Experiment 1

Program 1

Aim :: Write a program showing the implementation of array concatenation.

Code ::

```
#include <iostream>

int main() {
   int arr1[] = {2,5,6,8,9,23};
   int arr2[] = {102,105,106,108,109};
   int size_arr1 = (sizeof(arr1) / sizeof(int));
   int size_arr2 = (sizeof(arr2) / sizeof(int));
   int size_arr3 = (size_arr1+size_arr2);

   //Memory gets allocated for new array
   int arr3[size_arr3];

   //loop over first array and add its elements to final array
   for (int i = 0; i < size_arr1; i++)    arr3[i] = arr1[i];

   //loop over first array and add its elements to final array
   for (int i = 0; i < size_arr2; i++)    arr3[i+size_arr1] = arr2[i];

   //Print resulting arrays
   std::cout << "Array 1 :\t";
   for (int i = 0; i < size_arr1; i++) std::cout << arr1[i] << " ";
   std::cout << std::endl;

   std::cout << "Array 2 :\t";
   for (int i = 0; i < size_arr2; i++) std::cout << arr2[i] << " ";
   std::cout << std::endl;

   std::cout << "Array 3 :\t";
   for (int i = 0; i < size_arr3; i++) std::cout << arr3[i] << " ";
   std::cout << std::endl;

   std::cout << "\nWritten By: Lakshay Sharma 02396402721" << std::endl;
   return 0;
}
```

Output ::

```
(base) c:\Users\Lakshay Sharma\College\DS\Experiment 1>.\"q1_ArrayConcatenation.exe"
Array 1 :       2 5 6 8 9 23
Array 2 :       102 105 106 108 109
Array 3 :       2 5 6 8 9 23 102 105 106 108 109

Written By: Lakshay Sharma 02396402721
```

Program 2

Aim :: Write a program showing the implementation of Linear search.

Code ::

```
#include <iostream>

template <typename T>
int linearSearch(T element, T array[], int arr_size){
   int index;
   //Performing Linear Search
   for(index = 0; index < arr_size ; index++) {
      if (array[index] == element) {
         return index;   //return at first instance
      }
   }
   //If value is not in array
   return -1;
}

int main()
{
   int arr[10] = {8,9,5,4,7,3,1,5,6,12};
   int size_arr = (sizeof(arr)/sizeof(int));

   //Showing user the array to perform search operation
   std::cout << "Array:\t";
   for(int i = 0;i<10;i++) std::cout << arr[i] << " ";

   //Asking for element to find in array
   int ele;
   std::cout << "\nElement to find: ";  std::cin >> ele;

   //Linear Search Operation
   int foundAt = linearSearch(ele, arr, size_arr);

   //Returning result after searching
   if (foundAt > 0) std::cout << "Value <" << ele <<"> found at index: " << foundAt << std::endl;
   else std::cout << "Value <" << ele << "> is not in the array" << std::endl;

   std::cout << "\nWritten By: Lakshay Sharma 02396402721";
   return 0;
}
```

Output ::

```
(base) c:\Users\Lakshay Sharma\College\DS\Experiment 1>.\"q2_LinearSearch.exe"
Array:  8 9 5 4 7 3 1 5 6 12
Element to find: 5
Value <5> found at index: 2

Written By: Lakshay Sharma 02396402721
(base) c:\Users\Lakshay Sharma\College\DS\Experiment 1>.\"q2_LinearSearch.exe"
Array:  8 9 5 4 7 3 1 5 6 12
Element to find: 11
Value <11> is not in the array

Written By: Lakshay Sharma 02396402721
```

Program 3

Aim :: Write a program showing the implementation of Binary search.

Code ::

```
#include <iostream>

/*Iterative Approach*/
template <typename T>
int binarySearchI(T element, T array[], int lower_index, int upper_index){
   while (lower_index <= upper_index) {
      int middle_index = lower_index + (upper_index - lower_index) / 2;

      // Check if element is present at mid
      if (array[middle_index] == element) return middle_index;

      // If element smaller than middle, ignore right half
      if (element < array[middle_index]) upper_index = middle_index - 1;

      // If element is greater than middle, ignore left half
      else lower_index = middle_index + 1;
   }
   // Value is not found in array
   return -1;
}

/*Recursive Approach*/
template <typename T>
int binarySearchR(T element, T array[], int lower_index, int upper_index){
   if (upper_index >= lower_index) {
      int middle_index = lower_index + (upper_index - lower_index) / 2;

      // If the element is present at the middle
      if (array[middle_index] == element) return middle_index;

      // If element is smaller than middle, then element is in left subArray
      if (element < array[middle_index])
         return binarySearchR(element, array, lower_index, middle_index - 1);

      // Else, element is in right subArray
      return binarySearchR(element, array, middle_index + 1, upper_index);
   }
   // Value is not found in array
   return -1;
}

int main()
```

```
{
   int arr[10] = {1,2,3,5,7,11,13,17,19,23};
   int size_arr = (sizeof(arr)/sizeof(int));

   //Showing user the sorted array to perform search operation
   std::cout << "Array:\t";
   for(int i = 0;i<10;i++) std::cout << arr[i] << " ";

   //Asking for element to find in array
   int ele;
   std::cout << "\nElement to find: ";  std::cin >> ele;

   /*Iterative Binary Search Operation*/
   int foundAt = binarySearchI(ele, arr, 0, size_arr);
   //Returning result after searching
   std::cout << "Iterative Binary Search >> ";
   if (foundAt > 0) std::cout << "Value <" << ele << "> found at index: " << foundAt << std::endl;
   else std::cout << "Value <" << ele << "> is not in the array" << std::endl;

   /*Recursive Binary Search Operation*/
   foundAt = binarySearchR(ele, arr, 0, size_arr);
   //Returning result after searching
   std::cout << "Recursive Binary Search >> ";
   if (foundAt > 0) std::cout << "Value <" << ele << "> found at index: " << foundAt << std::endl;
   else std::cout << "Value <" << ele << "> is not in the array" << std::endl;

   std::cout << "\nWritten By: Lakshay Sharma 02396402721";
   return 0;
}
```

