VISVESVARAYA TECHNOLOGICAL UNIVERSITY

“JnanaSangama”, Belgaum -590014, Karnataka.

LAB REPORT
On

DATA STRUCTURES (23CS3PCDST)

Submitted by

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(1BM22CS296)

in partial fulfillment for the award of the degree of
BACHELOR OF ENGINEERING
in
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Department of Computer Science and Engineering

This is to certify that the Lab work entitled **"DATA STRUCTURES"** carried out by SUMIT KUMAR CHAUDHARY **(1BM22CS296)**, who is bonafide student of **B. M. S. College of Engineering**. It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visvesvaraya Technological University, Belgaum during the year 2023-
24. The Lab report has been approved as it satisfies the academic requirements in respect of Data structures Lab - **(23CS3PCDST)** work prescribed for the said degree.

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Index Sheet

Course outcomes:

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

LAB PROGRAM-1

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

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

#define STACK_SIZE 5

void push(int st[], int *top, int item) {
    if (*top == STACK_SIZE - 1) {
        printf("Stack overflow\n");
    } else {
        (*top)++;
        st[*top] = item;
    }
}

int pop(int st[], int *top) {
    int deletedItem;
    if (*top == -1) {
        printf("Stack underflow\n");
        return -1;
    } else {
        deletedItem = st[*top];
        (*top)--;
        return deletedItem;
    }
}

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

int main() {
    int st[STACK_SIZE];
    int top = -1, c, item;
```

```
    while (1) {
        printf("\n1. Push\n2. Pop\n3. Display\n4. Exit\n");
        printf("Enter your choice: ");
        scanf("%d", &c);

        switch (c) {
            case 1:
                printf("Enter an item: ");
                scanf("%d", &item);
                push(st, &top, item);
                break;
            case 2:
                item = pop(st, &top);
                if (item != -1)
                    printf("%d item was deleted\n", item);
                break;
            case 3:
                display(st, &top);
                break;
            case 4:
                exit(0);
            default:
                printf("Invalid choice!!!\n");
        }
    }

    return 0;
}
```

Output:

```
1. Push
2. Pop
3. Display
4. Exit
Enter your choice: 1
Enter an item: 34
Enter your choice: 1
Enter an item: 56
Enter your choice: 1
Enter an item: 23
Enter your choice: 3
Stack elements: 34  56  23
Enter your choice: 2
23 item was deleted
Enter your choice: 3
Stack elements: 34  56
Enter your choice: 2
56 item was deleted
Enter your choice: 3
Stack elements: 34
Enter your choice: 4
```

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 <string.h>

#define MAX_SIZE 100

typedef struct {
    char items[MAX_SIZE];
    int top;
} Stack;

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

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

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

void push(Stack *s, char c) {
    if (!isFull(s)) {
        s->items[++(s->top)] = c;
    }
}

char pop(Stack *s) {
    if (!isEmpty(s)) {
        return s->items[(s->top)--];
    }
    return '\0';
}

char peek(Stack *s) {
    if (!isEmpty(s)) {
        return s->items[s->top];
    }
    return '\0';
}
```

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

void infixToPostfix(char *infix, char *postfix) {
    Stack operatorStack;
    initialize(&operatorStack);
    int i, j = 0;
    for (i = 0; infix[i]; i++) {
        char token = infix[i];
        if (token == '(') {
            push(&operatorStack, token);
        } else if (token == ')') {
            while (!isEmpty(&operatorStack) && peek(&operatorStack) != '(') {
                postfix[j++] = pop(&operatorStack);
            }
            pop(&operatorStack); // Discard '('
        } else if (isOperator(token)) {
            while (!isEmpty(&operatorStack) && precedence(peek(&operatorStack)) >=
precedence(token)) {
                postfix[j++] = pop(&operatorStack);
            }
            push(&operatorStack, token);
        } else { // Operand
            postfix[j++] = token;
        }
    }
    while (!isEmpty(&operatorStack)) {
        postfix[j++] = pop(&operatorStack);
    }
    postfix[j] = '\0';
}

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

    printf("Enter a valid parenthesized infix arithmetic expression: ");
    fgets(infix, sizeof(infix), stdin);
    infix[strcspn(infix, "\n")] = '\0'; // Remove trailing newline

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

    return 0;  }
```

```
Enter a valid parenthesized infix arithmetic expression: ((A
    +B)*C/d)
Postfix expression: AB+C*d/
```

LAB PROGRAM-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>
#include <stdlib.h>

#define MAX_SIZE 5

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

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

int delete() {
   if (front == -1 || front > rear) {
      printf("Queue underflow\n");
      return -1; // Return some default value to indicate failure
   }
   int deletedItem = queue[front];
   front++;
   return deletedItem;
}

void display() {
   if (front == -1 || front > rear) {
```

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

int main() {
    int choice, value;

    while (1) {
        printf("\n1. Insert\n2. Delete\n3. Display\n4. Exit\n");
        printf("Enter your choice: ");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                printf("Enter the value to insert: ");
                scanf("%d", &value);
                insert(value);
                break;
            case 2:
                printf("Deleted item: %d\n", delete());
                break;
            case 3:
                display();
                break;
            case 4:
                exit(0);
            default:
                printf("Invalid choice\n");
        }
    }

    return 0;
}
```

```
1. Insert
2. Delete
3. Display
4. Exit
Enter your choice: 1
Enter the value to insert: 34
Enter your choice: 1
Enter the value to insert: 56
Enter your choice: 1
Enter the value to insert: 12
Enter your choice: 3
Queue elements: 34 56 12
Enter your choice: 2
Deleted item: 34
Enter your choice: 3
Queue elements: 56 12
Enter your choice: 2
Deleted item: 56
Enter your choice: 3
Queue elements: 12
Enter your choice: 2
Deleted item: 12
Enter your choice: 4
```

LAB PROGRAM-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>
#include <stdlib.h>

#define MAX_SIZE 5

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

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

int delete() {
   if (front == -1) {
      printf("Queue underflow\n");
      return -1; // Return some default value to indicate failure
   }
   int deletedItem = queue[front];
   if (front == rear) {
      front = rear = -1;
   } else if (front == MAX_SIZE - 1) {
      front = 0;
   } else {
      front++;
```

```
    }
    return deletedItem;
}

void display() {
    if (front == -1) {
        printf("Queue is empty\n");
        return;
    }
    printf("Queue elements: ");
    if (rear >= front) {
        for (int i = front; i <= rear; i++) {
            printf("%d ", queue[i]);
        }
    } else {
        for (int i = front; i < MAX_SIZE; i++) {
            printf("%d ", queue[i]);
        }
        for (int i = 0; i <= rear; i++) {
            printf("%d ", queue[i]);
        }
    }
    printf("\n");
}

int main() {
    int choice, value;

    while (1) {
        printf("\n1. Insert\n2. Delete\n3. Display\n4. Exit\n");
        printf("Enter your choice: ");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                printf("Enter the value to insert: ");
                scanf("%d", &value);
                insert(value);
                break;
            case 2:
                printf("Deleted item: %d\n", delete());
                break;
```

```
            case 3:
                display();
                break;
            case 4:
                exit(0);
            default:
                printf("Invalid choice\n");
        }
    }

    return 0;
}
```

