VISVESVARAYA TECHNOLOGICAL UNIVERSITY

“JnanaSangama”, Belgaum -590014, Karnataka.

LAB REPORT
On

DATA STRUCTURES (23CS3PCDST)

Submitted by

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

B.M.S. COLLEGE OF ENGINEERING
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This is to certify that the Lab work entitled **“DATA STRUCTURES”** carried out by **RAHUL N RAJU (1BM22CS215)**, who is a bonafide student of **B. M. S. College of Engineering**. It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visvesvaraya Technological University, Belgaum during the year 2023-24. The Lab report has been approved as it satisfies the academic requirements in respect of Data structures Lab - **(23CS3PCDST) work** prescribed for the said degree.

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Index Sheet

Course outcomes:

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

Lab program 1:

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.

```
//stack implementation

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

void main()
{
    int ch;
    while (1)
    {
        printf("Operations on the stack:\n");
        printf("1.Push the element 2.Pop the element 3.Show 4.End\n");
        printf("Enter the choice: ");
        scanf("%d",&ch);

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

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

void push()
```

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

OUTPUT :

```
C:\Users\Admin\Desktop\1bm22cs215\stack.exe
Operations on the stack:
1.Push the element 2.Pop the element 3.Show 4.End
Enter the choice: 1
Enter the element to be added :
 3
Operations on the stack:
1.Push the element 2.Pop the element 3.Show 4.End
Enter the choice: 1
Enter the element to be added :
 2
Operations on the stack:
1.Push the element 2.Pop the element 3.Show 4.End
Enter the choice: 2
Popped element: 2
Operations on the stack:
1.Push the element 2.Pop the element 3.Show 4.End
Enter the choice: 3
Elements in the stack are:
3
Operations on the stack:
1.Push the element 2.Pop the element 3.Show 4.End
Enter the choice: 4

Process returned 0 (0x0)   execution time : 14.749 s
Press any key to continue.
```

Lab program 2:

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

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

#define SIZE 100

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

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

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

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

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

```c
        return 1;
    } else {
        return -1;
    }
}

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

    push('#');

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

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

    postfix[j] = '\0';
}

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

    printf("Enter a valid parenthesized infix expression: ");
    scanf("%s", infix);

    infixToPostfix(infix, postfix);

    printf("The postfix expression is: %s\n", postfix);

    return 0;
}
```

OUTPUT :

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


...Program finished with exit code 0
Press ENTER to exit console.
```

Lab program 3:

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

```c
#include <stdio.h>
#define MAX 6

int Q[MAX];
int front = -1, rear = -1;

void insert(int element) {
    if (rear == MAX - 1) {
        printf("Queue Overflow\n");
        return;
    } else {
        if (front == -1) {
            front = 0;
        }
        rear++;
        Q[rear] = element;
    }
}

void delete() {
    if (front == -1 || front > rear) {
        printf("Queue Underflow\n");
        return;
    } else {
        printf("Deleted element: %d\n", Q[front]);
        front++;
```

```
    }
}

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

int main() {
    int choice, element;

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

        switch (choice) {
            case 1:
                printf("Enter element to insert: ");
                scanf("%d", &element);
                insert(element);
                break;
            case 2:
                delete();
                break;
            case 3:
                display();
                break;
            case 4:
                printf("Exiting...\n");
                break;
            default:
                printf("Invalid choice! Please enter a valid choice.\n");
        }
    } while (choice != 4);

    return 0;
}
```

OUTPUT :

```
1. Insert
2. Delete
3. Display
4. Exit
Enter your choice: 1
Enter element to insert: 10

1. Insert
2. Delete
3. Display
4. Exit
Enter your choice: 1
Enter element to insert: 20

1. Insert
2. Delete
3. Display
4. Exit
Enter your choice: 2
Deleted element: 10

1. Insert
2. Delete
3. Display
4. Exit
Enter your choice: 3
Elements in the queue: 20

1. Insert
2. Delete
3. Display
4. Exit
Enter your choice:
```

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

```
#include <stdio.h>

#define SIZE 5

int items[SIZE];
int front = -1, rear = -1;

