INSTITUTE OF TECHNOLOGY AND MANAGEMENT
SKILLS UNIVERSITY,
KHARGHAR, NAVI MUMBAI

DATA STRUCTURES & ALGORITHMS PROGRAMMING LAB

Prepared by:

Name of Student : Mahajan Piyush

Roll No: 35

Batch: 2023-27

Dept. of CSE

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

INSTITUTE OF TECHNOLOGY AND MANAGEMENT
SKILLS UNIVERSITY,
KHARGHAR, NAVI MUMBAI

CERTIFICATE

This is to certify that Mr. / Ms. ____Mahajan Piyush____ Roll No. ____35_____ Semester __2__ of B.Tech Computer Science & Engineering, ITM Skills University, Kharghar, Navi Mumbai , has completed the term work satisfactorily in subject _____DSA II_____ for the academic year 2023 - 2027 as prescribed in the curriculum.

Place: _Navi Mumbai_

Date: _6/4/24___

Subject I/C **HOD**

Exp. No	List of Experiment	Date of Submission	Sign
1	Implement Array and write a menu driven program to perform all the operation on array elements		
2	Implement Stack ADT using array.		
3	Convert an Infix expression to Postfix expression using stack ADT.		
4	Evaluate Postfix Expression using Stack ADT.		
5	Implement Linear Queue ADT using array.		
6	Implement Circular Queue ADT using array.		
7	Implement Singly Linked List ADT.		
8	Implement Circular Linked List ADT.		
9	Implement Stack ADT using Linked List		
10	Implement Linear Queue ADT using Linked List		
11	Implement Binary Search Tree ADT using Linked List.		
12	Implement Graph Traversal techniques: a) Depth First Search b) Breadth First Search		
13	Implement Binary Search algorithm to search an element in an array		
14	Implement Bubble sort algorithm to sort elements of an array in ascending and descending order		

Name of Student: Mahajan Piyush

Roll Number: 35

Experiment No: 1

Title: Implement Array and write a menu driven program to perform all the operation on array elements

Theory: Array is a collection of elements of similar data types and has a fixed size. We can access an element of the array through it's index. Indexing starts from 0 till n-1(where n=size of array). An element can be inserted in the array by shifting all the elements of the array to the right and making space for the element. Similarly, to delete an element, we need to shift all the elements from the right of the deleted element to the left side in order to overwrite the deleted element. In order to search for an element, we need to traverse through the array and print the appropriate message if the element is found or not.

Code:

```
#include <iostream>
#include <algorithm>
using namespace std;

void displayArray(int &a, int arr[]){
    int count = 0;
    cout << "Array: ";
    for (int i = 0; i < a; i++)
    {
        if (arr[i] != -1)
        {
            cout << arr[i] << " ";
            count++;
        }
        else
        {
            break;
        }
    }
    cout << endl
         << "Number of elements: " << count << endl;
}
```

```
void insertAtBegin(int &a, int arr[])
   if (a >= 45)
    {
        cout << "Array is full. Cannot insert at the beginning." <<
endl;
        return;
    }
    int b, count = 0;
    cout << "Enter beginning detail: ";
    cin >> b;
    for (int i = a - 1; i >= 0; i--)
    {
        arr[i + 1] = arr[i];
    }
    arr[0] = b;
    a++;
    for (int i = 0; i < a; i++)
    {
        if (arr[i] == -1)
        {
            break;
        }
        else
        {
            count++;
        }
    }
    for (int i = 0; i < count; i++)
    {
        cout << arr[i] << " ";
    }
}
```

```
void insertAtEnd(int &a, int arr[])
{
    if (a >= 45)
    {
        cout << "Array is full. Cannot insert at the end." << endl;
        return;
    }
    int b, count = 0;
    cout << "Enter end detail: ";
    cin >> b;
    for (int i = 0; i < a; i++)
    {
        if (arr[i] == -1)
        {
            break;
```

```
        }
        else
        {
            count++;
        }
    }
    arr[count] = b;
    count++;
    cout << "Size of array: " << count << endl;
    a = count;
    for (int i = 0; i < count; i++)
    {
        cout << arr[i] << " ";
    }
}

void insertAtIndexLocation(int &c, int arr[]){
    int a, b;
    cout << "Enter updated detail: ";
    cin >> b;
    cout << "Enter index location: ";
    cin >> a;
    int i = c - 1;
    while (i >= a)
    {
        arr[i + 1] = arr[i];
        i--;
    }
    c++;
    arr[a] = b;
    for (int i = 0; i < c; i++)
    {
        cout << arr[i] << " ";
    }
}

void insertBeforeElement(int &c, int arr[])   int b, a, pos;
    cout << "Enter updated detail: ";
    cin >> b;
    cout << "Enter element to insert before: ";
    cin >> a;
    for (int i = 0; i < c; i++)
    {
        if (arr[i] == a)
        {
            pos = i;
        }
    }
    for (int i = c - 1; i >= pos; i--)
```

```
    {
        arr[i + 1] = arr[i];
    }
    c++;
    arr[pos] = b;
    for (int i = 0; i < c; i++)
    {
        cout << arr[i] << " ";
    }
}

void insertAfterElement(int &c, int arr[]){
    int b, a, pos;
    cout << "Enter updated detail: ";
    cin >> b;
    cout << "Enter element to insert after: ";
    cin >> a;
    for (int i = 0; i < c; i++)
    {
        if (arr[i] == a)
        {
            pos = i;
        }
    }
    for (int i = c - 1; i > pos; i--)
    {
        arr[i + 1] = arr[i];
    }
    c++;
    arr[pos + 1] = b;
    for (int i = 0; i < c; i++)
    {
        cout << arr[i] << " ";
    }
}

void deleteFromBegin(int &c, int arr[])
    for (int i = 0; i < c; i++)
    {
        arr[i] = arr[i + 1];
    }
    c--;
    for (int i = 0; i < c; i++)
    {
        cout << arr[i] << " ";
    }
}

void deleteFromEnd(int &c, int arr[]){
```

```
    if (c <= 0)
    {
        cout << "Array is empty. Cannot delete from the end." <<
endl;
        return;
    }
    arr[c - 1] = arr[c];
    c--;
    for (int i = 0; i < c; i++)
    {
        cout << arr[i] << " ";
    }
}

void deleteBeforeElement(int &c, int arr[])    int b, pos;
    cout << "Enter element to delete after it: ";
    cin >> b;
    for (int i = 0; i < c; i++)
    {
        if (arr[i] == b)
        {
            pos = i;
        }
    }
    for (int i = pos - 1; i < c; i++)
    {
        arr[i] = arr[i + 1];
    }
    c--;
    for (int i = 0; i < c; i++)
    {
        cout << arr[i] << " ";
    }
}

void deleteAfterElement(int &c, int arr[]){
    int b, pos;
    cout << "Enter element to delete after it: ";
    cin >> b;
    for (int i = 0; i < c; i++)
    {
        if (arr[i] == b)
        {
            pos = i;
        }
    }
    for (int i = pos + 1; i < c; i++)
    {
        arr[i] = arr[i + 1];
```

```
    }
    c--;
    for (int i = 0; i < c; i++)
    {
        cout << arr[i] << " ";
    }
}

void deleteFromArray(int &a, int arr[]){
    int b, pos;
    cout << "Enter element to delete: ";
    cin >> b;
    for (int i = 0; i < a; i++)
    {
        if (arr[i] == b)
        {
            pos = i;
        }
    }
    for (int i = pos; i < a; i++)
    {
        arr[i] = arr[i + 1];
    }
    a--;
    for (int i = 0; i < a; i++)
    {
        cout << arr[i] << " ";
    }
}

void searchElement(int &a, int arr[]){
    int b, count = 0;
    cout << "Enter element to search: ";
    cin >> b;
    for (int i = 0; i < a; i++)
    {
        if (arr[i] == b)
        {
            cout << "Element found at index " << i << endl;
            count++;
        }
    }
    if (count == 0)
    {
        cout << "Element not found" << endl;
    }
}

int main()
```

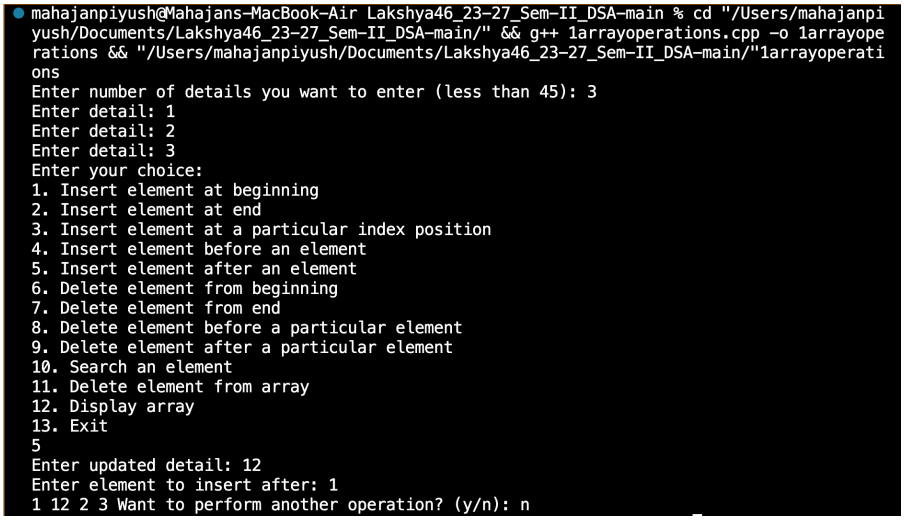
```
{
    int arr[46], n, choice;
    fill_n(arr, 46, -1);
    cout << "Enter number of details you want to enter (less than
45): ";
    cin >> n;
    while (n >= 45 || n <= 0)
    {
        cout << "Invalid size. Enter a valid size" << endl;
        cin >> n;
    }
    for (int i = 0; i < n; i++)
    {
        cout << "Enter detail: ";
        cin >> arr[i];
    }
    char ans = 'y';
    while (ans == 'y')
    {
        cout << "Enter your choice:\n1. Insert element at
beginning\n2. Insert element at end\n3. Insert element at a
particular index position\n4. Insert element before an element\n5.
Insert element after an element\n6. Delete element from
beginning\n7. Delete element from end\n8. Delete element before a
particular element\n9. Delete element after a particular
element\n10. Search an element\n11. Delete element from array\n12.
Display array\n13. Exit\n";
        cin >> choice;

        switch (choice)
        {
        case 1:
            insertAtBegin(n, arr);
            break;
        case 2:
            insertAtEnd(n, arr);
            break;
        case 3:
            insertAtIndexLocation(n, arr);
            break;
        case 4:
            insertBeforeElement(n, arr);
            break;
        case 5:
            insertAfterElement(n, arr);
            break;
        case 6:
            deleteFromBegin(n, arr);
            break;
```

```
        case 7:
            deleteFromEnd(n, arr);
            break;
        case 8:
            deleteBeforeElement(n, arr);
            break;
        case 9:
            deleteAfterElement(n, arr);
            break;
        case 10:
            searchElement(n, arr);
            break;
        case 11:
            deleteFromArray(n, arr);
            break;
        case 12:
            displayArray(n, arr);
            break;
        case 13:
            cout << "Exiting..." << endl;
            return 0;
        default:
            cout << "Invalid choice\n";
        }
        cout << "Want to perform another operation? (y/n): ";
        cin >> ans;
    }
    return 0;
}
```

Output: (screenshot)

```
mahajanpiyush@Mahajans-MacBook-Air Lakshya46_23-27_Sem-II_DSA-main % cd "/Users/mahajanpi
yush/Documents/Lakshya46_23-27_Sem-II_DSA-main/" && g++ 1arrayoperations.cpp -o 1arrayope
rations && "/Users/mahajanpiyush/Documents/Lakshya46_23-27_Sem-II_DSA-main/"1arrayoperati
ons
Enter number of details you want to enter (less than 45): 3
Enter detail: 1
Enter detail: 2
Enter detail: 3
Enter your choice:
1. Insert element at beginning
2. Insert element at end
3. Insert element at a particular index position
4. Insert element before an element
5. Insert element after an element
6. Delete element from beginning
7. Delete element from end
8. Delete element before a particular element
9. Delete element after a particular element
10. Search an element
11. Delete element from array
12. Display array
13. Exit
5
Enter updated detail: 12
Enter element to insert after: 1
1 12 2 3 Want to perform another operation? (y/n): n
```

Test Case: Any two (screenshot)



Conclusion: Therefore, using switch cases, we can perform multiple operations like insertion, deletion, and searching for an element in an array through traversal using index.

