head = NULL;

    head = createNode(1);
    head->next = createNode(2);
    head->next->next = createNode(3);

    printf("Initial:\n ");
    displayList(head);

    head = insertatbeginning(head, 0);
    printf("After insertion at the beginning:\n ");
    displayList(head);


    insertatposition(head, 3, 10);
    printf("After insertion at position 3:\n ");
    displayList(head);


    insertatend(head, 20);
    printf("After insertion at the end:\n ");
    displayList(head);

    return 0;
}
```

Output:

```
Initial Linked List: 1 -> 2 -> 3 -> NULL
After insertion at the beginning: Linked List: 0 -> 1 -> 2 -> 3 -> NULL
After insertion at position 3: Linked List: 0 -> 1 -> 10 -> 2 -> 3 -> NULL
After insertion at the end: Linked List: 0 -> 1 -> 10 -> 2 -> 3 -> 20 -> NULL

Process returned 0 (0x0)   execution time : 0.023 s
Press any key to continue.
```

Leetcode Problem-1:

Design a stack that supports push, pop, top, and retrieving the minimum element in constant time.

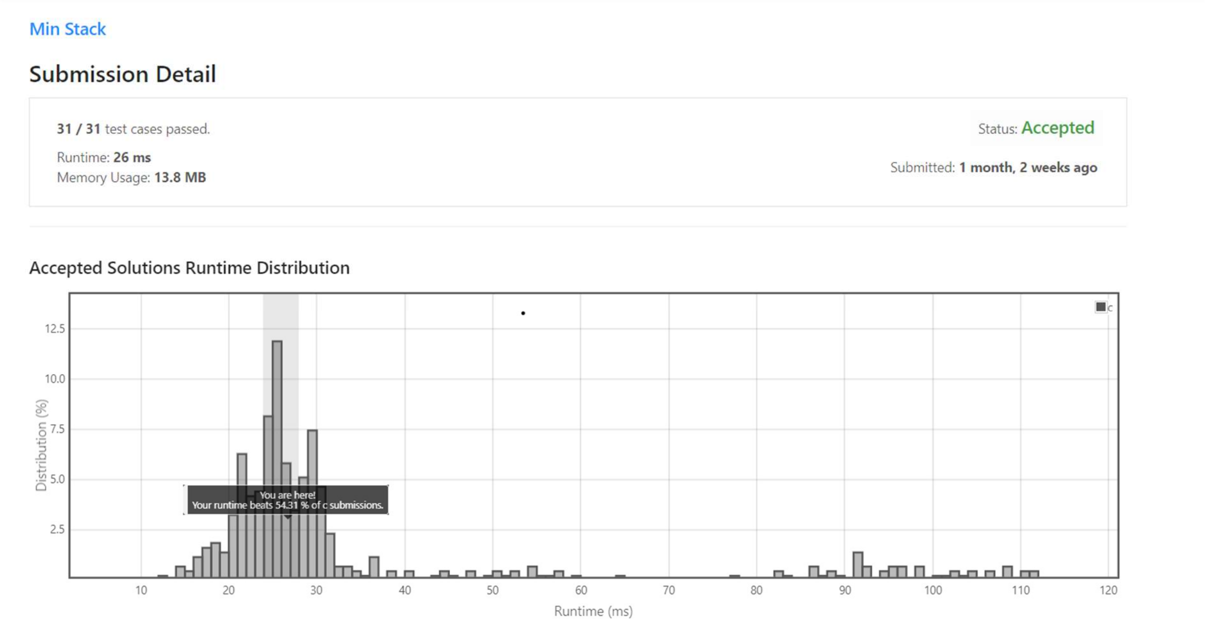
Implement the MinStack class:

MinStack() initializes the stack object.
void push(int val) pushes the element val onto the stack.
void pop() removes the element on the top of the stack.
int top() gets the top element of the stack.
int getMin() retrieves the minimum element in the stack.
You must implement a solution with O(1) time complexity for each function.