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

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

void enQueue(int element) {
  if (isFull())
    printf("\n Queue is full!! \n");
  else {
    if (front == -1) front = 0;
    rear = (rear + 1) % SIZE;
    items[rear] = element;
    printf("\n Inserted -> %d", element);
  }
  printf("\n");
}

int deQueue() {
  int element;
  if (isEmpty()) {
    printf("\n Queue is empty !! \n");
    return (-1);
  } else {
    element = items[front];
    if (front == rear) {
      front = -1;
      rear = -1;
    }
    else {
      front = (front + 1) % SIZE;
    }
    printf("\n Deleted element -> %d \n", element);
    return (element);
```

```c
  }
  printf("\n");
}

void display() {
  int i;
  if (isEmpty())
    printf(" \n Empty Queue\n");
  else {
    printf("\n Front -> %d ", front);
    printf("\n Items -> ");
    for (i = front; i != rear; i = (i + 1) % SIZE) {
      printf("%d ", items[i]);
    }
    printf("%d ", items[i]);
    printf("\n Rear -> %d \n", rear);
  }
  printf("\n");
}

void main()
{
    int option, val;
    int ele;
    do
    {
        printf("1.insert\n");
        printf("2.Delete\n");
        printf("3.Display\n");
        printf("4.Exit\n");
        printf("enter your option : \n");
        scanf("%d",&option);
        switch(option)
        {
            case 1:
                    printf("enter the element : ");
                    scanf("%d", &ele);
                    enQueue(ele);
                    break;
            case 2: val = deQueue();
                    if(val != -1)
                        printf("the number deleted is : %d \n",val);
                    break;
            case 3:display();
                    break;
        }
    }while(option!=4);
}
```

OUTPUT :

```
1.insert
2.Delete
3.Display
4.Exit
enter your option :
1
enter the element : 1

 Inserted -> 1
1.insert
2.Delete
3.Display
4.Exit
enter your option :
1
enter the element : 2

 Inserted -> 2
1.insert
2.Delete
3.Display
4.Exit
enter your option :
2

 Deleted element -> 1
the number deleted is : 1
1.insert
2.Delete
3.Display
4.Exit
enter your option :
3

 Front -> 1
 Items -> 2
 Rear -> 1

1.insert
2.Delete
3.Display
4.Exit
```

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.

```
// singly linked list

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

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

void insert(struct Node **head, int data)
{
    struct Node *newnode = (struct Node *)malloc (sizeof(struct Node));

    newnode ->
    data = data;
    newnode ->
    next= *head;

    *head = newnode;
}

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

void main()
{
    struct Node *head = NULL;
    insert(&head, 100);
    insert(&head, 80);
    insert(&head, 60);
```

```
    insert(&head, 40);
    display(head);
}
```

OUTPUT:

```
Linked List: 40 60 80 100


...Program finished with exit code 0
Press ENTER to exit console.
```

Program - Leetcode platform – MinStack

```
typedef struct {
    int str[8000];
    int top;
    int min[1000];
    int mincnt;
} MinStack;


MinStack* minStackCreate() {
    MinStack *Min;
    Min=(MinStack*)malloc(sizeof(MinStack));
    Min->top=-1;
    Min->mincnt=0;
    return Min;
}

void minStackPush(MinStack* obj, int x) {
    obj->top++;
    obj->str[obj->top]=x;

    printf("mincnt=%d push:%d\n",obj->mincnt,x);
    if( obj->mincnt==0 || x<=obj->min[obj->mincnt-1] )
    {
        obj->min[obj->mincnt++]=x;
        printf("%d*",x);
    }
    printf("\n===end===\n\n");
}

void minStackPop(MinStack* obj) {
    if(obj->top==-1)
        return ;
```

```c
    if(obj->mincnt==0)
        ;//////////////////////

    else if( obj->str[obj->top]==obj->min[obj->mincnt-1] )
        obj->mincnt--;

    obj->top--;
}

int minStackTop(MinStack* obj) {
    return obj->str[obj->top];
}

int minStackGetMin(MinStack* obj) {
    return obj->min[obj->mincnt-1];
}

void minStackFree(MinStack* obj) {
    free(obj);
}

/**
 * Your MinStack struct will be instantiated and called as such:
 * MinStack* obj = minStackCreate();
 * minStackPush(obj, val);

 * minStackPop(obj);

 * int param_3 = minStackTop(obj);

 * int param_4 = minStackGetMin(obj);