Output ::

```
(base) c:\Users\Lakshay Sharma\College\DS\Experiment 1>.\"q3_BinarySearch.exe"
Array:  1 2 3 5 7 11 13 17 19 23
Element to find: 7
Iterative Binary Search >> Value <7> found at index: 4
Recursive Binary Search >> Value <7> found at index: 4

Written By: Lakshay Sharma 02396402721
(base) c:\Users\Lakshay Sharma\College\DS\Experiment 1>.\"q3_BinarySearch.exe"
Array:  1 2 3 5 7 11 13 17 19 23
Element to find: 10
Iterative Binary Search >> Value <10> is not in the array
Recursive Binary Search >> Value <10> is not in the array

Written By: Lakshay Sharma 02396402721
```

Program 4

Aim :: Write a program showing the implementation of Matrix Multiplication.

Code ::

```
#include <iostream>
#include <vector>

using namespace std;

// Function to perform matrix multiplication
vector<vector<int>> multiply(vector<vector<int>>& A, vector<vector<int>>& B){
   int n = A.size();
   int m = B[0].size();
   int p = B.size();

   vector<vector<int>> C(n, vector<int>(m, 0));

   for (int i = 0; i < n; i++)
   {
      for (int j = 0; j < m; j++)
      {
         for (int k = 0; k < p; k++)
         {
            C[i][j] += A[i][k] * B[k][j];
         }
      }
   }

   return C;
}
void print(vector<vector<int>>&A){
   for (int i = 0; i < A.size(); i++)
   {
      for (int j = 0; j < A[0].size(); j++)
      {
         cout << A[i][j] << " ";
      }
      cout << endl;
   }
}
// Driver function
int main()
{
   // Initialize two matrices
   vector<vector<int>> A = {{1, 2, 3}, {4, 5, 6}, {7, 8, 9}};
   vector<vector<int>> B = {{1, 0, 0}, {0, 1, 0}, {0, 0, 1}};
```

```
    cout << "Matrix A : " << endl;
    print(A);
    cout << "Matrix B : " << endl;
    print(B);
    // Perform matrix multiplication
    vector<vector<int>> C = multiply(A, B);

    // Print the result
    cout << "Result of matrix multiplication:" << endl;
    print(C);

    std::cout << "\nWritten By: Lakshay Sharma 02396402721";
    return 0;
}
```

Output ::

```
c:\Users\Lakshay Sharma\College\DS\Experiment 1>.\"q4_MatrixMultiplication.exe"
Matrix A :
1 2 3
4 5 6
7 8 9
Matrix B :
1 0 0
0 1 0
0 0 1
Result of matrix multiplication:
1 2 3
4 5 6
7 8 9

Written By: Lakshay Sharma 02396402721
```

Experiment 2

Program 1

Aim :: Write a program showing the implementation of Stack and Queue with array.