OUTPUT:

```
1. Insert
2. Delete
3. Display
4. Exit
Enter your choice: 1
Enter the value to insert: 23
Enter your choice: 1
Enter the value to insert: 45
Enter your choice: 1
Enter the value to insert: 12
Enter your choice: 3
Queue elements: 23 45 12
Enter your choice: 2
Deleted item: 23
Enter your choice: 3
Queue elements: 45 12
Enter your choice: 2
Deleted item: 45
Enter your choice: 3
Queue elements: 12
Enter your choice: 2
Deleted item: 12
Enter your choice: 4
```

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>

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

// Function to create a new node
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->next = NULL;
    return newNode;
}

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

```
// Function to insert a node at the beginning of the list
struct Node* insertAtBeginning(struct Node* head, int data) {
    struct Node* newNode = createNode(data);
    newNode->next = head;
    return newNode;
}

// Function to insert a node at any position in the list
void insertAtPosition(struct Node* head, int data, int position) {
    if (position < 1) {
        printf("Invalid position\n");
        return;
    }
    struct Node* newNode = createNode(data);
    struct Node* current = head;
    for (int i = 1; i < position - 1 && current != NULL; i++) {
        current = current->next;
    }
    if (current == NULL) {
        printf("Position out of range\n");
        return;
    }
    newNode->next = current->next;
    current->next = newNode;
}

// Function to insert a node at the end of the list
void insertAtEnd(struct Node* head, int data) {
    struct Node* newNode = createNode(data);
    if (head == NULL) {
        head = newNode;
        return;
    }
    struct Node* current = head;
    while (current->next != NULL) {
        current = current->next;
    }
    current->next = newNode;
}

int main() {
```

```
    struct Node* head = NULL;
    int choice, data, position;

    while (1) {
        printf("\n1. Insert at beginning\n2. Insert at position\n3. Insert at end\n4. Display\n5.
Exit\n");
        printf("Enter your choice: ");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                printf("Enter the data to insert: ");
                scanf("%d", &data);
                head = insertAtBeginning(head, data);
                break;
            case 2:
                printf("Enter the data to insert: ");
                scanf("%d", &data);
                printf("Enter the position to insert: ");
                scanf("%d", &position);
                insertAtPosition(head, data, position);
                break;
            case 3:
                printf("Enter the data to insert: ");
                scanf("%d", &data);
                insertAtEnd(head, data);
                break;
            case 4:
                display(head);
                break;
            case 5:
                exit(0);
            default:
                printf("Invalid choice\n");
        }
    }

    return 0;
}
```

OUTPUT:

```
1. Insert at beginning
2. Insert at position
3. Insert at end
4. Display
5. Exit
Enter your choice: 1
Enter the data to insert: 12
Enter your choice: 4
12 -> NULL
Enter your choice: 1
Enter the data to insert: 8
Enter your choice: 4
8 -> 12 -> NULL
Enter your choice: 3
Enter the data to insert: 45
Enter your choice: 4
8 -> 12 -> 45 -> NULL
Enter your choice: 2
Enter the data to insert: 18
Enter the position to insert: 2
Enter your choice: 4
8 -> 18 -> 12 -> 45 -> NULL
Enter your choice: 5
```

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 *create_list() {
    struct node *head = NULL;
    struct node *temp, *new_node;
    int num;
    char ch;
    do {
        printf("Enter data: ");
        scanf("%d", &num);
        new_node = (struct node *)malloc(sizeof(struct node));
        new_node->data = num;
        new_node->next = NULL;
        if (head == NULL) {
            head = new_node;
            temp = head;
        } else {
            temp->next = new_node;
            temp = new_node;
        }
        printf("Do you want to add another node? (y/n): ");
        scanf(" %c", &ch);
    } while(ch == 'y' || ch == 'Y');
    return head;
}

struct node *delete_beg(struct node *head){
    struct node *temp;
```

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

struct node *delete_end(struct node *head){
    struct node *temp, *preptr;
    preptr=temp=head;
    while(temp->next!=NULL){
        preptr=temp;
        temp=temp->next;
    }
    if(temp==head){
        head=NULL;
    }
    else{
        preptr->next=NULL;
    }
    free(temp);
    return head;
}

struct node *deleteafter_pos(struct node *head){
    struct node *preptr,*temp;
    int value;
    printf("Enter the value after which you want to delete: ");
    scanf("%d",&value);
    temp=head;
    preptr=temp;
    while(preptr->data!=value){
        preptr=temp;
        temp=temp->next;
    }
    preptr->next=temp->next;
    free(temp);
    return head;
}

struct node *deletenode(struct node *head){
    struct node *preptr,*temp;
    int value;
```

```
    printf("Enter the value you want to delete: ");
    scanf("%d",&value);
    temp=head;
    if(temp->data==value){
        head=delete_beg(head);
        return head;
    }
    else{
        while(temp->data!=value){
            preptr=temp;
            temp=temp->next;
        }
        preptr->next=temp->next;
        free(temp);
        return head;
    }
}

void display(struct node *head){
    if(head == NULL){
        printf("List is empty.\n");
        return;
    }
    struct node *temp = head;
    while(temp != NULL){
        printf("%d ", temp->data);
        temp = temp->next;
    }
    printf("\n");
}

int main() {
    struct node *head = NULL;
    int choice;

    printf("Create Linked List:\n");
    head = create_list();

    do {
        printf("\n1. Delete First\n");
        printf("2. Delete Last\n");
        printf("3. Delete After Position\n");
```

```
        printf("4. Delete Node\n");
        printf("5. Display\n");
        printf("0. Exit\n");
        printf("Enter your choice: ");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                head = delete_beg(head);
                printf("Node deleted from beginning.\n");
                break;
            case 2:
                head = delete_end(head);
                printf("Node deleted from end.\n");
                break;
            case 3:
                head = deleteafter_pos(head);
                printf("Node deleted after given position.\n");
                break;
            case 4:
                head = deletenode(head);
                printf("Node deleted.\n");
                break;
            case 5:
                printf("Linked List: ");
                display(head);
                break;
            case 0:
                printf("Exiting...\n");
                break;
            default:
                printf("Invalid choice. Please try again.\n");
                break;
        }
    } while (choice != 0);

    return 0;
}
```