 * minStackFree(obj);
*/
```

OUTPUT :

Accepted Runtime: 3 ms

• Case 1

Input

```
["MinStack","push","push","push","getMin","pop","top","getMin"]
```

```
[[],[-2],[0],[-3],[],[],[],[]]
```

Stdout

```
mincnt=0 push:-2
-2*
===end===

mincnt=1 push:0

===end===
```

View more

Output

```
[null,null,null,null,-3,null,0,-2]
```

Expected

```
[null,null,null,null,-3,null,0,-2]
```

Lab program 5:

WAP to Implement Singly Linked List with following operations

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

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

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

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

void insertAtEnd(struct Node** head,int value)
{

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

//function to delete the first element from the linked list
```

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

//to delete a specified element
void deleteEle(struct Node** head,int value)
{
    struct Node* current  = *head;
    struct Node* prev = NULL;

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

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

//to delete the last element
void deleteLast(struct Node** head)
{
    if(*head == NULL)
    {
        printf("empty");
    }
    struct Node* temp = *head;
    struct Node* prev = NULL;
    while(temp -> next != NULL)
    {
        prev = temp;
        temp = temp -> next;
```

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

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

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

    insertAtEnd(&head,1);
    insertAtEnd(&head,2);
    insertAtEnd(&head,3);
    insertAtEnd(&head,4);

    printf("initial linked list : ");
    display(head);

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

    deleteEle(&head,2);
    printf("\nafter deleting the specified element : ");
    display(head);

    deleteLast(&head);
    printf("\nafter deleting the last element : ");
    display(head);

}
```

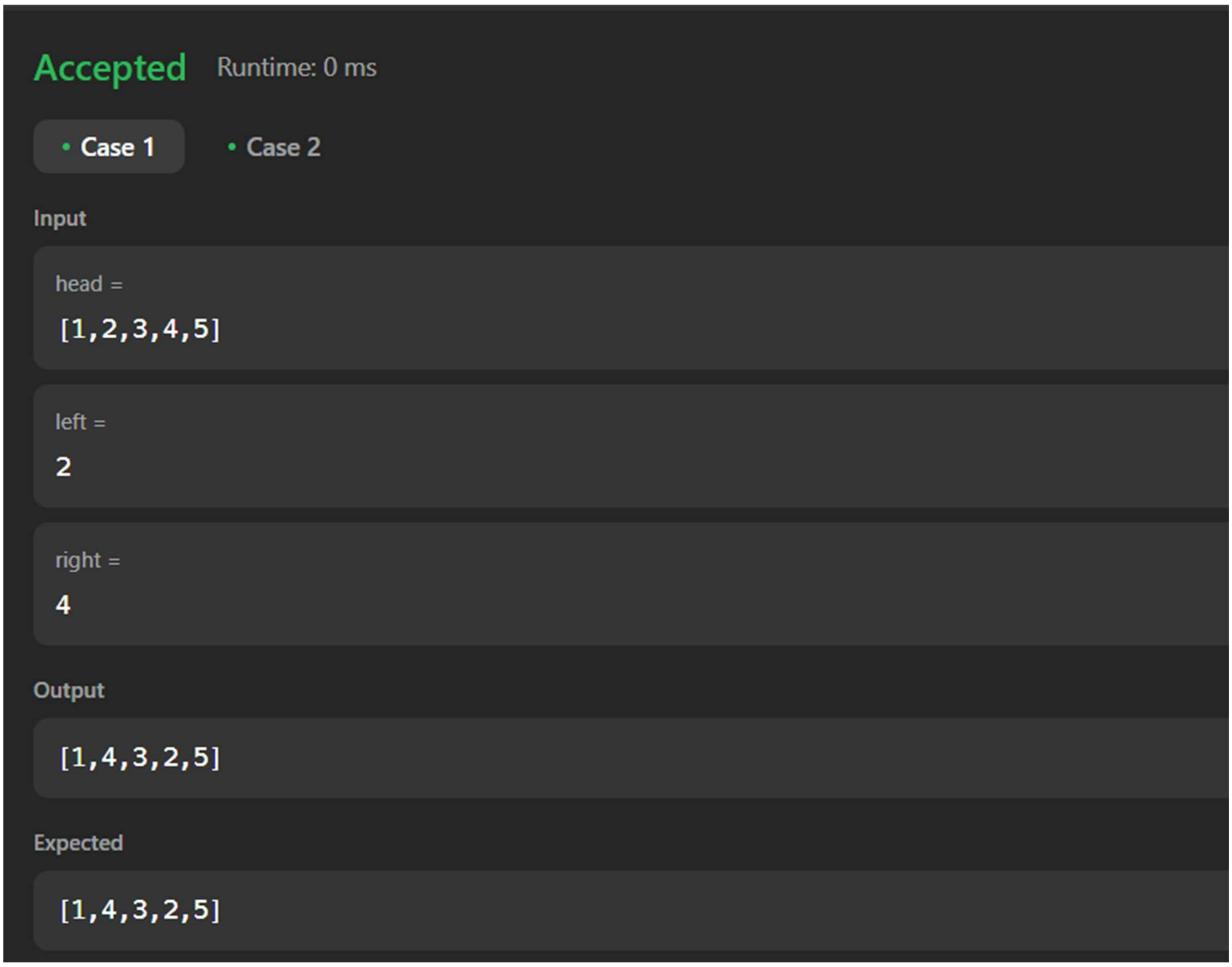
```
C:\Users\Admin\Desktop\1BM22CS215\DeleteLinkList.exe
initial linked list : 1 -> 2 -> 3 -> 4 -> NULL

After deleting the first element : 2 -> 3 -> 4 -> NULL

after deleting the specified element : 3 -> 4 -> NULL

after deleting the last element : 3 -> NULL

Process returned 0 (0x0)   execution time : 0.000 s
Press any key to continue.
```

