VISVESVARAYA TECHNOLOGICAL UNIVERSITY

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LAB REPORT
On

DATA STRUCTURES (23CS3PCDST)

Submitted by

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in partial fulfillment for the award of the degree of
BACHELOR OF ENGINEERING
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This is to certify that the Lab work entitled **"DATA STRUCTURES"** carried out by RISHABH KUMAR**(1BM22CS221)**, who is a bonafide student of **B. M. S. College of Engineering**. It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visvesvaraya Technological University, Belgaum during the year 2023-24. The Lab report has been approved as it satisfies the academic requirements in respect of Data structures Lab - **(23CS3PCDST) work** prescribed for the said degree.

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Index Sheet

Course outcomes:

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

LAB Program – 1 (Rishabh Kumar, 1BM22CS221)

Q) 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>

#define MAX_SIZE 5

int stack[MAX_SIZE];
int top = -1;

void push(int value) {
	if (top == MAX_SIZE - 1) {
	printf("Stack Overflow: Cannot push %d, stack is full.\n", value);
	} else {
	top++;
	stack[top] = value;
	printf("Pushed %d onto the stack.\n", value);
	}
}
```

```c
void pop() {
    if (top == -1) {
    printf("Stack Underflow: Cannot pop, stack is empty.\n");
    } else {
    printf("Popped %d from the stack.\n", stack[top]);
    top--;
    }
}

void display() {
    if (top == -1) {
    printf("Stack is empty.\n");
    } else {
    printf("Stack elements: ");
    for (int i = 0; i <= top; i++) {
    printf("%d ", stack[i]);
    }
    printf("\n");
    }
}

int main() {
    push(10);
    push(20);
    push(30);
    display();

    pop();
    display();
```

```
        push(40);

        push(50);

        push(60); // This will cause a stack overflow

        display();


        pop();

        pop();

        pop();

        pop(); // This will cause a stack underflow

        display();


        return 0;

}
```

```
PS C:\Users\risku\coding> cd "c:\Users\risku\coding\" ; if ($?) { gcc rough.c -o rough } ; if ($?) { .\rough }
Pushed 10 onto the stack.
Pushed 20 onto the stack.
Pushed 30 onto the stack.
Stack elements: 10 20 30
Popped 30 from the stack.
Stack elements: 10 20
Pushed 40 onto the stack.
Pushed 50 onto the stack.
Pushed 60 onto the stack.
Stack elements: 10 20 40 50 60
Popped 60 from the stack.
Popped 50 from the stack.
Popped 40 from the stack.
Popped 20 from the stack.
Stack elements: 10
```

LAB Program – 2 (Rishabh Kumar, 1BM22CS221)

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 MAX_SIZE 50


char stack[MAX_SIZE];

int top = -1;


// Function to check if the given character is an operator

int isOperator(char ch) {

	return (ch == '+' || ch == '-' || ch == '*' || ch == '/');

}


// Function to get the precedence of an operator

int getPrecedence(char ch) {

	switch (ch) {

	case '+':

	case '-':

	return 1;

	case '*':

	case '/':

	return 2;

	default:

	return 0;

	}

}


// Function to push a character onto the stack
```

```
void push(char ch) {
	if (top == MAX_SIZE - 1) {
	printf("Stack Overflow: Cannot push %c, stack is full.\n", ch);
	exit(1);
	} else {
	top++;
	stack[top] = ch;
	}
}

// Function to pop a character from the stack
char pop() {
	if (top == -1) {
	printf("Stack Underflow: Cannot pop, stack is empty.\n");
	exit(1);
	} else {
	return stack[top--];
	}
}

// Function to convert infix to postfix
void infixToPostfix(char infix[]) {
	printf("Infix Expression: %s\n", infix);
	printf("Postfix Expression: ");

	for (int i = 0; infix[i] != '\0'; i++) {
	if (isalnum(infix[i])) {
	printf("%c", infix[i]);
	} else if (infix[i] == '(') {
```

```
push(infix[i]);
} else if (infix[i] == ')') {
while (top != -1 && stack[top] != '(') {
printf("%c", pop());
}
if (top != -1 && stack[top] == '(') {
pop(); // Discard '('
}
} else if (isOperator(infix[i])) {
while (top != -1 && getPrecedence(stack[top]) >= getPrecedence(infix[i])) {
printf("%c", pop());
}
push(infix[i]);
}
}

// Pop remaining operators from the stack
while (top != -1) {
printf("%c", pop());
}

printf("\n");
}

int main() {
char infixExpression[MAX_SIZE];

// Get infix expression as input
printf("Enter a valid parenthesized infix arithmetic expression: ");
```

```
fgets(infixExpression, sizeof(infixExpression), stdin);

// Remove newline character from the input
for (int i = 0; infixExpression[i] != '\0'; i++) {
if (infixExpression[i] == '\n') {
infixExpression[i] = '\0';
break;
}
}

// Convert infix to postfix and display the result
infixToPostfix(infixExpression);

return 0;
}
```

```
PS C:\Users\risku\coding> cd "c:\Users\risku\coding\" ; if ($?) { gcc rough.c -o rough } ; if ($?) { .\rough }
Enter a valid parenthesized infix arithmetic expression: a+b-c+d/c
Infix Expression: a+b-c+d/c
Postfix Expression: ab+c-dc/+
```

LAB Program – 3 (Rishabh Kumar, 1BM22CS221)

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 MAX_SIZE 5
```

```
int queue[MAX_SIZE];

int front = -1, rear = -1;


// Function to check if the queue is empty

int isEmpty() {

        return front == -1;

}


// Function to check if the queue is full

int isFull() {

        return (rear == MAX_SIZE - 1 && front == 0) || (rear + 1 == front);

}


// Function to insert an element into the queue

void insert(int value) {

        if (isFull()) {

        printf("Queue Overflow: Cannot insert %d, queue is full.\n", value);

        } else {

        if (front == -1) {

        front = 0;

        }

        rear = (rear + 1) % MAX_SIZE;

        queue[rear] = value;

        printf("Inserted %d into the queue.\n", value);

        }

}


// Function to delete an element from the queue

void delete() {

        if (isEmpty()) {

        printf("Queue Underflow: Cannot delete, queue is empty.\n");
```

```
        } else {
        printf("Deleted %d from the queue.\n", queue[front]);
        if (front == rear) {
        // If there was only one element in the queue
        front = rear = -1;
        } else {
        front = (front + 1) % MAX_SIZE;
        }
        }
}

// Function to display the elements in the queue
void display() {
        if (isEmpty()) {
        printf("Queue is empty.\n");
        } else {
        printf("Queue elements: ");
        int i = front;
        do {
        printf("%d ", queue[i]);
        i = (i + 1) % MAX_SIZE;
        } while (i != (rear + 1) % MAX_SIZE);
        printf("\n");
        }
}

int main() {
        insert(10);
        insert(20);
        insert(30);
        display();
```

```
    delete();

    display();


    insert(40);

    insert(50);

    insert(60); // This will cause a queue overflow

    display();


    delete();

    delete();

    delete();

    delete(); // This will cause a queue underflow

    display();


    return 0;

