VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT
On

DATA STRUCTURES (23CS3PCDST)

Submitted by

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in partial fulfillment for the award of the degree of
BACHELOR OF ENGINEERING
in
COMPUTER SCIENCE AND ENGINEERING

B.M.S. COLLEGE OF ENGINEERING
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Department of Computer Science and Engineering

This is to certify that the Lab work entitled **"DATA STRUCTURES"** carried out by SPARSHA KADABA **(1BM22CS287)**, 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

19	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.	64

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.

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.

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

#define max 10

int stack[max];
int top = -1;
int val;

void push(int);
void pop();
void display();

int main()
{
    int choice = 0;

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

        switch (choice)
        {
        case 1:
            if (top == max - 1)
            {
                printf("Overflow\n");
            }
            else
            {
                printf("Enter value to be pushed\n");
                scanf("%d", &val);
                push(val);
                printf("Push operation completed\n");
```

```
            }
            break;

        case 2:
            if (top == -1)
            {
                printf("Underflow\n");
            }
            else
            {
                pop();
                printf("Pop operation completed\n");
            }
            break;

        case 3:
            if (top == -1)
            {
                printf("Stack is empty\n");
            }
            else
            {
                display();
            }
            break;

        case 4:
            printf("Exit\n");
            exit(0);

        default:
            printf("Incorrect input\n");
        }
    } while (choice != 4);

    return 0;
}

void push(int val)
{
    if (top != max - 1)
    {
        top++;
```

```
        stack[top] = val;
    }
    else
    {
        printf("Overflow\n");
    }
}

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

void display()
{
    if (top != -1)
    {
        for (int i = 0; i <= top; i++)
            printf("%d\t", stack[i]);
    }
    printf("\n");
}
```

```
PS C:\Users\kadab\OneDrive\Desktop\DS> gcc one.c
PS C:\Users\kadab\OneDrive\Desktop\DS> .\a.exe
Enter your choice
1.Push
2.Pop
3.Display
4.Exit
1
Enter value to be pushed
1
Push operation completed
Enter your choice
1.Push
2.Pop
3.Display
4.Exit
1
Enter value to be pushed
2
Push operation completed
Enter your choice
1.Push
2.Pop
3.Display
4.Exit
1
Enter value to be pushed
3
Push operation completed
Enter your choice
1.Push
2.Pop
3.Display
4.Exit
3
1       2       3
Enter your choice
1.Push
2.Pop
3.Display
4.Exit
2
Pop operation completed
Enter your choice
1.Push
2.Pop
3.Display
4.Exit
3
1       2
Enter your choice
1.Push
2.Pop
3.Display
4.Exit
4
Exit
PS C:\Users\kadab\OneDrive\Desktop\DS>
```

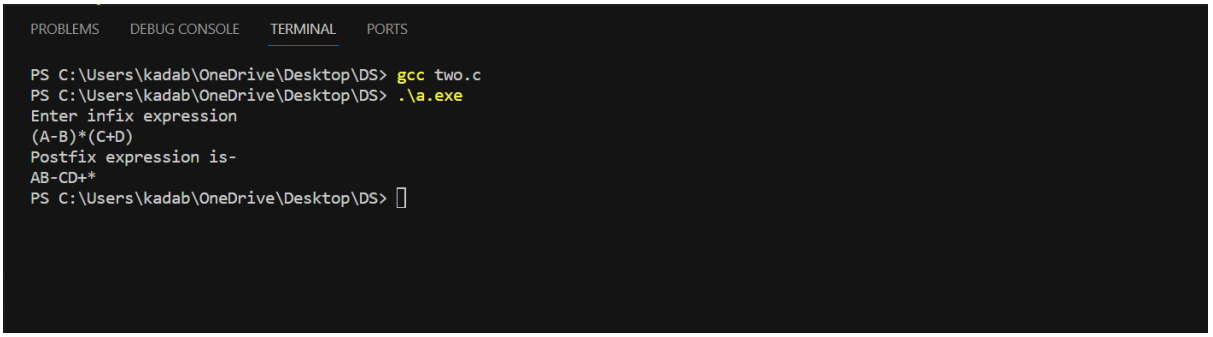
Program 2

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

```
#include<stdio.h>
#include<conio.h>
#include<string.h>
#include<ctype.h>
#include<stdlib.h>
#define max 100

char st[max];
int top=-1;
void push(char st[], char);
char pop(char st[]);
void infixToPostfix(char source[], char target[]);
int getPriority(char);

int main()
{
    char infix[100], postfix[100];
    printf("Enter infix expression\n");
    gets(infix);
    strcpy(postfix,"  ");
    infixToPostfix(infix, postfix);
    printf("Postfix expression is-\n");
    puts(postfix);
    return 0;
}

void infixToPostfix(char source[], char target[])
{
    int i=0, j=0;
    char temp;
    strcpy(target,"  ");
    while (source[i]!='\0')
    {
        if(source[i]=='(')
        {
            push(st,source[i]);
            i++;
        }
```

```
        else if(source[i]==')')
        {
            while((top!=-1)&&(st[top]!='('))
            {
                target[j]=pop(st);
                j++;
            }
            if(top==-1)
            {
                printf("Incorrect expression\n");
                exit(1);
            }
            temp=pop(st);
            i++;
        }
        else if(isdigit(source[i])||isalpha(source[i]))
        {
            target[j]=source[i];
            j++;
            i++;
        }
        else
if(source[i]=='+'||source[i]=='-'||source[i]=='*'||source[i]=='/'||sour
ce[i]=='%')
        {
            while( (top!=-1) && (st[top]!='(') &&
(getPriority(st[top])>getPriority(source[i])) )
            {
                target[j]=pop(st);
                j++;
            }
            push(st,source[i]);
            i++;
        }
        else
        {
            printf("Incorrect element in expression\n");
            exit(1);
        }
    }
    while((top!=-1)&&(st[top]!='('))
    {
        target[j]=pop(st);
```

```
        j++;
    }
    target[j]='\0';
}

int getPriority(char op)
{
    if(op=='/'|| op=='*'||op=='%')
        return 1;
    else if(op=='+'||op=='-')
        return 0;
}

void push(char st[],char val)
{
    if(top==max-1)
    {
        printf("Stack overflow\n");
    }
    else
    {
        top++;
        st[top]=val;
    }
}

char pop(char st[])
{
    char val = ' ';
    if(top == -1)
    {
        printf("Stack underflow\n");
    }
    else
    {
        val = st[top];
        top--;
    }
    return val;
}
```


PROBLEMS
DEBUG CONSOLE
TERMINAL
PORTS
PS C:\Users\kadab\OneDrive\Desktop\DS> gcc two.c
PS C:\Users\kadab\OneDrive\Desktop\DS> .\a.exe
Enter infix expression
(A-B)*(C+D)
Postfix expression is-
AB-CD+*
PS C:\Users\kadab\OneDrive\Desktop\DS>

Program 3

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

```
#include<stdio.h>
#include<conio.h>
#include<stdlib.h>
#define max 100

int q[max], front=1, rear=-1;
void insert();
void delete();
void display();

void main()
{
    while(1)
    {
        printf("Enter your choice\n");
        printf("1.Enqueue\n 2.Dequeue\n 3.Display\n 4.Exit\n");
        int choice=0;
        scanf("%d", & choice);
        switch(choice)
        {
            case 1:
            insert();
            break;
            case 2:
            delete();
            break;
            case 3:
            display();
            break;
            case 4:
            exit(0);
            break;
            default:
            printf("Incorrect Input\n");
        }
    }
}
```

```
void insert()
{
    int val=0;
    printf("Enter value to be inserted\n");
    scanf("%d", & val);
    if(rear==max-1)
    printf("Queue Overflow\n");
    if (front==-1||rear==-1)
    {
        front=0;
        rear=0;
    }
    else{
        rear=rear+1;
    }
    q[rear]=val;
}

void delete()
{
    if (front>rear||front==-1)
    {
        printf("Queue Underflow\n");
    }
    else{
        printf("%d has been deleted\n",q[front]);
        front=front+1;
    }
}
void display()
{
    printf("The queue is-\n");
    for(int i=front; i<=rear; i++)
    printf("%d\t\t",q[i]);
    printf("\n");
}
```