Program - Leetcode platform – Reverse Linked List 2

```c
/**
 * Definition for singly-linked list.
 * struct ListNode {
 *     int val;
 *     struct ListNode *next;
 * };
 */
struct ListNode* reverseBetween(struct ListNode* head, int left, int right) {
    if (head == NULL) return NULL;

    if (left == right) return head;

    struct ListNode* prev = NULL;
    struct ListNode* curr = head;

    int index = 1;
    while (index < left)
    {
        prev = curr;
        curr = curr->next;
        index++;
    }

    struct ListNode* leftMinusOneNode = prev;
```

```
    struct ListNode* leftNode = curr;
    struct ListNode* next = NULL;

    while (left <= right)
    {
        next = curr->next;

        curr->next = prev;

        prev = curr;
        curr = next;
        left++;
    }

    if (leftMinusOneNode == NULL) // means head changes
        head = prev;
    else
        leftMinusOneNode->next = prev;   // [   1   (2  <-  3   <-  4)  5   ]  //
when input -> 5 2 4
                                         //  1 is leftMinusOneNode and 4 is prev
                                         //  so 1's next is 4
    leftNode->next = curr;               //  and 2 is leftNode, so makes 2's next
is 5

    return head;
}
```

OUTPUT :


Accepted
Runtime: 0 ms
Case 1
Case 2
Input
head =
[1,2,3,4,5]
left =
2
right =
4
Output
[1,4,3,2,5]
Expected
[1,4,3,2,5]

Lab program 6:

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

```c
//linked list operation

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

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

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

Node *sortList(Node *head)
{
    if(head == NULL || head -> next == NULL)
        return head;
    int swapped;
    Node *temp;
    Node *end = NULL;
    do
    {
        swapped = 0;
        temp = head;
        while(temp -> next != end)
        {
```

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

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

Node *concatLists(Node *list1 , Node *list2)
{
    if(list1 == list2)
        return list2;
    Node *temp = list1;
    while(temp -> next != NULL)
    {
        temp = temp -> next;
    }
    temp -> next = list2;
    return list1;
}

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

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

```
    printf("original list 1 : ");
    display(list1);
    printf("original list 2 : ");
    display(list2);

    list1 = sortList(list1);
    printf("sorted list 1 : ");
    display(list1);

    list1 = reverseList(list1);
    printf("reversed list 1 : ");
    display(list1);

    Node *concatenated = concatLists(list1,list2);
    printf("concatenated list : ");
    display(concatenated);
}
```

C:\Users\Admin\Desktop\1BM22CS215\link_list_operation.exe

```
original list 1 : 3 -> 1 -> 4 -> NULL
original list 2 : 2 -> 5 -> NULL
sorted list 1 : 1 -> 3 -> 4 -> NULL
reversed list 1 : 4 -> 3 -> 1 -> NULL
concatenated list : 4 -> 3 -> 1 -> 2 -> 5 -> NULL

Process returned 0 (0x0)   execution time : 0.000 s
Press any key to continue.
```