}
```

```
PS C:\Users\risku\coding> cd "c:\Users\risku\coding\" ; if ($?) { gcc rough.c -o rough } ; if ($?) { .\rough }
Inserted 10 into the queue.
Inserted 20 into the queue.
Inserted 30 into the queue.
Queue elements: 10 20 30
Deleted 10 from the queue.
Queue elements: 20 30
Inserted 40 into the queue.
Inserted 50 into the queue.
Inserted 60 into the queue.
Queue elements: 20 30 40 50 60
Deleted 20 from the queue.
Deleted 30 from the queue.
Deleted 40 from the queue.
Deleted 50 from the queue.
Queue elements: 60
```

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 MAX_SIZE 5

int circularQueue[MAX_SIZE];
int front = -1, rear = -1;

// Function to check if the circular queue is empty
int isEmpty() {
	return front == -1;
}

// Function to check if the circular queue is full
int isFull() {
	return (rear + 1) % MAX_SIZE == front;
}

// Function to insert an element into the circular queue
void insert(int value) {
	if (isFull()) {
	printf("Circular Queue Overflow: Cannot insert %d, queue is full.\n", value);
	} else {
	if (front == -1) {
	front = 0;
	}
	rear = (rear + 1) % MAX_SIZE;
	circularQueue[rear] = value;
	printf("Inserted %d into the circular queue.\n", value);
	}
}
```

```c
// Function to delete an element from the circular queue
void delete() {
    if (isEmpty()) {
    printf("Circular Queue Underflow: Cannot delete, queue is empty.\n");
    } else {
    printf("Deleted %d from the circular queue.\n", circularQueue[front]);
    if (front == rear) {
    // If there was only one element in the circular queue
    front = rear = -1;
    } else {
    front = (front + 1) % MAX_SIZE;
    }
    }
}

// Function to display the elements in the circular queue
void display() {
    if (isEmpty()) {
    printf("Circular Queue is empty.\n");
    } else {
    printf("Circular Queue elements: ");
    int i = front;
    do {
    printf("%d ", circularQueue[i]);
    i = (i + 1) % MAX_SIZE;
    } while (i != (rear + 1) % MAX_SIZE);
    printf("\n");
    }
}

int main() {
```

```
insert(10);

insert(20);

insert(30);

display();


delete();

display();


insert(40);

insert(50);

insert(60); // This will cause a circular queue overflow

display();


delete();

delete();

delete();

delete(); // This will cause a circular queue underflow

display();


return 0;

}
```

```
PS C:\Users\risku\coding> cd "c:\Users\risku\coding\" ; if ($?) { gcc rough.c -o rough } ; if ($?) { .\rough }
Inserted 10 into the circular queue.
Inserted 20 into the circular queue.
Inserted 30 into the circular queue.
Circular Queue elements: 10 20 30
Deleted 10 from the circular queue.
Circular Queue elements: 20 30
Inserted 40 into the circular queue.
Inserted 50 into the circular queue.
Inserted 60 into the circular queue.
Circular Queue elements: 20 30 40 50 60
Deleted 20 from the circular queue.
Deleted 30 from the circular queue.
Deleted 40 from the circular queue.
Deleted 50 from the circular queue.
Circular Queue elements: 60
```

LAB Program – 4 (Rishabh Kumar, 1BM22CS221)

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>


// Node structure

struct Node {

        int data;

        struct Node* next;

};


// Function to create a new node

struct Node* createNode(int value) {

        struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));

        if (newNode == NULL) {

        printf("Memory allocation failed.\n");

        exit(1);

        }

        newNode->data = value;

        newNode->next = NULL;

        return newNode;

}


// Function to insert a node at the first position of the linked list

struct Node* insertFirst(struct Node* head, int value) {
```

```
struct Node* newNode = createNode(value);
newNode->next = head;
return newNode;
}

// Function to insert a node at any position of the linked list
struct Node* insertAtPosition(struct Node* head, int value, int position) {
struct Node* newNode = createNode(value);

if (position == 1) {
newNode->next = head;
return newNode;
}

struct Node* current = head;
for (int i = 1; i < position - 1 && current != NULL; i++) {
current = current->next;
}

if (current == NULL) {
printf("Invalid position for insertion.\n");
free(newNode);
return head;
}

newNode->next = current->next;
current->next = newNode;
return head;
}

// Function to insert a node at the end of the linked list
```

```
struct Node* insertEnd(struct Node* head, int value) {
	struct Node* newNode = createNode(value);

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

	struct Node* current = head;
	while (current->next != NULL) {
	current = current->next;
	}

	current->next = newNode;
	return head;
}

// Function to display the contents of the linked list
void display(struct Node* head) {
	printf("Linked List: ");
	struct Node* current = head;
	while (current != NULL) {
	printf("%d -> ", current->data);
	current = current->next;
	}
	printf("NULL\n");
}

// Function to free the memory allocated for the linked list
void freeList(struct Node* head) {
	struct Node* current = head;
	struct Node* nextNode;
```

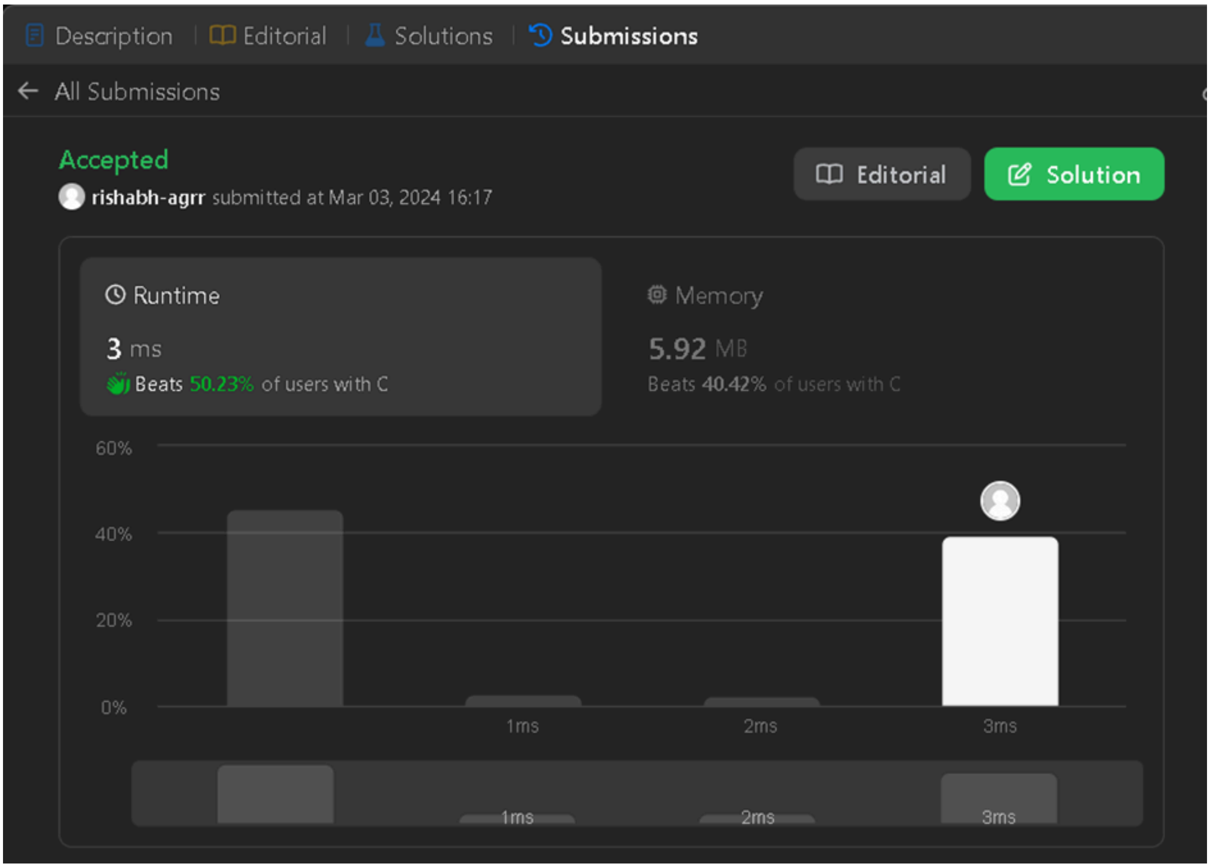
```
        while (current != NULL) {
        nextNode = current->next;
        free(current);
        current = nextNode;
        }
}