```
PS C:\Users\kadab\OneDrive\Desktop\DS> gcc three.c
PS C:\Users\kadab\OneDrive\Desktop\DS> .\a.exe
Enter your choice
1.Enqueue
 2.Dequeue
 3.Display
 4.Exit
1
Enter value to be inserted
1
Enter your choice
1.Enqueue
 2.Dequeue
 3.Display
 4.Exit
1
Enter value to be inserted
2
Enter your choice
1.Enqueue
 2.Dequeue
 3.Display
 4.Exit
1
Enter value to be inserted
3
Enter your choice
1.Enqueue
 2.Dequeue
 3.Display
 4.Exit
3
The queue is-
1               2               3
Enter your choice
1.Enqueue
 2.Dequeue
 3.Display
 4.Exit
2
1 has been deleted
Enter your choice
1.Enqueue
 2.Dequeue
 3.Display
 4.Exit
3
The queue is-
2               3
Enter your choice
1.Enqueue
 2.Dequeue
 3.Display
 4.Exit
4
PS C:\Users\kadab\OneDrive\Desktop\DS>
```

Program 4

Write a program 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<conio.h>
#include<stdlib.h>
#define max 20

int q[max], rear=-1, front=-1;
int isFull();
int isEmpty();
void insert (int element);
int delete();
void display();

void main()
{
    int choice, element;
    while(1)
{
    printf("Enter choice\n");
    printf("1.Insert\n2.Delete\n3.Display\n4.Exit\n\n");
    scanf("%d", &choice);
switch(choice)
{
    case 1:
    printf("Enter element to be inserted\n");
    scanf("%d", & element);
    insert(element);
    break;
    case 2:
    element=delete();
    break;
    case 3:
    display();
    break;
    case 4:
    exit(0); break;
    default:
    printf("Incorrect Input\n");
    break;
```

```
}
}
}

int isFull()
{
    if((front==rear+1)||(front==0 && rear==max-1))
        return 1;
    return 0;
}

int isEmpty()
{
    if(front==-1)
        return 1;
    return 0;
}

void insert(int element)
{
    if (isFull())
    {     printf("Overflow\n");
    }
    else
    {
        if(front==-1)
            front=0;
        rear=(rear+1)%max;
        q[rear]=element;
    }
}

int delete()
{
    int value;
    if (isEmpty())
    {
        printf("Underflow\n");
        return -1;
    }
    else{
        value=q[front];
        if(front==rear)
```

```
    {
    front==-1;
    rear==-1;
}
else
{
    front=(front+1)%max;
}
return(value);
}}

void display()
{
    int i;
    if(isEmpty())
        printf("Underflow\n");
    else{
        for(i=front;i!=rear;i=(i+1)%max)
            printf("%d\t",q[i]);
        printf("%d\t",q[i]);
        printf("\n");
        }
        }
```

```
PS C:\Users\kadab\OneDrive\Desktop\DS> gcc four.c
PS C:\Users\kadab\OneDrive\Desktop\DS> .\a.exe
Enter choice
1.Insert
2.Delete
3.Display
4.Exit

1
Enter element to be inserted
1
Enter choice
1.Insert
2.Delete
3.Display
4.Exit

1
Enter element to be inserted
2
Enter choice
1.Insert
2.Delete
3.Display
4.Exit

1
Enter element to be inserted
3
Enter choice
1.Insert
2.Delete
3.Display
4.Exit

3
1       2       3
Enter choice
1.Insert
2.Delete
3.Display
4.Exit

2
Enter choice
1.Insert
2.Delete
3.Display
4.Exit

3
2       3
Enter choice
1.Insert
2.Delete
3.Display
4.Exit

4
PS C:\Users\kadab\OneDrive\Desktop\DS>
```

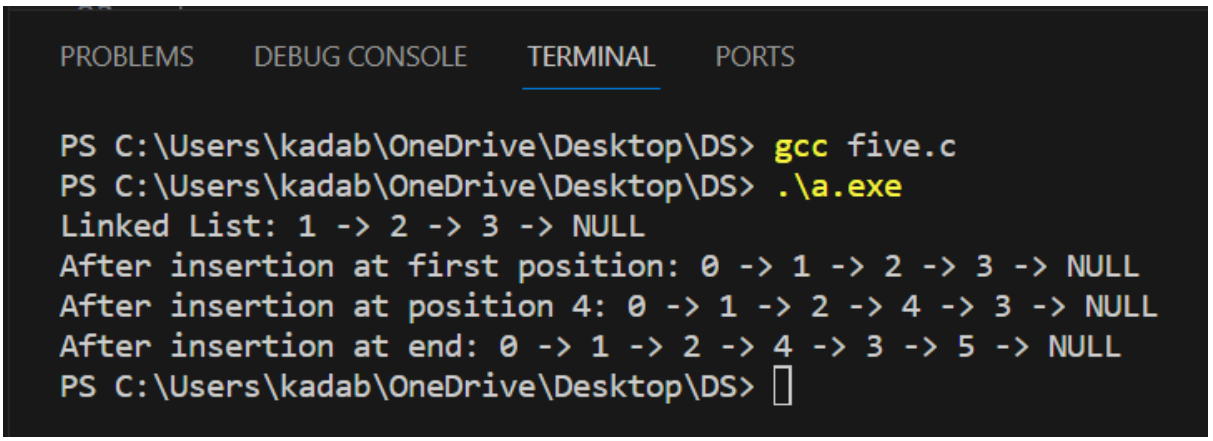
Program 5

Write a program to Implement Singly Linked List with following operations a) Create a linked list. b) Insertion of a node at first position, at any position and at end of list. Display the contents of the linked list.

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

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

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

struct Node* insertAtFirst(struct Node* head, int newData) {
    struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));
    newNode->data=newData;
    newNode->next = head;
    return newNode;
}

struct Node* insertAtPosition(struct Node* head, int newData, int
position)
{
    struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));
    newNode->data=newData;

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

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

```
    if (temp == NULL) {
        printf("Invalid position\n");
        return head;
    }

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

struct Node* insertAtEnd(struct Node* head, int newData)
{
    struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));
    newNode->data=newData;
    newNode->next=NULL;

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

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

    temp->next = newNode;
    return head;
}

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

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

    head = insertAtEnd(head, 1);
    head = insertAtEnd(head, 2);
```

```
    head = insertAtEnd(head, 3);

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

    head = insertAtFirst(head, 0);

    printf("After insertion at first position: ");
    displayList(head);

    head = insertAtPosition(head, 4, 4);

    printf("After insertion at position 4: ");
    displayList(head);

    head = insertAtEnd(head, 5);

    printf("After insertion at end: ");
    displayList(head);
}
```



Program 6

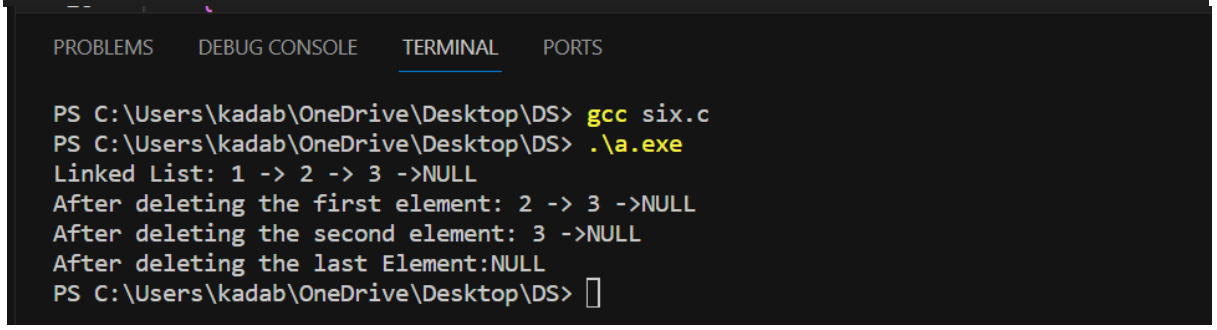
Write a program to Implement Singly Linked List with following operations a) Create a linked list. b) Deletion of a node at first position, at any position and at end of list. Display the contents of the linked list.