Code ::

```
#include <iostream>

const int MAX_SIZE = 100;

class Stack {
  private:
    int arr[MAX_SIZE];
    int top;

  public:
  Stack() {
    top = -1;
  }

  bool isEmpty() {
    return top == -1;
  }

  bool isFull() {
    return top == MAX_SIZE - 1;
  }

  void push(int x) {
    if (isFull()) {
      std::cout << "Error: stack is full" << std::endl;
      return;
    }
    top++;
    arr[top] = x;
  }

  void pop() {
    if (isEmpty()) {
      std::cout << "Error: stack is empty" << std::endl;
      return;
    }
    top--;
  }
```

```
    int peek() {
        if (isEmpty()) {
            std::cout << "Error: stack is empty" << std::endl;
            return -1;
        }
        return arr[top];
    }
};
class Queue {
    private:
        int arr[MAX_SIZE];
        int front;
        int rear;

    public:
    Queue() {
        front = 0;
        rear = -1;
    }

    bool isEmpty() {
        return front == rear+1;
    }

    bool isFull() {
        return rear == MAX_SIZE - 1;
    }

    void enqueue(int x) {
        if (isFull()) {
            std::cout << "Error: queue is full" << std::endl;
            return;
        }
        rear++;
        arr[rear] = x;
    }

    void dequeue() {
        if (isEmpty()) {
        std::cout << "Error: queue is empty" << std::endl;
        return;
        }
        front++;
    }

    int peek() {
        if (isEmpty()) {
        std::cout << "Error: queue is empty" << std::endl;
```

```
        return -1;
        }
        return arr[front];
    }
};
int main() {
    std::cout << "------------------STACK------------------" << std::endl;

    Stack s;
    s.push(1);
    s.push(2);
    s.push(3);
    std::cout << s.peek() << std::endl;  // Output: 3
    s.pop();
    std::cout << s.peek() << std::endl;  // Output: 2
    s.pop();
    std::cout << s.peek() << std::endl;  // Output: 1
    s.pop();
    s.pop();  // Error: stack is empty

    std::cout << std::endl << std::endl;
    std::cout << "------------------QUEUE------------------" << std::endl;

    Queue q;
    q.enqueue(1);
    q.enqueue(2);
    q.enqueue(3);
    std::cout << q.peek() << std::endl;  // Output: 1
    q.dequeue();
    std::cout << q.peek() << std::endl;  // Output: 2
    q.dequeue();
    std::cout << q.peek() << std::endl;  // Output: 3
    q.dequeue();
    q.dequeue();  // Error: queue is empty

    std::cout << "\nWritten By: Lakshay Sharma 02396402721";
    return 0;
}
```

Output ::

```
c:\Users\Lakshay Sharma\College\DS\Experiment 2>.\"q1_StackQueueViaArray.exe"
------------------STACK-----------------
3
2
1
Error: stack is empty


------------------QUEUE-----------------
1
2
3
Error: queue is empty

Written By: Lakshay Sharma 02396402721
```

Program 2

Aim :: Write a program to implement two stacks using single array.

Code ::

```
#include <iostream>
#include <cstdlib>

using namespace std;

const int STACK_SIZE = 10;

class Stack {
private:
   int* arr;
   int top1, top2;

public:
   Stack() {
      arr = new int[STACK_SIZE];
      top1 = -1;
      top2 = STACK_SIZE;
   }

   ~Stack() {
      delete[] arr;
   }

   void push1(int value) {
      if (top1 + 1 == top2) {
         cout << "Error: stack overflow" << endl;
         return;
      }
      arr[++top1] = value;
   }

   void push2(int value) {
      if (top1 + 1 == top2) {
         cout << "Error: stack overflow" << endl;
         return;
      }
      arr[--top2] = value;
   }

   int pop1() {
      if (top1 < 0) {
         cout << "Error: stack underflow" << endl;
```

```
            exit(EXIT_FAILURE);
        }
        return arr[top1--];
    }

    int pop2() {
        if (top2 > STACK_SIZE - 1) {
            cout << "Error: stack underflow" << endl;
            exit(EXIT_FAILURE);
        }
        return arr[top2++];
    }
};

int main() {
    Stack stack;
    stack.push1(1);
    stack.push1(2);
    stack.push2(3);
    stack.push2(4);

    cout << stack.pop1() << endl;
    cout << stack.pop1() << endl;
    cout << stack.pop2() << endl;
    cout << stack.pop2() << endl;

    std::cout << "\nWritten By: Lakshay Sharma 02396402721";
    return 0;
}

/* Two stack Array ::  2 1 X X X X X 3 4 */
```

Output ::

```
c:\Users\Lakshay Sharma\College\DS\Experiment 2>.\"q2_TwoStacksViaArray.exe"
2
1
4
3

Written By: Lakshay Sharma 02396402721
```

Experiment 3

Program 1

Aim :: Write a program showing the implementation of Linked list

Code ::

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

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

int main() {
   Node* n1 = new Node();
   Node* n2 = new Node();
   Node* n3 = new Node();
   n1->data = 11;  n1->next = n2;
   n2->data = 13;  n2->next = n3;
   n3->data = 15;  n3->next = NULL;
/*
| 11 , &n2 | -> | 13 , &n3 | -> | 15 , NULL |
*/
   std::cout << "Linked List :: ";
   std::cout << n1->data << " -> " << n2->data << " -> " << n3->data << std::endl;

   delete(n1); delete(n2); delete(n3);
   std::cout << "\nWritten By: Lakshay Sharma 02396402721";
   return 0;
}
```

Output ::

```
c:\Users\Lakshay Sharma\College\DS\Experiment 3>.\"q1_VanillaLinkedList.exe"
Linked List :: 11 -> 13 -> 15

Written By: Lakshay Sharma 02396402721
```

Program 2

Aim :: Write a program for the insertion (at beginning,end and any position) in a Linked list.

Code ::

```
#include <iostream>

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

class LinkedList
{
private:
   Node* head;
   int list_length;
public:
   LinkedList() {
      head = NULL;
   }
   ~LinkedList() {
      Node* current = head;
      while (current != NULL) {
         Node* temp = current;
         current = current->next;
         delete temp;
      }
   }
   void insertAtBeginning(int value){
      Node* newNode = new Node();
      newNode->data = value;
      newNode->next = head;
      head = newNode;
      list_length++;
   }
   void insertAtEnd(int value){
      if (head == NULL) {insertAtBeginning(value); return;};
      Node* temp = head;
      while (temp->next != NULL) {
         temp = temp->next;
      }
      Node* newNode = new Node();
      newNode->data = value;
      newNode->next = NULL;
      temp->next = newNode;
```