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

        // Inserting nodes at various positions
        head = insertEnd(head, 10);
        head = insertEnd(head, 20);
        head = insertFirst(head, 5);
        head = insertAtPosition(head, 15, 2);

        // Displaying the linked list
        display(head);

        // Freeing the memory allocated for the linked list
        freeList(head);

        return 0;
}
```

```
PS C:\Users\risku\coding> cd "c:\Users\risku\coding\" ; if ($?) { gcc rough.c -o rough } ; if ($?) { .\rough }
Linked List: 5 -> 15 -> 10 -> 20 -> NULL
PS C:\Users\risku\coding> 
```

LEETCODE – 206 Reverse Linked list

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

//Reverse the linked list from node head, and link it with other
//nodes which came from the original one's tail
struct ListNode* reverse(struct ListNode* head,int len){
        if(len == 1){
        return head;
        }

        int count = 0;
        struct ListNode* p = head;
        while(count < len-1){
        p = p->next;
        count++;
        }
        struct ListNode* pEnd = p->next;

        struct ListNode* pPre = head;
        p = head->next;
        struct ListNode* pNext;

        count = 0;
        while(count < len-1){
        pNext = p->next;
        p->next = pPre;
```

```
        pPre = p;
        p = pNext;
        count++;
        }
        head->next = pEnd;

        return pPre;
}

struct ListNode* reverseBetween(struct ListNode* head, int left, int right){
        struct ListNode* p = head;struct ListNode* pPre = NULL;
        int count = 1;
        while(count < left){
        pPre = p;
        p = p->next;
        count++;
        }
        if(pPre){
        pPre->next = reverse(p,right-left+1);
        }
        else{
        head = reverse(p,right-left+1);
        }

        return head;
}
```



LAB Program – 5 (Rishabh Kumar, 1BM22CS221)

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>


// Node structure

struct Node {

        int data;

        struct Node* next;
```

```
};

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

// Function to insert a node at the end of the linked list
struct Node* insertEnd(struct Node* head, int value) {
    struct Node* newNode = createNode(value);

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

    struct Node* current = head;
    while (current->next != NULL) {
    current = current->next;
    }

    current->next = newNode;
    return head;
}
```

```
// Function to delete the first element from the linked list
struct Node* deleteFirst(struct Node* head) {
	if (head == NULL) {
	printf("List is empty. Cannot delete.\n");
	return NULL;
	}

	struct Node* newHead = head->next;
	free(head);
	return newHead;
}

// Function to delete a specified element from the linked list
struct Node* deleteElement(struct Node* head, int value) {
	if (head == NULL) {
	printf("List is empty. Cannot delete.\n");
	return NULL;
	}

	if (head->data == value) {
	struct Node* newHead = head->next;
	free(head);
	return newHead;
	}

	struct Node* current = head;
	while (current->next != NULL && current->next->data != value) {
	current = current->next;
	}

	if (current->next == NULL) {
```

```
        printf("Element %d not found in the list. Cannot delete.\n", value);
        return head;
        }

        struct Node* temp = current->next;
        current->next = current->next->next;
        free(temp);
        return head;
}

// Function to delete the last element from the linked list
struct Node* deleteLast(struct Node* head) {
        if (head == NULL) {
        printf("List is empty. Cannot delete.\n");
        return NULL;
        }

        if (head->next == NULL) {
        free(head);
        return NULL;
        }

        struct Node* current = head;
        while (current->next->next != NULL) {
        current = current->next;
        }

        free(current->next);
        current->next = NULL;
        return head;
}
```

```
// Function to display the contents of the linked list
void display(struct Node* head) {
        printf("Linked List: ");
        struct Node* current = head;
        while (current != NULL) {
        printf("%d -> ", current->data);
        current = current->next;
        }
        printf("NULL\n");
}

// Function to free the memory allocated for the linked list
void freeList(struct Node* head) {
        struct Node* current = head;
        struct Node* nextNode;