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

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

struct Node* insertAtEnd(struct Node* head, int newData)
{
    struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));
    newNode->data = newData;
    newNode->next = NULL;
    if (head == NULL)
    {
        return newNode;
    }
    struct Node* temp = head;
    while (temp->next != NULL)
    {
        temp = temp->next;
    }
    temp->next = newNode;
    return head;
}

struct Node* deleteFirst(struct Node* head)
{
    if (head == NULL)
    {
        printf("List is Empty! Deletion not Possible");
        return NULL;
    }
    struct Node* newHead = head->next;
    free(head);
    return newHead;
}
```

```c
struct Node* deleteElement(struct Node* head, int target)
{
    if (head == NULL)
    {
        printf("List is Empty, hence cannot Delete \n");
        return NULL;
    }
    if (head->data == target)
    {
        struct Node* newHead = head->next;
        free(head);
        return newHead;
    }

    struct Node* temp = head;
    while (temp->next != NULL && temp->next->data != target)
    {
        temp = temp->next;
    }
    if (temp->next == NULL)
    {
        printf("Element %d not found in the list \n", target);
        return head;
    }
    struct Node* nodeToDelete = temp->next;
    temp->next = temp->next->next;
    free(nodeToDelete);
    return head;
}

struct Node* deleteLast(struct Node* head)
{
    if (head == NULL)
    {
        printf("List is Empty, hence cannot Delete \n");
        return NULL;
    }

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

```
    struct Node* temp = head;
    while (temp->next->next != NULL)
    {
        temp = temp->next;
    }
    free(temp->next);
    temp->next = NULL;
    return head;
}

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

int main()
{
    struct Node* head = NULL;
    head = insertAtEnd(head, 1);
    head = insertAtEnd(head, 2);
    head = insertAtEnd(head, 3);

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

    head = deleteFirst(head);
    printf("After deleting the first element:");
    displayList(head);

    head = deleteElement(head, 2);
    printf("After deleting the second element:");
    displayList(head);

    head = deleteLast(head);
    printf("After deleting the last Element:");
    displayList(head);
```

```
    return 0;
}
```


PROBLEMS
DEBUG CONSOLE
TERMINAL
PORTS
PS C:\Users\kadab\OneDrive\Desktop\DS> gcc six.c
PS C:\Users\kadab\OneDrive\Desktop\DS> .\a.exe
Linked List: 1 -> 2 -> 3 ->NULL
After deleting the first element: 2 -> 3 ->NULL
After deleting the second element: 3 ->NULL
After deleting the last Element:NULL
PS C:\Users\kadab\OneDrive\Desktop\DS>

Program 7
Write a program to Implement Single Link List to simulate Stack Operations.

```c
#include <stdio.h>
#include <stdlib.h>
#include <limits.h>
#define CAPACITY 1000

struct stack
{
    int data;
    struct stack *next;
} *top;

int size = 0;

void push(int element);
int pop();
void display();


int main()
{
    int choice, data;
    while(1)
    {
        printf("1. Push\n");
        printf("2. Pop\n");
        printf("3. Display\n");
        printf("4. Exit\n");
        scanf("%d", &choice);

        switch(choice)
        {
            case 1:
                printf("Enter data to push into stack: ");
                scanf("%d", &data);
                push(data);
                break;

            case 2:
                data = pop();
```

```
                // If stack is not empty
                if (data != INT_MIN)
                    printf("Data => %d\n", data);
                break;

            case 3:
                display();
                break;

            case 4:
                exit(0);
                break;

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

        printf("\n\n");
    }
    return 0;
}

void push(int element)
{
    if (size >= CAPACITY)
    {
        printf("Stack Overflow\n");
        return;
    }
    struct stack * newNode = (struct stack *) malloc(sizeof(struct
stack));
    newNode->data = element;
    newNode->next = top;
    top = newNode;
    size++;
    printf("Data pushed to stack.\n");
}

int pop()
{
    int data = 0;
    struct stack * topNode;
    if (size <= 0 || !top)
```

```
    {
        printf("Stack is empty.\n");
        return INT_MIN;
    }
    topNode = top;
    data = top->data;
    top = top->next;
    free(topNode);
    size--;
    return data;
}

void display()
{
    if(size<=0||!top)
    {
        printf("Stack is empty\n");
        return;
    }
    struct stack *current=top;
    printf("Stack elements: ");
    while(current!=NULL)
    {
        printf("%d  ",current->data);
        current=current->next;
    }
    printf("\n\n");
}
```

```
PS C:\Users\kadab\OneDrive\Desktop\DS> .\a.exe
1. Push
2. Pop
3. Display
4. Exit
1
Enter data to push into stack: 1
Data pushed to stack.


1. Push
2. Pop
3. Display
4. Exit
1
Enter data to push into stack: 2
Data pushed to stack.


1. Push
2. Pop
3. Display
4. Exit
1
Enter data to push into stack: 3
Data pushed to stack.


1. Push
2. Pop
3. Display
4. Exit
3
Stack elements: 3  2  1



1. Push
2. Pop
3. Display
4. Exit
2
Data => 3


1. Push
2. Pop
3. Display
4. Exit
3
Stack elements: 2  1



1. Push
2. Pop
3. Display
4. Exit
4
PS C:\Users\kadab\OneDrive\Desktop\DS>
```

Program 8

Write a program to Implement Single Link List to simulate Queue Operations.

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

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

struct node * front = NULL;
struct node * rear = NULL;

void enqueue(int value) {
    struct node * ptr;
    ptr = (struct node * ) malloc(sizeof(struct node));
    ptr -> data = value;
    ptr -> next = NULL;
    if ((front == NULL) && (rear == NULL)) {
        front = rear = ptr;
    } else {
        rear -> next = ptr;
        rear = ptr;
    }
    printf("Node is Inserted\n\n");
}

int dequeue() {
    if (front == NULL) {
        printf("\nUnderflow\n");
        return -1;
    } else {
        struct node * temp = front;
        int temp_data = front -> data;
        front = front -> next;
        free(temp);
        return temp_data;
    }
}

void display() {
    struct node * temp;
    if ((front == NULL) && (rear == NULL)) {
```

```
        printf("\nQueue is Empty\n");
    } else {
        printf("The queue is \n");
        temp = front;
        while (temp) {
            printf("%d--->", temp -> data);
            temp = temp -> next;
        }
        printf("NULL\n\n");
    }
}

int main() {
    int choice, value;
    printf("\nImplementation of Queue using Linked List\n");
    while (choice != 4) {
        printf("1.Enqueue\n2.Dequeue\n3.Display\n4.Exit\n");
        printf("\nEnter your choice : ");
        scanf("%d", & choice);
        switch (choice) {
            case 1:
                printf("\nEnter the value to insert: ");
                scanf("%d", & value);
                enqueue(value);
                break;
            case 2:
                printf("Popped element is :%d\n", dequeue());
                break;
            case 3:
                display();
                break;
            case 4:
                exit(0);
                break;
            default:
                printf("\nWrong Choice\n");
        }
    }
    return 0;
}
```

```
1.Enqueue
2.Dequeue
3.Display
4.Exit
1

Enter the value to insert: 1
Node is Inserted

1.Enqueue
2.Dequeue
3.Display
4.Exit
1

Enter the value to insert: 2
Node is Inserted

1.Enqueue
2.Dequeue
3.Display
4.Exit
3
The queue is
1--->2--->NULL

1.Enqueue
2.Dequeue
3.Display
4.Exit
2
Popped element is :1
1.Enqueue
2.Dequeue
3.Display
4.Exit
3
The queue is
2--->NULL