OUTPUT:

```
Create Linked List:
Enter data: 12
Do you want to add another node? (y/n): y
Enter data: 23
Do you want to add another node? (y/n): y
Enter data: 45
Do you want to add another node? (y/n): y
Enter data: 67
Do you want to add another node? (y/n): y
Enter data: 78
Do you want to add another node? (y/n): n

1. Delete First
2. Delete Last
3. Delete After Position
4. Delete Node
5. Display
0. Exit
Enter your choice: 1
Node deleted from beginning.
Enter your choice: 2
Node deleted from end.
Enter your choice: 5
Linked List: 23 45 67
Enter your choice: 3
Enter the value after which you want to delete: 23
Node deleted after given position.
```

LAB PROGRAM-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 data) {
   Node* newNode = (Node*)malloc(sizeof(Node));
   if (newNode == NULL) {
      printf("Memory allocation failed!\n");
      exit(1);
   }
   newNode->data = data;
   newNode->next = NULL;
   return newNode;
}

void append(Node** head, int data) {
   Node* newNode = createNode(data);
   if (*head == NULL) {
      *head = newNode;
      return;
   }
   Node* current = *head;
   while (current->next != NULL) {
      current = current->next;
   }
   current->next = newNode;
}

void display(Node* head) {
```

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

void sort(Node** head) {
    Node *current, *index;
    int temp;

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

    for (current = *head; current->next != NULL; current = current->next) {
        for (index = current->next; index != NULL; index = index->next) {
            if (current->data > index->data) {
                temp = current->data;
                current->data = index->data;
                index->data = temp;
            }
        }
    }
}

void reverse(Node** head) {
    Node *prev, *current, *next;
    prev = NULL;
    current = *head;
    while (current != NULL) {
        next = current->next;
        current->next = prev;
        prev = current;
        current = next;
    }
    *head = prev;
}

void concatenate(Node** head1, Node* head2) {
    if (*head1 == NULL) {
        *head1 = head2;
```

```
        return;
    }
    Node* current = *head1;
    while (current->next != NULL) {
        current = current->next;
    }
    current->next = head2;
}

Node* createLinkedList() {
    Node* head = NULL;
    int n, data;
    printf("Enter the number of elements: ");
    scanf("%d", &n);
    printf("Enter the elements: ");
    for (int i = 0; i < n; ++i) {
        scanf("%d", &data);
        append(&head, data);
    }
    return head;
}

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

    printf("Creating list 1:\n");
    list1 = createLinkedList();

    printf("Creating list 2:\n");
    list2 = createLinkedList();

    int choice;
    do {
        printf("\nChoose operation:\n");
        printf("1. Sort the linked list\n");
        printf("2. Reverse the linked list\n");
        printf("3. Concatenate two linked lists\n");
        printf("4. Display the linked list\n");
        printf("5. Exit\n");

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

```
        switch (choice) {
            case 1:
                sort(&list1);
                break;
            case 2:
                reverse(&list1);
                break;
            case 3:
                concatenate(&list1, list2);
                break;
            case 4:
                display(list1);
                break;
            case 5:
                printf("Exiting...\n");
                break;
            default:
                printf("Invalid choice. Please enter a valid option.\n");
        }
    } while (choice != 5);

    return 0;
}
```

OUTPUT:

```
Creating list 1:
Enter the number of elements: 3
Enter the elements: 12
34
45
Creating list 2:
Enter the number of elements: 3
Enter the elements: 56
78
89
1. Sort the linked list
2. Reverse the linked list
3. Concatenate two linked lists
4. Display the linked list
5. Exit

Choose operation:
1

Choose operation:
4
12 -> 34 -> 45 -> NULL

Choose operation:
2

Choose operation:
4
45 -> 34 -> 12 -> NULL
```

```
Choose operation:
3

Choose operation:
4
45 -> 34 -> 12 -> 56 -> 78 -> 89 -> NULL

Choose operation:
5
Exiting...
```

LAB PROGRAM-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;
};

typedef struct Node Node;

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

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

// Stack operations: push and pop
void push(Node** top, int data) {
    Node* newNode = createNode(data);
    newNode->next = *top;
    *top = newNode;
}

int pop(Node** top) {
    if (*top == NULL) {
        printf("Stack underflow!\n");
        exit(1);
    }
    Node* temp = *top;
    int poppedData = temp->data;
    *top = (*top)->next;
    free(temp);
    return poppedData;
}

// Queue operations: enqueue and dequeue
void enqueue(Node** rear, int data) {
    Node* newNode = createNode(data);
    if (*rear == NULL) {
        *rear = newNode;
    } else {
        (*rear)->next = newNode;
        *rear = newNode;
    }
}

int dequeue(Node** front) {
    if (*front == NULL) {
        printf("Queue underflow!\n");
        exit(1);
    }
    Node* temp = *front;
    int dequeuedData = temp->data;
    *front = (*front)->next;
```

```c
    free(temp);
    return dequeuedData;
}

// Display the elements of the stack or queue
void display(Node* head) {
    if (head == NULL) {
        printf("Empty\n");
        return;
    }
    while (head != NULL) {
        printf("%d ", head->data);
        head = head->next;
    }
    printf("\n");
}

int main() {
    Node* stackTop = NULL;  // Initialize stack top
    Node* queueFront = NULL; // Initialize queue front
    Node* queueRear = NULL; // Initialize queue rear

    int choice, data;
    do {
        printf("\nChoose operation:\n");
        printf("1. Push (Stack)\n");
        printf("2. Pop (Stack)\n");
        printf("3. Enqueue (Queue)\n");
        printf("4. Dequeue (Queue)\n");
        printf("5. Display (Stack)\n");
        printf("6. Display (Queue)\n");
        printf("7. Exit\n");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                printf("Enter data to push: ");
                scanf("%d", &data);
                push(&stackTop, data);
                break;
            case 2:
                if (stackTop == NULL) {
```

```
            printf("Stack is empty.\n");
        } else {
            printf("Popped element: %d\n", pop(&stackTop));
        }
        break;
    case 3:
        printf("Enter data to enqueue: ");
        scanf("%d", &data);
        enqueue(&queueRear, data);
        if (queueFront == NULL) {
            queueFront = queueRear;
        }
        break;
    case 4:
        if (queueFront == NULL) {
            printf("Queue is empty.\n");
        } else {
            printf("Dequeued element: %d\n", dequeue(&queueFront));
        }
        break;
    case 5:
        printf("Stack elements: ");
        display(stackTop);
        break;
    case 6:
        printf("Queue elements: ");
        display(queueFront);
        break;
    case 7:
        printf("Exiting...\n");
        break;
    default:
        printf("Invalid choice. Please enter a valid option.\n");
    }
  } while (choice != 7);

  return 0;
}
```