```
        list_length++;
    }
    void insertAtIndex(int value, int index){
        if (index == 0) insertAtBeginning(value);
        else if ((index == list_length-1) || ( index == -1))    insertAtEnd(value);
        else{
            Node* temp = head;
            for (int i = 0; i < index-1; i++) temp = temp->next;
            Node* newNode = new Node();
            newNode->data = value;
            newNode->next = temp->next;
            temp->next = newNode;
        }
        list_length++;
    }
    friend std::ostream& operator<<(std::ostream& os, LinkedList& myList) {
        Node* temp = myList.head;
        while (temp != NULL) {
            std::cout << temp->data  << " -> ";
            temp = temp->next;
        }
        return os << "";
    }
};
int main() {
    LinkedList l1;
    l1.insertAtBeginning(1);    //  1
    std::cout << "insertAtBeginning(1) Linked List :: \t" << l1 << std::endl;
    l1.insertAtBeginning(2);    //  2 -> 1
    std::cout << "insertAtBeginning(2) Linked List :: \t" << l1 << std::endl;

    l1.insertAtEnd(3);          //  2 -> 1 -> 3
    std::cout << "insertAtEnd(3) Linked List :: \t\t" << l1 << std::endl;
    l1.insertAtEnd(4);          //  2 -> 1 -> 3 -> 4
    std::cout << "insertAtEnd(4) Linked List :: \t\t" << l1 << std::endl;

    l1.insertAtIndex(5,0);      //  5 -> 2 -> 1 -> 3 -> 4
    std::cout << "insertAtIndex(5,0) Linked List :: \t" << l1 << std::endl;

    l1.insertAtIndex(6,3);      //  5 -> 2 -> 1 -> 3 -> 4
    std::cout << "insertAtIndex(6,3) Linked List :: \t" << l1 << std::endl;

    l1.insertAtIndex(7,-1);     //  5 -> 2 -> 1 -> 3 -> 4
    std::cout << "insertAtIndex(7,-1) Linked List :: \t" << l1 << std::endl;

    std::cout << "\nWritten By: Lakshay Sharma 02396402721";
    return 0;
}
```

Output ::

```
c:\Users\Lakshay Sharma\College\DS\Experiment 3>.\"q2_InsertionInLinkedList.exe"
insertAtBeginning(1) Linked List ::     1 ->
insertAtBeginning(2) Linked List ::     2 -> 1 ->
insertAtEnd(3) Linked List ::           2 -> 1 -> 3 ->
insertAtEnd(4) Linked List ::           2 -> 1 -> 3 -> 4 ->
insertAtIndex(5,0) Linked List ::       5 -> 2 -> 1 -> 3 -> 4 ->
insertAtIndex(6,3) Linked List ::       5 -> 2 -> 1 -> 6 -> 3 -> 4 ->
insertAtIndex(7,-1) Linked List ::      5 -> 2 -> 1 -> 6 -> 3 -> 4 -> 7 ->

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```

Program 3

Aim :: Write a program for the deletion (at beginning,end and any position) in a Linked list..

Code ::

```
#include <iostream>

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

class LinkedList
{
private:
   Node* head;
   int list_length;
public:
   LinkedList() {
      head = NULL;
   }

   ~LinkedList() {
      Node* current = head;
      while (current != NULL) {
         Node* temp = current;
         current = current->next;
         delete temp;
      }
   }
   void insertAtBeginning(int value){
      Node* newNode = new Node();
      newNode->data = value;
      newNode->next = head;
      head = newNode;
      list_length++;
   }

   void insertAtEnd(int value){
      if (head == NULL) {insertAtBeginning(value); return;};
      Node* temp = head;
      while (temp->next != NULL) {
         temp = temp->next;
      }
      Node* newNode = new Node();
      newNode->data = value;
```

```
    newNode->next = NULL;
    temp->next = newNode;
    list_length++;
}

void deleteAtBeginning(){
    if(list_length != 0){
    Node* temp = head;
    head = head->next;
    delete temp;
    list_length--;
    }
    else std::cout << "List is empty" << std::endl;
}

void deleteAtEnd(){
    if(list_length != 0){
    Node* temp = head;
    while (temp->next->next != NULL) {
        temp = temp->next;
    }
    delete temp->next;
    temp->next = NULL;
    list_length--;
    }
    else std::cout << "List is empty" << std::endl;
}
void deleteAtIndex(int index){
    if(list_length != 0){
        if (index == 0) deleteAtBeginning();
        else if ((index == list_length-1) || ( index == -1))    deleteAtEnd();
        else{
            Node* temp = head;
            for (int i = 0; i < index-1; i++) temp = temp->next;
            Node* toDelete = temp->next;
            temp->next = temp->next->next;
            delete(toDelete);
        }
        list_length--;
    }
    else std::cout << "List is empty" << std::endl;
}
friend std::ostream& operator<<(std::ostream& os, LinkedList& myList) {
    Node* temp = myList.head;
    while (temp != NULL) {
        std::cout << temp->data  << " -> ";
        temp = temp->next;
    }
```

```
        return os << "";
    }
};
int main()
{
    LinkedList l1;
    l1.insertAtEnd(1);
    l1.insertAtEnd(2);
    l1.insertAtEnd(3);
    l1.insertAtEnd(4);
    l1.insertAtEnd(5);
    l1.insertAtEnd(6);
    l1.insertAtEnd(7);
    l1.insertAtEnd(8);

    //1 -> 2 -> 3 -> 4 -> 5 -> 6 -> 7 -> 8
    std::cout << "Linked List :: \t\t\t\t" << l1 << std::endl;

    l1.deleteAtBeginning();     //  2 -> 3 -> 4 -> 5 -> 6 -> 7 -> 8
    std::cout << "deleteAtBeginning() Linked List :: \t" << l1 << std::endl;

    l1.deleteAtEnd();          //  2 -> 3 -> 4 -> 5 -> 6 -> 7
    std::cout << "deleteAtEnd() Linked List :: \t\t" << l1 << std::endl;

    l1.deleteAtIndex(0);       //  3 -> 4 -> 5 -> 6 -> 7
    std::cout << "deleteAtIndex(0) Linked List :: \t" << l1 << std::endl;

    l1.deleteAtIndex(3);       //  3 -> 4 -> 5 -> 7
    std::cout << "deleteAtIndex(3) Linked List :: \t" << l1 << std::endl;

    l1.deleteAtIndex(-1);      //  3 -> 4 -> 5
    std::cout << "deleteAtIndex(-1) Linked List :: \t" << l1 << std::endl;

    std::cout << "\nWritten By: Lakshay Sharma 02396402721";
    return 0;
}
```