1.Enqueue
2.Dequeue
3.Display
4.Exit
4

Process returned 0 (0x0)   execution time : 15.932 s
Press any key to continue.
```

Program 9

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

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

struct node {
    int info;
    struct node* link;
};

void createList(struct node** start);
void displayList(struct node* start);
void sort(struct node* start);
void reverseLL(struct node** start);
void concat(struct node** start1, struct node* start2);

int main() {
    struct node* start1 = NULL;
    struct node* start2 = NULL;
    int choice;

    while (1) {
        printf("1. Create List 1\n");
        printf("2. Create List 2\n");
        printf("3. Display List 1\n");
        printf("4. Display List 2\n");
        printf("5. Sort List 1\n");
        printf("6. Sort List 2\n");
        printf("7. Reverse List 1\n");
        printf("8. Reverse List 2\n");
        printf("9. Concatenate Lists\n");
        printf("0. Exit\n");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                createList(&start1);
                break;

            case 2:
                createList(&start2);
                break;
```

```
            case 3:
                displayList(start1);
                break;

            case 4:
                displayList(start2);
                break;

            case 5:
                sort(start1);
                printf("List 1 sorted.\n");
                break;

            case 6:
                sort(start2);
                printf("List 2 sorted.\n");
                break;

            case 7:
                reverseLL(&start1);
                printf("List 1 reversed.\n");
                break;

            case 8:
                reverseLL(&start2);
                printf("List 2 reversed.\n");
                break;

            case 9:
                concat(&start1, start2);
                printf("Lists concatenated.\n");
                break;

            case 0:
                printf("Exiting from the program.\n");
                exit(0);

            default:
                printf("Invalid choice. Please try again.\n");
        }
    }
```

```
    return 0;
}

void createList(struct node** start) {
    if (*start == NULL) {
        int n, data;
        printf("\nEnter the number of nodes: ");
        scanf("%d", &n);

        struct node* newnode;
        struct node* temp;

        for (int i = 1; i <= n; i++) {
            newnode = malloc(sizeof(struct node));

            printf("\nEnter number to be inserted: ");
            scanf("%d", &data);

            newnode->info = data;
            newnode->link = NULL;

            if (*start == NULL) {
                *start = newnode;
                temp = newnode;
            } else {
                temp->link = newnode;
                temp = temp->link;
            }
        }
        printf("\nThe list is created\n");
    } else {
        printf("\nThe list is already created\n");
    }
}


void displayList(struct node* start) {
    if (start == NULL) {
        printf("List is empty.\n");
    } else {
        struct node* current = start;

        printf("List: ");
```

```
        while (current != NULL) {
            printf("%d -> ", current->info);
            current = current->link;
        }
        printf("NULL\n");
    }
}


void sort(struct node* start) {
    struct node *current, *index;
    int temp;

    if (start == NULL || start->link == NULL) {
        return;
    } else {
        current = start;

        while (current != NULL) {
            index = current->link;

            while (index != NULL) {
                if (current->info > index->info) {
                    temp = current->info;
                    current->info = index->info;
                    index->info = temp;
                }
                index = index->link;
            }

            current = current->link;
        }
    }
}


void reverseLL(struct node** start) {
    struct node *prev, *current, *next;
    current = (*start)->link;
    prev = NULL;

    while (current != NULL) {
        next = current->link;
```

```
        current->link = prev;
        prev = current;
        current = next;
    }

    (*start)->link = prev;
}

void concat(struct node** start1, struct node* start2) {
    if (start2 == NULL) {
        return;  // Nothing to concatenate
    }

    struct node* temp = *start1;

    if (*start1 == NULL) {
        *start1 = start2;
    } else {
        while (temp->link != NULL) {
            temp = temp->link;
        }

        temp->link = start2;
    }
}
```

```
PS C:\Users\kadab\OneDrive\Desktop\DS> gcc nine.c
PS C:\Users\kadab\OneDrive\Desktop\DS> .\a.exe
1. Create List 1
2. Create List 2
3. Display List 1
4. Display List 2
5. Sort List 1
6. Sort List 2
7. Reverse List 1
8. Reverse List 2
9. Concatenate Lists
0. Exit
1

Enter the number of nodes: 2

Enter number to be inserted: 1

Enter number to be inserted: 2

The list is created
1. Create List 1
2. Create List 2
3. Display List 1
4. Display List 2
5. Sort List 1
6. Sort List 2
7. Reverse List 1
8. Reverse List 2
9. Concatenate Lists
0. Exit
2

Enter the number of nodes: 2

Enter number to be inserted: 5

Enter number to be inserted: 3
```

```
The list is created
1. Create List 1
2. Create List 2
3. Display List 1
4. Display List 2
5. Sort List 1
6. Sort List 2
7. Reverse List 1
8. Reverse List 2
9. Concatenate Lists
0. Exit
5
List 1 sorted.
1. Create List 1
2. Create List 2
3. Display List 1
4. Display List 2
5. Sort List 1
6. Sort List 2
7. Reverse List 1
8. Reverse List 2
9. Concatenate Lists
0. Exit
6
List 2 sorted.
1. Create List 1
2. Create List 2
3. Display List 1
4. Display List 2
5. Sort List 1
6. Sort List 2
7. Reverse List 1
8. Reverse List 2
9. Concatenate Lists
0. Exit
7
```

```
List 1 reversed.
1. Create List 1
2. Create List 2
3. Display List 1
4. Display List 2
5. Sort List 1
6. Sort List 2
7. Reverse List 1
8. Reverse List 2
9. Concatenate Lists
0. Exit
8
List 2 reversed.
1. Create List 1
2. Create List 2
3. Display List 1
4. Display List 2
5. Sort List 1
6. Sort List 2
7. Reverse List 1
8. Reverse List 2
9. Concatenate Lists
0. Exit
9
Lists concatenated.
1. Create List 1
2. Create List 2
3. Display List 1
4. Display List 2
5. Sort List 1
6. Sort List 2
7. Reverse List 1
8. Reverse List 2
9. Concatenate Lists
0. Exit
3
List: 1 -> 2 -> 3 -> 5 -> NULL
```

```
1. Create List 1
2. Create List 2
3. Display List 1
4. Display List 2
5. Sort List 1
6. Sort List 2
7. Reverse List 1
8. Reverse List 2
9. Concatenate Lists
0. Exit
4
List: 3 -> 5 -> NULL
1. Create List 1
2. Create List 2
3. Display List 1
4. Display List 2
5. Sort List 1
6. Sort List 2
7. Reverse List 1
8. Reverse List 2
9. Concatenate Lists
0. Exit
0
Exiting from the program.
PS C:\Users\kadab\OneDrive\Desktop\DS>
```

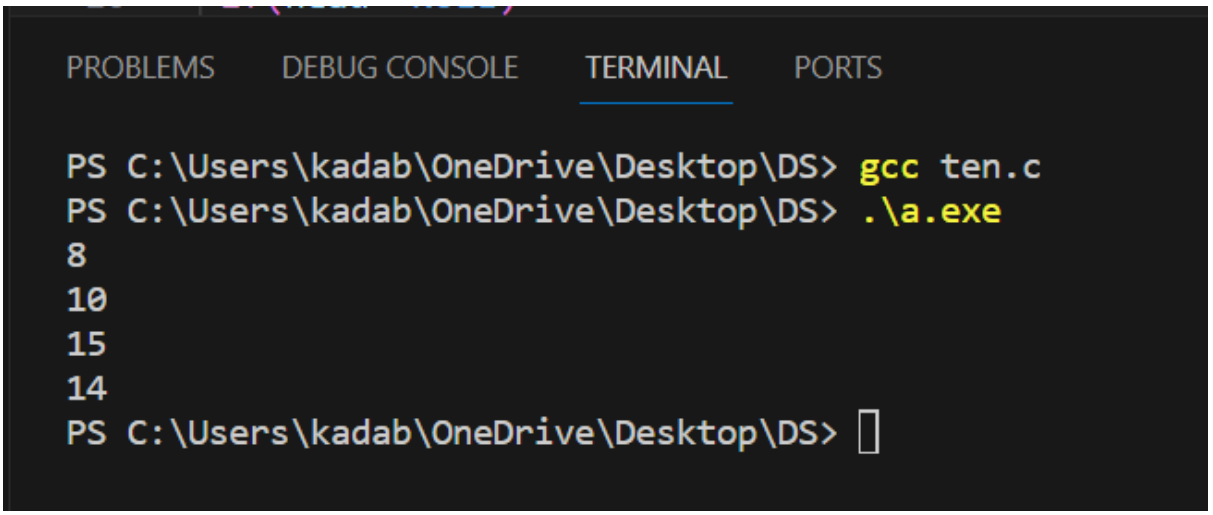
Program 10

Write a program to Implement doubly link list with primitive operations a) Create a doubly linked list. b) Insert a new node to the left of the node. c) Delete the node based on a specific value d) Display the contents of the list

```
#include<stdio.h>
#include<stdlib.h>
typedef struct node{
 int value;
 struct node *prev;
 struct node *next;
} Node;
Node *insertleft(Node *head, int data, int key)
{
 Node *new,*ptr;
 new = malloc(sizeof(Node));
 new->value = data;
 new->prev = NULL;
 new->next = NULL;
 ptr = head;
 if(head==NULL)
 {
 return new;
 }
 while(ptr!=NULL)
 {
 if(ptr->value==key)
 {
 break;
 }
 ptr=ptr->next;
 }
 if(ptr->value==key)
 {
 new->prev = ptr->prev;
 (ptr->prev)->next = new;
 new->next = ptr;
 ptr->prev = new;
 return head;
 }
 printf("no values");
 return head;
}
```

```
Node *deleteval(Node *head,int key)
{
 Node *ptr;
 if(head==NULL)
 {
 printf("list empty");
 return NULL;
 }
 ptr=head;
 while(ptr!=NULL&&ptr->value!=key)
 {
 ptr=ptr->next;
 }
 if(ptr->value==key)
 {
 (ptr->next)->prev=ptr->prev;
 (ptr->prev)->next=ptr->next;
 free(ptr);
 return head;
 }
 printf("no value");
 return head;
}
int main()
{
 Node *head = malloc(sizeof(Node));
 head->value = 8;
 head->prev = NULL;
 head->next = NULL;
 Node *current = malloc(sizeof(Node));
 current->value = 10;
 current->prev = head;
 current->next = NULL;
 head->next = current;
 Node *current2 = malloc(sizeof(Node));
 current2->value = 14;
 current2->prev = current;
 current2->next = NULL;
 current->next = current2;
 insertleft(head, 15, 14);
 Node *ptr1 = head;
 while (ptr1 != NULL)
 {
```

```
printf("%d\n", ptr1->value);
ptr1 = ptr1->next;
}
deleteval(head,8);
Node *ptr = head;
while (ptr != NULL)
{
printf("%d", ptr->value);
ptr = ptr->next;
}
}
```