OUTPUT:

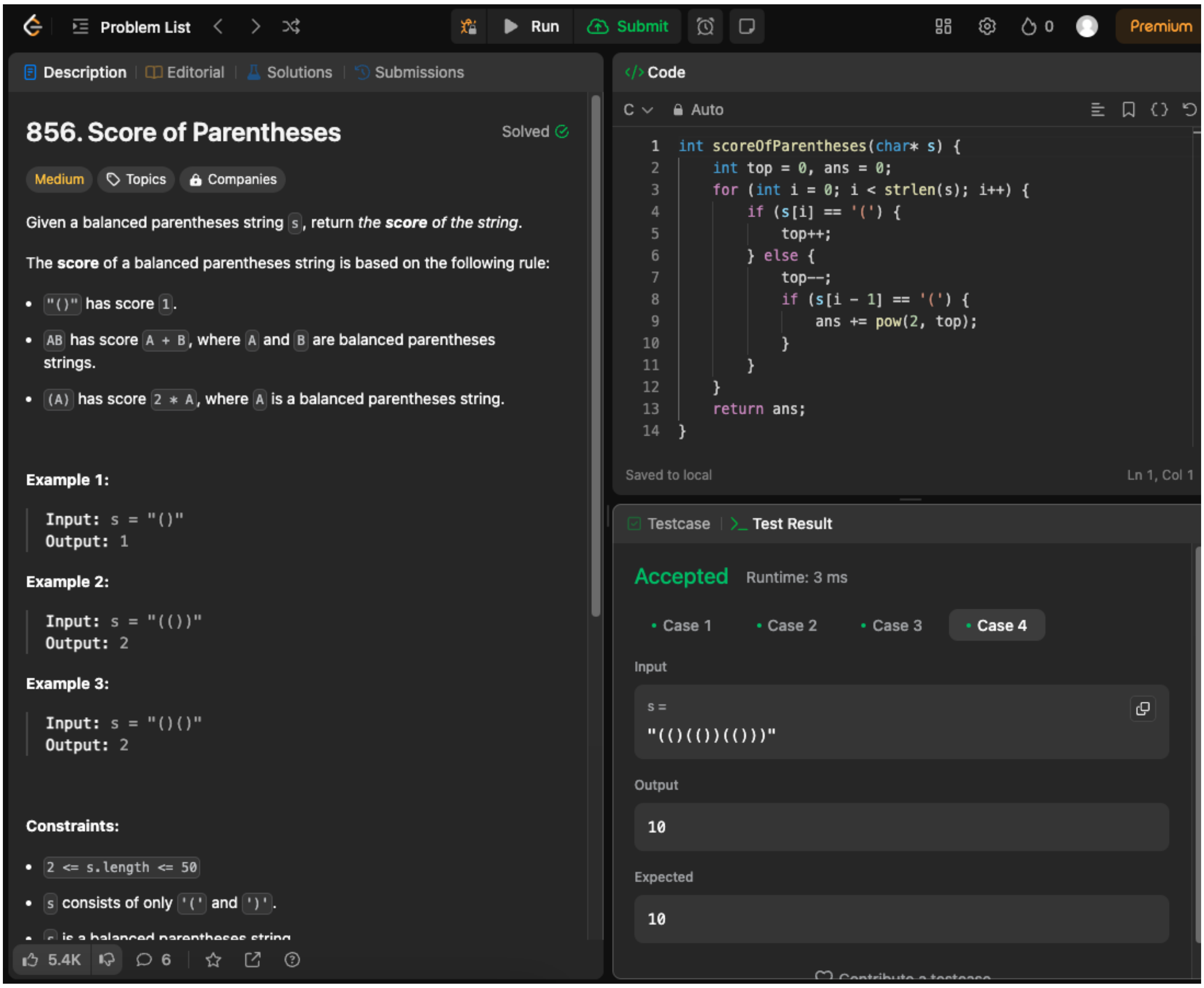
```
1. Push (Stack)
2. Pop (Stack)
3. Enqueue (Queue)
4. Dequeue (Queue)
5. Display (Stack)
6. Display (Queue)
7. Exit

Choose operation:
1
Enter data to push: 12

Choose operation:
1
Enter data to push: 23

Choose operation:
5
Stack elements: 23 12

Choose operation:
2
Popped element: 23

Choose operation:
5
Stack elements: 12

Choose operation:
```

```
1. Push (Stack)
2. Pop (Stack)
3. Enqueue (Queue)
4. Dequeue (Queue)
5. Display (Stack)
6. Display (Queue)
7. Exit

Choose operation:
3
Enter data to enqueue: 23

Choose operation:
3
Enter data to enqueue: 45

Choose operation:
6
Queue elements: 23 45

Choose operation:
4
Dequeued element: 23

Choose operation:
6
Queue elements: 45

Choose operation:
7
Exiting...
```

LEETCODE PROBLEM-1:

Score of Parentheses:

```
int scoreOfParentheses(char* s) {
    int count=0;
    int ans=0;
    int size=sizeof(s)/sizeof(s[0]);
    for(int i=0;s[i]!='\0';i++)
    {
        if(s[i]=='(')
        {
            count++;
        }
        else{
            count--;
            if(s[i-1]=='(')
            {
                ans+=pow(2,count);
            }
        }

    }
     return ans;
}
```



<u>LAB PROGRAM-7:</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;
};

typedef struct Node Node;


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

// Function to insert a new node to the left of a specified node
void insertLeft(Node** head, int value, int newValue) {
    Node* newNode = createNode(newValue);
    Node* current = *head;
    while (current != NULL && current->data != value) {
        current = current->next;
    }
    if (current == NULL) {
        printf("Node with value %d not found. New node not inserted.\n", value);
        free(newNode);
        return;
    }
    newNode->next = current;
    newNode->prev = current->prev;
    if (current->prev != NULL) {
        current->prev->next = newNode;
    }
    current->prev = newNode;
    if (current == *head) {
        *head = newNode;
    }
}