Output ::

```
c:\Users\Lakshay Sharma\College\DS\Experiment 3>.\"q3_DeletionInLinkedList.exe"
Linked List ::                          1 -> 2 -> 3 -> 4 -> 5 -> 6 -> 7 -> 8 ->
deleteAtBeginning() Linked List ::      2 -> 3 -> 4 -> 5 -> 6 -> 7 -> 8 ->
deleteAtEnd() Linked List ::            2 -> 3 -> 4 -> 5 -> 6 -> 7 ->
deleteAtIndex(0) Linked List ::         3 -> 4 -> 5 -> 6 -> 7 ->
deleteAtIndex(3) Linked List ::         3 -> 4 -> 5 -> 7 ->
deleteAtIndex(-1) Linked List ::        3 -> 4 -> 5 ->

Written By: Lakshay Sharma 02396402721
```

Program 4

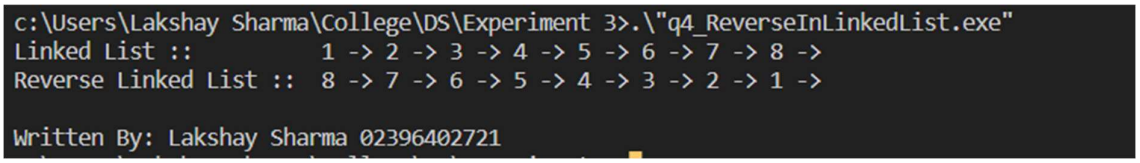
Aim :: Write a program for the reverse of a Linked list.

Code ::

```
#include <iostream>

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

class LinkedList
{
private:
   Node* head;
   int list_length;
public:
   LinkedList() {
      head = NULL;
   }

   ~LinkedList() {
      Node* current = head;
      while (current != NULL) {
         Node* temp = current;
         current = current->next;
         delete temp;
      }
   }
   void insertAtBeginning(int value){
      Node* newNode = new Node();
      newNode->data = value;
      newNode->next = head;
      head = newNode;
      list_length++;
   }

   void insertAtEnd(int value){
      if (head == NULL) {insertAtBeginning(value); return;};
      Node* temp = head;
      while (temp->next != NULL) {
         temp = temp->next;
      }
      Node* newNode = new Node();
      newNode->data = value;
```

```
        newNode->next = NULL;
        temp->next = newNode;
        list_length++;
    }
    void reverse() {
        Node* current = head;
        Node* prev = NULL;
        Node* next = NULL;
        while (current != NULL) {
            next = current->next;
            current->next = prev;
            prev = current;
            current = next;
        }
        head = prev;
    }

    friend std::ostream& operator<<(std::ostream& os, LinkedList& myList) {
        Node* temp = myList.head;
        while (temp != NULL) {
            std::cout << temp->data  << " -> ";
            temp = temp->next;
        }
        return os << "";
    }
};
int main()
{
    LinkedList l1;
    l1.insertAtEnd(1);
    l1.insertAtEnd(2);
    l1.insertAtEnd(3);
    l1.insertAtEnd(4);
    l1.insertAtEnd(5);
    l1.insertAtEnd(6);
    l1.insertAtEnd(7);
    l1.insertAtEnd(8);

    //1 -> 2 -> 3 -> 4 -> 5 -> 6 -> 7 -> 8
    std::cout << "Linked List :: \t\t" << l1 << std::endl;

    l1.reverse();    // 8 -> 7 -> 6 -> 5 -> 4 -> 3 -> 2 -> 1
    std::cout << "Reverse Linked List :: \t" << l1 << std::endl;


    std::cout << "\nWritten By: Lakshay Sharma 02396402721";
    return 0;
}
```