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

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

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

typedef struct Node Node;

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

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

typedef struct {
    Node *top;
}LinkedList;

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

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

```c
    int poppedValue = stack -> top -> data;
    Node *temp = stack -> top;
    stack -> top = stack -> top -> next;
    free(temp);
    return poppedValue;
}

void main() {
    LinkedList stack;
    stack.top = NULL;
    printf("stack operations : \n");
     push(&stack, 10);
     push(&stack, 20);
     push(&stack, 25);
     push(&stack, 30);
     display(stack.top);
    printf("popped value : %d\n", pop(&stack));
    printf("popped value : %d\n", pop(&stack));
     display(stack.top);
}
```

C:\Users\Admin\Desktop\1BM22CS215\stack_using_linked.exe

```
stack operations :
30 -> 25 -> 20 -> 10 -> NULL
popped value : 30
popped value : 25
20 -> 10 -> NULL

Process returned 0 (0x0)   execution time : 0.016 s
Press any key to continue.
```

```c
//queue implementation using linked list

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

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

typedef struct Node Node;

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

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

typedef struct {
    Node *front;
    Node *rear;
}LinkedList;

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

```
        queue -> rear = newNode;
    }
}

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

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

    printf("\n queue operations : \n");
    enqueue(&queue,40);
    enqueue(&queue,50);
    enqueue(&queue,60);
    display(queue.front);
    printf("dequeued from queue : %d\n",dequeue(&queue));
    printf("dequeued from queue : %d\n",dequeue(&queue));
    display(queue.front);
}
```

```
C:\Users\Admin\Desktop\1BM22CS215\queue_linked_list.exe

 queue operations :
40 -> 50 -> 60 -> NULL
dequeued from queue : 40
dequeued from queue : 50
60 -> NULL

Process returned 0 (0x0)   execution time : 0.000 s
Press any key to continue.
```

Lab program 7:

WAP to Implement doubly link list with primitive operations

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

```c
//doubly linked list operations

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

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

struct Node *createNode(int data)
{

    struct Node *newNode = (struct Node*)malloc(sizeof(struct Node));
    if(newNode == NULL)
    {

        printf("memory allocation failed \n");
        exit(1);
    }
    newNode -> data = data;
```

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

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

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

void display(struct Node *head)
{
```

```c
    printf("doubly linked list : \n");
    while(head != NULL)
    {
        printf("%d <-> ",head -> data);
        head = head -> next;
    }
    printf("NULL\n");
}

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

    display(head);

    insertNode(head,head -> next,10);
    printf("after insertion : \n");
    display(head);

    deleteNode(head,2);
    printf("after deletion : \n");
    display(head);
    return 0;
}
```