// Function to delete a node based on a specific value
```

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

// Function to display the contents of the list
void display(Node* head) {
    if (head == NULL) {
        printf("List is empty.\n");
        return;
    }
    while (head != NULL) {
        printf("%d <-> ", head->data);
        head = head->next;
    }
    printf("NULL\n");
}

int main() {
    Node* head = createNode(1);
    head->next = createNode(2);
    head->next->prev = head;
    head->next->next = createNode(3);
    head->next->next->prev = head->next;

    int choice, value, newValue;
```

```
    do {
        printf("\nChoose operation:\n");
        printf("1. Insert a new node to the left of a specified node\n");
        printf("2. Delete a node based on a specific value\n");
        printf("3. Display the contents of the list\n");
        printf("4. Exit\n");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                printf("Enter the value of the existing node: ");
                scanf("%d", &value);
                printf("Enter the value of the new node: ");
                scanf("%d", &newValue);
                insertLeft(&head, value, newValue);
                break;
            case 2:
                printf("Enter the value of the node to delete: ");
                scanf("%d", &value);
                deleteNode(&head, value);
                break;
            case 3:
                printf("List contents:\n");
                display(head);
                break;
            case 4:
                printf("Exiting...\n");
                break;
            default:
                printf("Invalid choice. Please enter a valid option.\n");
        }
    } while (choice != 4);

    return 0;
}
```

OUTPUT:

```
enter operation
1.create
2.display
3.insert at left
4.delete at position
5.-1 to end
enter operation
1
Enter the no. of elements:
2
Enter the 1 element :
23
Enter the 2 element :
45
enter operation
2
23
45
enter operation
3
enter the node
2
enter data
56
```

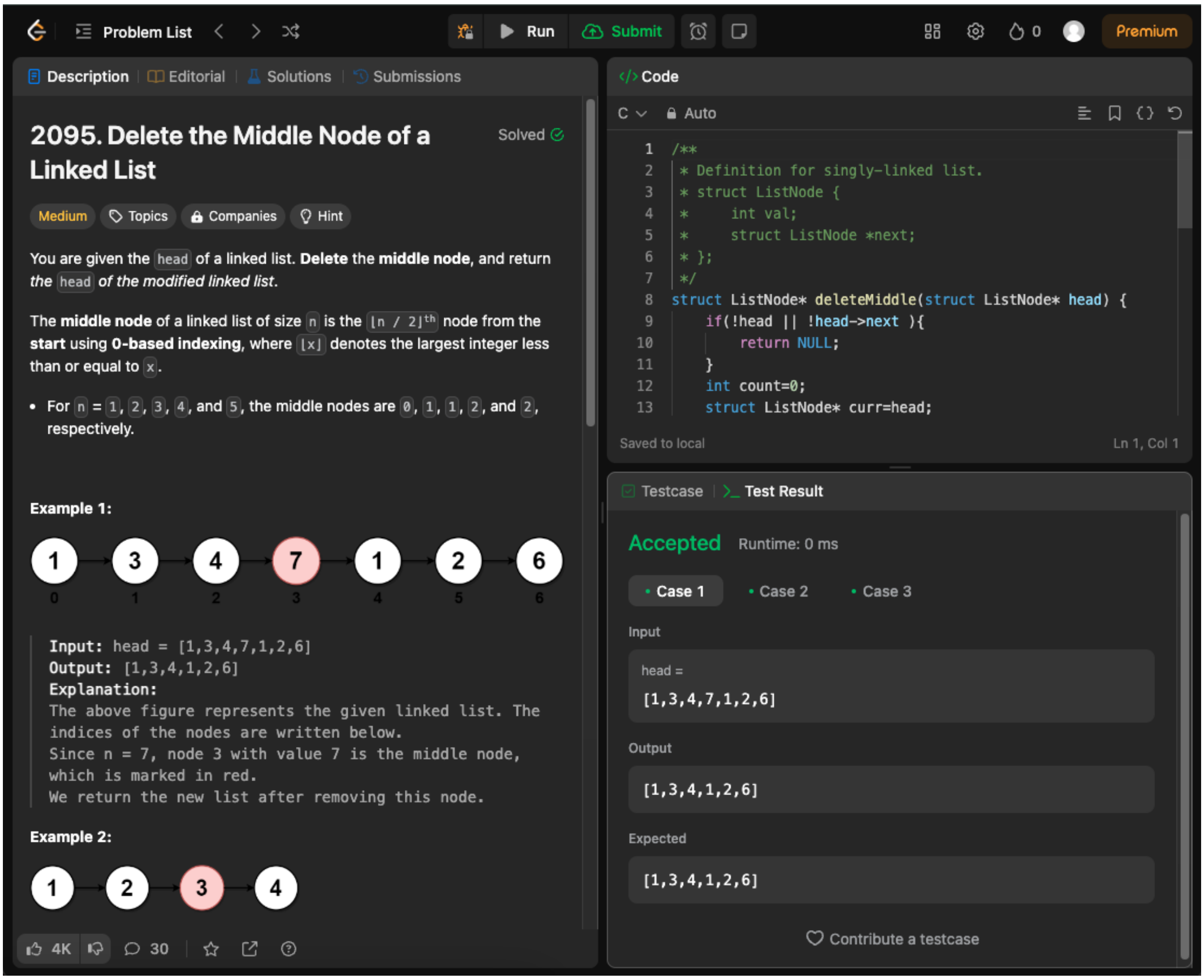
```
enter operation
2
23
56
45
enter operation
4
enter position
2
enter operation
2
23
45
enter operation
```

LEETCODE PROBLEM-2:

Delete the Middle Node of the Linked List

```
struct node {
 int val;
  struct node *next;
};

struct node* deleteMiddle(struct node* head) {
   if(head==NULL) return NULL;
   struct node* newnode=(struct node*)malloc(sizeof(struct node));
   newnode->val=0;
   newnode->next=head;
   struct node* preptr=newnode;
   struct node* ptr=head;
   while(ptr!=NULL && ptr->next!=NULL){
      preptr=preptr->next;
      ptr=ptr->next->next;
```

```
    }
    struct node *temp=preptr->next;
    preptr->next=preptr->next->next;
    free(temp);
    struct node* newHead=newnode->next;
    free(newnode);
    return newHead;
    return head;
}
```



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>

// Structure for a node of 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));
    newNode->data = value;
    newNode->left = newNode->right = NULL;
    return newNode;
}

// Function to insert a new node 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 traverse the binary search tree using inorder traversal
void inorderTraversal(struct Node* root) {
    if (root != NULL) {
        inorderTraversal(root->left);
        printf("%d ", root->data);
        inorderTraversal(root->right);
    }
}