Output ::


c:\Users\Lakshay Sharma\College\DS\Experiment 3>.\"q4_ReverseInLinkedList.exe"
Linked List ::   1 -> 2 -> 3 -> 4 -> 5 -> 6 -> 7 -> 8 ->
Reverse Linked List :: 8 -> 7 -> 6 -> 5 -> 4 -> 3 -> 2 -> 1 ->
Written By: Lakshay Sharma 02396402721

Experiment 4

Program 1

Aim :: Write a program showing the implementation of Doubly and Circular linked list?

Code ::

```
#include <iostream>
struct Node{
   int data;
   Node* next;
   Node* prev;
};
int main() {
   Node* d1 = new Node();
   Node* d2 = new Node();
   Node* d3 = new Node();
   Node* d4 = new Node();
   Node* c1 = new Node();
   Node* c2 = new Node();
   Node* c3 = new Node();
   d1->prev = NULL; d1->data = 11; d1->next = d2;
   d2->prev = d1; d2->data = 12; d2->next = d3;
   d3->prev = d2; d3->data = 13; d3->next = d4;
   d4->prev = d3; d4->data = 14; d4->next = NULL;
   Node* temp = d1;
   std::cout << "Doubly Linked List :: \t\t";
   while (temp->next != NULL){
      std::cout << temp->data << " " << char(29) << " ";
      temp = temp->next;
   }
   std::cout << temp->data << std::endl;
   c1->prev = c3; c1->data = 21; c1->next = c2;
   c2->prev = c2; c2->data = 22; c2->next = c3;
   c3->prev = c1; c3->data = 23; c3->next = c1;
   Node* temp2 = c1;
   std::cout << "Circular Linked List :: \t" << char(4) << " ";
   while (temp2->next != c1){
      std::cout << temp2->data << " " << char(29) << " ";
      temp2 = temp2->next;
   }
   std::cout << temp2->data << " " <<char(4) << std::endl;
   delete(d1);delete(d2);delete(d3);delete(d4);delete(c1);delete(c2);delete(c3);
   std::cout << "\nWritten By: Lakshay Sharma 02396402721";
   return 0;
}
```

Output ::


(base) c:\Users\Lakshay Sharma\College\DS\Experiment 4>.\"q1_DoubleAndCircularLinkedList.exe"
Doubly Linked List :: 11 ⇔ 12 ⇔ 13 ⇔ 14
Circular Linked List :: ♦ 21 ⇔ 22 ⇔ 23 ♦
Written By: Lakshay Sharma 02396402721

Program 2

Aim :: Write a program for the insertion (at beginning, end and any position) in a Doubly and Circular linked list.

Code ::

```
#include <iostream>

class DoublyLinkedList {
private:
   // Definition for a node in the linked list
   struct Node {
      int data;
      Node* next;
      Node* prev;
   };

   Node* head;
   Node* tail;
   int size;
public:
   DoublyLinkedList() {
      head = NULL;
      tail = NULL;
      size = 0;
   }

   // Insert a new node at the front of the list
   void insertAtBeginning(int data) {
      Node* newNode = new Node;
      newNode->data = data;
      newNode->prev = NULL;
      newNode->next = head;
      if (head != NULL) {
         head->prev = newNode;
      }
      head = newNode;
      if (tail == NULL) {
         tail = newNode;
      }
      size++;
   }

   // Insert a new node at the back of the list
   void insertAtEnd(int data) {
      Node* newNode = new Node;
      newNode->data = data;
```