```
#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 * sizeof(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);
}
```

Result:



Lab program 5:

WAP to Implement Singly Linked List with following operations

a) Create a linked list.
b) Deletion of first element, specified element and last element in the list.
c) Display the contents of the linked list.

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


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


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

```
void insertAtEnd(struct Node** head, int value) {
    struct Node* newNode = createNode(value);
    if (*head == NULL) {
        *head = newNode;
    } else {
        struct Node* temp = *head;
        while (temp->next != NULL) {
            temp = temp->next;
        }
        temp->next = newNode;
    }
}


void deleteFirst(struct Node** head) {
    if (*head != NULL) {
        struct Node* temp = *head;
        *head = (*head)->next;
        free(temp);
    }
}

void deleteElement(struct Node** head, int value) {
    struct Node* current = *head;
    struct Node* prev = NULL;

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

    if (current == NULL) {
        return;
    }

    if (prev == NULL) {
        *head = current->next;
    } else {
        prev->next = current->next;
    }

    free(current);
}

void deleteLast(struct Node** head) {
    if (*head == NULL) {
```

```
        return;
    }

    struct Node* temp = *head;
    struct Node* prev = NULL;

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

    if (prev == NULL) {
        *head = NULL;
    } else {
        prev->next = NULL;
    }

    free(temp);
}


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


int main() {
    struct Node* head = NULL;


    insertAtEnd(&head, 1);
    insertAtEnd(&head, 2);
    insertAtEnd(&head, 3);


    printf("Initial Linked List: ");
    displayList(head);

    deleteFirst(&head);
    printf("\nAfter deleting the first element: ");
    displayList(head);
```

```
    deleteElement(&head, 2);
    printf("\nAfter deleting the specified element (2): ");
    displayList(head);


    deleteLast(&head);
    printf("\nAfter deleting the last element: ");
    displayList(head);

    return 0;
}
```

Output:

```
Initial Linked List: 1 -> 2 -> 3 -> NULL

After deleting the first element: 2 -> 3 -> NULL

After deleting the specified element (2): 3 -> NULL

After deleting the last element: NULL

Process returned 0 (0x0)   execution time : 0.052 s
Press any key to continue.
```

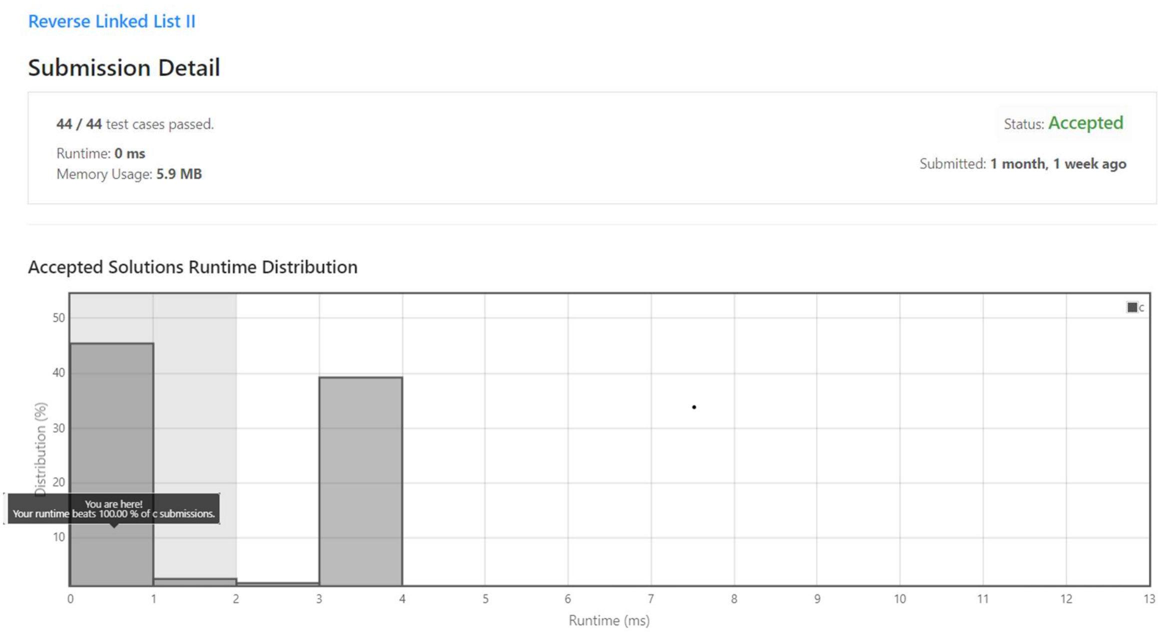
Leetcode Problem -2:

Given the head of a singly linked list and two integers left and right where left <= right, reverse the nodes of the list from position left to position right, and return the reversed list.