// Function to traverse the binary search tree using postorder traversal
void postorderTraversal(struct Node* root) {
    if (root != NULL) {
```

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

// Function to traverse the binary search tree using preorder traversal
void preorderTraversal(struct Node* root) {
    if (root != NULL) {
        printf("%d ", root->data);
        preorderTraversal(root->left);
        preorderTraversal(root->right);
    }
}

// Function to display the elements in the binary search tree
void display(struct Node* root) {
    printf("Elements in the tree: ");
    inorderTraversal(root);
    printf("\n");
}

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

    do {
        printf("\nBinary Search Tree Operations:\n");
        printf("1. Insert\n");
        printf("2. Inorder Traversal\n");
        printf("3. Postorder Traversal\n");
        printf("4. Preorder Traversal\n");
        printf("5. Display\n");
        printf("6. Exit\n");
        printf("Enter your choice: ");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                printf("Enter value to insert: ");
                scanf("%d", &value);
                root = insert(root, value);
                break;
            case 2:
                printf("Inorder Traversal: ");
                inorderTraversal(root);
                printf("\n");
                break;
            case 3:
                printf("Postorder Traversal: ");
                postorderTraversal(root);
                printf("\n");
                break;
            case 4:
                printf("Preorder Traversal: ");
                preorderTraversal(root);
```

```
            printf("\n");
            break;
        case 5:
            display(root);
            break;
        case 6:
            printf("Exiting...\n");
            break;
        default:
            printf("Invalid choice! Please enter a valid option.\n");
      }
   } while (choice != 6);

   return 0;
}
```

OUTPUT:

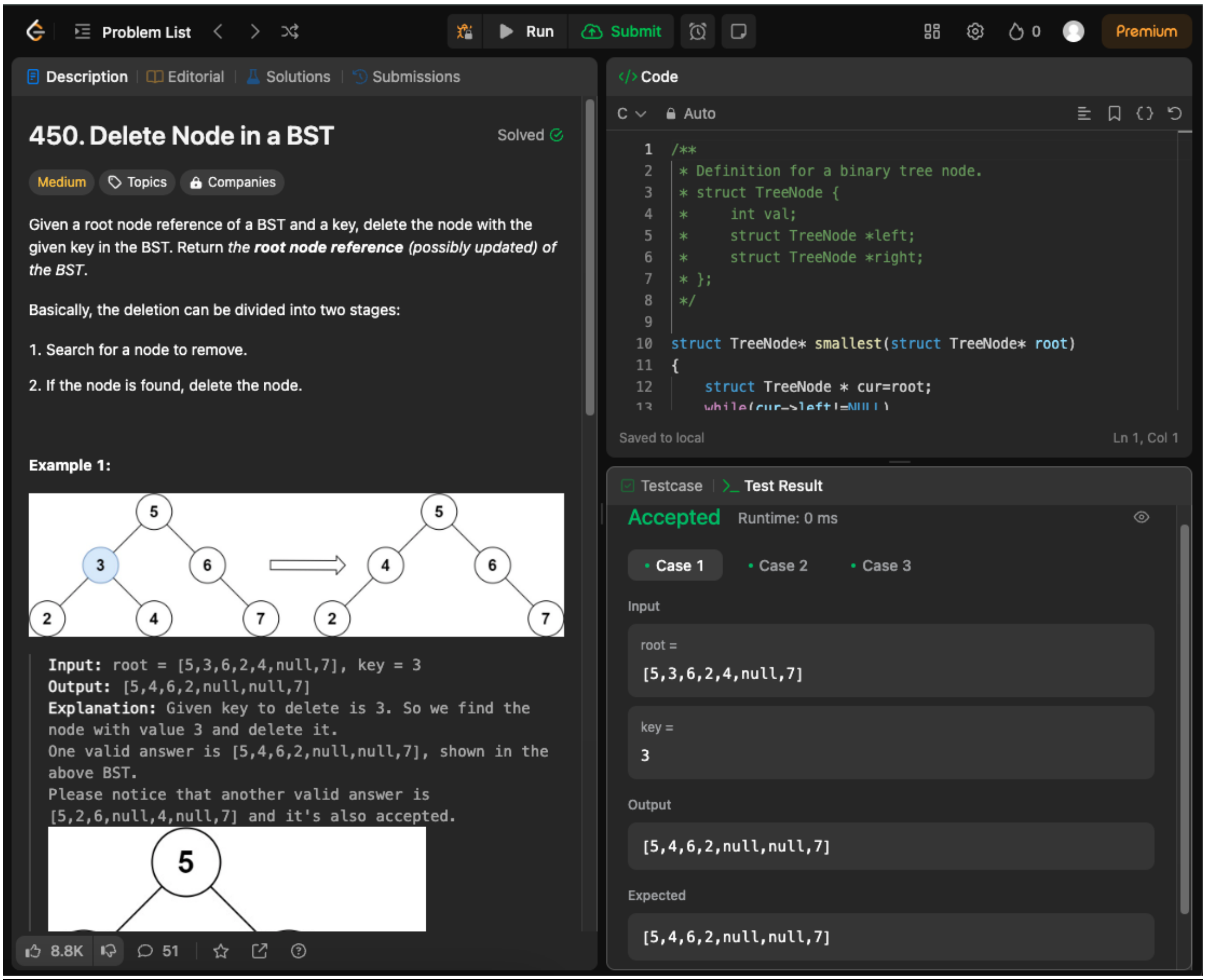
```
1.Create
2.InOrder display
3.PostOrder Display
4.PreOrder Display
5.EXIT
ENTER YOUR CHOICE : 1
ENTER THE DATA : 21
DO YOU WANT TO ENTER MORE (Y/N) : y
ENTER THE DATA : 45
DO YOU WANT TO ENTER MORE (Y/N) : y
ENTER THE DATA : 12
DO YOU WANT TO ENTER MORE (Y/N) : n
ENTER YOUR CHOICE : 2
ELEMENTS OF TREE ARE (INORDER) : 12 21 45
ENTER YOUR CHOICE : 3
ELEMENTS OF TREE ARE (PREORDER) : 21 12 45
ENTER YOUR CHOICE : 4
ELEMENTS OF TREE ARE (POSTORDER) : 12 45 21
ENTER YOUR CHOICE : 5
```

LEETCODE PROBLEM-4:

Delete a node in BST

```
struct TreeNode* smallest(struct TreeNode* root)
{
    struct TreeNode * cur=root;
    while(cur->left!=NULL)
    {
        cur=cur->left;
    }
    return cur;
}

struct TreeNode* deleteNode(struct TreeNode* root, int key)
{

            // base case
    if(root==NULL)
    {
        return root;
    }
    if(key < root->val)
    {
        root->left = deleteNode(root->left,key);
    }
    else if(key > root->val)
    {
        root->right=deleteNode(root->right,key);
    }
 else
    {

        if (root->left == NULL)
        {
            struct TreeNode *temp = root->right;
            free(root);
            return temp;
        }
        else if (root->right == NULL)
        {
            struct TreeNode *temp = root->left;
```

```
            free(root);
            return temp;
        }
        struct TreeNode *temp = smallest(root->right);
        root->val = temp->val;
        root->right = deleteNode(root->right, root->val);
    }

    return root;
}
```