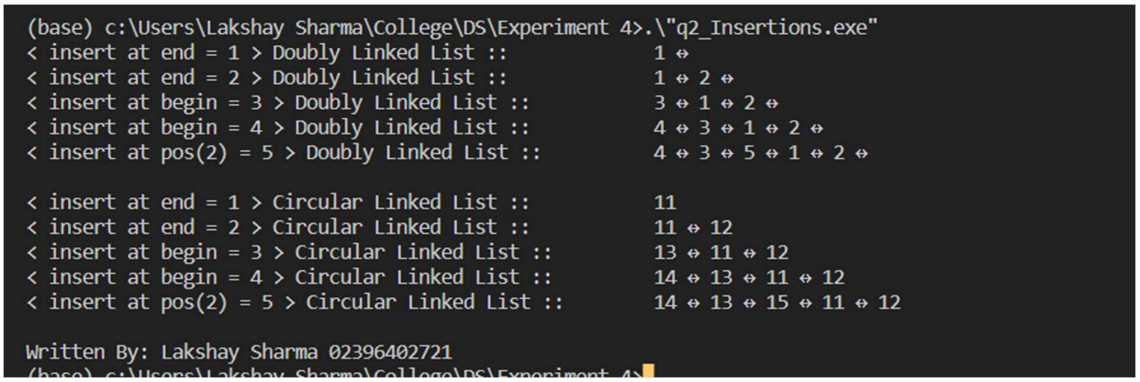
```
    newNode->next = NULL;
    newNode->prev = tail;
    if (tail != NULL) {
        tail->next = newNode;
    }
    tail = newNode;
        if (head == NULL) {
    head = newNode;
    }
    size++;
}

void insertAtPos(int pos, int data) {
    Node *newNode = new Node;
    newNode->data = data;
    newNode->prev = NULL;
    newNode->next = NULL;

    if (pos == 0) {
        insertAtBeginning(data);
        return;
    }

    Node *temp = head;
    int i = 0;
    while (i < pos - 1 && temp->next != NULL) {
        temp = temp->next;
        i++;
    }

    if (temp->next == NULL) {
        std::cout << "Invalid position!" << std::endl;
    }
    else {
        newNode->prev = temp;
        newNode->next = temp->next;
        temp->next->prev = newNode;
        temp->next = newNode;
    }
}
// Prints out the list
friend std::ostream& operator<<(std::ostream& os, DoublyLinkedList& myList) {
    Node* temp = myList.head;
    while (temp != NULL) {
        std::cout << temp->data << " " << char(29) << " ";
        temp = temp->next;
    }
    return os << "";
```

```
    }
    // Check if the list is empty
    bool empty() {
        return size == 0;
    }
};

class CircularLinkedList {
private:
    struct Node {
        int data;
        Node *next;
    };
    Node *head;
public:
    CircularLinkedList() {
        head = NULL;
    }
    void insertAtEnd(int data) {
        Node *newNode = new Node;
        newNode->data = data;
        newNode->next = NULL;

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

    void insertAtBegin(int data) {
        Node *newNode = new Node;
        newNode->data = data;
        newNode->next = NULL;

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

```
            while (temp->next != head) {
            temp = temp->next;
            }
            temp->next = newNode;
            newNode->next = head;
            head = newNode;
        }
    }

    void insertAtPos(int pos, int data) {
        Node *newNode = new Node;
        newNode->data = data;
        newNode->next = NULL;

        if (pos == 0) {
            insertAtBegin(data);
            return;
        }

        Node *temp = head;
        int i = 0;
        while (i < pos - 1 && temp->next != head) {
            temp = temp->next;
            i++;
        }

        if (temp->next == head) {
            std::cout << "Invalid position!" << std::endl;
        } else {
            newNode->next = temp->next;
            temp->next = newNode;
        }
    }

    // Prints out the list
    friend std::ostream& operator<<(std::ostream& os, CircularLinkedList& myList) {
        Node* temp = myList.head;
        while (temp->next != myList.head) {
            std::cout << temp->data  << " " << char(29) << " ";
            temp = temp->next;
        }
        return os << temp->data;
    }
};

int main() {
    DoublyLinkedList list;
```

```
    list.insertAtEnd(1);
    std::cout << "< insert at end = 1 > Doubly Linked List :: \t\t" <<  list <<std::endl;

    list.insertAtEnd(2);
    std::cout << "< insert at end = 2 > Doubly Linked List :: \t\t" <<  list <<std::endl;

    list.insertAtBeginning(3);
    std::cout << "< insert at begin = 3 > Doubly Linked List :: \t\t" <<  list <<std::endl;

    list.insertAtBeginning(4);
    std::cout << "< insert at begin = 4 > Doubly Linked List :: \t\t" <<  list <<std::endl;

    list.insertAtPos(2, 5);
    std::cout << "< insert at pos(2) = 5 > Doubly Linked List :: \t\t" <<  list <<std::endl << std::endl;

    CircularLinkedList clist;
    clist.insertAtEnd(11);
    std::cout << "< insert at end = 1 > Circular Linked List :: \t\t" <<  clist <<std::endl;

    clist.insertAtEnd(12);
    std::cout << "< insert at end = 2 > Circular Linked List :: \t\t" <<  clist <<std::endl;

    clist.insertAtBegin(13);
    std::cout << "< insert at begin = 3 > Circular Linked List :: \t" <<  clist <<std::endl;

    clist.insertAtBegin(14);
    std::cout << "< insert at begin = 4 > Circular Linked List :: \t" <<  clist <<std::endl;

    clist.insertAtPos(2, 15);
    std::cout << "< insert at pos(2) = 5 > Circular Linked List :: \t" <<  clist <<std::endl;

    std::cout << "\nWritten By: Lakshay Sharma 02396402721";
    return 0;
}
```

Output ::


(base) c:\Users\Lakshay Sharma\College\DS\Experiment 4>.\"q2_Insertions.exe"
< insert at end = 1 > Doubly Linked List :: 1 ↔
< insert at end = 2 > Doubly Linked List :: 1 ↔ 2 ↔
< insert at begin = 3 > Doubly Linked List :: 3 ↔ 1 ↔ 2 ↔
< insert at begin = 4 > Doubly Linked List :: 4 ↔ 3 ↔ 1 ↔ 2 ↔
< insert at pos(2) = 5 > Doubly Linked List :: 4 ↔ 3 ↔ 5 ↔ 1 ↔ 2 ↔
< insert at end = 1 > Circular Linked List :: 11
< insert at end = 2 > Circular Linked List :: 11 ↔ 12
< insert at begin = 3 > Circular Linked List :: 13 ↔ 11 ↔ 12
< insert at begin = 4 > Circular Linked List :: 14 ↔ 13 ↔ 11 ↔ 12
< insert at pos(2) = 5 > Circular Linked List :: 14 ↔ 13 ↔ 15 ↔ 11 ↔ 12
Written By: Lakshay Sharma 02396402721

Program 3

Aim :: Write a program for the deletion (at beginning, end and any position) in a Doubly and Circular linked list.

Code ::