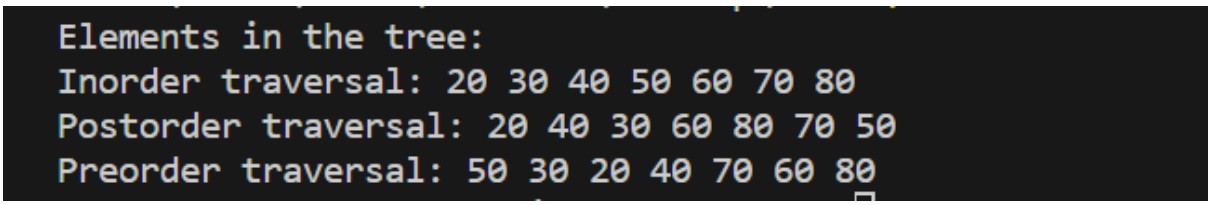


Program 11

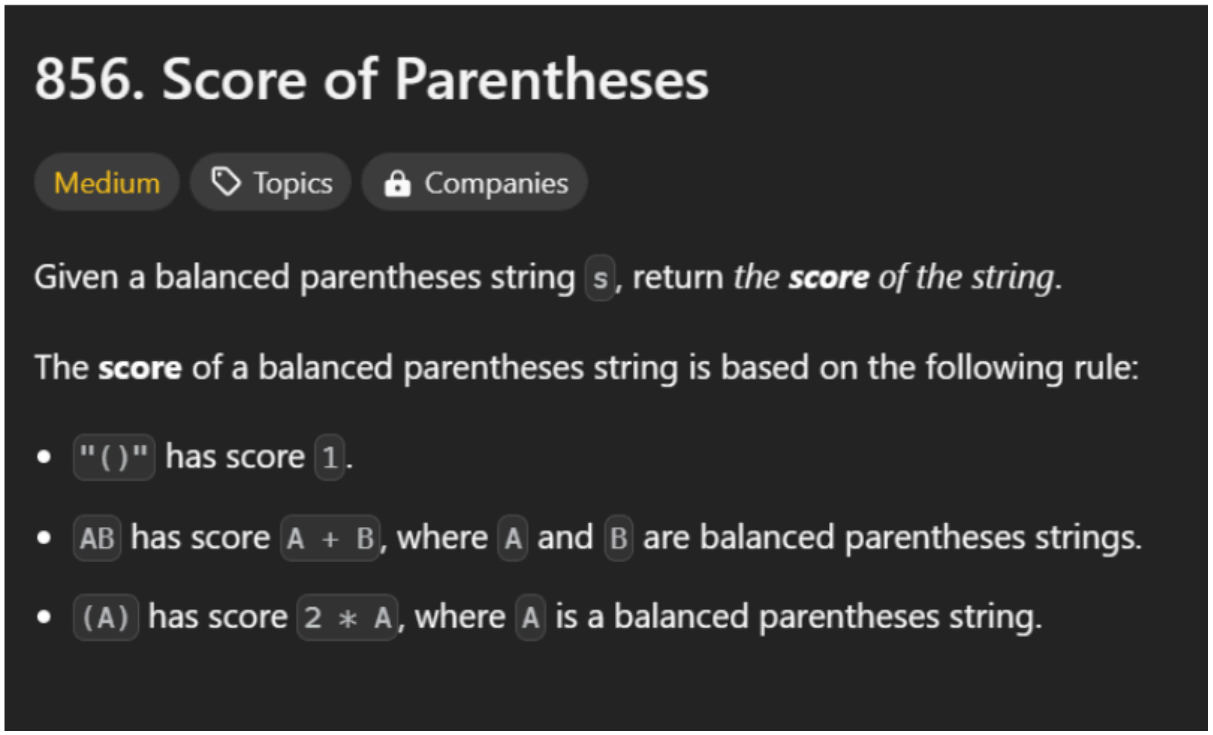
Write a program a) To construct a binary Search tree. b) To traverse the tree using all the methods i.e., in-order, preorder and post order c) To display the elements in the tree

```
#include <stdio.h>
#include <stdlib.h>
struct TreeNode
{
    int data;
    struct TreeNode *left;
    struct TreeNode *right;
};
struct TreeNode* createNode(int data)
{
    struct TreeNode* newNode = (struct TreeNode*)malloc(sizeof(struct
TreeNode));
    newNode->data = data;
    newNode->left = NULL;
    newNode->right = NULL;
    return newNode;
}
struct TreeNode* insert(struct TreeNode* root, int data) {
    if (root == NULL) {
        return createNode(data);
    } else {
        if (data <= root->data) {
            root->left = insert(root->left, data);
        } else {
            root->right = insert(root->right, data);
        }
        return root;
    }
}
void inorder(struct TreeNode* root) {
    if (root != NULL) {
        inorder(root->left);
        printf("%d ", root->data);
        inorder(root->right);
    }
}
void postorder(struct TreeNode* root) {
    if (root != NULL) {
        postorder(root->left);
        postorder(root->right);
```

```
        printf("%d ", root->data);
    }
}
void preorder(struct TreeNode* root) {
    if (root != NULL) {
        printf("%d ", root->data);
        preorder(root->left);
        preorder(root->right);
    }
}
void display(struct TreeNode* root) {
    if (root != NULL) {
        printf("Inorder traversal: ");
        inorder(root);
        printf("\n");

        printf("Postorder traversal: ");
        postorder(root);
        printf("\n");

        printf("Preorder traversal: ");
        preorder(root);
        printf("\n");
    } else {
        printf("Tree is empty.\n");
    }
}

void main() {
    struct TreeNode* root = NULL;
    root = insert(root, 50);
    insert(root, 30);
    insert(root, 20);
    insert(root, 40);
    insert(root, 70);
    insert(root, 60);
    insert(root, 80);
    printf("Elements in the tree:\n");
    display(root);
}
```


Elements in the tree:
Inorder traversal: 20 30 40 50 60 70 80
Postorder traversal: 20 40 30 60 80 70 50
Preorder traversal: 50 30 20 40 70 60 80

Program 12
Score of Parentheses - Leetcode



856. Score of Parentheses

Medium | Topics | Companies

Given a balanced parentheses string `s`, return *the **score** of the string*.

The **score** of a balanced parentheses string is based on the following rule:

- `"()"` has score `1`.
- `AB` has score `A + B`, where `A` and `B` are balanced parentheses strings.
- `(A)` has score `2 * A`, where `A` is a balanced parentheses string.

```c
int scoreOfParentheses(char* s)
{
    int len = strlen(s);
    int score = 0;
    int depth = 0;

    for (int i = 0; i < len; i++)
    {
        if (s[i] == '(')
        {
            depth++;
        }
        else
        {
            depth--;
            if (s[i - 1] == '(')
            {
               score += 1 << depth;
            }
        }
    }
```

```
    return score;
}
```