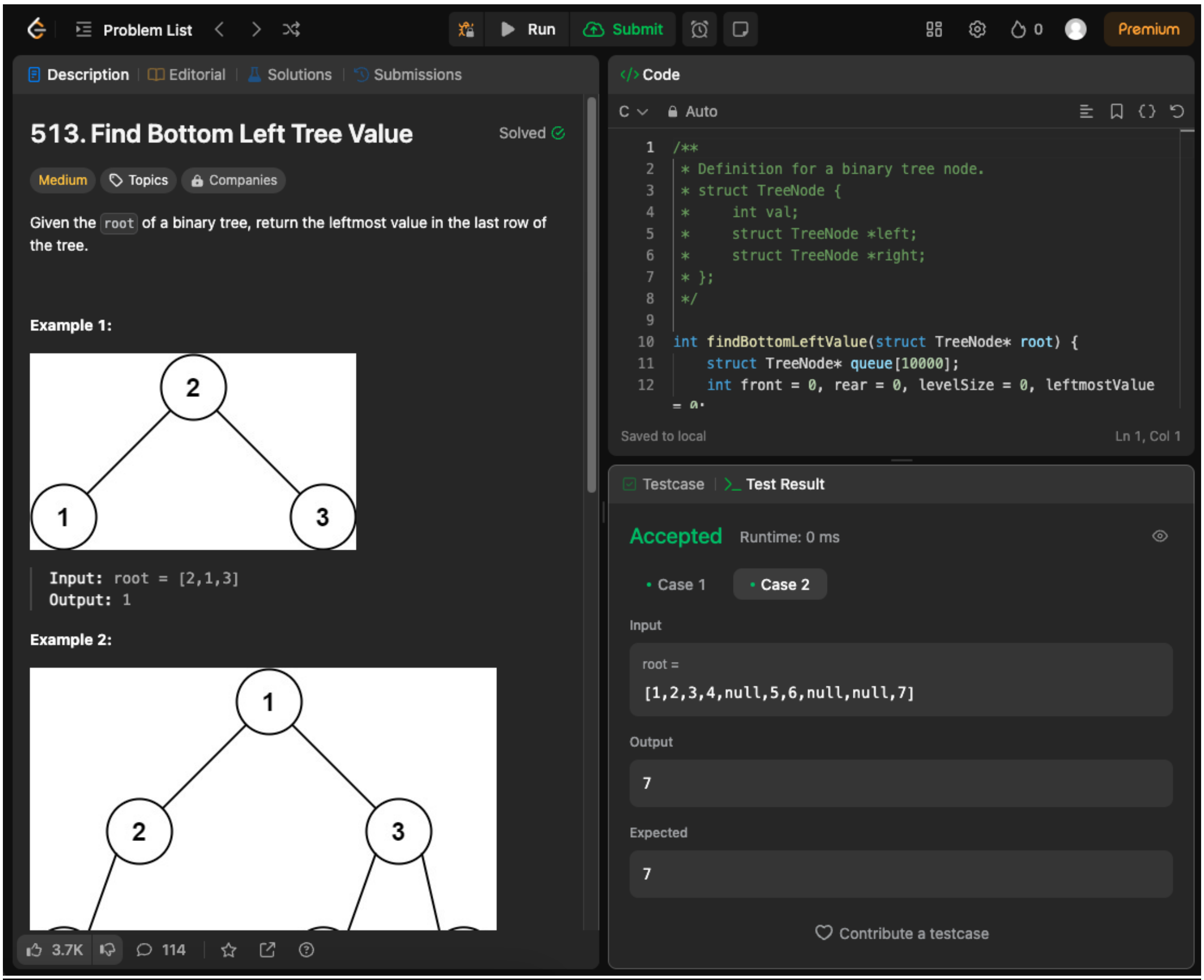


LEETCODE PROBLEM-5:

Find bottom left tree value

```
/**
 * Definition for a binary tree node.
 * struct TreeNode {
 *     int val;
 *     struct TreeNode *left;
 *     struct TreeNode *right;
 * };
 */

#define MAX_SIZE 1000

typedef struct {
    struct TreeNode* data[MAX_SIZE];
    int front;
    int rear;
} RingBuffer;

void append(RingBuffer* buffer, struct TreeNode* node) {
    if (buffer->front == -1) {
        buffer->front = 0;
        buffer->rear = 0;
    }
    else if (buffer->rear == MAX_SIZE - 1)  buffer->rear = 0;
    else buffer->rear++;

    buffer->data[buffer->rear] = node;
}

struct TreeNode* popleft(RingBuffer* buffer) {
    struct TreeNode* node = buffer->data[buffer->front];
    if (buffer->front == buffer->rear) {
        buffer->front = -1;
        buffer->rear = -1;
    }
    else if (buffer->front == MAX_SIZE - 1)  buffer->front = 0;
    else     buffer->front++;

    return node;
}
```

```c
int findBottomLeftValue(struct TreeNode* root) {
    if (root == NULL)  return -1;
    RingBuffer buffer = {
        .front = -1,
        .rear = -1
    };
    append(&buffer, root);

    struct TreeNode* node;
    while( buffer.front != -1 ){
        node = popleft(&buffer);
        if (node->right) append(&buffer, node->right);
        if (node->left)  append(&buffer, node->left);
    }

    return node->val;
}
```



LAB PROGRAM-9a):

Write a program to traverse a graph using BFS method.

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

#define MAX_NODES 100

// Define a structure for a node in the graph
struct Node {
    int data;
    struct Node* next;
};

// Define a structure for the graph
struct Graph {
    int numNodes;
    struct Node* adjLists[MAX_NODES];
    int visited[MAX_NODES];
};

// Function to create a new node
struct Node* createNode(int data) {
    struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));
    newNode->data = data;
    newNode->next = NULL;
    return newNode;
}

// Function to create a graph with n nodes
struct Graph* createGraph(int n) {
    struct Graph* graph = (struct Graph*)malloc(sizeof(struct Graph));
    graph->numNodes = n;
    for (int i = 0; i < n; i++) {
        graph->adjLists[i] = NULL;
        graph->visited[i] = 0;
    }
    return graph;
}

// Function to add an edge to the graph
void addEdge(struct Graph* graph, int src, int dest) {
    // Add edge from src to dest
    struct Node* newNode = createNode(dest);
    newNode->next = graph->adjLists[src];
    graph->adjLists[src] = newNode;
```

```
    // Add edge from dest to src
    newNode = createNode(src);
    newNode->next = graph->adjLists[dest];
    graph->adjLists[dest] = newNode;
}

// Function to perform Breadth First Search
void BFS(struct Graph* graph, int startNode) {
    // Create a queue for BFS
    int queue[MAX_NODES];
    int front = 0, rear = 0;