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

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

        // Inserting nodes at the end of the linked list
        head = insertEnd(head, 10);
        head = insertEnd(head, 20);
        head = insertEnd(head, 30);
```

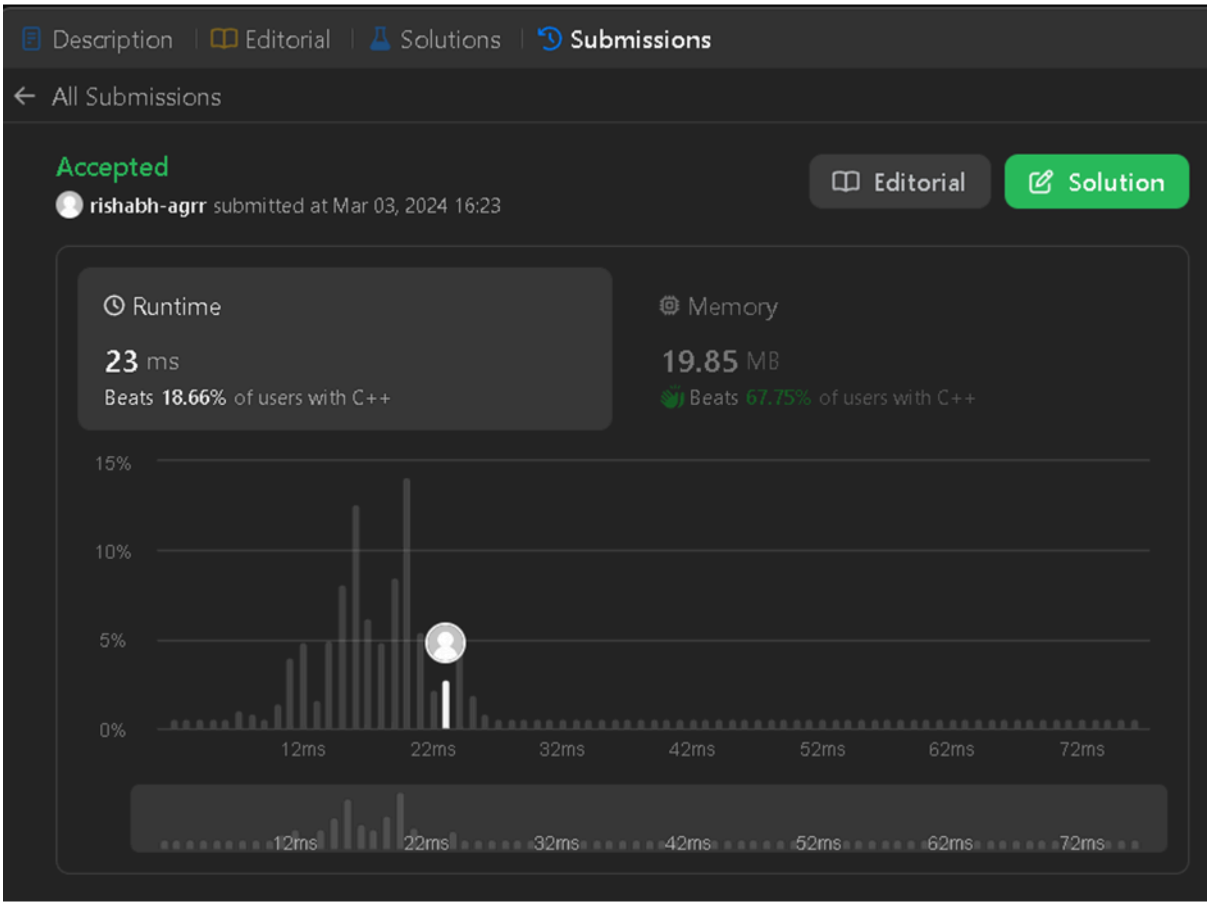
```
    // Displaying the linked list
    display(head);

    // Deleting the first element
    head = deleteFirst(head);
    display(head);

    // Deleting a specified element
    head = deleteElement(head, 20);
    display(head);

    // Deleting the last element
    head = deleteLast(head);
    display(head);

    // Freeing the memory allocated for the linked list
    freeList(head);

    return 0;
}
```

```
PS C:\Users\risku\coding> cd "c:\Users\risku\coding\" ; if ($?) { gcc rough.c -o rough } ; if ($?) { .\rough }
Linked List: 10 -> 20 -> 30 -> NULL
Linked List: 20 -> 30 -> NULL
Linked List: 30 -> NULL
Linked List: NULL
PS C:\Users\risku\coding>
```

LEETCODE – 155 (MIN STACK)

```cpp
#include <stack>

#include <climits>


class MinStack {

private:

        std::stack<int> mainStack;

        std::stack<int> minStack;


public:

        /** initialize your data structure here */

        MinStack() {}


        void push(int val) {

        mainStack.push(val);

        if (minStack.empty() || val <= minStack.top()) {

        minStack.push(val);

        }

        }


        void pop() {

        if (mainStack.top() == minStack.top()) {

        minStack.pop();

        }

        mainStack.pop();

        }


        int top() {

        return mainStack.top();

        }


        int getMin() {
```

```
        return minStack.top();
        }
};

// Example usage:
int main() {
        MinStack minStack;
        minStack.push(-2);
        minStack.push(0);
        minStack.push(-3);

        // Output: -3
        std::cout << minStack.getMin() << std::endl;

        minStack.pop();

        // Output: 0
        std::cout << minStack.top() << std::endl;

        // Output: -2
        std::cout << minStack.getMin() << std::endl;

        return 0;
}
```



LAB Program – 6 (Rishabh Kumar, 1BM22CS221)

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>


// Node structure

struct Node {

        int data;

        struct Node* next;

};
```

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

// Function to insert a node at the end of the linked list
struct Node* insertEnd(struct Node* head, int value) {
        struct Node* newNode = createNode(value);

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

        struct Node* current = head;
        while (current->next != NULL) {
        current = current->next;
        }

        current->next = newNode;
        return head;
}

// Function to display the contents of the linked list
```

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

// Function to sort the linked list (bubble sort)
struct Node* sortLinkedList(struct Node* head) {
    if (head == NULL || head->next == NULL) {
    return head;
    }

    int swapped;
    struct Node* temp;
    struct Node* current;

    do {
    swapped = 0;
    current = head;

    while (current->next != NULL) {
    if (current->data > current->next->data) {
    // Swap the data of current and next nodes
    temp = createNode(current->data);
    current->data = current->next->data;
    current->next->data = temp->data;
    free(temp);
```

```
            swapped = 1;
        }

        current = current->next;
    }
} while (swapped);

return head;
}

// Function to reverse the linked list
struct Node* reverseLinkedList(struct Node* head) {
    struct Node* prev = NULL;
    struct Node* current = head;
    struct Node* next = NULL;

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

    head = prev;
    return head;
}

// Function to concatenate two linked lists
struct Node* concatenateLinkedLists(struct Node* list1, struct Node* list2) {
    if (list1 == NULL) {
```

```
        return list2;
        }

        struct Node* current = list1;
        while (current->next != NULL) {
        current = current->next;
        }

        current->next = list2;
        return list1;
}

// Function to free the memory allocated for the linked list
void freeList(struct Node* head) {
        struct Node* current = head;
        struct Node* nextNode;

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

int main() {
        struct Node* list1 = NULL;
        struct Node* list2 = NULL;

        // Inserting nodes into list1
        list1 = insertEnd(list1, 10);
        list1 = insertEnd(list1, 30);
```

```
list1 = insertEnd(list1, 20);
list1 = insertEnd(list1, 40);

// Inserting nodes into list2
list2 = insertEnd(list2, 50);
list2 = insertEnd(list2, 70);
list2 = insertEnd(list2, 60);
list2 = insertEnd(list2, 80);

// Displaying the original linked lists
printf("Original List 1:\n");
display(list1);
printf("Original List 2:\n");
display(list2);

// Sorting list1
list1 = sortLinkedList(list1);
printf("Sorted List 1:\n");
display(list1);

// Reversing list2
list2 = reverseLinkedList(list2);
printf("Reversed List 2:\n");
display(list2);

// Concatenating list1 and list2
list1 = concatenateLinkedLists(list1, list2);
printf("Concatenated List 1 and List 2:\n");
display(list1);

// Freeing the memory allocated for the linked lists
```

```
	freeList(list1);

	return 0;
}
```

```
PS C:\Users\risku\coding> cd "c:\Users\risku\coding\" ; if ($?) { gcc rough.c -o rough } ; if ($?) { .\rough }
Original List 1:
Linked List: 10 -> 30 -> 20 -> 40 -> NULL
Original List 2:
Linked List: 50 -> 70 -> 60 -> 80 -> NULL
Sorted List 1:
Linked List: 10 -> 20 -> 30 -> 40 -> NULL
Reversed List 2:
Linked List: 80 -> 60 -> 70 -> 50 -> NULL
Concatenated List 1 and List 2:
Linked List: 10 -> 20 -> 30 -> 40 -> 80 -> 60 -> 70 -> 50 -> NULL
```