Program 13
Delete the middle node of a linked list - Leetcode

2095. Delete the Middle Node of a Linked List

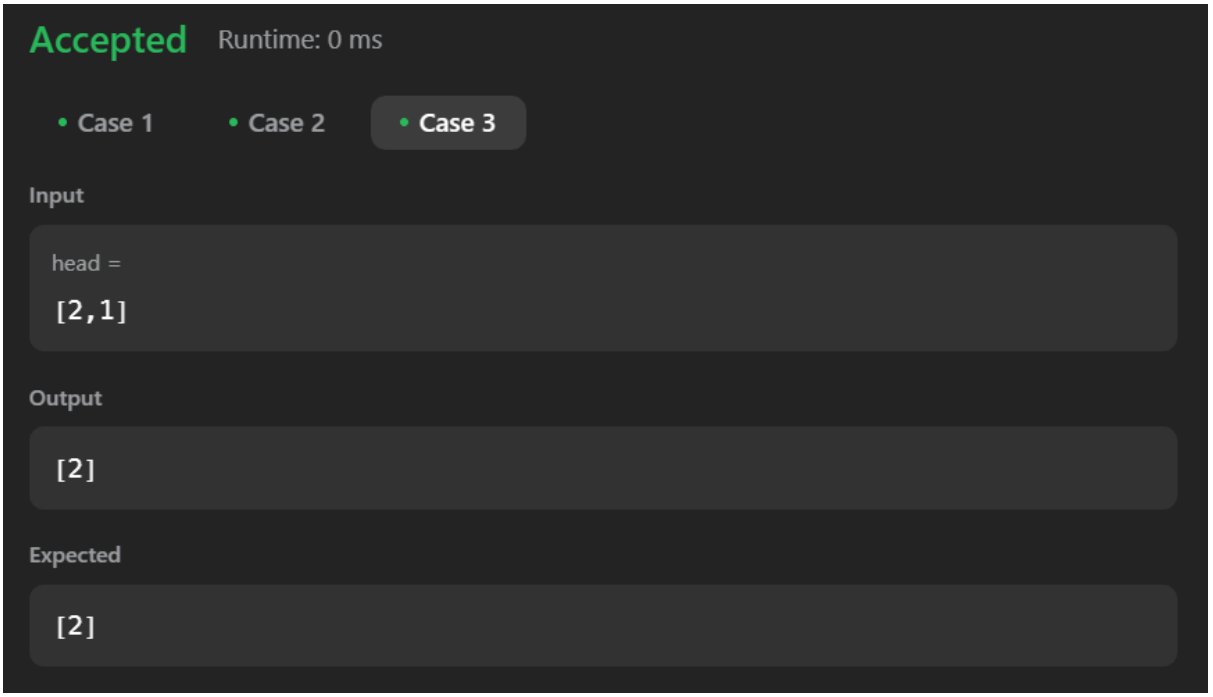
Medium | Topics | Companies | Hint

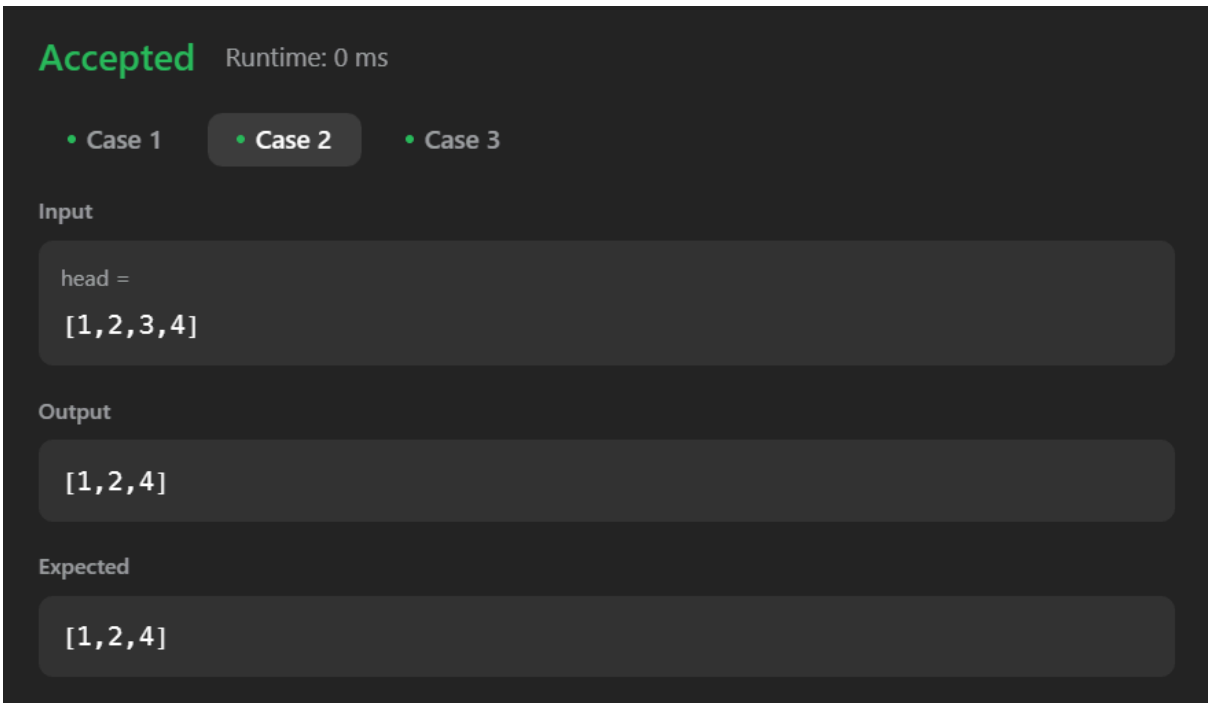
You are given the `head` of a linked list. **Delete** the **middle node**, and return *the* `head` *of the modified linked list.*

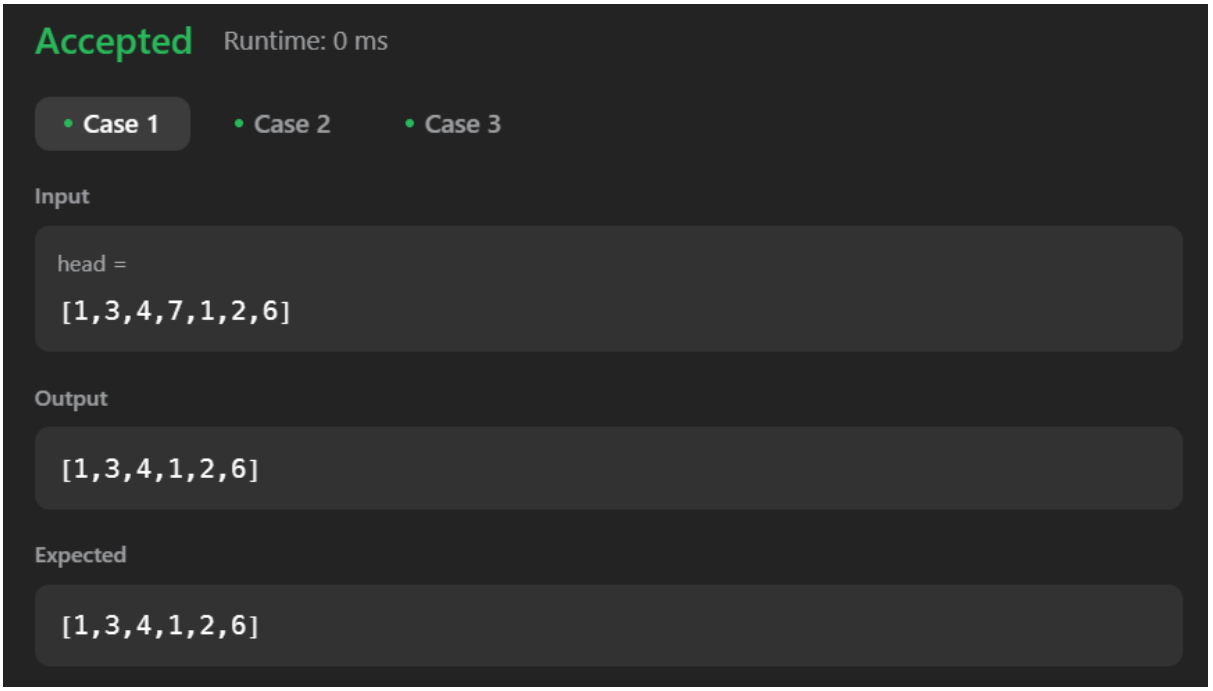
The **middle node** of a linked list of size `n` is the `⌊n / 2⌋th` node from the **start** using **0-based indexing**, where `⌊x⌋` denotes the largest integer less than or equal to `x`.

- For `n` = `1`, `2`, `3`, `4`, and `5`, the middle nodes are `0`, `1`, `1`, `2`, and `2`, respectively.

```
struct ListNode* deleteMiddle(struct ListNode* head)
{
    int count=0, middleNode, i=0;
    struct ListNode* temp=head;
    struct ListNode* node=head;
    struct ListNode* prev;
    struct ListNode* next=head;
    while(temp!=NULL)
    {
        count++;
        temp=temp->next;
    }
    middleNode=count/2;
    if(middleNode==0)
    {
        struct ListNode* newHead=head->next;
        free(head);
        return newHead;
    }
    while(i<middleNode)
    {
        prev=node;
        node=node->next;
        next=node->next;
        i++;
    }
    prev->next=next;
    free(node);
    return head;
}
```


Accepted
Runtime: 0 ms
• Case 1
• Case 2
• Case 3
Input
head =
[2,1]
Output
[2]
Expected
[2]


Accepted
Runtime: 0 ms
• Case 1
• Case 2
• Case 3
Input
head =
[1,2,3,4]
Output
[1,2,4]
Expected
[1,2,4]


Accepted
Runtime: 0 ms
• Case 1
• Case 2
• Case 3
Input
head =
[1,3,4,7,1,2,6]
Output
[1,3,4,1,2,6]
Expected
[1,3,4,1,2,6]

Program 14
Odd Even Linked List - Leetcode

328. Odd Even Linked List

Medium | Topics | Companies

Given the `head` of a singly linked list, group all the nodes with odd indices together followed by the nodes with even indices, and return *the reordered list*.