Name of Student: Mahajan Piyush

Roll Number: 35

Experiment No: 2

Title: Implement Stack ADT using Array.

Theory: Array is a collection of elements of similar data types and has a fixed size. We can access an element of the array through it's index. Indexing starts from 0 till n-1(where n=size of array).

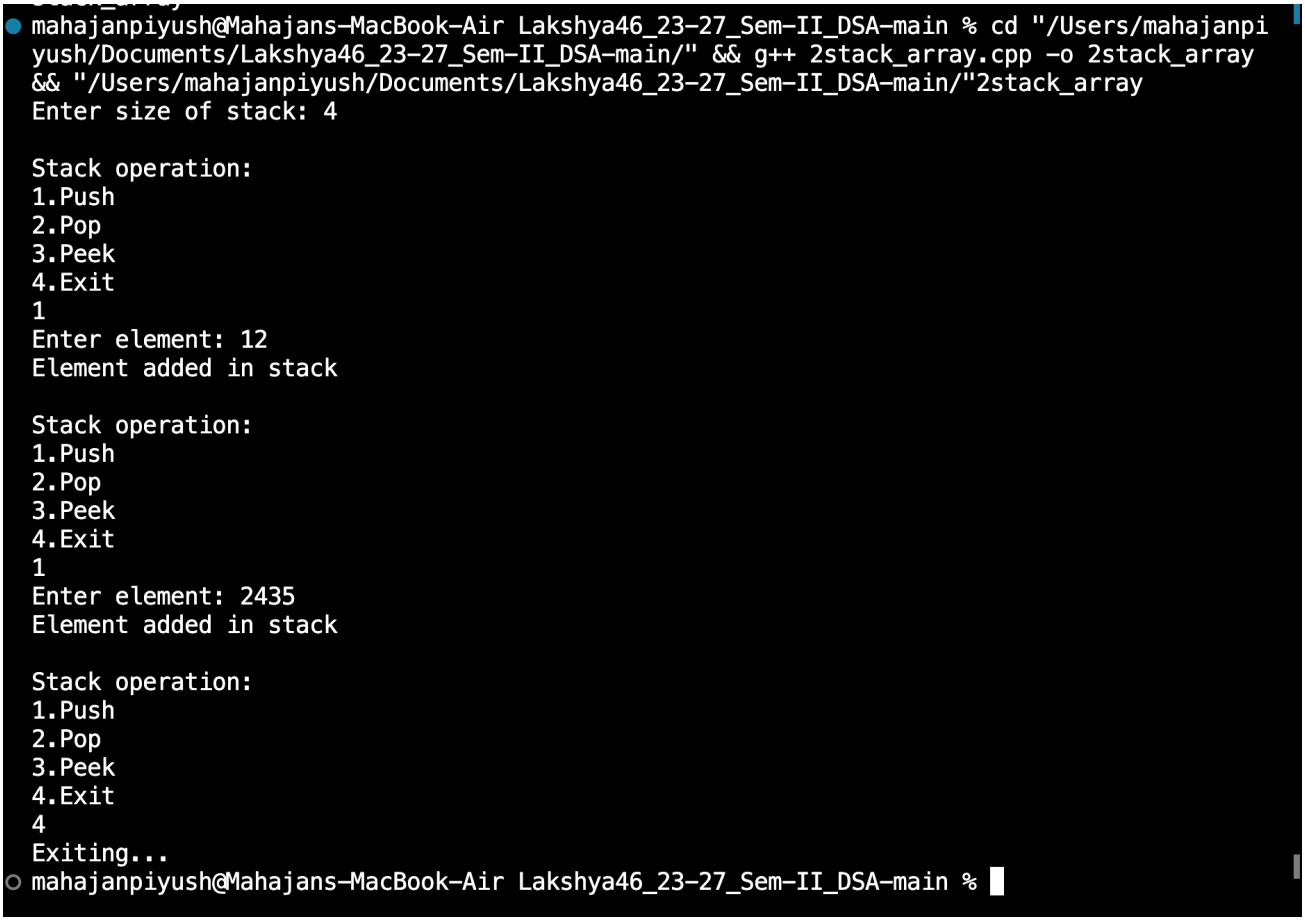
Stack is an Abstract Data Type which can be implemented using Linked List or Array. It consists of a variable named Top which points to the topmost element of the stack. Stack follows LIFO principle(Last In, First Out) which means that the element which is inserted last will be deleted first. There are three operations in Stack: Push- insertion from top, Pop- deletion from top, Peek- returning the topmost element from the stack.

Code:

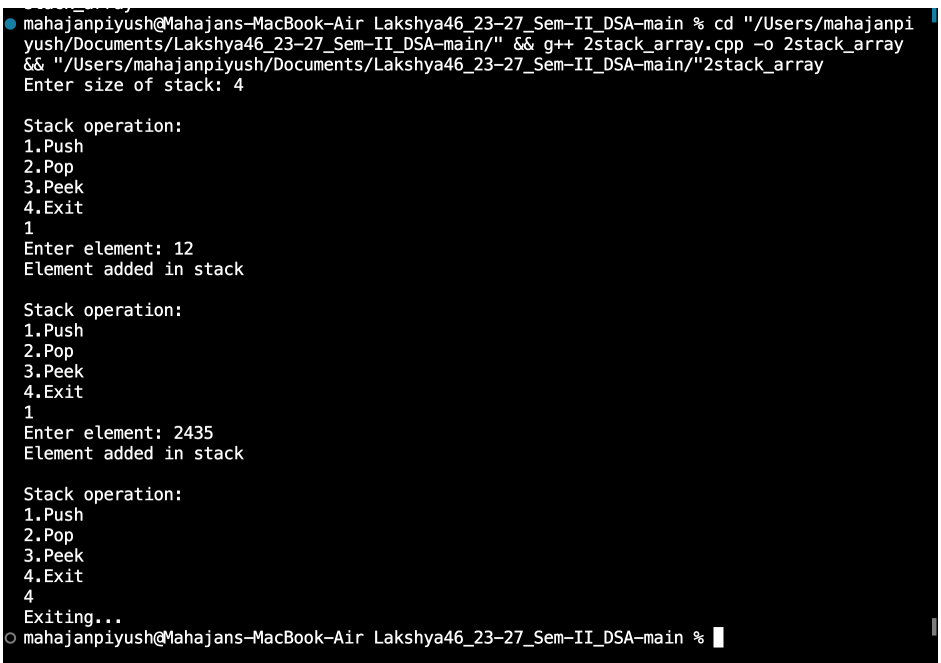
```
#include <iostream>
using namespace std;

int main()
{
    int top = -1, element, op,n;
    cout<<"Enter size of stack: ";
    cin>>n;
    int stack[n];
    while (true)
    {
        cout << "\nStack operation:
\n1.Push\n2.Pop\n3.Peek\n4.Exit\n";
        cin >> op;
        switch (op)
        {
```

```
        case 1:
            if (top == n - 1)
            {
                cout << "Stack is full. Cannot add more elements.
\n";
                break;
            }
            else
            {
                cout << "Enter element: ";
                cin >> element;
                top++;
                stack[top] = element;
                cout << "Element added in stack\n";
            }
            break;
        case 2:
            if (top == -1)
            {
                cout << "Stack is empty.\n";
                break;
            }
            else
            {
                cout << stack[top] << " is popped from stack\n";
                top--;
            }
            break;
        case 3:
            if (top == -1)
            {
                cout << "Stack is empty.\n";
                break;
            }
            else
            {
                cout << "Top element: " << stack[top] << "\n";
            }
            break;
        case 4:
            cout << "Exiting...\n";
            return 0;
        default:
            cout << "Wrong choice\n";
            break;
        }
    }
    return 0;
}
```

Output: (screenshot)



Test Case: Any two (screenshot)



Conclusion: Therefore, using switch cases, we can perform multiple operations like push, pop, and peek in a stack using array.

Name of Student: Mahajan Piyush

Roll Number: 35

Experiment No: 3

Title: Convert an Infix expression to Postfix expression using Stack ADT.

Theory: Stack is an Abstract Data Type which can be implemented using Linked List or Array. It consists of a variable named Top which points to the topmost element of the stack. Stack follows LIFO principle(Last In, First Out) which means that the element which is inserted last will be deleted first. There are three operations in Stack: Push- insertion from top, Pop- deletion from top, Peek- returning the topmost element from the stack. Using stack, we can convert an infix expression to postfix expression by pushing the operators and brackets in the stack and the operands to the expression and popping the elements to the expression through operator precedence after encountering a closing bracket.

Code:

```
#include <iostream>
using namespace std;

int precedence(char op)
{
```

```
    if (op == '+' || op == '-')
    {
        return 1;
    }
    else if (op == '*' || op == '/' || op == '%')
    {
        return 2;
    }
    else
    {
        return 0;
    }
}

int main()
{
    string exp, result = "";
    char stack[100];
    int top = -1;
    cout << "Enter infix expression: ";
    getline(cin, exp);
    int n = exp.length();
    char express[n + 2];
    express[0] = '(';
    for (int i = 0; i < n; i++)
    {
        express[i + 1] = exp[i];
    }
    express[n + 1] = ')';
    for (int i = 0; i < n + 2; i++)
    {
        if (express[i] == '(')
        {
            top++;
            stack[top] = express[i];
        }
        else if (express[i] == ')')
        {
            while (stack[top] != '(' && top > -1)
            {
                result += stack[top];
                top--;
            }
            top--;
        }
        else if ((express[i] >= 'a' && express[i] <= 'z') ||
(express[i] >= 'A' && express[i] <= 'Z') || (express[i] >= '0' &&
express[i] <= '9'))
        {
```

```
            result += express[i];
        }
        else
        {
            while (top > -1 && precedence(stack[top]) >=
precedence(express[i]))
            {
                result += stack[top];
                top--;
            }
            top++;
            stack[top] = express[i];
        }
    }
    while (top > -1)
    {
        result += stack[top];
        top--;
    }
    cout << "Postflix Result: " << result << endl;
    return 0;
}
```

Output: (screenshot)

```
Exiting...
mahajanpiyush@Mahajans-MacBook-Air Lakshya46_23-27_Sem-II_DSA-main % cd "/Users/mahajanpi
yush/Documents/Lakshya46_23-27_Sem-II_DSA-main/" && g++ 3infix_postfix_conversion_stack.c
pp -o 3infix_postfix_conversion_stack && "/Users/mahajanpiyush/Documents/Lakshya46_23-27_
Sem-II_DSA-main/"3infix_postfix_conversion_stack
Enter infix expression: ()a+b
```

Test Case: Any two (screenshot)

```
Exiting...
mahajanpiyush@Mahajans-MacBook-Air Lakshya46_23-27_Sem-II_DSA-main % cd "/Users/mahajanpi
yush/Documents/Lakshya46_23-27_Sem-II_DSA-main/" && g++ 3infix_postfix_conversion_stack.c
pp -o 3infix_postfix_conversion_stack && "/Users/mahajanpiyush/Documents/Lakshya46_23-27_
Sem-II_DSA-main/"3infix_postfix_conversion_stack
Enter infix expression: ()a+b
```

```
mahajanpiyush@Mahajans-MacBook-Air Lakshya46_23-27_Sem-II_DSA-main % cd "/Users/mahajanpi
yush/Documents/Lakshya46_23-27_Sem-II_DSA-main/" && g++ 3infix_postfix_conversion_stack.c
pp -o 3infix_postfix_conversion_stack && "/Users/mahajanpiyush/Documents/Lakshya46_23-27_
Sem-II_DSA-main/"3infix_postfix_conversion_stack
Enter infix expression: ()a+b()
Postflix Result: ab+
```

Conclusion: Therefore, using stack ADT, we can convert infix expression to postfix expression by operations like Push and Pop.