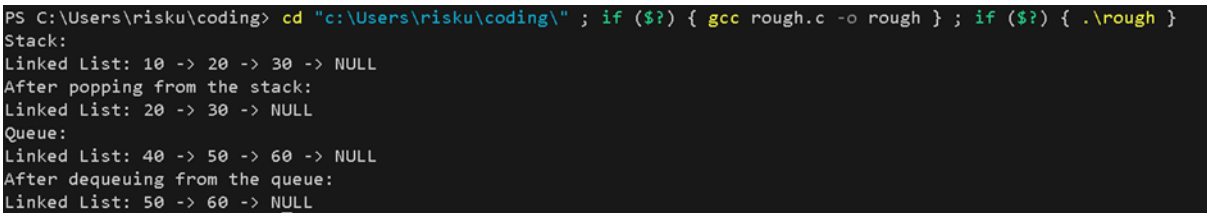
6b) WAP to Implement Single Link List to simulate Stack & Queue Operations

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

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

// Function to create a new node
struct Node* createNode(int value) {
	struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));
	if (newNode == NULL) {
	printf("Memory allocation failed.\n");
	exit(1);
```

```
}
newNode->data = value;
newNode->next = NULL;
return newNode;
}

// Function to insert a node at the end of the linked list (for both stack and queue)
struct Node* insertEnd(struct Node* head, int value) {
struct Node* newNode = createNode(value);

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

struct Node* current = head;
while (current->next != NULL) {
current = current->next;
}

current->next = newNode;
return head;
}

// Function to delete the first node (for both stack and queue)
struct Node* deleteFirst(struct Node* head) {
if (head == NULL) {
printf("List is empty.\n");
return NULL;
}

struct Node* temp = head;
```

```
        head = head->next;
        free(temp);
        return head;
}

// Function to display the contents of the linked list
void display(struct Node* head) {
        printf("Linked List: ");
        struct Node* current = head;
        while (current != NULL) {
        printf("%d -> ", current->data);
        current = current->next;
        }
        printf("NULL\n");
}

int main() {
        struct Node* stack = NULL;
        struct Node* queue = NULL;

        // Pushing elements onto the stack
        stack = insertEnd(stack, 10);
        stack = insertEnd(stack, 20);
        stack = insertEnd(stack, 30);

        // Displaying the stack
        printf("Stack:\n");
        display(stack);

        // Popping an element from the stack
        stack = deleteFirst(stack);
```

```
    printf("After popping from the stack:\n");
    display(stack);

    // Enqueuing elements into the queue
    queue = insertEnd(queue, 40);
    queue = insertEnd(queue, 50);
    queue = insertEnd(queue, 60);

    // Displaying the queue
    printf("Queue:\n");
    display(queue);

    // Dequeuing an element from the queue
    queue = deleteFirst(queue);
    printf("After dequeuing from the queue:\n");
    display(queue);

    // Freeing the memory allocated for the linked lists
    while (stack != NULL) {
    stack = deleteFirst(stack);
    }

    while (queue != NULL) {
    queue = deleteFirst(queue);
    }

    return 0;
}
```



```
PS C:\Users\risku\coding> cd "c:\Users\risku\coding\" ; if ($?) { gcc rough.c -o rough } ; if ($?) { .\rough }
Stack:
Linked List: 10 -> 20 -> 30 -> NULL
After popping from the stack:
Linked List: 20 -> 30 -> NULL
Queue:
Linked List: 40 -> 50 -> 60 -> NULL
After dequeuing from the queue:
Linked List: 50 -> 60 -> NULL
```

<u>LAB Program – 7 (Rishabh Kumar, 1BM22CS221)</u>

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>


// Node structure

struct Node {

        int data;

        struct Node* prev;

        struct Node* next;

};


// Function to create a new node

struct Node* createNode(int value) {

        struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));

        if (newNode == NULL) {

        printf("Memory allocation failed.\n");

        exit(1);
```

```
        }
        newNode->data = value;
        newNode->prev = NULL;
        newNode->next = NULL;
        return newNode;
}

// Function to insert a new node to the left of a specific node
struct Node* insertLeft(struct Node* head, int value, int targetValue) {
        struct Node* newNode = createNode(value);

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

        struct Node* current = head;

        // Find the target node
        while (current != NULL && current->data != targetValue) {
        current = current->next;
        }

        if (current == NULL) {
        printf("Target node not found.\n");
        free(newNode);
        return head;
        }

        // Insert the new node to the left
        if (current->prev != NULL) {
        current->prev->next = newNode;
```

```
newNode->prev = current->prev;
} else {
head = newNode;
}

newNode->next = current;
current->prev = newNode;

return head;
}

// Function to delete a node based on a specific value
struct Node* deleteNode(struct Node* head, int value) {
if (head == NULL) {
printf("List is empty.\n");
return NULL;
}

struct Node* current = head;

// Find the node with the specified value
while (current != NULL && current->data != value) {
current = current->next;
}

if (current == NULL) {
printf("Node with specified value not found.\n");
return head;
}

// Update the pointers of the adjacent nodes
```

```
        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 head;
}

// Function to display the contents of the doubly linked list
void display(struct Node* head) {
        printf("Doubly Linked List: ");
        struct Node* current = head;
        while (current != NULL) {
        printf("%d <-> ", current->data);
        current = current->next;
        }
        printf("NULL\n");
}

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

        // Inserting nodes into the doubly linked list
        doublyLinkedList = insertLeft(doublyLinkedList, 20, 0);
        doublyLinkedList = insertLeft(doublyLinkedList, 30, 20);
```

```c
doublyLinkedList = insertLeft(doublyLinkedList, 40, 30);
doublyLinkedList = insertLeft(doublyLinkedList, 50, 0);

// Displaying the original doubly linked list
display(doublyLinkedList);

// Deleting a node with a specific value
doublyLinkedList = deleteNode(doublyLinkedList, 30);

// Displaying the doubly linked list after deletion
display(doublyLinkedList);

// Freeing the memory allocated for the doubly linked list
while (doublyLinkedList != NULL) {
struct Node* temp = doublyLinkedList;
doublyLinkedList = doublyLinkedList->next;
free(temp);
}

return 0;
}
```