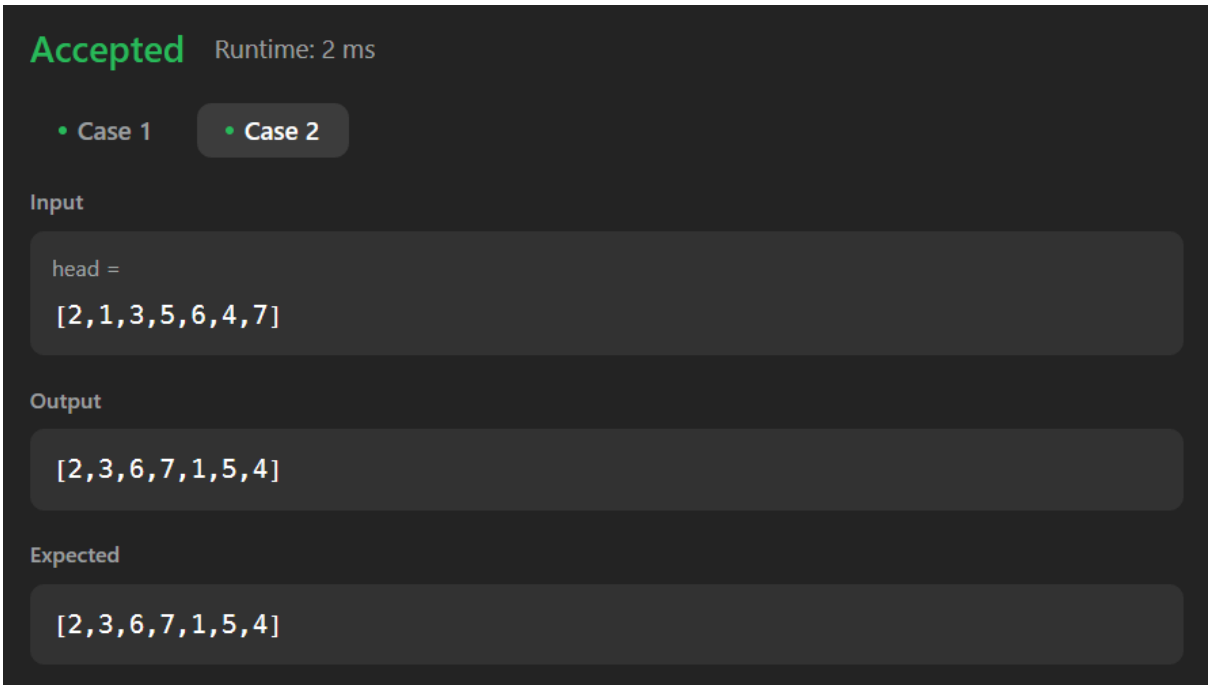
The **first** node is considered **odd**, and the **second** node is **even**, and so on.

Note that the relative order inside both the even and odd groups should remain as it was in the input.

You must solve the problem in `O(1)` extra space complexity and `O(n)` time complexity.

```
struct ListNode* oddEvenList(struct ListNode* head)
{
    if(head==NULL||head->next==NULL)
    {
        return head;
    }
    struct ListNode* oddTemp=head;
    struct ListNode* evenTemp=head->next;
    struct ListNode* evenHead=evenTemp;
    while(evenTemp!=NULL && evenTemp->next!=NULL)
    {
        oddTemp->next=evenTemp->next;
        oddTemp=oddTemp->next;
        evenTemp->next=oddTemp->next;
        evenTemp=evenTemp->next;
    }
    oddTemp->next=evenHead;
    return head;
}
```


Accepted
Runtime: 2 ms
Case 1
Case 2
Input
head =
[1,2,3,4,5]
Output
[1,3,5,2,4]
Expected
[1,3,5,2,4]


Accepted
Runtime: 2 ms
Case 1
Case 2
Input
head =
[2,1,3,5,6,4,7]
Output
[2,3,6,7,1,5,4]
Expected
[2,3,6,7,1,5,4]

Program 15
Write a program to traverse a graph using BFS method.

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

#define MAX_VERTICES 100

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

struct Graph {
    struct Node* adjLists[MAX_VERTICES];
    int visited[MAX_VERTICES];
};

struct Node* createNode(int v) {
    struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));
    newNode->vertex = v;
    newNode->next = NULL;
    return newNode;
}

struct Graph* createGraph() {
    struct Graph* graph = (struct Graph*)malloc(sizeof(struct Graph));
    int i;
    for (i = 0; i < MAX_VERTICES; i++) {
        graph->adjLists[i] = NULL;
        graph->visited[i] = 0;
    }
    return graph;
}

void addEdge(struct Graph* graph, int src, int dest) {
    struct Node* newNode = createNode(dest);
    newNode->next = graph->adjLists[src];
    graph->adjLists[src] = newNode;

    newNode = createNode(src);
    newNode->next = graph->adjLists[dest];
    graph->adjLists[dest] = newNode;
```

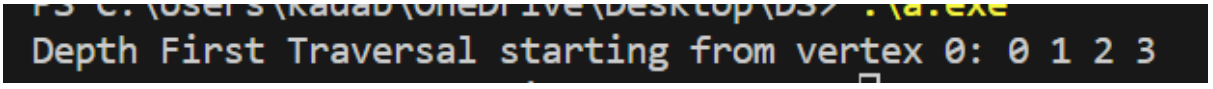
```
}

void BFS(struct Graph* graph, int startVertex) {
    struct Node* temp;
    int queue[MAX_VERTICES];
    int front = 0, rear = 0, v;

    graph->visited[startVertex] = 1;
    queue[rear++] = startVertex;

    while (front < rear) {
        v = queue[front++];
        printf("%d ", v);

        for (temp = graph->adjLists[v]; temp != NULL; temp =
temp->next) {
            if (!graph->visited[temp->vertex]) {
                graph->visited[temp->vertex] = 1;
                queue[rear++] = temp->vertex;
            }
        }
    }
}

void main() {
    struct Graph* graph = createGraph();

    addEdge(graph, 0, 1);
    addEdge(graph, 0, 2);
    addEdge(graph, 1, 2);
    addEdge(graph, 2, 3);
    addEdge(graph, 1, 3);

    printf("Breadth First Traversal starting from vertex 0: ");
    BFS(graph, 0);
}
```

```
Breadth First Traversal starting from vertex 0: 0 2 1 3
```

Program 16
Write a program to traverse a graph using DFS method.

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

#define MAX_VERTICES 100

struct Graph {
    int matrix[MAX_VERTICES][MAX_VERTICES];
    int visited[MAX_VERTICES];
    int numVertices;
};

struct Graph* createGraph(int numVertices) {
    struct Graph* graph = (struct Graph*)malloc(sizeof(struct Graph));
    graph->numVertices = numVertices;
    int i, j;
    for (i = 0; i < numVertices; i++) {
        for (j = 0; j < numVertices; j++) {
            graph->matrix[i][j] = 0;
        }
        graph->visited[i] = 0;
    }
    return graph;
}

void addEdge(struct Graph* graph, int src, int dest) {
    graph->matrix[src][dest] = 1;
    graph->matrix[dest][src] = 1;
}

void DFS(struct Graph* graph, int vertex) {
    printf("%d ", vertex);
    graph->visited[vertex] = 1;
    int i;
    for (i = 0; i < graph->numVertices; i++) {
        if (graph->matrix[vertex][i] && !graph->visited[i]) {
            DFS(graph, i);
        }
    }
}

void main() {
```

```c
    int numVertices = 5;
    struct Graph* graph = createGraph(numVertices);

    addEdge(graph, 0, 1);
    addEdge(graph, 0, 2);
    addEdge(graph, 1, 2);
    addEdge(graph, 2, 3);
    addEdge(graph, 1, 3);

    printf("Depth First Traversal starting from vertex 0: ");
    DFS(graph, 0);
}
```



Program 17
Delete Node in BST - Leetcode

450. Delete Node in a BST

Medium | Topics | Companies

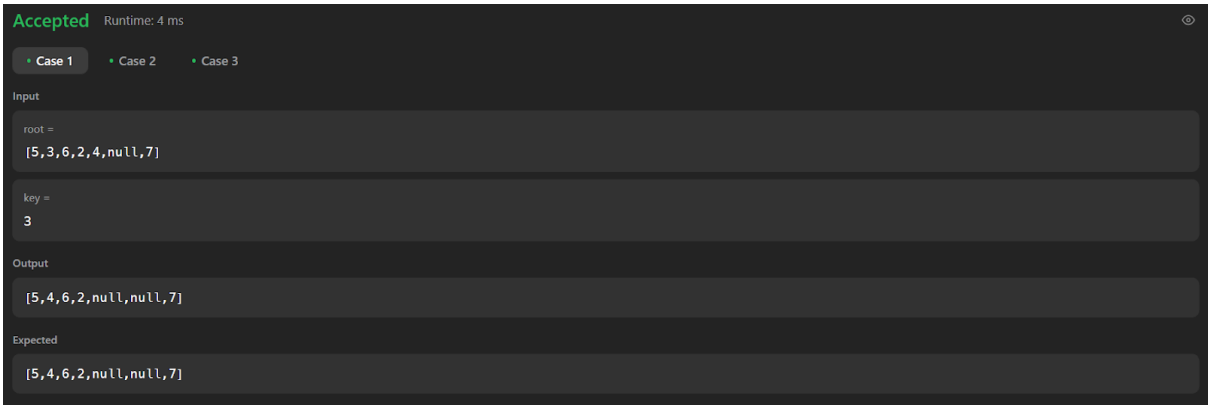
Given a root node reference of a BST and a key, delete the node with the given key in the BST. Return *the **root node reference** (possibly updated) of the BST*.