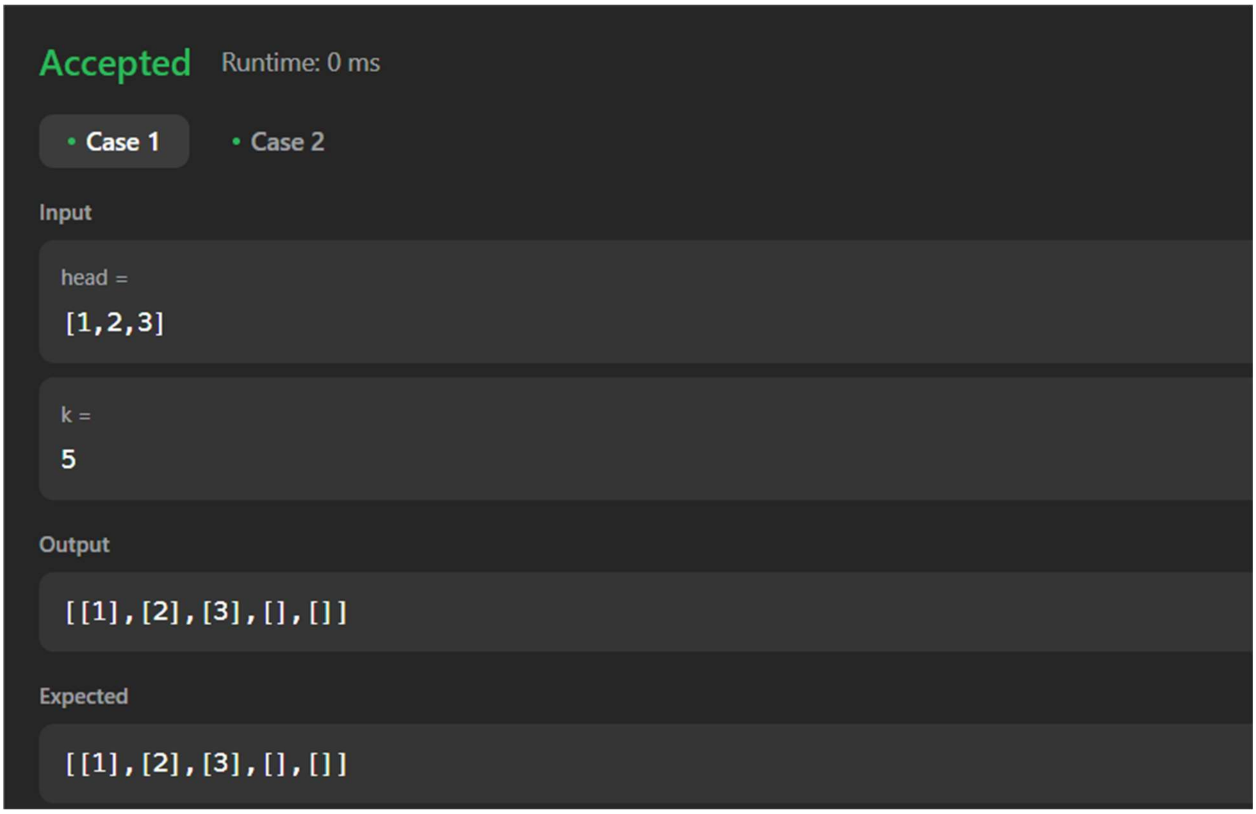
```
doubly linked list :
1 <-> 2 <-> 3 <-> NULL
after insertion :
doubly linked list :
1 <-> 10 <-> 2 <-> 3 <-> NULL
after deletion :
doubly linked list :
1 <-> 10 <-> 3 <-> NULL


...Program finished with exit code 5
Press ENTER to exit console.
```

Program - Leetcode platform – Split Linked list in parts

```
/**
 * Definition for singly-linked list.
 * struct ListNode {
 *     int val;
 *     struct ListNode *next;
 * };
 */
/**
 * Note: The returned array must be malloced, assume caller calls free().
 */
 int getLength(struct ListNode* head) {
    int length = 0;
    while (head != NULL) {
        length++;
        head = head->next;
    }
    return length;
}


struct ListNode** splitListToParts(struct ListNode* head, int k, int* returnSize)
{
    int length = getLength(head);
    int partSize = length / k;
    int remainder = length % k;

    struct ListNode** result = (struct ListNode**)malloc(k * sizeof(struct
ListNode*));
    *returnSize = k;

    for (int i = 0; i < k; i++) {
        int currentPartSize = partSize + (i < remainder ? 1 : 0);

        if (currentPartSize == 0) {
            result[i] = NULL;
        } else {
            result[i] = head;
            for (int j = 0; j < currentPartSize - 1; j++) {
                head = head->next;
            }

            struct ListNode* temp = head->next;
            head->next = NULL;
            head = temp;
        }
    }
```

```
    return result;
}
```

OUTPUT :



Lab program 8:

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

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

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

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

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

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

void preorder(struct Node* temp)
{
    if(temp == NULL)
```

```
        return;
    printf("%d ",temp -> data);
    preorder(temp -> left);
    preorder(temp -> right);
}