    // Mark the current node as visited and enqueue it
    graph->visited[startNode] = 1;
    queue[rear++] = startNode;

    while (front < rear) {
        // Dequeue a vertex from queue and print it
        int current = queue[front++];
        printf("%d ", current);

        // Get all adjacent vertices of the dequeued vertex current
        // If an adjacent has not been visited, then mark it visited and enqueue it
        struct Node* temp = graph->adjLists[current];
        while (temp) {
            int adjNode = temp->data;
            if (!graph->visited[adjNode]) {
                graph->visited[adjNode] = 1;
                queue[rear++] = adjNode;
            }
            temp = temp->next;
        }
    }
}

int main() {
    // Get the number of nodes from the user
    int numNodes;
    printf("Enter the number of nodes: ");
    scanf("%d", &numNodes);

    // Create a graph with the specified number of nodes
    struct Graph* graph = createGraph(numNodes);

    // Get the number of edges from the user
    int numEdges;
    printf("Enter the number of edges: ");
    scanf("%d", &numEdges);

    // Add edges
    for (int i = 0; i < numEdges; i++) {
```

```c
        int src, dest;
        printf("Enter edge %d (source destination): ", i + 1);
        scanf("%d %d", &src, &dest);
        addEdge(graph, src, dest);
    }

    // Print BFS traversal
    int startNode;
    printf("Enter the starting node for BFS traversal: ");
    scanf("%d", &startNode);
    printf("BFS traversal starting from node %d: ", startNode);
    BFS(graph, startNode);

    return 0;
}
```

OUTPUT:

```
Enter the number of nodes: 5
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): 2
3
Enter edge 4 (source destination): 1
4
Enter the starting node for BFS traversal: 0
BFS traversal starting from node 0: 0 2 1 3 4
```

LAB PROGRAM-9b):

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

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

#define MAX_NODES 100

// Define a structure for a node in the graph
struct Node {
    int data;
    struct Node* next;
};

// Define a structure for the graph
struct Graph {
    int numNodes;
    struct Node* adjLists[MAX_NODES];
    int visited[MAX_NODES];
};

// Function to create a new node
struct Node* createNode(int data) {
    struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));
    newNode->data = data;
    newNode->next = NULL;
    return newNode;
}

// Function to create a graph with n nodes
struct Graph* createGraph(int n) {
    struct Graph* graph = (struct Graph*)malloc(sizeof(struct Graph));
    graph->numNodes = n;
    for (int i = 0; i < n; i++) {
        graph->adjLists[i] = NULL;
        graph->visited[i] = 0;
    }
    return graph;
}

// Function to add an edge to the graph
void addEdge(struct Graph* graph, int src, int dest) {
    // Add edge from src to dest
    struct Node* newNode = createNode(dest);
    newNode->next = graph->adjLists[src];
    graph->adjLists[src] = newNode;

    // Add edge from dest to src
    newNode = createNode(src);
```

```
    newNode->next = graph->adjLists[dest];
    graph->adjLists[dest] = newNode;
}

// Function to perform Depth First Search
void DFS(struct Graph* graph, int startNode) {
    // Mark the current node as visited
    graph->visited[startNode] = 1;
    printf("%d ", startNode);

    // Get all adjacent vertices of the current node
    struct Node* temp = graph->adjLists[startNode];
    while (temp) {
        int adjNode = temp->data;
        if (!graph->visited[adjNode]) {
            DFS(graph, adjNode);
        }
        temp = temp->next;
    }
}

int main() {
    // Get the number of nodes from the user
    int numNodes;
    printf("Enter the number of nodes: ");
    scanf("%d", &numNodes);

    // Create a graph with the specified number of nodes
    struct Graph* graph = createGraph(numNodes);

    // Get the number of edges from the user
    int numEdges;
    printf("Enter the number of edges: ");
    scanf("%d", &numEdges);

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

    // Print DFS traversal
    int startNode;
    printf("Enter the starting node for DFS traversal: ");
    scanf("%d", &startNode);
    printf("DFS traversal starting from node %d: ", startNode);
    DFS(graph, startNode);

    return 0;
```

```
}
```

OUTPUT:

```
Enter the number of nodes: 5
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): 1
4
Enter the starting node for DFS traversal: 0
DFS traversal starting from node 0: 0 2 1 4 3
```

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>
#include <stdlib.h>

#define SIZE 10 // Size of the hash table

// Employee structure
struct Employee {
```

```
    int key; // 4-digit key
    int data; // Data associated with the employee
};

typedef struct Employee Employee;

// Hash table structure
struct HashTable {
    Employee* table[SIZE];
};

typedef struct HashTable HashTable;

// Function to initialize the hash table
void initializeHashTable(HashTable* ht) {
    for (int i = 0; i < SIZE; i++) {
        ht->table[i] = NULL;
    }
}

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

// Function to insert a record into the hash table
void insert(HashTable* ht, int key, int data) {
    int index = hashFunction(key);
    while (ht->table[index] != NULL) {
        index = (index + 1) % SIZE; // Linear probing
    }
    Employee* newEmployee = (Employee*)malloc(sizeof(Employee));
    newEmployee->key = key;
    newEmployee->data = data;
    ht->table[index] = newEmployee;
}

// Function to display the contents of the hash table
void displayHashTable(HashTable* ht) {
    printf("Hash Table Contents:\n");
    printf("Index\tKey\tData\n");
    for (int i = 0; i < SIZE; i++) {
```

```
        if (ht->table[i] != NULL) {
            printf("%d\t%d\t%d\n", i, ht->table[i]->key, ht->table[i]->data);
        } else {
            printf("%d\tEmpty\n", i);
        }
    }
}

int main() {
    HashTable ht;
    initializeHashTable(&ht);

    int key, data;
    char choice;
    do {
        printf("Enter employee key (4-digit): ");
        scanf("%d", &key);
        printf("Enter employee data: ");
        scanf("%d", &data);
        insert(&ht, key, data);

        printf("Do you want to enter another employee record? (y/n): ");
        scanf(" %c", &choice);
    } while (choice == 'y' || choice == 'Y');

    // Displaying the contents of the hash table
    displayHashTable(&ht);

    return 0;
}
```

OUTPUT:

```
Enter employee key (4-digit): 1234
Enter employee data: 1001
Do you want to enter another employee record? (y/n): y
Enter employee key (4-digit): 1235
Enter employee data: 1002
Do you want to enter another employee record? (y/n): n
Hash Table Contents:
Index   Key Data
0   Empty
1   Empty
2   Empty
3   Empty
4   1234    1001
5   1235    1002
6   Empty
7   Empty
8   Empty
9   Empty
```