```
/**
 * 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;
}
```

Result:



Lab program 6:

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

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

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

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:");
```

```c
    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

Process returned 0 (0x0)   execution time : 20.431 s
Press any key to continue.
```

6b) WAP to Implement Single Link List to simulate Stack & Queue Operations.

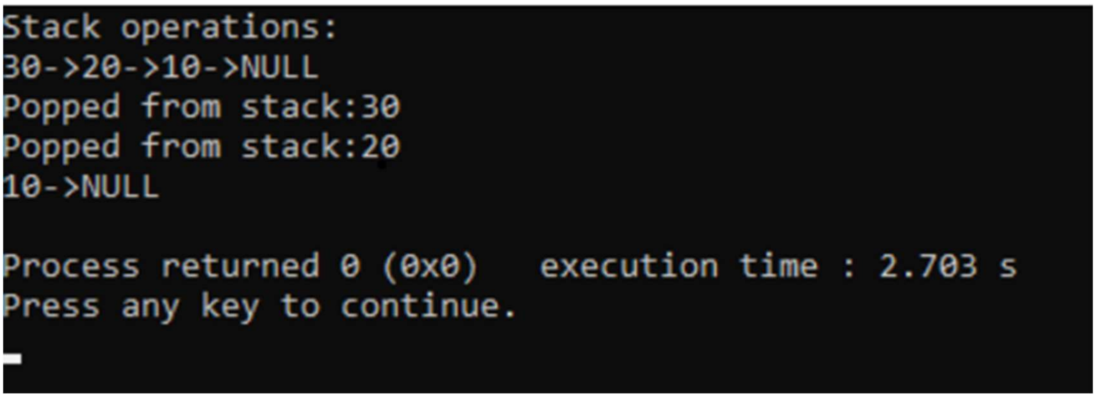
//Stack

```c
#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");
}

typedef struct
{
   Node *top;

}LinkedList;

void push(LinkedList *stack,int value)
{
   Node *newNode=createNode(value);
   newNode->next=stack->top;
   stack->top=newNode;
}

int pop(LinkedList *stack)
{
   if(stack->top==NULL)
   {
      printf("stack is empty\n");
      return -1;
   }
   int poppedValue=stack->top->data;
   Node *temp=stack->top;
   stack->top=stack->top->next;
```

```
    free(temp);

    return poppedValue;
}

int main()
{

    LinkedList stack;
    stack.top=NULL;

    printf("Stack operations:\n");
    push(&stack,10);
    push(&stack,20);
    push(&stack,30);
    displayList(stack.top);

    printf("Popped from stack:%d\n",pop(&stack));
    printf("Popped from stack:%d\n",pop(&stack));

    displayList(stack.top);
    return 0;
}
```

Output:



```
Stack operations:
30->20->10->NULL
Popped from stack:30
Popped from stack:20
10->NULL

Process returned 0 (0x0)   execution time : 2.703 s
Press any key to continue.
```

```
//Queue

#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");
}

typedef struct
{
   Node *front;
   Node *rear;

}LinkedList;

void enqueue(LinkedList *queue,int value)
{
   Node *newNode=createNode(value);
   if(queue->front==NULL)
   {
      queue->front=newNode;
      queue->rear=newNode;
   }
   else
   {
     queue->rear->next=newNode;
     queue->rear=newNode;
   }

}
```

```
int dequeue(LinkedList *queue)
{
   if(queue->front==NULL)
   {
      printf("Queue is empty\n");
      return -1;
   }
   int dequeuedvalue=queue->front->data;
   Node *temp=queue->front;
   queue->front=queue->front->next;
   free(temp);

   return dequeuedvalue;
}

int main()
{
   LinkedList queue;
   queue.front=NULL;
   queue.rear=NULL;

   printf("Queue operations:\n");
   enqueue(&queue,40);
   enqueue(&queue,50);
   enqueue(&queue,60);
   displayList(queue.front);

   printf("Popped from queue:%d\n",dequeue(&queue));
   printf("Popped from queue:%d\n",dequeue(&queue));

   displayList(queue.front);
   return 0;
}
```