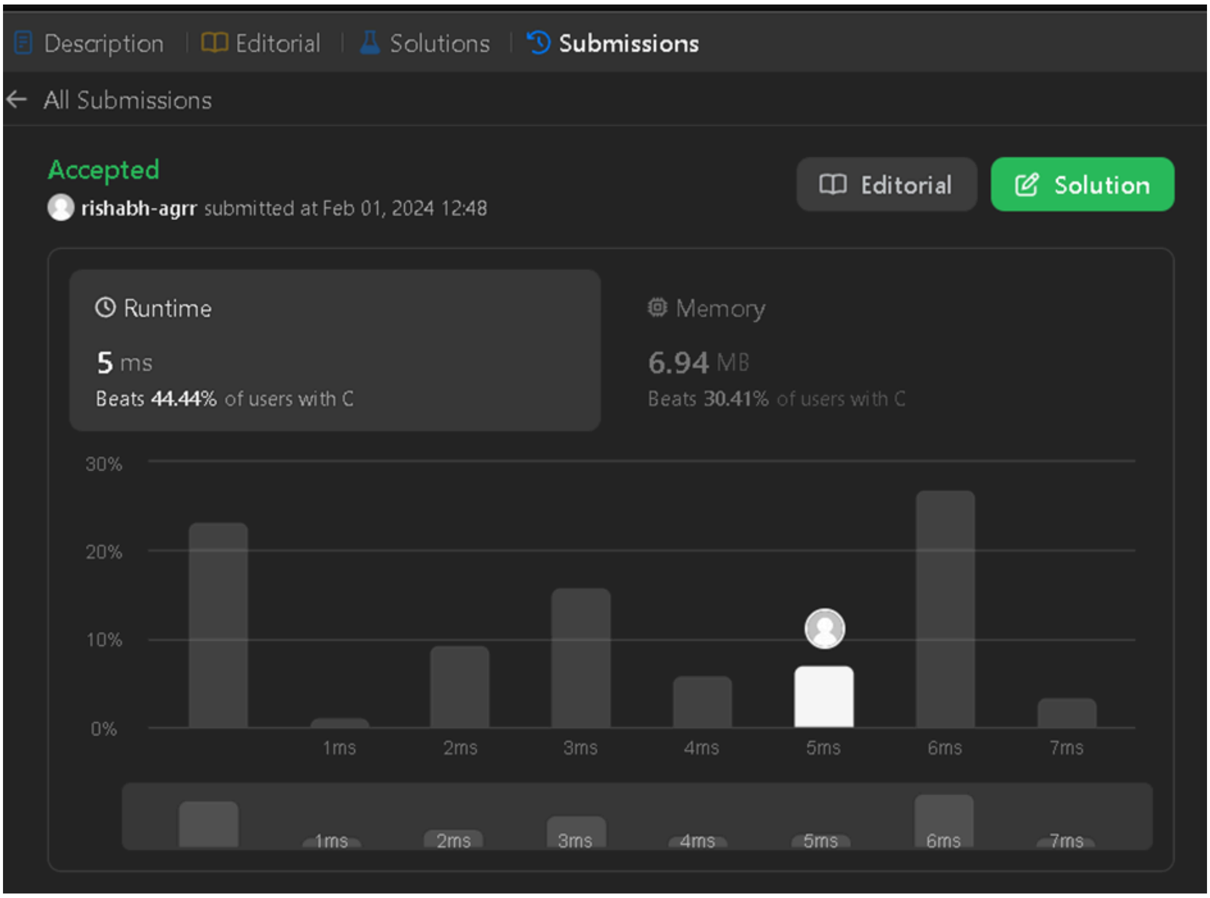
```
PS C:\Users\risku\coding> cd "c:\Users\risku\coding\" ; if ($?) { gcc rough.c -o rough } ; if ($?) { .\rough }
Target node not found.
Doubly Linked List: 40 <-> 30 <-> 20 <-> NULL
Doubly Linked List: 40 <-> 20 <-> NULL
PS C:\Users\risku\coding>
```

LEETCODE _ 725 (split linked list into parts)

```c
/**
 * Definition for singly-linked list.
```

```
 * struct ListNode {
 *     int val;
 *     struct ListNode *next;
 * };
 */
/**
 * Note: The returned array must be malloced, assume caller calls free().
 */
void append(struct ListNode **head, int val){
    struct ListNode* new=(struct ListNode*)malloc(sizeof(struct ListNode));
    struct ListNode* prev=*head;
    new->val=val;
    new->next=NULL;
    if(*head==NULL)
    *head=new;

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

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

```
}

struct ListNode** splitListToParts(struct ListNode* head, int k, int* returnSize) {
        struct ListNode** heads=(struct ListNode**)malloc(sizeof(struct ListNode*)*k);
        int len=length(head);
        struct ListNode* prev=head;
        for(int i=0;i<k;i++){
        struct ListNode* nhead=NULL;
        heads[i]=nhead;
        }

        int common=len/k;
        int extra=len%k;

        int iter;
        int i=0;
        while(prev!=NULL){
        for(int j=0;j<common+((extra>0)?1:0);j++){
      append(&heads[i],prev->val);
        prev=prev->next;
        }
        i++;
        extra--;
        }
        *returnSize=k;
        return heads;
}
```



LAB Program – 8 (Rishabh Kumar, 1BM22CS221)

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>


// Node structure for the binary search tree

struct Node {

    int data;
```

```
struct Node* left;

struct Node* right;

};


// Function to create a new node

struct Node* createNode(int value) {

struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));

if (newNode == NULL) {

printf("Memory allocation failed.\n");

exit(1);

}

newNode->data = value;

newNode->left = newNode->right = NULL;

return newNode;

}


// Function to insert a value into the binary search tree

struct Node* insert(struct Node* root, int value) {

if (root == NULL) {

return createNode(value);

}


if (value < root->data) {

root->left = insert(root->left, value);

} else if (value > root->data) {

root->right = insert(root->right, value);

}


return root;

}
```

```
// Function to perform in-order traversal of the binary search tree

void inOrderTraversal(struct Node* root) {

        if (root != NULL) {

    inOrderTraversal(root->left);

        printf("%d ", root->data);

    inOrderTraversal(root->right);

        }

}


// Function to perform pre-order traversal of the binary search tree

void preOrderTraversal(struct Node* root) {

        if (root != NULL) {

        printf("%d ", root->data);

    preOrderTraversal(root->left);

    preOrderTraversal(root->right);

        }

}


// Function to perform post-order traversal of the binary search tree

void postOrderTraversal(struct Node* root) {

        if (root != NULL) {

    postOrderTraversal(root->left);

    postOrderTraversal(root->right);

        printf("%d ", root->data);

        }

}


// Function to free the memory allocated for the binary search tree

void freeTree(struct Node* root) {

        if (root != NULL) {

        freeTree(root->left);
```

```
        freeTree(root->right);
        free(root);
        }
}

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

        // Constructing a binary search tree
        root = insert(root, 50);
        insert(root, 30);
        insert(root, 20);
        insert(root, 40);
        insert(root, 70);
        insert(root, 60);
        insert(root, 80);

        // Displaying the elements in the tree using in-order traversal
        printf("In-order Traversal: ");
        inOrderTraversal(root);
        printf("\n");

        // Displaying the elements in the tree using pre-order traversal
        printf("Pre-order Traversal: ");
        preOrderTraversal(root);
        printf("\n");

        // Displaying the elements in the tree using post-order traversal
        printf("Post-order Traversal: ");
        postOrderTraversal(root);
        printf("\n");
```