Name of Student: Mahajan Piyush

Roll Number: 35

Experiment No: 4

Title: Evaluate Postfix expression using Stack ADT.

Theory: Stack is an Abstract Data Type which can be implemented using Linked List or Array. It consists of a variable named Top which points to the topmost element of the stack. Stack follows LIFO principle(Last In, First Out) which means that the element which is inserted last will be deleted first. There are three operations in Stack: Push- insertion from top, Pop- deletion from top, Peek- returning the topmost element from the stack. Using stack, we can evaluate a postfix expression by pushing the operands in the stack and popping them and evaluating them when an operator is encountered and popping the result back in the stack and printing the topmost element after the whole expression is evaluated.

Code:

```cpp
#include <iostream>
#include <string>
using namespace std;
int main()
{
    string expression;
    char stack[100];
    int stack1[100];
    int top = -1, a, b, result = 0;
    cout << "Enter postfix expression: ";
    getline(cin, expression);
    for (int i = 0; i < expression.length(); i++)
    {
        stack[i] = expression[i];
    }
    stack[expression.length()] = ')';
    int i = 0;
    while (stack[i] != ')')
    {
        if (stack[i] == '*' || stack[i] == '/' || stack[i] == '%'
|| stack[i] == '-' || stack[i] == '+')
        {
            a = stack1[top];
            top--;
            b = stack1[top];
            top--;
            if (stack[i] == '*')
            {
                result = b * a;
            }
            else if (stack[i] == '/')
            {
                if (a != 0)
                {
                    result = b / a;
                }
                else
                {
                    cout << "Error: Division by zero." << endl;
                    return 1;
                }
            }
            else if (stack[i] == '%')
            {
                result = b % a;
            }
            else if (stack[i] == '+')
            {
                result = b + a;
```

```
            }
            else
            {
                result = b - a;
            }
            top++;
            stack1[top] = result;
        }
        else
        {
            top++;
            stack1[top] = int(stack[i]) - 48;
        }
        i++;
    }
    cout << "Result: " << stack1[top] << endl;
    return 0;
}
```

Output: (screenshot)

```
mahajanpiyush@Mahajans-MacBook-Air Lakshya46_23-27_Sem-II_DSA-main % cd "/Users/mahajanpi
yush/Documents/Lakshya46_23-27_Sem-II_DSA-main/" && g++ 4eval_postfix_stack.cpp -o 4eval_
postfix_stack && "/Users/mahajanpiyush/Documents/Lakshya46_23-27_Sem-II_DSA-main/"4eval_p
ostfix_stack
Enter postfix expression: a+b(a+b+c)
Result: 51
```

Test Case: Any two (screenshot)

```
mahajanpiyush@Mahajans-MacBook-Air Lakshya46_23-27_Sem-II_DSA-main % cd "/Users/mahajanpi
yush/Documents/Lakshya46_23-27_Sem-II_DSA-main/" && g++ 4eval_postfix_stack.cpp -o 4eval_
postfix_stack && "/Users/mahajanpiyush/Documents/Lakshya46_23-27_Sem-II_DSA-main/"4eval_p
ostfix_stack
Enter postfix expression: 1+2-3
Result: 3
```

```
mahajanpiyush@Mahajans-MacBook-Air Lakshya46_23-27_Sem-II_DSA-main % cd "/Users/mahajanpi
yush/Documents/Lakshya46_23-27_Sem-II_DSA-main/" && g++ 4eval_postfix_stack.cpp -o 4eval_
postfix_stack && "/Users/mahajanpiyush/Documents/Lakshya46_23-27_Sem-II_DSA-main/"4eval_p
ostfix_stack
Enter postfix expression: a+b(a+b+c)
Result: 51
```

Conclusion: Therefore, using stack ADT, we can evaluate a postfix expression by operations like Push and Pop.

Name of Student: Mahajan Piyush

Roll Number: 35

Experiment No: 5

Title: Implement Linear Queue ADT using array.

Theory: Array is a collection of elements of similar data types and has a fixed size. We can access an element of the array through it's index. Indexing starts from 0 till n-1(where n=size of array).

Queue is an Abstract Data Type which can be implemented using Linked List or Array. It consists of two variables named Front and Rear which point to the first and last elements of the stack, respectively. Queue follows FIFO principle(First In, First Out) which means that the element which is inserted first will be deleted first. There are three operations in Stack: Enqueue- insertion from rear, Dequeue- deletion from front, Peek- returning the frontmost element from the queue.

Code:

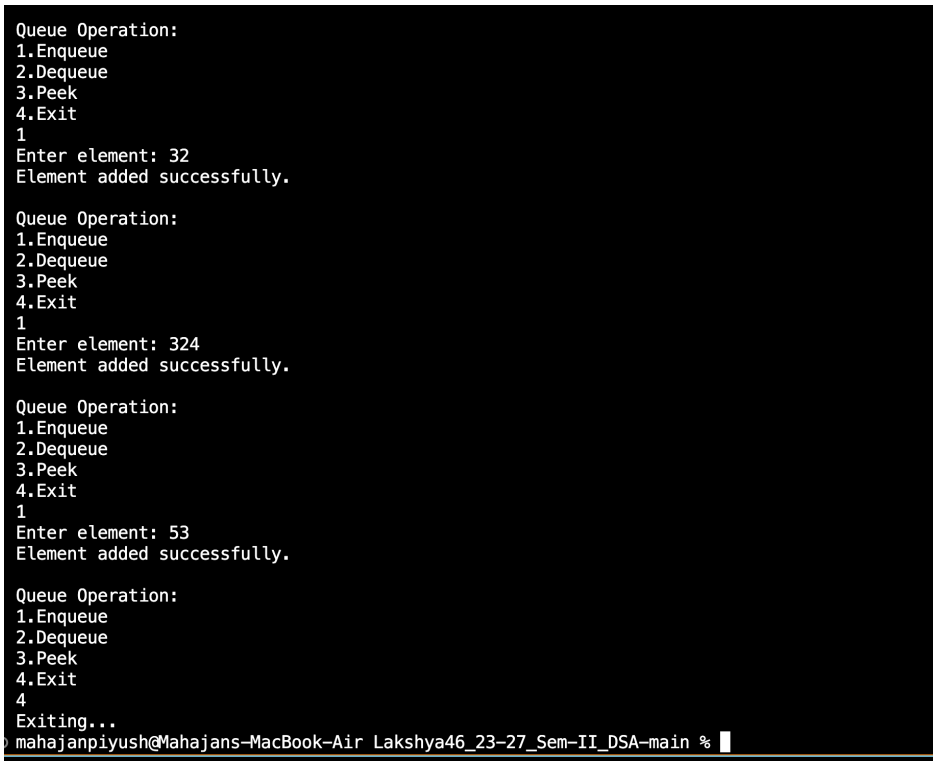
```
#include <iostream>
using namespace std;
int main()
{
    int front = -1, rear = -1, choice, element, n;
    cout << "Enter size of queue: ";
    cin >> n;
    int queue[n];
    while (true)
    {
        cout << "\nQueue Operation:
\n1.Enqueue\n2.Dequeue\n3.Peek\n4.Exit\n";
        cin >> choice;
        switch (choice)
        {
```

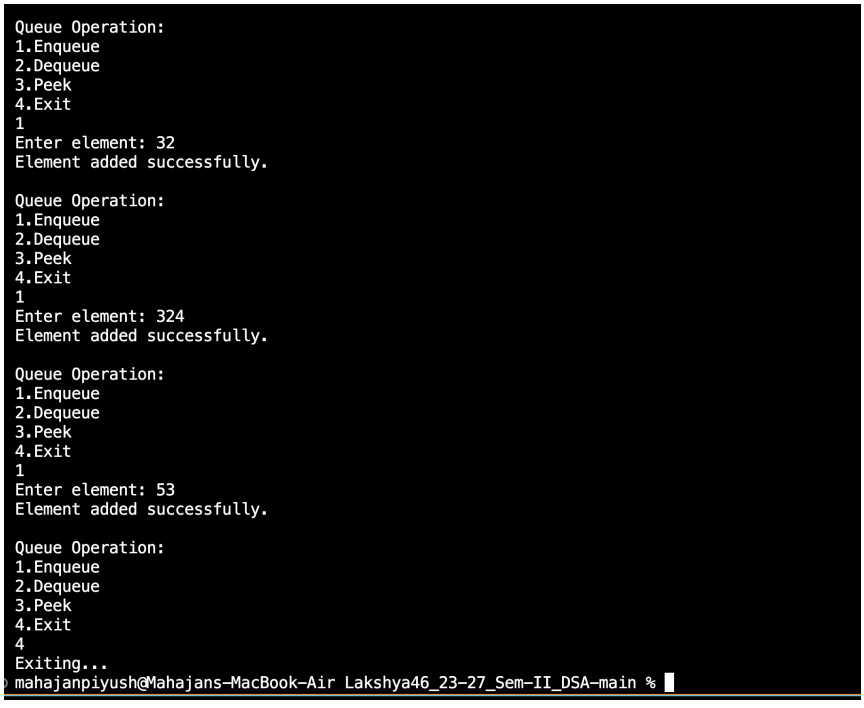
```
        case 1:
            if (rear == n - 1)
            {
                cout << "Queue is full. Cannot add more elements.
\n";
            }
            else
            {
                cout << "Enter element: ";
                cin >> element;
                if (front == -1 && rear == -1)
                {
                    front = 0, rear = 0;
                }
                else
                {
                    rear++;
                }
                queue[rear] = element;
                cout << "Element added successfully.\n";
            }
            break;
        case 2:
            if (front == -1 || front > rear)
            {
                cout << "Queue is empty. Cannot delete more
elements.\n";
            }
            else
            {
                element = queue[front];
                front++;
                cout << "Element " << element << " removed
successfully.\n";
            }
            break;
        case 3:
            if (front == -1)
            {
                cout << "Queue is empty.\n";
            }
            else
            {
                cout << "Front element: " << queue[front] << endl;
            }
            break;
        case 4:
            cout << "Exiting...\n";
            return 0;
```

```
        default:
            cout << "Wrong choice.\n";
            break;
        }
    }
    return 0;
}
```

Output: (screenshot)

Test Case: Any two (screenshot)





Conclusion: Therefore, using array, we can implement a linear queue and perform operations like Enqueue, Dequeue and Peek.

Name of Student: Mahajan Piyush

Roll Number: 35

Experiment No: 6

Title: Implement Circular Queue ADT using array.

Theory: Array is a collection of elements of similar data types and has a fixed size. We can access an element of the array through it's index. Indexing starts from 0 till n-1(where n=size of array).

Queue is an Abstract Data Type which can be implemented using Linked List or Array. It consists of two variables named Front and Rear which point to the first and last elements of the stack, respectively. Queue follows FIFO principle(First In, First Out) which means that the element which is inserted first will be deleted first. There are three operations in Stack: Enqueue- insertion from rear, Dequeue- deletion from front, Peek- returning the frontmost element from the queue. As size of array is fixed, in order to overcome the challenges, we can move the rear pointer to the start of the array if rear=n-1 and front is not at first index, so we can continue to insert elements.