Basically, the deletion can be divided into two stages:

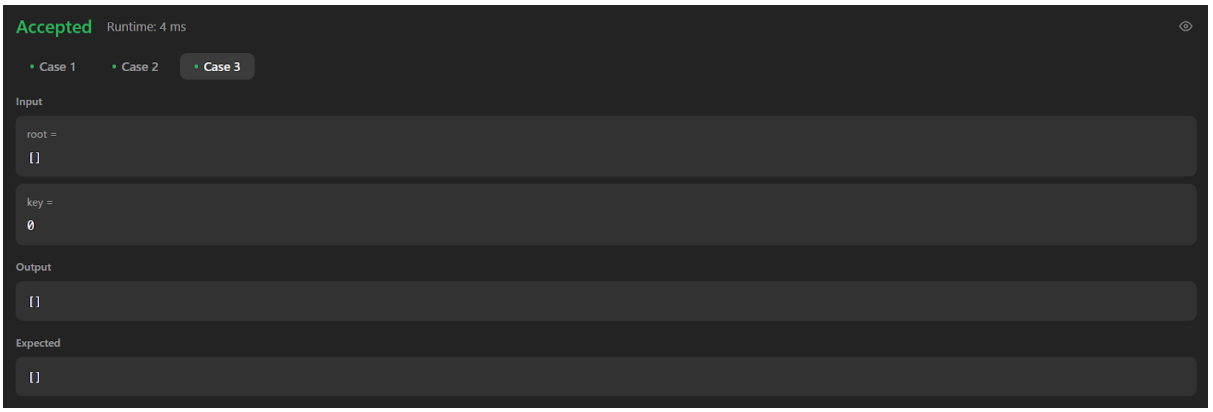
1. Search for a node to remove.
2. If the node is found, delete the node.

```
struct TreeNode* deleteNode(struct TreeNode* root, int key)
{
    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 = root->right;
        while (temp && temp->left != NULL)
            temp = temp->left;
        root->val = temp->val;
        root->right = deleteNode(root->right, temp->val);
    }
```

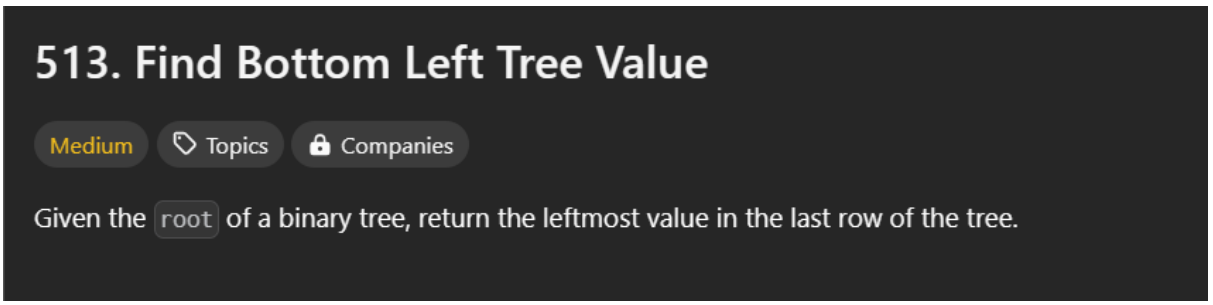
```
    return root;
}
```


Accepted
Runtime: 4 ms
Case 1
Case 2
Case 3
Input
root =
[5,3,6,2,4,null,7]
key =
3
Output
[5,4,6,2,null,null,7]
Expected
[5,4,6,2,null,null,7]

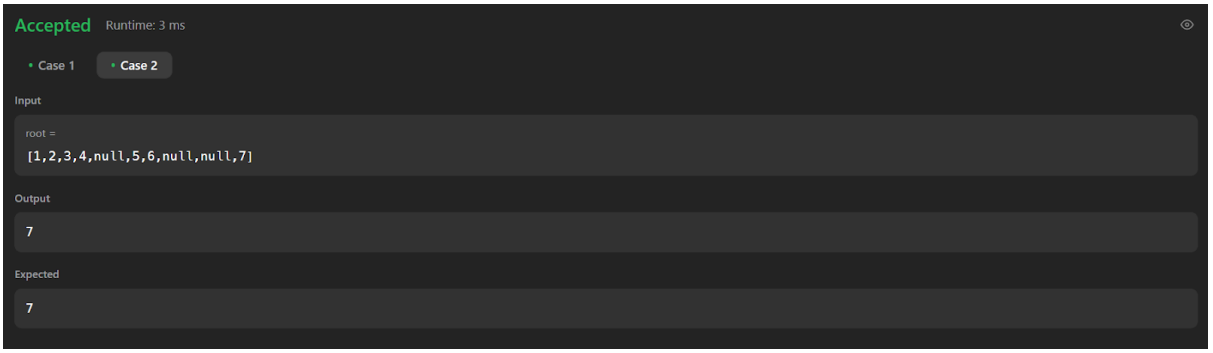

Accepted
Runtime: 4 ms
Case 1
Case 2
Case 3
Input
root =
[5,3,6,2,4,null,7]
key =
0
Output
[5,3,6,2,4,null,7]
Expected
[5,3,6,2,4,null,7]


Accepted
Runtime: 4 ms
Case 1
Case 2
Case 3
Input
root =
[]
key =
0
Output
[]
Expected
[]

Program 18
Find bottom left tree value - Leetcode




```
int findBottomLeftValue(struct TreeNode* root)
{
    if (root == NULL)
 return -1; // No nodes in the tree
 struct TreeNode** queue = (struct TreeNode**)malloc(sizeof(struct TreeNode*)
* 10000);
 int front = 0, rear = 0, nextLevelCount = 0, currentLevelCount = 1;
 int leftmostValue = root->val;
 queue[rear++] = root;
 while (front < rear) {
 struct TreeNode* current = queue[front++];
 currentLevelCount--;
 if (current->left != NULL) {
 queue[rear++] = current->left;
 nextLevelCount++;
 }
 if (current->right != NULL) {
 queue[rear++] = current->right;
 nextLevelCount++;
 }
 if (currentLevelCount == 0) {
 if (nextLevelCount > 0)
 leftmostValue = queue[front]->val;
 currentLevelCount = nextLevelCount;
 nextLevelCount = 0;
 }
 }
 free(queue);
 return leftmostValue;
}
```


Accepted
Runtime: 3 ms
Case 1
Case 2
Input
root =
[1,2,3,4,null,5,6,null,null,7]
Output
7
Expected
7


Accepted
Runtime: 3 ms
Case 1
Case 2
Input
root =
[2,1,3]
Output
1
Expected
1

Program 19

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 HT_SIZE 10
typedef struct {
 int key;
 } Employee;
typedef struct {
 int key;
 Employee employee;
} HashEntry;
typedef struct {
 HashEntry *table;
 int size;
} HashTable;
int hashFunction(int key, int size) {
 return key % size;
}
void initializeHashTable(HashTable *ht, int size) {
 ht->size = size;
 ht->table = (HashEntry *)malloc(size * sizeof(HashEntry));
 for (int i = 0; i < size; i++) {
 ht->table[i].key = -1;
 }
}
void insert(HashTable *ht, int key, Employee employee) {
 int index = hashFunction(key, ht->size);
 while (ht->table[index].key != -1) {
 index = (index + 1) % ht->size;
 }
 ht->table[index].key = key;
 ht->table[index].employee = employee;
}
int search(HashTable *ht, int key) {
 int index = hashFunction(key, ht->size);
 int originalIndex = index;
 while (ht->table[index].key != key && ht->table[index].key != -1) {
 index = (index + 1) % ht->size;
 if (index == originalIndex)
 return -1;
 }
```

```
 if (ht->table[index].key == key) {
 return index;
 } else {
 return -1;
 }
}
int main() {
 HashTable ht;
 initializeHashTable(&ht, HT_SIZE);
 int numEmployees;
 printf("Enter the number of employees: ");
 scanf("%d", &numEmployees);
 for (int i = 0; i < numEmployees; i++) {
 Employee emp;
 printf("Enter key for employee %d: ", i+1);
 scanf("%d", &emp.key);
 insert(&ht, emp.key, emp);
 }
 int searchKey;
 printf("Enter key to search: ");
 scanf("%d", &searchKey);
 int resultIndex = search(&ht, searchKey);
 if (resultIndex != -1) {
 printf("Employee with key %d found at index %d.\n", searchKey,
resultIndex);
 } else {
 printf("Employee with key %d not found.\n", searchKey);
 }
 return 0;
}
```

```
PS C:\Users\kadab\OneDrive\Desktop\DS> gcc ninteen.c
PS C:\Users\kadab\OneDrive\Desktop\DS> .\a.exe
Enter the number of employees: 2
Enter key for employee 1: 234
Enter key for employee 2: 567
Enter key to search: 234
Employee with key 234 found at index 4.
```