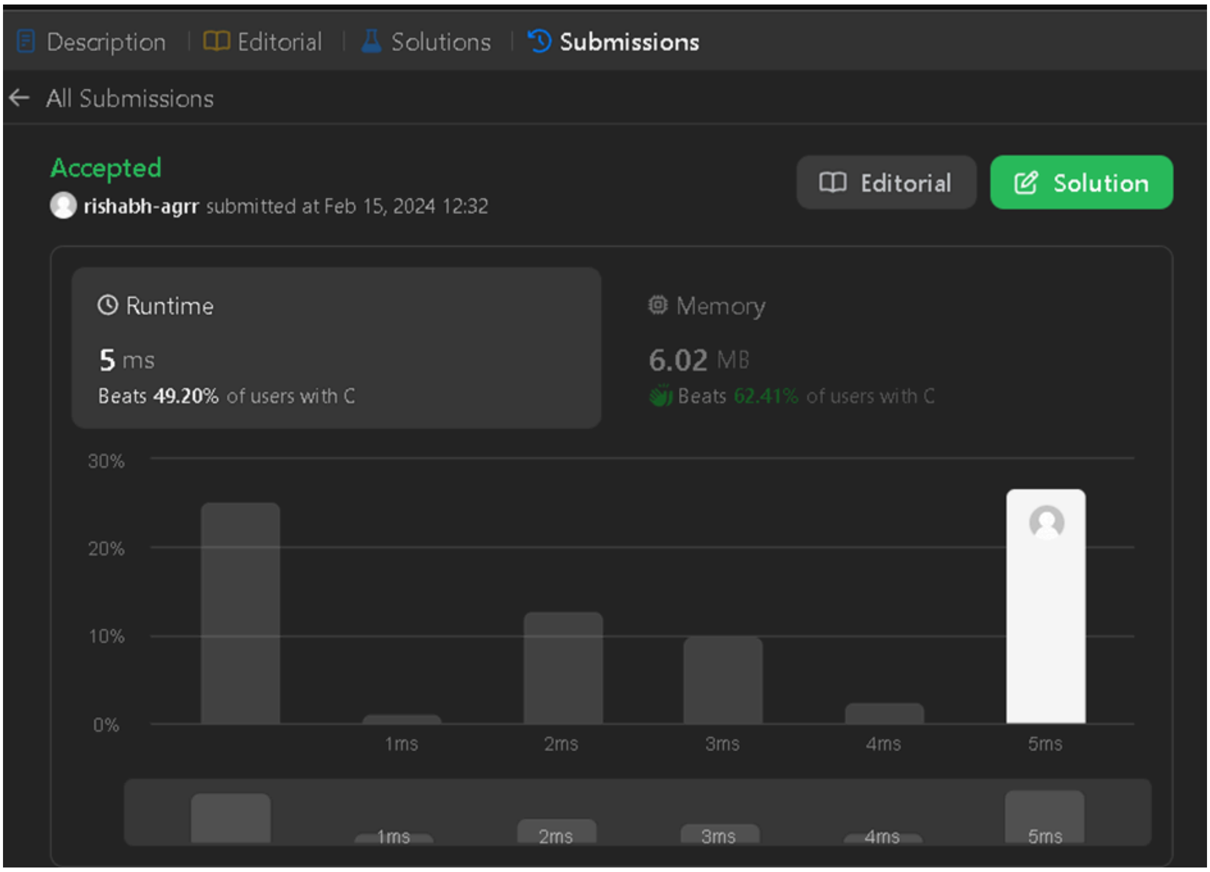
```
        // Freeing the memory allocated for the binary search tree
        freeTree(root);

        return 0;
}
```

```
PS C:\Users\risku\coding> cd "c:\Users\risku\coding\" ; if ($?) { gcc rough.c -o rough } ; if ($?) { .\rough }
In-order Traversal: 20 30 40 50 60 70 80
Pre-order Traversal: 50 30 20 40 70 60 80
Post-order Traversal: 20 40 30 60 80 70 50
```

Leetcode 61 – rotate the list

```
/**
 * Definition for singly-linked list.
 * struct ListNode {
 *      int val;
 *      struct ListNode *next;
 * };
 */
 int GetLength(struct ListNode* head)
{
                if (head == NULL)
                        return 0;

                return 1 + GetLength(head->next);
}
struct ListNode* rotateRight(struct ListNode* head, int k){
        if (head == NULL || k == 0)
                        return head;
        int length = GetLength(head);
```

```
                if (length == 1)
                        return head;
        for(int i=0;i<k%length;i++)
        {
        struct ListNode *p=head;
    while(p->next->next!=NULL)
        {
        p=p->next;
        }
        struct ListNode *a=(struct ListNode *)malloc(sizeof(struct ListNode));
    a->val=p->next->val;
        a->next=head;
        head=a;
        p->next=NULL;
        }
        return head;

}
```



LAB Program – 9 (Rishabh Kumar, 1BM22CS221)

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

```
#include <stdio.h>

#include <stdlib.h>

#include <stdbool.h>


#define MAX_VERTICES 100


// Queue structure for BFS
```

```
struct Queue {
	int front, rear;
	int capacity;
	int* array;
};

// Function to create a new queue
struct Queue* createQueue(int capacity) {
	struct Queue* queue = (struct Queue*)malloc(sizeof(struct Queue));
	if (queue == NULL) {
	printf("Memory allocation failed.\n");
	exit(1);
	}
	queue->capacity = capacity;
	queue->front = queue->rear = -1;
	queue->array = (int*)malloc(capacity * sizeof(int));
	if (queue->array == NULL) {
	printf("Memory allocation failed.\n");
	exit(1);
	}
	return queue;
}

// Function to check if the queue is empty
bool isEmpty(struct Queue* queue) {
	return queue->front == -1;
}

// Function to enqueue a vertex into the queue
void enqueue(struct Queue* queue, int vertex) {
	if (queue->rear == queue->capacity - 1) {
```

```
        printf("Queue overflow.\n");
        exit(1);
        }
        if (isEmpty(queue)) {
        queue->front = 0;
        }
        queue->rear++;
    queue->array[queue->rear] = vertex;
}

// Function to dequeue a vertex from the queue
int dequeue(struct Queue* queue) {
        if (isEmpty(queue)) {
        printf("Queue underflow.\n");
        exit(1);
        }
        int vertex = queue->array[queue->front];
        if (queue->front == queue->rear) {
        queue->front = queue->rear = -1;
        } else {
        queue->front++;
        }
        return vertex;
}

// Function to perform BFS traversal on the graph
void BFS(int graph[MAX_VERTICES][MAX_VERTICES], int vertices, int startVertex) {
        struct Queue* queue = createQueue(vertices);
        bool visited[MAX_VERTICES] = {false};

        visited[startVertex] = true;
```

```
        enqueue(queue, startVertex);

        printf("BFS Traversal starting from vertex %d: ", startVertex);

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

        for (int adjacentVertex = 0; adjacentVertex < vertices; adjacentVertex++) {
        if (graph[currentVertex][adjacentVertex] == 1 && !visited[adjacentVertex]) {
        visited[adjacentVertex] = true;
        enqueue(queue, adjacentVertex);
        }
        }
        }

        printf("\n");

        free(queue->array);
        free(queue);
}

int main() {
        int vertices, edges;

        // Get the number of vertices and edges in the graph
        printf("Enter the number of vertices: ");
        scanf("%d", &vertices);
        printf("Enter the number of edges: ");
        scanf("%d", &edges);
```

```
        // Initialize the adjacency matrix with zeros

        int graph[MAX_VERTICES][MAX_VERTICES] = {0};


        // Get the edges of the graph

        printf("Enter the edges (vertex1 vertex2):\n");

        for (int i = 0; i < edges; i++) {

        int vertex1, vertex2;

        scanf("%d %d", &vertex1, &vertex2);

        graph[vertex1][vertex2] = 1;

        graph[vertex2][vertex1] = 1; // For undirected graph

        }


        // Perform BFS traversal starting from vertex 0

        BFS(graph, vertices, 0);


        return 0;

}
```

```
PS C:\Users\risku\coding> cd "c:\Users\risku\coding\" ; if ($?) { gcc rough.c -o rough } ; if ($?) { .\rough }
Enter the number of vertices: 2
Enter the number of edges: 4
Enter the edges (vertex1 vertex2):
9
5
2
1
5
6
2
5
BFS Traversal starting from vertex 0: 0
```