Code:

```
#include <iostream>
using namespace std;
int main()
{
    int element, front = -1, rear = -1, n, choice;
    cout << "Enter size of queue: ";
    cin >> n;
    int queue[n];
    while (true)
    {
        cout << "\nCircular queue operations:
\n1.Enqueue\n2.Dequeue\n3.Peek\n4.Exit\n";
        cin >> choice;
        switch (choice)
        {
        case 1:
            if ((front == 0 && rear == n - 1) || rear == front - 1)
            {
                cout << "Queue is full. Cannot add more elements.
\n";
            }
            else
            {
                if (rear == n - 1 && front != 0)
                {
                    rear = (rear + 1) % n;
                }
                else if (front == -1 && rear == -1)
                {
                    front++;
                    rear++;
                }
                else
                {
                    rear++;
                }
                cout << "Enter element: ";
                cin >> element;
                queue[rear] = element;
                cout << "Element added successfully.\n";
            }
            break;
        case 2:
            if (front == -1)
            {
                cout << "Queue is empty. Cannot delete elements.
\n";
            }
            else
```

```
            {
                element = queue[front];
                if (front == rear)
                {
                    front = -1;
                    rear = -1;
                }
                else if (front == n - 1)
                {
                    front = (front + 1) % n;
                }
                else
                {
                    front++;
                }
                cout << "Element " << element << " is popped from
the queue.\n";
            }
            break;
        case 3:
            if (front == -1)
            {
                cout << "Queue is empty.\n";
            }
            else
            {
                cout << "Top element: " << queue[front] << endl;
            }
            break;
        case 4:
            cout << "Exiting...\n";
            return 0;
        default:
            cout << "Wrong input\n";
            break;
        }
    }
    return 0;
}
```

Output: (screenshot)

```
Circular queue operations:
1.Enqueue
2.Dequeue
3.Peek
4.Exit
1
Enter element: 3453
Element added successfully.

Circular queue operations:
1.Enqueue
2.Dequeue
3.Peek
4.Exit
1
Enter element: 53535
Element added successfully.

Circular queue operations:
1.Enqueue
2.Dequeue
3.Peek
4.Exit
4
Exiting...
mahajanpiyush@Mahajans-MacBook-Air Lakshya46_23-27_Sem-II_DSA-main %
```

Exiting...

Test Case: Any two (screenshot)

```
Circular queue operations:
1.Enqueue
2.Dequeue
3.Peek
4.Exit
1
Enter element: 3453
Element added successfully.

Circular queue operations:
1.Enqueue
2.Dequeue
3.Peek
4.Exit
1
Enter element: 53535
Element added successfully.

Circular queue operations:
1.Enqueue
2.Dequeue
3.Peek
4.Exit
4
Exiting...
mahajanpiyush@Mahajans-MacBook-Air Lakshya46_23-27_Sem-II_DSA-main %
```

Conclusion: Therefore, using array, we can implement a circular queue and perform operations like Enqueue, Dequeue and Peek without being constrained by the limitation of the fixed size of the array.

Name of Student: Mahajan Piyush

Roll Number: 35

Experiment No: 7

Title: Implement Singly Linked List ADT.

Theory: Linked List is a data type which consists of nodes which contain data and a next pointer which points to the next node in the list. It stores the address of the next node. There is a start pointer in stack memory which points to the first node in the heap memory. It utilises dynamic memory and allocates heap memory to the nodes in the list. The last node's next pointer has NULL value to indicate it's the last node in the list.

Code:

```
#include <iostream>
using namespace std;

class Node
{
public:
    int data;
    Node *next;
    Node()
    {
        cout << "Enter data: ";
        cin >> data;
        next = NULL;
    }
};

Node *createList(int n)
    Node *start = NULL;
    Node *ptr = NULL;
    for (int i = 0; i < n; i++)
    {
        Node *new_node = new Node();
        if (start == NULL)
        {
            start = new_node;
            ptr = start;
```

```
        }
        else
        {
            ptr->next = new_node;
            ptr = new_node;
        }
    }
    return start;
}

void insertAtStart(Node *&a)
{
    Node *new_node = new Node();
    if (new_node == NULL)
    {
        cout << "Overflow";
        return;
    }
    else
    {
        new_node->next = a;
        a = new_node;
    }
}

void insertAtEnd(Node *&a){
    Node *new_node = new Node();
    Node *ptr = a;
    while (ptr->next != NULL)
    {
        ptr = ptr->next;
    }
    ptr->next = new_node;
    new_node->next = NULL;
}

void insertAfterElement(Node *&a){
    int n;
    cout << "Enter element after which to add a node: ";
    cin >> n;
    Node *new_node = new Node();
    Node *ptr = a;
    Node *preptr = ptr;
    if (new_node == NULL)
    {
        cout << "Overflow" << endl;
        return;
    }
    else
```

```
    {
        while (preptr->data != n)
        {
            preptr = ptr;
            ptr = ptr->next;
        }
        if (ptr == NULL)
        {
            cout << "No element found" << endl;
        }
        else if (ptr == a)
        {
            new_node->next = ptr->next;
            a->next = new_node;
        }
        else
        {
            new_node->next = ptr;
            preptr->next = new_node;
        }
    }
}

void insertBeforeElement(Node *&a){
    Node *ptr = a;
    Node *preptr = ptr;
    int b;
    cout << "Enter element to add a node before it: ";
    cin >> b;
    Node *new_node = new Node();
    if (new_node == NULL)
    {
        cout << "Overflow" << endl;
        return;
    }
    else
    {
        while (ptr->data != b)
        {
            preptr = ptr;
            ptr = ptr->next;
        }
        if (ptr == NULL)
        {
            cout << "No element found" << endl;
        }
        else if (ptr == a)
        {
            new_node->next = ptr;
```

```
            a = new_node;
        }
        else
        {
            preptr->next = new_node;
            new_node->next = ptr;
        }
    }
}

void deleteFirstNode(Node *&a){
    Node *ptr = a;
    if (a == NULL)
    {
        cout << "Underflow" << endl;
        return;
    }
    else
    {
        a = ptr->next;
        delete ptr;
    }
}

void deleteLastNode(Node *&a){
    Node *ptr = a;
    Node *preptr = ptr;
    if (a == NULL)
    {
        cout << "Underflow" << endl;
        return;
    }
    else
    {
        while (ptr->next != NULL)
        {
            preptr = ptr;
            ptr = ptr->next;
        }
        if (preptr == ptr)
        {
            delete ptr;
            a = NULL;
        }
        else
        {
            preptr->next = NULL;
            delete ptr;
        }
```

```
    }
}

void deleteBeforeElement(Node *&a){
    Node *ptr = a;
    Node *preptr = NULL;
    Node *temp = a;
    int b;
    cout << "Enter element to delete a node before it: ";
    cin >> b;
    if (a == NULL)
    {
        cout << "Underflow" << endl;
        return;
    }
    else
    {
        while (ptr->data != b)
        {
            temp = preptr;
            preptr = ptr;
            ptr = ptr->next;
            if (ptr == NULL)
            {
                cout << "Element not found" << endl;
                return;
            }
        }
        if (preptr == NULL) /
        {
            cout << "Element not found" << endl;
        }
        else
        {
            if (preptr == a)
            {
                a = ptr;
            }
            else
            {
                temp->next = ptr;
            }
            delete preptr;
        }
    }
}

void deleteAfterElement(Node *&a)
{
```

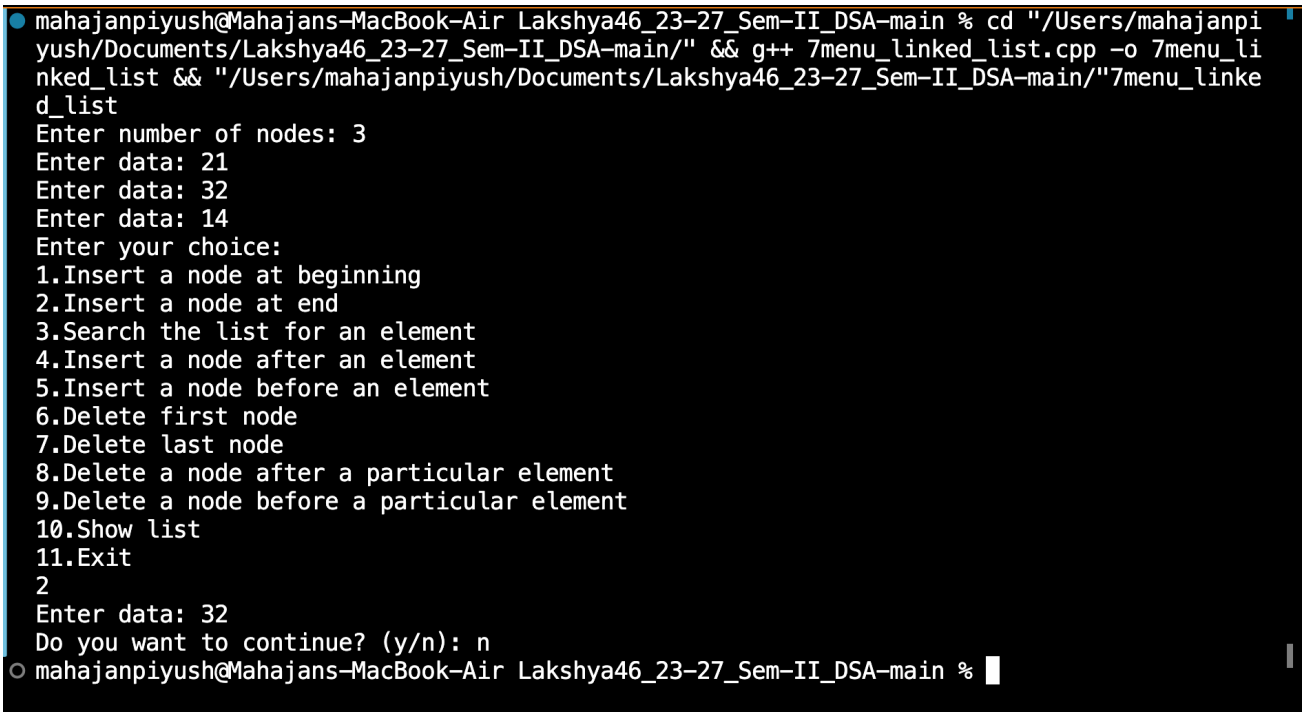
```
    Node *ptr = a;
    Node *preptr = a;
    Node *temp = NULL;
    int b;
    cout << "Enter element to delete node after: ";
    cin >> b;
    ptr = a;
    if (a == NULL)
    {
        cout << "Underflow" << endl;
        return;
    }
    else
    {
        while (ptr->data != b)
        {
            preptr = ptr;
            ptr = ptr->next;
            if (ptr == NULL)
            {
                cout << "Element not found" << endl;
                return;
            }
        }
        if (ptr == NULL)
        {
            cout << "Element not found" << endl;
        }
        else
        {
            if (ptr->next == NULL)
            {
                cout << "No element to delete" << endl;
            }
            else
            {
                preptr = ptr;
                temp = ptr->next;
                preptr->next = temp->next;
                delete temp;
            }
        }
    }
}

void searchElement(Node *a, int b)
{
    Node *ptr = a;
    Node *pos = NULL;
```

```
    while (ptr != NULL)
    {
        if (ptr->data == b)
        {
            pos = ptr;
            break;
        }
        else
        {
            ptr = ptr->next;
        }
    }
    if (pos == NULL)
    {
        cout << "Element not found" << endl;
    }
    else
    {
        cout << "Element " << pos->data << " found at " << pos <<
endl;
    }
}

void showList(Node *a)
{
    int count = 0;
    Node *ptr = a;
    while (ptr != NULL)
    {
        cout << ptr->data << " ";
        ptr = ptr->next;
        count++;
    }
    cout << endl
         << "Number of nodes: " << count << endl;
}

void deleteList(Node *&a)
{
    Node *ptr = a;
    Node *temp = NULL;
    while (ptr != NULL)
    {
        temp = ptr;
        ptr = ptr->next;
        delete temp;
    }
    a = NULL;
}
```

```
int main()
{
    int n;
    cout << "Enter number of nodes: ";
    cin >> n;
    Node *start = createList(n);
    int choice;
    char ans = 'y';
    do
    {
        cout << "Enter your choice: \n1.Insert a node at
beginning\n2.Insert a node at end\n3.Search the list for an
element\n4.Insert a node after an element\n5.Insert a node before
an element\n6.Delete first node\n7.Delete last node\n8.Delete a
node after a particular element\n9.Delete a node before a
particular element\n10.Show list\n11.Exit\n";
        cin >> choice;
        switch (choice)
        {
        case 1:
            insertAtStart(start);
            break;
        case 2:
            insertAtEnd(start);
            break;
        case 3:
            int element;
            cout << "Enter the element to search for: ";
            cin >> element;
            searchElement(start, element);
            break;
        case 4:
            insertAfterElement(start);
            break;
        case 5:
            insertBeforeElement(start);
            break;
        case 6:
            deleteFirstNode(start);
            break;
        case 7:
            deleteLastNode(start);
            break;
        case 8:
            deleteAfterElement(start);
            break;
        case 9:
            deleteBeforeElement(start);
```

```
            break;
        case 10:
            showList(start);
            break;
        case 11:
            cout << "Exiting...\n";
            return 0;
        default:
            cout << "Wrong choice" << endl;
        }
        cout << "Do you want to continue? (y/n): ";
        cin >> ans;
    } while (ans == 'y');
    deleteList(start);
    return 0;
}
```