Output:

```
Queue operations:
40->50->60->NULL
Popped from queue:40
Popped from queue:50
60->NULL

Process returned 0 (0x0)   execution time : 1.494 s
Press any key to continue.
```

Lab program 7:

WAP to Implement doubly link list with primitive operations

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

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

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


struct Node* 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

Process returned 0 (0x0)   execution time : 0.076 s
Press any key to continue.
```

Leetcode Problem -3:

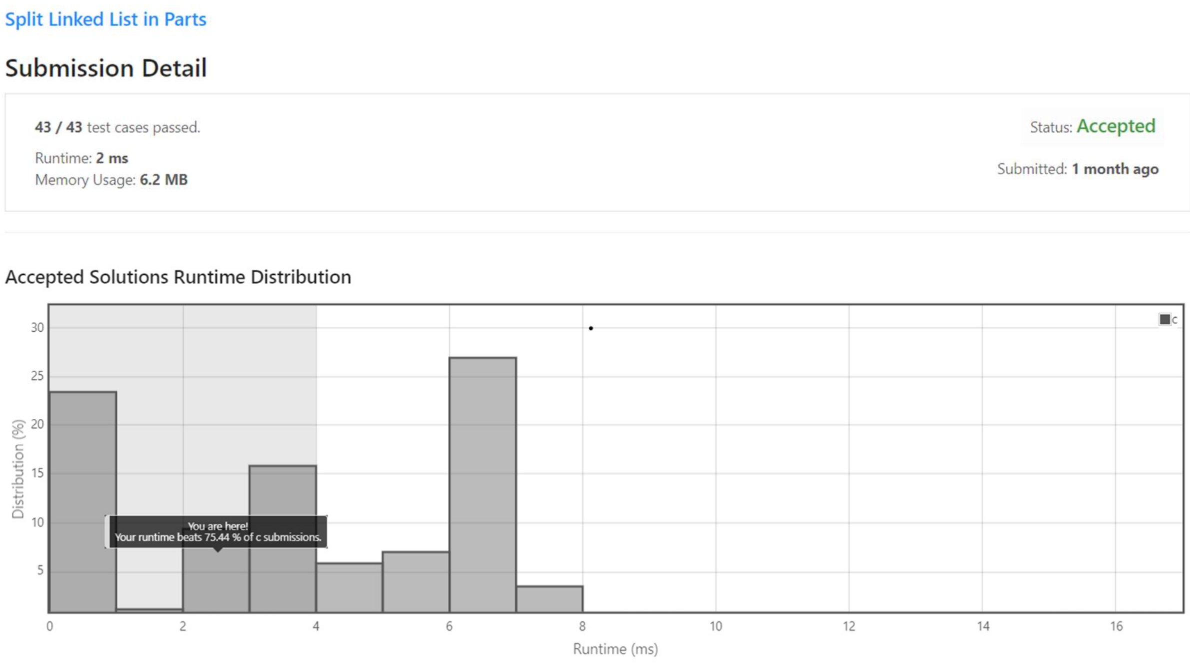
Given the head of a singly linked list and an integer k, split the linked list into k consecutive linked list parts.
The length of each part should be as equal as possible: no two parts should have a size differing by more than one. This may lead to some parts being null.
The parts should be in the order of occurrence in the input list, and parts occurring earlier should always have a size greater than or equal to parts occurring later.

Return an array of the k 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;
```

```
}
```

Result:



Lab program 8:

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

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

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

struct node* newNode(int data) {
  struct node* node = (struct node*)malloc(sizeof(struct node));
  node->data = data;
  node->left = node->right = NULL;
  return node;
```

```
}

struct node* insert(struct node* root, int data) {
  if (root == NULL) return newNode(data);
  if (data <= root->data) root->left = insert(root->left, data);
  else root->right = insert(root->right, data);
  return root;
}