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

```
#include <stdio.h>

#include <stdlib.h>
```

```
#include <stdbool.h>

#define MAX_VERTICES 100

// Function to perform DFS traversal on the graph

void DFS(int graph[MAX_VERTICES][MAX_VERTICES], int vertices, int startVertex, bool
visited[MAX_VERTICES]) {

    visited[startVertex] = true;


    for (int adjacentVertex = 0; adjacentVertex < vertices; adjacentVertex++) {

    if (graph[startVertex][adjacentVertex] == 1 && !visited[adjacentVertex]) {

    DFS(graph, vertices, adjacentVertex, visited);

    }

    }

}


// Function to check whether the graph is connected or not

bool isConnected(int graph[MAX_VERTICES][MAX_VERTICES], int vertices) {

    bool visited[MAX_VERTICES] = {false};


    // Perform DFS traversal starting from the first vertex

    DFS(graph, vertices, 0, visited);


    // Check if all vertices are visited

    for (int i = 0; i < vertices; i++) {

    if (!visited[i]) {

    return false;

    }

    }


    return true;

}
```

```
int main() {
	int vertices, edges;

	// Get the number of vertices and edges in the graph
	printf("Enter the number of vertices: ");
	scanf("%d", &vertices);
	printf("Enter the number of edges: ");
	scanf("%d", &edges);

	// Initialize the adjacency matrix with zeros
	int graph[MAX_VERTICES][MAX_VERTICES] = {0};

	// Get the edges of the graph
	printf("Enter the edges (vertex1 vertex2):\n");
	for (int i = 0; i < edges; i++) {
	int vertex1, vertex2;
	scanf("%d %d", &vertex1, &vertex2);
	graph[vertex1][vertex2] = 1;
	graph[vertex2][vertex1] = 1; // For undirected graph
	}

	// Check whether the graph is connected or not
	if (isConnected(graph, vertices)) {
	printf("The graph is connected.\n");
	} else {
	printf("The graph is not connected.\n");
	}

	return 0;
}
```

```
PS C:\Users\risku\coding> cd "c:\Users\risku\coding\" ; if ($?) { gcc rough.c -o rough } ; if ($?) { .\rough }
Enter the number of vertices: 2
Enter the number of edges: 4
Enter the edges (vertex1 vertex2):
5 5
4 2
8 9
7 6
The graph is not connected.
```

<u>LAB Program – 10 (Rishabh Kumar, 1BM22CS221)</u>

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.

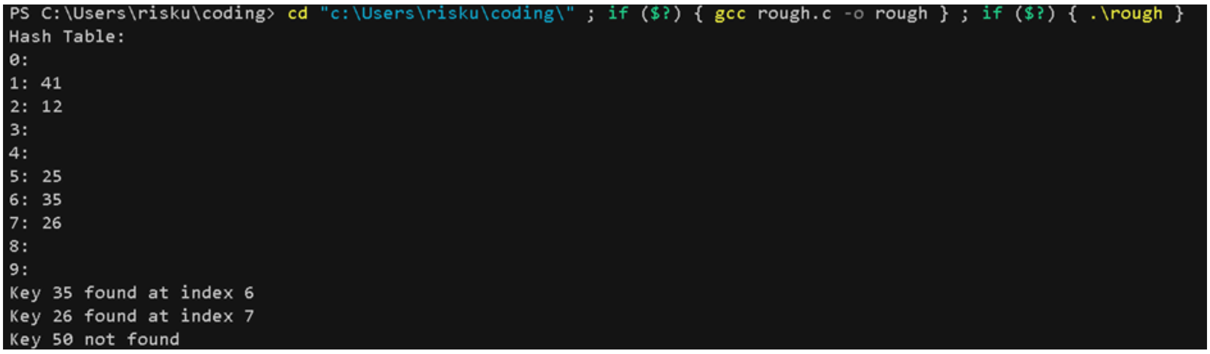
Resolve the collision (if any) using linear probing.

```
#include <stdio.h>

#define TABLE_SIZE 10

int hash_table[TABLE_SIZE];

// Function to initialize hash table
void initializeHashTable() {
    for (int i = 0; i < TABLE_SIZE; i++) {
    hash_table[i] = -1; // -1 indicates empty slot
    }
}
```

```
// Function to calculate hash value using remainder method
int hash(int key) {
        return key % TABLE_SIZE;
}

// Function to insert a value into the hash table using linear probing
void insert(int key) {
        int hkey = hash(key);
        int index = hkey;
        int i = 0;

        while (hash_table[index] != -1) {
        i++;
        index = (hkey + i) % TABLE_SIZE;
        if (i == TABLE_SIZE) {
        printf("Hash table is full. Unable to insert key %d\n", key);
        return;
        }
        }

        hash_table[index] = key;
}

// Function to search for a value in the hash table using linear probing
void search(int key) {
        int hkey = hash(key);
        int index = hkey;
        int i = 0;

        while (hash_table[index] != key) {
```

```
        i++;
        index = (hkey + i) % TABLE_SIZE;
        if (hash_table[index] == -1 || i == TABLE_SIZE) {
        printf("Key %d not found\n", key);
        return;
        }
        }

        printf("Key %d found at index %d\n", key, index);
}

// Function to display the hash table
void displayHashTable() {
        printf("Hash Table:\n");
        for (int i = 0; i < TABLE_SIZE; i++) {
        printf("%d: ", i);
        if (hash_table[i] != -1) {
        printf("%d", hash_table[i]);
        }
        printf("\n");
        }
}

int main() {
        initializeHashTable();

        insert(12);
        insert(25);
        insert(35);
        insert(26);
        insert(41);
```

```c
        displayHashTable();

        search(35);
        search(26);
        search(50);

        return 0;
}
```



```
PS C:\Users\risku\coding> cd "c:\Users\risku\coding\" ; if ($?) { gcc rough.c -o rough } ; if ($?) { .\rough }
Hash Table:
0:
1: 41
2: 12
3:
4:
5: 25
6: 35
7: 26
8:
9:
Key 35 found at index 6
Key 26 found at index 7
Key 50 not found
```