Output: (screenshot)



Test Case: Any two (screenshot)

```
mahajanpiyush@Mahajans-MacBook-Air Lakshya46_23-27_Sem-II_DSA-main % cd "/Users/mahajanpi
yush/Documents/Lakshya46_23-27_Sem-II_DSA-main/" && g++ 7menu_linked_list.cpp -o 7menu_li
nked_list && "/Users/mahajanpiyush/Documents/Lakshya46_23-27_Sem-II_DSA-main/"7menu_linke
d_list
Enter number of nodes: 3
Enter data: 21
Enter data: 32
Enter data: 14
Enter your choice:
1.Insert a node at beginning
2.Insert a node at end
3.Search the list for an element
4.Insert a node after an element
5.Insert a node before an element
6.Delete first node
7.Delete last node
8.Delete a node after a particular element
9.Delete a node before a particular element
10.Show list
11.Exit
2
Enter data: 32
Do you want to continue? (y/n): n
mahajanpiyush@Mahajans-MacBook-Air Lakshya46_23-27_Sem-II_DSA-main %
```

```
Do you want to continue? (y/n): y
Enter your choice:
1.Insert a node at beginning
2.Insert a node at end
3.Search the list for an element
4.Insert a node after an element
5.Insert a node before an element
6.Delete first node
7.Delete last node
8.Delete a node after a particular element
9.Delete a node before a particular element
10.Show list
11.Exit
10
12 54
Number of nodes: 2
Do you want to continue? (y/n):
```

Conclusion: Therefore, we can implement a linked list by using class or structure and allocate heap memory for the node by using new operator or malloc function. We can deallocate memory for the node by using free function or delete operator.

Name of Student: Mahajan Piyush

Roll Number: 35

Experiment No: 8

Title: Implement Circular Linked List ADT.

Theory: Linked List is a data type which consists of nodes which contain data and a next pointer which points to the next node in the list. It stores the address of the next node. There is a start pointer in stack memory which points to the first node in the heap memory. It utilises dynamic memory and allocates heap memory to the nodes in the list. The last node's next pointer has the address of first node, hence it's called circular linked list.

Code:

```
#include <iostream>
using namespace std;

class Node
{
public:
    int data;
    Node *next;
    Node()
    {
        cout << "Enter data: ";
        cin >> data;
        next = NULL;
    }
};

Node *createList(int n)
{
    Node *start = NULL;
    Node *ptr = start;
    for (int i = 0; i < n; i++)
    {
```

```
        Node *newNode = new Node();
        if (start == NULL)
        {
            start = newNode;
            ptr = newNode;
        }
        else
        {
            ptr->next = newNode;
            ptr = ptr->next;
        }
    }
    ptr->next = start;
    return start;
}

void searchElement(Node *&a)
{
    int element;
    cout << "Enter element to search: ";
    cin >> element;
    Node *ptr = a;
    Node *preptr = ptr;
    Node *temp = NULL;
    while (preptr->next != a)
    {
        if (ptr->data == element)
        {
            cout << "Element " << ptr->data << " found in node " <<
ptr << endl;
            temp = ptr;
            break;
        }
        preptr = ptr;
        ptr = ptr->next;
    }
    if (temp == NULL)
    {
        cout << "No element found" << endl;
    }
}

void traverseList(Node *&a)
{
    int count = 0;
    Node *ptr = a;
    Node *preptr = ptr;
    cout << "Circular Linked List: " << endl;
    while (preptr->next != a)
```

```
    {
        cout << ptr->data << endl;
        preptr = ptr;
        ptr = ptr->next;
        count++;
    }
    cout << "Number of nodes: " << count << endl;
}

void insertAtBegin(Node *&a)
{
    Node *ptr = a;
    Node *newNode = new Node();
    if (newNode == NULL)
    {
        cout << "Overflow" << endl;
        return;
    }
    newNode->next = a;
    while (ptr->next != a)
    {
        ptr = ptr->next;
    }
    ptr->next = newNode;
    a = newNode;
}

void insertAtEnd(Node *&a)
{
    Node *ptr = a;
    Node *newNode = new Node();
    if (newNode == NULL)
    {
        cout << "Overflow" << endl;
        return;
    }
    newNode->next = a;
    while (ptr->next != a)
    {
        ptr = ptr->next;
    }
    ptr->next = newNode;
}

void insertBeforeElement(Node *&a)
{
    Node *ptr = a;
    Node *preptr = a;
    Node *newNode = new Node();
```

```
    if (newNode == NULL)
    {
        cout << "Overflow" << endl;
        return;
    }
    else
    {
        int element;
        cout << "Enter element to insert a node before it: ";
        cin >> element;
        if (ptr->data == element)
        {
            newNode->next = a;
            while (ptr->next != a)
            {
                ptr = ptr->next;
            }
            ptr->next = newNode;
            a = newNode;
            return;
        }
        else
        {
            do
            {
                if (ptr->data == element)
                {
                    preptr->next = newNode;
                    newNode->next = ptr;
                    return;
                }
                preptr = ptr;
                ptr = ptr->next;
            } while (ptr != a);
            if (ptr == a)
            {
                cout << "Element not found" << endl;
                return;
            }
        }
    }
}

void insertAfterElement(Node *&a)
{
    Node *ptr = a;
    Node *preptr = ptr;
    Node *newNode = new Node();
    if (newNode == NULL)
```

```
    {
        cout << "Overflow" << endl;
        return;
    }
    else
    {
        int element;
        cout << "Enter element to insert a node after it: ";
        cin >> element;
        do
        {
            if (preptr->data == element)
            {
                if (preptr == a)
                {
                    newNode->next = a->next;
                    a->next = newNode;
                    return;
                }
                if (preptr->next == a)
                {
                    preptr->next = newNode;
                    newNode->next = a;
                    a = newNode;
                    return;
                }
                preptr->next = newNode;
                newNode->next = ptr;
                return;
            }
            preptr = ptr;
            ptr = ptr->next;
        } while (ptr != a);
        if (ptr == a)
        {
            cout << "Element not found" << endl;
            return;
        }
    }
}

void deleteAtBegin(Node *&a)
{
    Node *ptr = a;
    if (a == NULL)
    {
        cout << "Underflow" << endl;
        return;
    }
```

```
    while (ptr->next != a)
    {
        ptr = ptr->next;
    }
    Node *temp = a;
    ptr->next = temp->next;
    a = temp->next;
    delete temp;
}

void deleteAtEnd(Node *&a)
{
    Node *ptr = a;
    Node *preptr = ptr;
    if (a == NULL)
    {
        cout << "Underflow" << endl;
        return;
    }
    while (ptr->next != a)
    {
        preptr = ptr;
        ptr = ptr->next;
    }
    preptr->next = a;
    delete ptr;
}

void deleteBeforeElement(Node *&a)
{
    int element;
    cout << "Enter element to delete node before it: ";
    cin >> element;
    Node *ptr = a;
    Node *preptr = NULL;
    Node *temp = NULL;
    if (a == NULL)
    {
        cout << "Underflow" << endl;
        return;
    }
    else
    {
        if (element == a->data)
        {
            cout << "Cannot delete before first element" << endl;
            return;
        }
        else
```

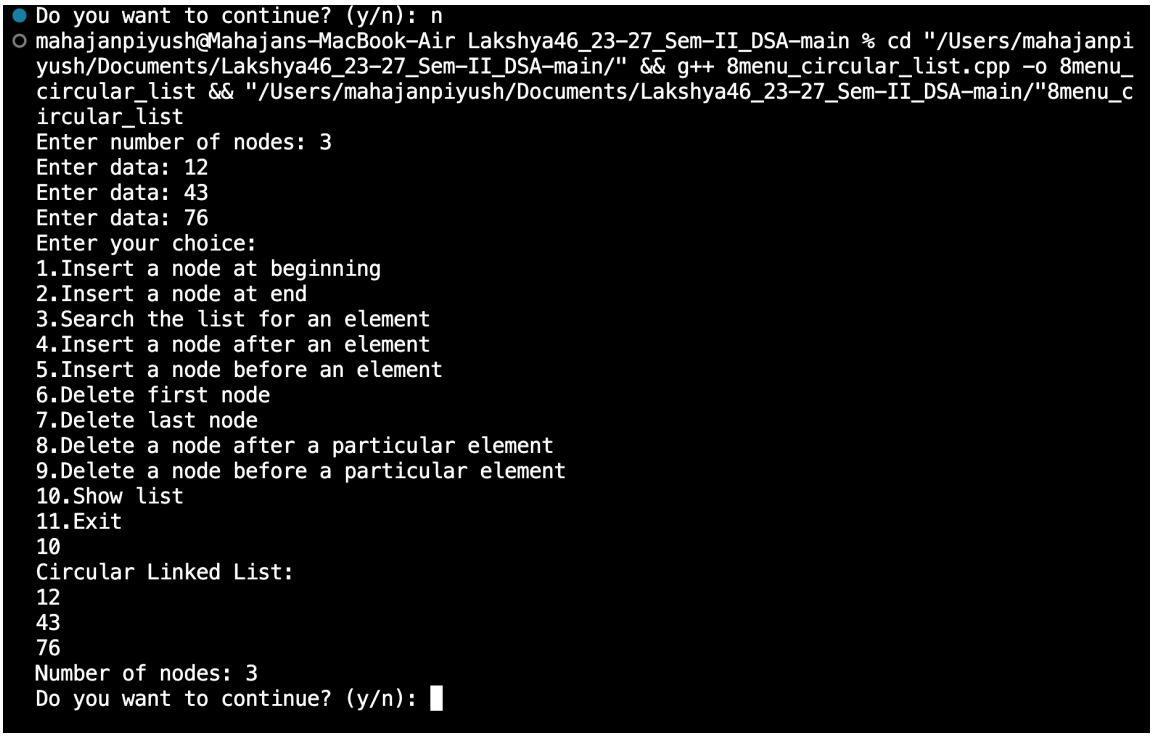
```
        {
            do
            {
                if (ptr->data == element)
                {
                    if (temp == NULL)
                    {
                        ptr = a;
                        while (ptr->next != a)
                        {
                            ptr = ptr->next;
                        }
                        temp = a;
                        ptr->next = temp->next;
                        a = temp->next;
                        delete temp;
                        return;
                    }
                    temp->next = ptr;
                    delete preptr;
                }
                temp = preptr;
                preptr = ptr;
                ptr = ptr->next;
            } while (ptr != a);
            return;
            if (ptr == a)
            {
                cout << "Element not found" << endl;
                return;
            }
        }
    }
}

void deleteAfterElement(Node *&a)
{
    int element;
    cout << "Enter element to delete node after it: ";
    cin >> element;
    if (a == NULL)
    {
        cout << "Underflow" << endl;
        return;
    }
    Node *ptr = a;
    Node *preptr = NULL;
    do
    {
```

```
        if (ptr->data == element)
        {
            if (ptr->next == a)
            {
                Node *temp = ptr->next;
                ptr->next = temp->next;
                delete temp;
                a = ptr->next;
                return;
            }
            else
            {
                preptr = ptr;
                ptr = ptr->next;
                preptr->next = ptr->next;
                delete ptr;
                return;
            }
        }
        preptr = ptr;
        ptr = ptr->next;
    } while (ptr != a);
    return;
    cout << "Element not found" << endl;
}

void deleteList(Node *&a)
{
    Node *ptr = a;
    Node *preptr = ptr;
    while (ptr->next != a)
    {
        preptr = ptr;
        ptr = ptr->next;
        delete preptr;
    }
    a = NULL;
}

int main()
{
    int n;
    cout << "Enter number of nodes: ";
    cin >> n;
    Node *start = createList(n);
    int choice;
    char ans = 'y';
    do
    {
```