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

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

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

int main() {
  struct node* root = NULL;
  int data, choice;

  do {
    printf("Enter your choice:\n1. Insert\n2. Print Inorder\n3. Print Preorder\n4. Print
Postorder\n5. Exit\n");
    scanf("%d", &choice);

    switch (choice) {
      case 1:
        printf("Enter the value to be inserted: ");
        scanf("%d", &data);
        root = insert(root, data);
        break;
      case 2:
```

```
        printf("Inorder traversal of binary tree is \n");
        inorder(root);
        printf("\n");
        break;
      case 3:
        printf("Preorder traversal of binary tree is \n");
        preorder(root);
        printf("\n");
        break;
      case 4:
        printf("Postorder traversal of binary tree is \n");
        postorder(root);
        printf("\n");
        break;
      case 5:
        printf("Exiting...\n");
        break;
      default:
        printf("Invalid choice. Please try again.\n");
    }
  } while (choice != 5);

  return 0;
}
```

Output:

```
Enter your choice:
1. Insert
2. Print Inorder
3. Print Preorder
4. Print Postorder
5. Exit
1
Enter the value to be inserted: 20
Enter your choice:
1. Insert
2. Print Inorder
3. Print Preorder
4. Print Postorder
5. Exit
1
Enter the value to be inserted: 10
Enter your choice:
1. Insert
2. Print Inorder
3. Print Preorder
4. Print Postorder
5. Exit
1
Enter the value to be inserted: 30
Enter your choice:
1. Insert
2. Print Inorder
3. Print Preorder
4. Print Postorder
5. Exit
1
Enter the value to be inserted: 5
Enter your choice:
1. Insert
2. Print Inorder
3. Print Preorder
4. Print Postorder
5. Exit
1
Enter the value to be inserted: 15
Enter your choice:
1. Insert
2. Print Inorder
3. Print Preorder
4. Print Postorder
5. Exit
1
Enter the value to be inserted: 45
Enter your choice:
1. Insert
2. Print Inorder
3. Print Preorder
4. Print Postorder
5. Exit
2
Inorder traversal of binary tree is
5 10 15 20 30 45
Enter your choice:
1. Insert
2. Print Inorder
3. Print Preorder
4. Print Postorder
5. Exit
3
Preorder traversal of binary tree is
20 10 5 15 30 45
Enter your choice:
1. Insert
2. Print Inorder
3. Print Preorder
4. Print Postorder
5. Exit
4
Postorder traversal of binary tree is
5 15 10 45 30 20
Enter your choice:
1. Insert
2. Print Inorder
3. Print Preorder
4. Print Postorder
5. Exit
5
Exiting...

Process returned 0 (0x0)   execution time : 42.620 s
Press any key to continue.
```

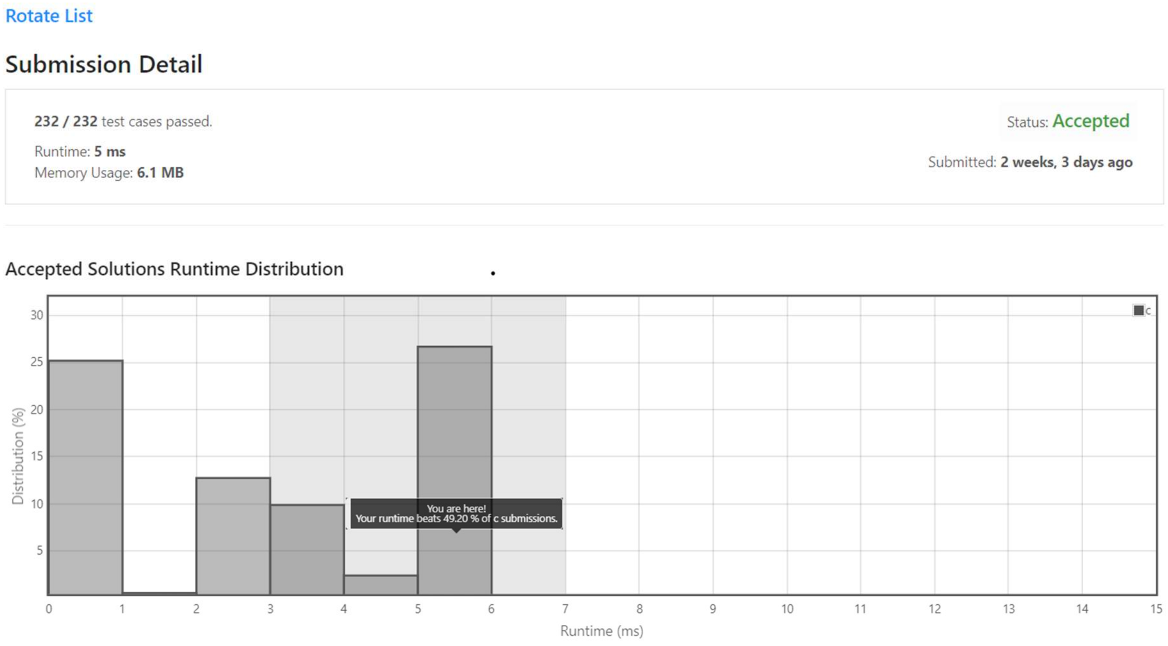
Leetcode Problem -4:

Given the head of a linked list, rotate the list to the right by k places.