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

void main()
{
    struct Node* root = NULL;
    int data,choice;
    root = insert(root,20);
    root = insert(root,10);
    root = insert(root,5);
    root = insert(root,15);
    root = insert(root,40);
    root = insert(root,30);
    root = insert(root,50);
    printf("\n the inorder traversal is : \n");
    inorder(root);
    printf("\n");
    printf("\n the preorder traversal is : \n");
    preorder(root);
    printf("\n");
    printf("\n the postorder traversal is : \n");
    postorder(root);
    printf("\n");
}
```

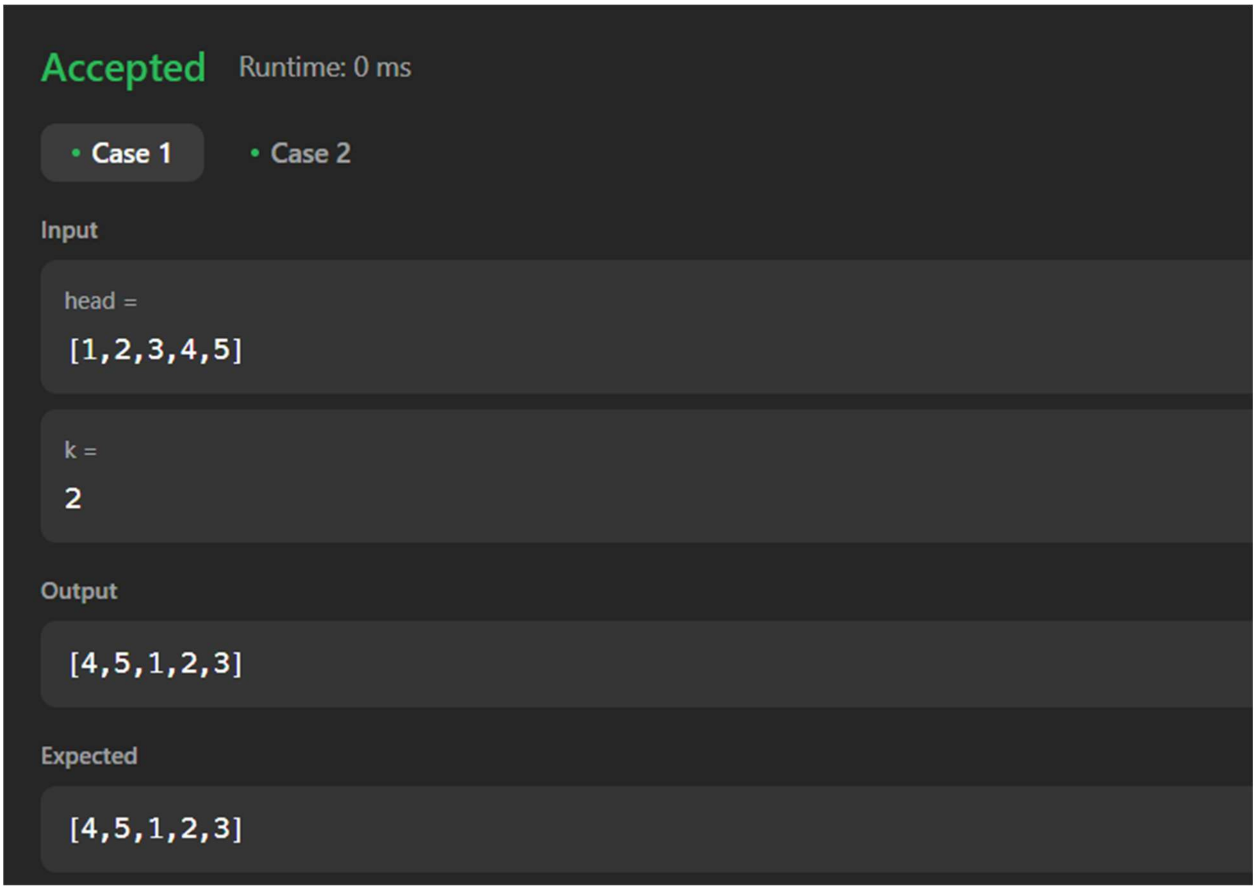
```
C:\Users\RAHUL\OneDrive\Documents\BST.exe

 the inorder traversal is :
5 10 15 20 30 40 50

 the preorder traversal is :
20 10 5 15 40 30 50

 the postorder traversal is :
5 15 10 30 50 40 20

Process returned 10 (0xA)   execution time : 0.295 s
Press any key to continue.
```

Program - Leetcode platform – Rotate List

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

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

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

```c
        struct ListNode *a=(struct ListNode *)malloc(sizeof(struct ListNode));
        a->val=p->next->val;
        a->next=head;
        head=a;
        p->next=NULL;
    }
    return head;