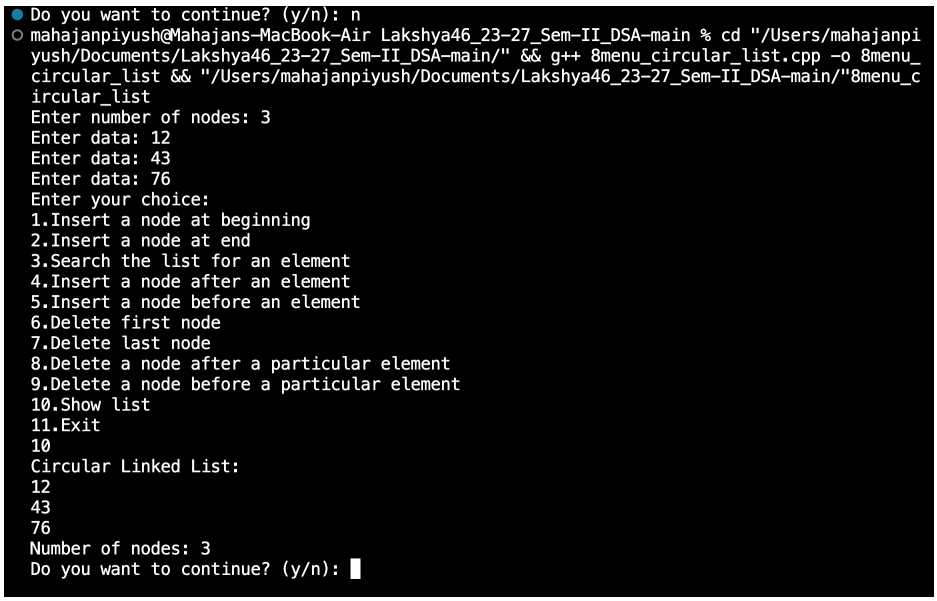
```
        cout << "Enter your choice: \n1.Insert a node at
beginning\n2.Insert a node at end\n3.Search the list for an
element\n4.Insert a node after an element\n5.Insert a node before
an element\n6.Delete first node\n7.Delete last node\n8.Delete a
node after a particular element\n9.Delete a node before a
particular element\n10.Show list\n11.Exit\n";
        cin >> choice;
        switch (choice)
        {
        case 1:
            insertAtBegin(start);
            break;
        case 2:
            insertAtEnd(start);
            break;
        case 3:
            searchElement(start);
            break;
        case 4:
            insertAfterElement(start);
            break;
        case 5:
            insertBeforeElement(start);
            break;
        case 6:
            deleteAtBegin(start);
            break;
        case 7:
            deleteAtEnd(start);
            break;
        case 8:
            deleteAfterElement(start);
            break;
        case 9:
            deleteBeforeElement(start);
            break;
        case 10:
            traverseList(start);
            break;
        case 11:
            cout << "Exiting...\n";
            return 0;
        default:
            cout << "Wrong choice" << endl;
        }
        cout << "Do you want to continue? (y/n): ";
        cin >> ans;
    } while (ans == 'y');
    deleteList(start);
```

```
    return 0;
}
```

Output: (screenshot)



Test Case: Any two (screenshot)



Conclusion: Therefore, we can implement a circular linked list by using class or structure and allocate heap memory for the node by using new operator or malloc function. We can deallocate memory for the node by using free function or delete operator.

Name of Student: Mahajan Piyush

Roll Number: 35

Experiment No: 9

Title: Implement Stack ADT using Linked List.

Theory: Stack is an Abstract Data Type which can be implemented using Linked List or Array. It consists of a variable named Top which points to the topmost element of the stack. Stack follows LIFO principle(Last In, First Out) which means that the element which is inserted last will be deleted first. There are three operations in Stack: Push- insertion from top, Pop- deletion from top, Peek- returning the topmost element from the stack. We can implement insertion at beginning, deletion from beginning algorithms to implement Stack using Linked List.

Linked List is a data type which consists of nodes which contain data and a next pointer which points to the next node in the list. It stores the address of the next node. There is a start pointer in stack memory which points to the first node in the heap memory. It utilises dynamic memory and allocates heap memory to the nodes in the list. The last node's next pointer has the address of first node, hence it's called circular linked list.

Code:

```
#include <iostream>
using namespace std;
```

```
class Node
{
public:
    int element;
    Node *next;
    Node()
    {
        cout << "Enter element: ";
        cin >> element;
        next = NULL;
    }
};

void pushList(Node *&a)
{
    Node *newnode = new Node();
    if (a == NULL)
    {
        a = newnode;
    }
    else
    {
        newnode->next = a;
        a = newnode;
    }
    cout << "Element pushed successfully\n";
}

void popList(Node *&a)
{
    Node *ptr = a;
    if (a == NULL)
    {
        cout << "Stack is empty\n";
    }
    else
    {
        cout << "Element " << a->element << " popped
successfully\n";
        a = a->next;
        delete ptr;
    }
}

void peekList(Node *&a)
{
    if (a == NULL)
    {
        cout << "Stack is empty\n";
```

```
    }
    else
    {
        cout << "Top element: " << a->element << endl;
    }
}

void deleteList(Node *&a)
{
    Node *ptr = a;
    Node *temp = ptr;
    if (a == NULL)
    {
        return;
    }
    else
    {
        while (ptr)
        {
            temp = ptr;
            ptr = ptr->next;
            delete temp;
        }
    }
    a = NULL;
}

void seeList(Node *&a)
{
    Node *ptr = a;
    if (a == NULL)
    {
        cout << "Empty stack\n";
    }
    else
    {
        while (ptr)
        {
            cout << ptr->element << endl;
            ptr = ptr->next;
        }
    }
}

int main()
{
    Node *top = NULL;
    int choice;
    while (true)
```

```
    {
        cout << "\nStack operation:
\n1.Push\n2.Pop\n3.Peek\n4.Exit\n";
        cin >> choice;
        switch (choice)
        {
        case 1:
            pushList(top);
            break;
        case 2:
            popList(top);
            break;
        case 3:
            peekList(top);
            break;
        case 4:
            cout << "Exiting...\n";
            return 0;
        default:
            cout << "Wrong choice\n";
            break;
        }
    }
    deleteList(top);
    return 0;
}
```

Output: (screenshot)

```
mahajanpiyush@Mahajans-MacBook-Air Lakshya46_23-27_Sem-II_DSA-main % cd "/Users/mahajanpi
yush/Documents/Lakshya46_23-27_Sem-II_DSA-main/" && g++ 9stack_list.cpp -o 9stack_list &&
 "/Users/mahajanpiyush/Documents/Lakshya46_23-27_Sem-II_DSA-main/"9stack_list

Stack operation:
1.Push
2.Pop
3.Peek
4.Exit
1
Enter element: 21
Element pushed successfully

Stack operation:
1.Push
2.Pop
3.Peek
4.Exit
4
Exiting...
```

Test Case: Any two (screenshot)

```
mahajanpiyush@Mahajans-MacBook-Air Lakshya46_23-27_Sem-II_DSA-main % cd "/Users/mahajanpi
yush/Documents/Lakshya46_23-27_Sem-II_DSA-main/" && g++ 9stack_list.cpp -o 9stack_list &&
 "/Users/mahajanpiyush/Documents/Lakshya46_23-27_Sem-II_DSA-main/"9stack_list

Stack operation:
1.Push
2.Pop
3.Peek
4.Exit
1
Enter element: 21
Element pushed successfully

Stack operation:
1.Push
2.Pop
3.Peek
4.Exit
4
Exiting...
```

```
mahajanpiyush@Mahajans-MacBook-Air Lakshya46_23-27_Sem-II_DSA-main % cd "/Users/mahajanpi
yush/Documents/Lakshya46_23-27_Sem-II_DSA-main/" && g++ 9stack_list.cpp -o 9stack_list &&
 "/Users/mahajanpiyush/Documents/Lakshya46_23-27_Sem-II_DSA-main/"9stack_list

Stack operation:
1.Push
2.Pop
3.Peek
4.Exit
1
Enter element: 331
Element pushed successfully

Stack operation:
1.Push
2.Pop
3.Peek
4.Exit
2
Element 331 popped successfully
```

Conclusion: Therefore, we can implement Stack by linked list by using class or structure and allocate heap memory for the node by using new operator or malloc function. We can deallocate memory for the node by using free function or delete operator. We can implement push and pop operations through insertion at beginning and deletion from beginning algorithms.

Name of Student: Mahajan Piyush

Roll Number: 35

Experiment No: 10

Title: Implement Linear Queue ADT using Linked List.

Theory: Queue is an Abstract Data Type which can be implemented using Linked List or Array. It consists of two variables named Front and Rear which point to the first and last elements of the stack, respectively. Queue follows FIFO principle(First In, First Out) which means that the element which is inserted first will be deleted first. There are three operations in Stack: Enqueue- insertion from rear, Dequeue- deletion from front, Peek- returning the frontmost element from the queue. It can be implemented by insertion at end and deletion from beginning algorithms.

Linked List is a data type which consists of nodes which contain data and a next pointer which points to the next node in the list. It stores the address of the next node. There is a start pointer in stack memory which points to the first node in the heap memory. It utilises dynamic memory and allocates heap memory to the nodes in the list. The last node's next pointer has the address of first node, hence it's called circular linked list.

Code:

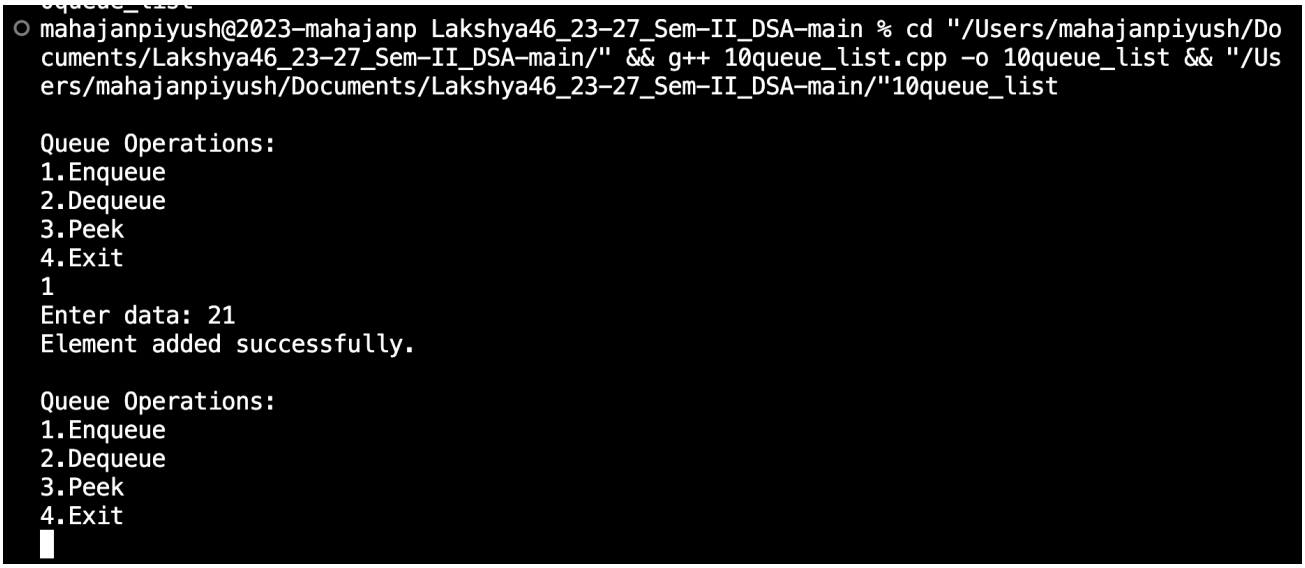
```
#include <iostream>
```

```
using namespace std;

class Node
{
public:
    int data;
    Node *next;
    Node()
    {
        cout << "Enter data: ";
        cin >> data;
        next = NULL;
    }
};

void enqueue(Node *&start, Node *&end)
{
    Node *newnode = new Node();
    if (start == NULL)
    {
        start = newnode;
        end = newnode;
    }
    else
    {
        end->next = newnode;
        end = newnode;
    }
    cout << "Element added successfully.\n";
}

void dequeue(Node *&start, Node *&end)
{
    Node *ptr = NULL;
    if (start == NULL)
    {
        cout << "Queue is empty.\n";
        return;
    }
    else
    {
        ptr = start;
        start = start->next;
        cout << "Element " << ptr->data << " deleted successfully.
\n";
        delete ptr;
    }
}
```

```
void peek(Node *&start)
{
    if (start == NULL)
    {
        cout << "Queue is empty.\n";
        return;
    }
    else
    {
        cout << "Top element: " << start->data << endl;
    }
}

void deleteQueue(Node *&start)
{
    Node *ptr = start;
    Node *temp = NULL;
    if (start == NULL)
    {
        return;
    }
    else
    {
        while (ptr != NULL)
        {
            temp = ptr;
            ptr = ptr->next;
            delete temp;
        }
    }
    start = NULL;
}

void showQueue(Node *start)
{
    Node *ptr = start;
    while (ptr != NULL)
    {
        cout << ptr->data << endl;
        ptr = ptr->next;
    }
}

int main()
{
    Node *front = NULL;
    Node *rear = NULL;
    int choice;
    while (true)
```

```
    {
        cout << "\nQueue Operations:
\n1.Enqueue\n2.Dequeue\n3.Peek\n4.Exit\n";
        cin >> choice;
        switch (choice)
        {
        case 1:
            enqueue(front, rear);
            break;
        case 2:
            dequeue(front, rear);
            break;
        case 3:
            peek(front);
            break;
        case 4:
            cout << "Exiting...\n";
            return 0;
        default:
            cout << "Wrong choice.\n";
            break;
        }
    }
    return 0;
}
```

Output: (screenshot)



Test Case: Any two (screenshot)

```
mahajanpiyush@2023-mahajanp Lakshya46_23-27_Sem-II_DSA-main % cd "/Users/mahajanpiyush/Do
cuments/Lakshya46_23-27_Sem-II_DSA-main/" && g++ 10queue_list.cpp -o 10queue_list && "/Us
ers/mahajanpiyush/Documents/Lakshya46_23-27_Sem-II_DSA-main/"10queue_list

Queue Operations:
1.Enqueue
2.Dequeue
3.Peek
4.Exit
1
Enter data: 21
Element added successfully.

Queue Operations:
1.Enqueue
2.Dequeue
3.Peek
4.Exit
```

```
Queue Operations:
1.Enqueue
2.Dequeue
3.Peek
4.Exit
2
Element 21 deleted successfully.

Queue Operations:
1.Enqueue
2.Dequeue
3.Peek
4.Exit
```

Conclusion: Therefore, we can implement Linear Queue by linked list by using class or structure and allocate heap memory for the node by using new operator or malloc function. We can deallocate memory for the node by using free function or delete operator. We can implement enqueue and dequeue operations through insertion at end and deletion from beginning algorithms.

Name of Student: Mahajan Piyush

Roll Number: 35

Experiment No: 11

Title: Implement Binary Search Tree ADT using Linked List.

Theory:

A binary tree is a non-linear data structure in which there is a root node and each parent node has 0,1 or 2 child nodes at most. In binary search tree, all the nodes having values less than that of the root node are present in the left subtree of the root node and all the nodes having values greater than or equal to that of the root node are present in the right subtree of the root node.

Code:

```
#include <iostream>
using namespace std;

class Node
{
public:
    int data;
    Node *left;
    Node *right;
    Node()
    {
        cout << "Enter data: ";
        cin >> data;
        left = right = NULL;
    }
};

class BST
{
public:
    Node *root;
    BST()
    {
        root = NULL;
    }
    void insert(Node *node)
    {
```

```
        if (root == NULL)
        {
            root = node;
            return;
        }
        Node *temp = root;
        while (temp != NULL)
        {
            if (node->data < temp->data)
            {
                if (temp->left == NULL)
                {
                    temp->left = node;
                    return;
                }
                temp = temp->left;
            }
            else
            {
                if (temp->right == NULL)
                {
                    temp->right = node;
                    return;
                }
                temp = temp->right;
            }
        }
    }
    void inorder(Node *node)
    {
        if (node == NULL)
            return;
        inorder(node->left);
        cout << node->data << " ";
        inorder(node->right);
    }
    void preorder(Node *node)
    {
        if (node == NULL)
            return;
        cout << node->data << " ";
        preorder(node->left);
        preorder(node->right);
    }
    void postorder(Node *node)
    {
        if (node == NULL)
            return;
        postorder(node->left);
```

```
        postorder(node->right);
        cout << node->data << " ";
    }
};

int main()
{
    BST bst;
    int n;
    cout << "Enter number of nodes: ";
    cin >> n;
    for (int i = 0; i < n; i++)
    {
        Node *node = new Node();
        bst.insert(node);
    }
    cout << "Inorder: ";
    bst.inorder(bst.root);
    cout << endl;
    cout << "Preorder: ";
    bst.preorder(bst.root);
    cout << endl;
    cout << "Postorder: ";
    bst.postorder(bst.root);
    cout << endl;
    return 0;
}
```

Output: (screenshot)

```
mahajanpiyush@2023-mahajanp Lakshya46_23-27_Sem-II_DSA-main % cd "/Users/mahajanpiyush/Do
cuments/Lakshya46_23-27_Sem-II_DSA-main/" && g++ 11binarysearchtree_list.cpp -o 11binarys
earchtree_list && "/Users/mahajanpiyush/Documents/Lakshya46_23-27_Sem-II_DSA-main/"11bina
rysearchtree_list
Enter number of nodes: 3
Enter data: 12
Enter data: 43
Enter data: 134
Inorder: 12 43 134
Preorder: 12 43 134
Postorder: 134 43 12
mahajanpiyush@2023-mahajanp Lakshya46_23-27_Sem-II_DSA-main %
```

Test Case: Any two (screenshot)

```
mahajanpiyush@2023-mahajanp Lakshya46_23-27_Sem-II_DSA-main % cd "/Users/mahajanpiyush/Do
cuments/Lakshya46_23-27_Sem-II_DSA-main/" && g++ 11binarysearchtree_list.cpp -o 11binarys
earchtree_list && "/Users/mahajanpiyush/Documents/Lakshya46_23-27_Sem-II_DSA-main/"11bina
rysearchtree_list
Enter number of nodes: 4
Enter data: 12
Enter data: 65
Enter data: 7557
Enter data: 23
Inorder: 12 23 65 7557
Preorder: 12 65 23 7557
Postorder: 23 7557 65 12
mahajanpiyush@2023-mahajanp Lakshya46_23-27_Sem-II_DSA-main %
```

```
mahajanpiyush@2023-mahajanp Lakshya46_23-27_Sem-II_DSA-main % cd "/Users/mahajanpiyush/Do
cuments/Lakshya46_23-27_Sem-II_DSA-main/" && g++ 11binarysearchtree_list.cpp -o 11binarys
earchtree_list && "/Users/mahajanpiyush/Documents/Lakshya46_23-27_Sem-II_DSA-main/"11bina
rysearchtree_list
Enter number of nodes: 3
Enter data: 12
Enter data: 43
Enter data: 134
Inorder: 12 43 134
Preorder: 12 43 134
Postorder: 134 43 12
mahajanpiyush@2023-mahajanp Lakshya46_23-27_Sem-II_DSA-main %
```

Conclusion: Therefore, we can implement Binary Search Tree ADT using Linked List.

Name of Student: Mahajan Piyush

Roll Number: 35

Experiment No: 12

Title: Implement Graph Traversal techniques: a) Depth First Search b) Breadth First Search

Theory: A Graph is a non-linear data structure which can have parent-child as well as other complex relationships between the nodes. It is a set of edges and vertices, where vertices are the nodes, and the edges are the links connecting the nodes. We can implement a graph using adjacency matrix or adjacency list.

Code:

```
#include <iostream>
#include <queue>

using namespace std;

const int MAXN = 100;


void dfs(int graph[][MAXN], bool visited[], int n, int node)
{
    visited[node] = true;
    cout << node << " ";

    for (int i = 0; i < n; ++i)
    {
        if (graph[node][i] == 1 && !visited[i])
        {
            dfs(graph, visited, n, i);
        }
    }
}


void bfs(int graph[][MAXN], bool visited[], int n, int start)
{
    queue<int> q;
```

```
    q.push(start);
    visited[start] = true;

    while (!q.empty())
    {
        int node = q.front();
        q.pop();
        cout << node << " ";

        for (int i = 0; i < n; ++i)
        {
            if (graph[node][i] == 1 && !visited[i])
            {
                q.push(i);
                visited[i] = true;
            }
        }
    }
}

int main()
{
    int n;
    cout << "Enter the number of vertices: ";
    cin >> n;

    int graph[MAXN][MAXN];
    cout << "Enter the adjacency matrix:" << endl;
    for (int i = 0; i < n; ++i)
    {
        for (int j = 0; j < n; ++j)
        {
            cin >> graph[i][j];
        }
    }

    bool visited[MAXN] = {false};
    cout << "Depth First Search (DFS): ";
    for (int i = 0; i < n; ++i)
    {
        if (!visited[i])
        {
            dfs(graph, visited, n, i);
        }
    }
    cout << endl;


    fill(visited, visited + n, false);
```

```
    cout << "Breadth First Search (BFS): ";
    for (int i = 0; i < n; ++i)
    {
        if (!visited[i])
        {
            bfs(graph, visited, n, i);
        }
    }
    cout << endl;

    return 0;
}
```

Output: (screenshot)

```
mahajanpiyush@2023-mahajanp Lakshya46_23-27_Sem-II_DSA-main % cd "/Users/mahajanpiyush/Documents/Lakshya46_23-27_Sem-II_DSA-main/" && g++ 12graphtraversal.cpp -o 12graphtraversal && "/Users/mahajanpiyush/Documents/Lakshya46_23-27_Sem-II_DSA-main/"12graphtraversal
Enter the number of vertices: 2
Enter the adjacency matrix:
12
24
64
24
Depth First Search (DFS): 0 1
Breadth First Search (BFS): 0 1
mahajanpiyush@2023-mahajanp Lakshya46_23-27_Sem-II_DSA-main %
```

Test Case: Any two (screenshot)

```
mahajanpiyush@2023-mahajanp Lakshya46_23-27_Sem-II_DSA-main % cd "/Users/mahajanpiyush/Documents/Lakshya46_23-27_Sem-II_DSA-main/" && g++ 12graphtraversal.cpp -o 12graphtraversal && "/Users/mahajanpiyush/Documents/Lakshya46_23-27_Sem-II_DSA-main/"12graphtraversal
Enter the number of vertices: 2
Enter the adjacency matrix:
12
24
64
24
Depth First Search (DFS): 0 1
Breadth First Search (BFS): 0 1
mahajanpiyush@2023-mahajanp Lakshya46_23-27_Sem-II_DSA-main %
```

```
mahajanpiyush@2023-mahajanp Lakshya46_23-27_Sem-II_DSA-main % cd "/Users/mahajanpiyush/Documents/Lakshya46_23-27_Sem-II_DSA-main/" && g++ 12graphtraversal.cpp -o 12graphtraversal && "/Users/mahajanpiyush/Documents/Lakshya46_23-27_Sem-II_DSA-main/"12graphtraversal
Enter the number of vertices: 3
Enter the adjacency matrix:
12
42
64
68
979
54
25
757
244
Depth First Search (DFS): 0 1 2
Breadth First Search (BFS): 0 1 2
mahajanpiyush@2023-mahajanp Lakshya46_23-27_Sem-II_DSA-main %
```

Conclusion: Therefore, we can implement Graph Traversal techniques by Depth First and Breadth First using adjacency matrix.