```
/**
 * 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;

}
```

Result:



Lab program 9:

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

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

#define MAX_SIZE 100

// Queue implementation
struct Queue
{
    int items[MAX_SIZE];
    int front;
    int rear;
};

// Initialize queue
struct Queue* createQueue()
```

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

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

// Add an item to the queue
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;
    }
}

// Remove an item from the queue
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;
}

// 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
}

// 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: ");
```

```c
    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: 6
Enter the number of edges: 5
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): 1 4
Enter edge 5 (source destination): 2 5
Enter the starting vertex for BFS: 0
Breadth First Search Traversal: 0 1 2 3 4 5

Process returned 0 (0x0)   execution time : 57.435 s
Press any key to continue.
```

9b) 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: 6
Enter the number of edges: 5
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): 1 4
Enter edge 5 (source destination): 2 5
The graph is connected.

Process returned 0 (0x0)   execution time : 13.878 s
Press any key to continue.
```

HackerRank Problem

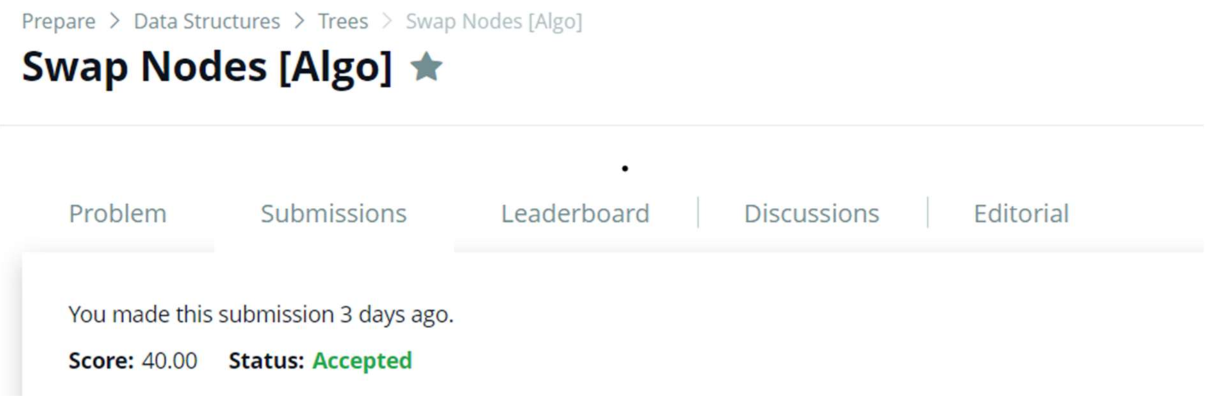
Given a tree and an integer, k, in one operation, we need to swap the subtrees of all the nodes at each depth h, where h ∈ [k, 2k, 3k,...]. In other words, if h is a multiple of k, swap the left and right subtrees of that level. You are given a tree of n nodes where nodes are indexed from [1..n] and it is rooted at 1. You have to perform t swap operations on it, and after each swap operation print the in-order traversal of the current state of the tree.

```
#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;
}
```

Result:



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.
```