}
```

OUTPUT :



Lab program 9:

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

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

#define MAX_SIZE 100

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

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

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

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

// Add an item to the queue
void enqueue(struct Queue* queue, int value) {
    if (isFull(queue))
        printf("\nQueue is Full!!");
    else {
        if (queue->front == -1)
            queue->front = 0;
        queue->rear++;
        queue->items[queue->rear] = value;
```

```c
    }
}

// Remove an item from the queue
int dequeue(struct Queue* queue) {
    int item;
    if (isEmpty(queue)) {
        printf("Queue is empty");
        item = -1;
    } else {
        item = queue->items[queue->front];
        queue->front++;
        if (queue->front > queue->rear) {
            queue->front = queue->rear = -1;
        }
    }
    return item;
}

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

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

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

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

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

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

    printf("Breadth First Search Traversal: ");

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

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

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

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

    struct Graph* graph = createGraph(vertices);

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

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

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

    BFS(graph, startVertex);

    return 0;
}
```

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


...Program finished with exit code 0
Press ENTER to exit console.
```

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

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

#define MAX_SIZE 100

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

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

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

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

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

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

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

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

    DFS(graph, 0, visited);

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

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

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

    struct Graph* graph = createGraph(vertices);

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

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

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

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

    return 0;
}
```

```
Enter the number of vertices: 5
Enter the number of edges: 4
Enter edge 1 (source destination): 0 1
Enter edge 2 (source destination): 0 1
Enter edge 3 (source destination): 1 2
Enter edge 4 (source destination): 1 2
The graph is not connected.


...Program finished with exit code 0
Press ENTER to exit console.
```

Hackerrank program

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

struct node
{
    int id;
    int depth;
    struct node *left, *right;
};

void
inorder(struct node* tree)
{
    if(tree == NULL)
        return;
```

```
    inorder(tree->left);
    printf("%d ",tree->id);
    inorder((tree->right));

}


int
main(void)
{
    int no_of_nodes, i = 0;
    int l,r, max_depth,k;
    struct node* temp = NULL;
    scanf("%d",&no_of_nodes);
    struct node* tree = (struct node *) calloc(no_of_nodes , sizeof(struct
node));
    tree[0].depth = 1;
    while(i <  no_of_nodes )
    {
        tree[i].id = i+1;
        scanf("%d %d",&l,&r);
        if(l ==  -1)
            tree[i].left = NULL;
        else
             {
                 tree[i].left = &tree[l-1];
                 tree[i].left->depth = tree[i].depth + 1;
                 max_depth = tree[i].left->depth;
             }

         if(r ==  -1)
            tree[i].right = NULL;
        else
             {
                 tree[i].right = &tree[r-1];
                 tree[i].right->depth = tree[i].depth + 1;
                 max_depth = tree[i].right->depth+2;
             }

    i++;
    }

    scanf("%d", &i);
    while(i--)
    {
        scanf("%d",&l);
        r = l;
        while(l <= max_depth)
        {
```

```
            for(k = 0;k < no_of_nodes; ++k)
            {
                if(tree[k].depth == l)
                {
                    temp = tree[k].left;
                    tree[k].left = tree[k].right;
                    tree[k].right = temp;
                }
            }
            l = l + r;
        }
        inorder(tree);
        printf("\n");
    }



    return 0;
}
```

Lab program 10:

Given a File of N employee records with a set K of Keys(4-digit) which uniquely determine the records in file F.
Assume that file F is maintained in memory by a Hash Table (HT) of m memory locations with L as the set of memory addresses (2-digit) of locations in HT.
Let the keys in K and addresses in L are integers.
Design and develop a Program in C that uses Hash function H: K -> L as H(K)=K mod m (remainder method), and implement hashing technique to map a given key K to the address space L.
Resolve the collision (if any) using linear probing.

```
#include <stdio.h>

#define SIZE 10

int hashFunction(int key)
{
    return key%SIZE;
}
void insertValue(int hashTable[],int key)
{
    int i=0;
    int hkey = hashFunction(key);
    int index;

do
{
    index = (hkey + i)% SIZE;
    if(hashTable[index] == -1)
    {
        hashTable[index] = key;
        printf("inserted key %d at index %d\n",key,index);
        return;
    }
    i++;
}while(i<SIZE);
printf("unable to insert key %d Hash table is full\n",key);
}

int searchValue(int hashTable[],int key)
{
    int i = 0;
    int hkey = hashFunction(key);
    int index;
    do
```

```
    {
        index = (hkey + i)%SIZE;
        if(hashTable[index] == key)
        {
            printf("key %d found at index %d\n",key,index);
            return index;
        }
        i++;
    }while(i < SIZE);
    printf("key %d not found in hash table\n",key);
    return -1;
}

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

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


...Program finished with exit code 0
Press ENTER to exit console.
```