Name of Student: Mahajan Piyush

Roll Number: 35

Experiment No: 13

Title: Implement Binary Search algorithm to search an element in the array.

Theory:

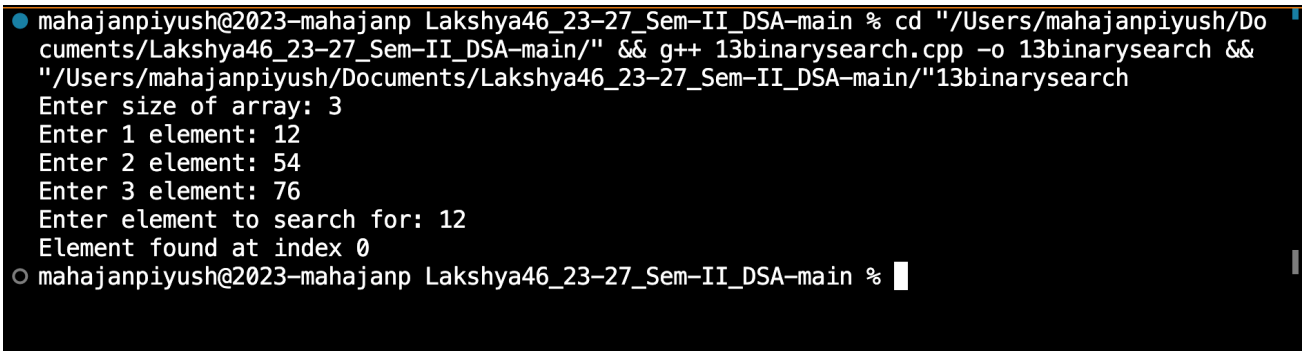
Binary Search is a searching algorithm which is used in a sorted array by repeatedly dividing the search interval in half. The idea of binary search is to use the information that the array is sorted and reduce the time complexity to O(log N).

Code:

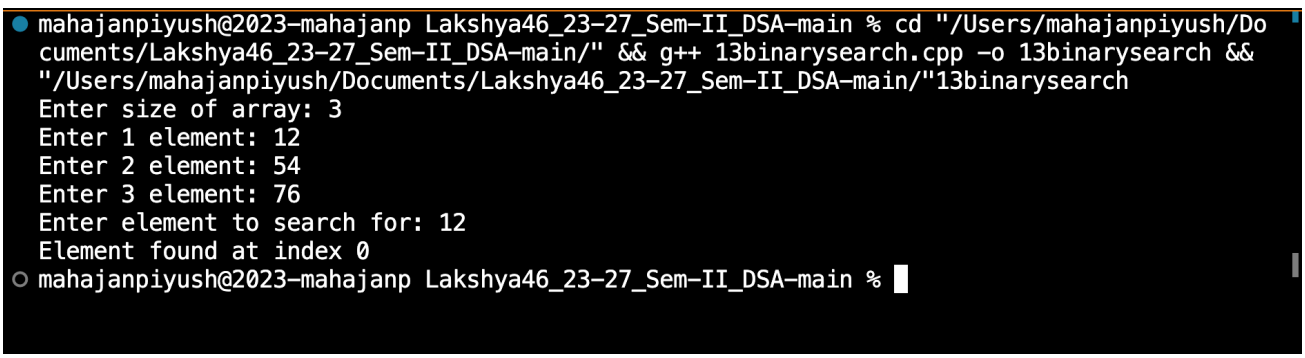
```
#include <iostream>
using namespace std;

int binarySearch(int arr[], int n, int a)
{
    int l = 0, r = n - 1;
    while (l <= r)
    {
        int m = l + (r - l) / 2;
        if (arr[m] == a)
        {
            return m;
        }
        if (arr[m] < a)
        {
            l = m + 1;
        }
        else
        {
            r = m - 1;
        }
    }
    return -1;
}

int main()
```

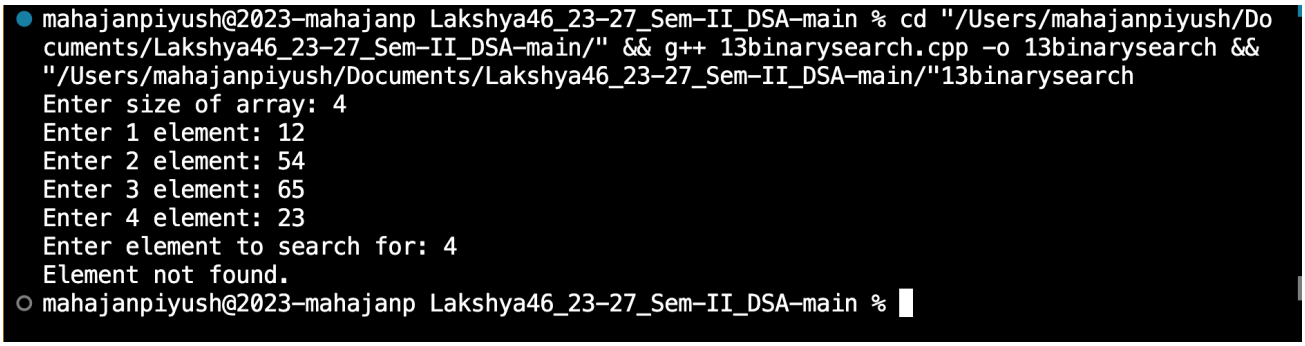
```
{
    int n, a;
    cout << "Enter size of array: ";
    cin >> n;
    int arr[n];
    for (int i = 0; i < n; i++)
    {
        cout << "Enter " << i + 1 << " element: ";
        cin >> arr[i];
    }
    cout << "Enter element to search for: ";
    cin >> a;
    int b = binarySearch(arr, n, a);
    if (b == -1)
    {
        cout << "Element not found." << endl;
    }
    else
    {
        cout << "Element found at index " << b << endl;
    }
    return 0;
}
```

Output: (screenshot)



Test Case: Any two (screenshot)





Conclusion: Therefore, we can implement Binary Search algorithm in a sorted array to search the index location of an element present in the array in an efficient manner.

Name of Student: Mahajan Piyush

Roll Number: 35

Experiment No: 14

Title: Implement Bubble Sort algorithm to sort elements of an array in ascending and descending order.

Theory:

In Bubble Sort algorithm, we traverse from left and compare adjacent elements and the higher one is placed at right side. In this way, the largest element is moved to the rightmost end at first. This process is then continued to find the second largest and place it and so on until the data is sorted.

Code:

```
#include <iostream>
using namespace std;

int main()
{
    int n;
    cout << "Enter number of elements: ";
    cin >> n;
    int arr[n];
    for (int i = 0; i < n; i++)
    {
        cout << "Enter " << i + 1 << " element: ";
        cin >> arr[i];
    }
    cout << "Array: ";
    for (int i = 0; i < n; i++)
    {
        cout << arr[i] << " ";
    }

    // ascending order
    for (int i = 0; i < n - 1; i++)
    {
        for (int j = 0; j < n - 1; j++)
        {
            if (arr[j] > arr[j + 1])
            {
```

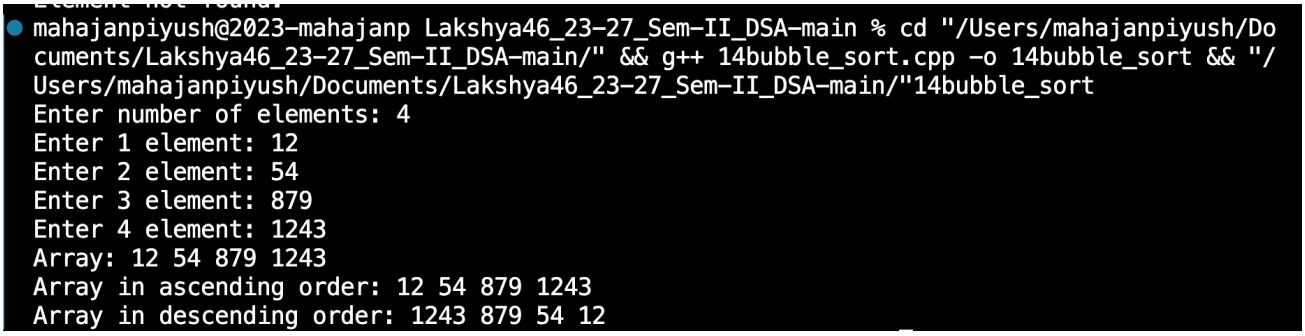
```
                int temp = arr[j];
                arr[j] = arr[j + 1];
                arr[j + 1] = temp;
            }
        }
    }
    cout << "\nArray in ascending order: ";
    for (int i = 0; i < n; i++)
    {
        cout << arr[i] << " ";
    }
```

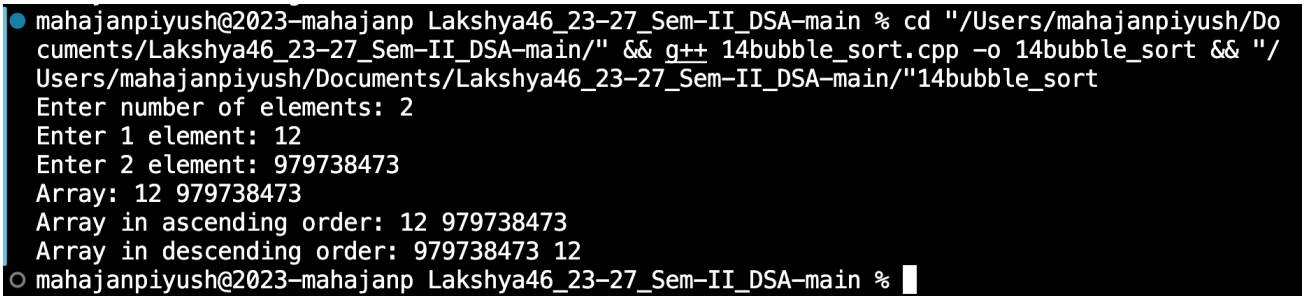
```
    for (int i = 0; i < n - 1; i++)
    {
        for (int j = 0; j < n - 1 - i; j++)
        {
            if (arr[j] < arr[j + 1])
            {
                int temp = arr[j];
                arr[j] = arr[j + 1];
                arr[j + 1] = temp;
            }
        }
    }
    cout << "\nArray in descending order: ";
    for (int i = 0; i < n; i++)
    {
        cout << arr[i] << " ";
    }
    cout<<endl;
    return 0;
}
```

Output: (screenshot)

```
mahajanpiyush@2023-mahajanp Lakshya46_23-27_Sem-II_DSA-main % cd "/Users/mahajanpiyush/Do
cuments/Lakshya46_23-27_Sem-II_DSA-main/" && g++ 14bubble_sort.cpp -o 14bubble_sort && "/
Users/mahajanpiyush/Documents/Lakshya46_23-27_Sem-II_DSA-main/"14bubble_sort
Enter number of elements: 4
Enter 1 element: 12
Enter 2 element: 54
Enter 3 element: 879
Enter 4 element: 1243
Array: 12 54 879 1243
Array in ascending order: 12 54 879 1243
Array in descending order: 1243 879 54 12
```

Test Case: Any two (screenshot)





Conclusion: Therefore, we can implement Bubble Sort algorithm to sort the array in ascending or descending order by traversing through the array and comparing the elements to the adjacent elements.