```
#include <iostream>

class DoublyLinkedList {
private:
   // Definition for a node in the linked list
   struct Node {
      int data;
      Node* next;
      Node* prev;
   };
   Node* head;
   Node* tail;
   int size;
public:
   DoublyLinkedList() {
      head = NULL;
      tail = NULL;
      size = 0;
   }
   // Insert a new node at the back of the list
   void insertAtEnd(int data) {
      Node* newNode = new Node;
      newNode->data = data;
      newNode->next = NULL;
      newNode->prev = tail;
      if (tail != NULL) {
         tail->next = newNode;
      }
      tail = newNode;
         if (head == NULL) {
      head = newNode;
      }
      size++;
   }

   // Remove the front node of the list
   void deleteAtBeginning() {
      if (head == NULL) {
         return;
      }
      Node* temp = head;
```

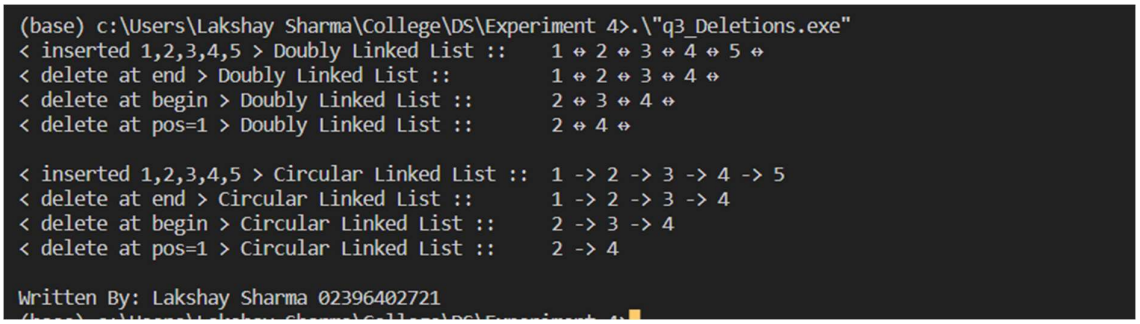
```
    head = head->next;
    if (head != NULL) {
        head->prev = NULL;
    }
    delete temp;
    size--;
}

// Remove the back node of the list
void deleteAtEnd() {
    if (tail == NULL) {
        return;
    }
    Node* temp = tail;
    tail = tail->prev;
    if (tail != NULL) {
        tail->next = NULL;
    }
    delete temp;
    size--;
}

void deleteAtPos(int pos) {
    Node *temp = head;
    if (pos == 0) { deleteAtBeginning(); return;}
    int i = 0;
    while (i < pos && temp->next != NULL) {
        temp = temp->next;
        i++;
    }
    if (temp->next == NULL) {
        std::cout << "Invalid position!" << std::endl;
    }
    else {
        temp->prev->next = temp->next;
        temp->next->prev = temp->prev;
        delete temp;
    }
}

// Prints out the list
friend std::ostream& operator<<(std::ostream& os, DoublyLinkedList& myList) {
    Node* temp = myList.head;
    while (temp != NULL) {
        std::cout << temp->data  << " " << char(29) << " ";
        temp = temp->next;
    }
    return os << "";
```

```
    }
    // Check if the list is empty
    bool empty() {
        return size == 0;
    }
};

class CircularLinkedList {
private:
    struct Node {
        int data;
        Node *next;
    };
    Node *head;

public:
    CircularLinkedList() {
        head = NULL;
    }
    void insertAtEnd(int data) {
        Node *newNode = new Node;
        newNode->data = data;
        newNode->next = NULL;

        if (head == NULL) {
            head = newNode;
            newNode->next = head;
        }
        else {
            Node *temp = head;
            while (temp->next != head) {
                temp = temp->next;
            }
            temp->next = newNode;
            newNode->next = head;
        }
    }
    void deleteAtEnd() {
        Node *temp = head;
        Node *prev = NULL;
        while (temp->next != head) {
            prev = temp;
            temp = temp->next;
        }
        prev->next = head;
        delete temp;
    }
```

```
    void deleteAtBegin() {
        Node *temp = head;
        Node *prev = head;
        while (temp->next != head) {
            temp = temp->next;
        }
        temp->next = head->next;
        delete prev;
        head = temp->next;
    }

    void deleteAtPos(int pos) {
        Node *temp = head;
        Node *prev = NULL;
        if (pos == 0) { deleteAtBegin(); return; };

        int i = 0;
        while (i < pos && temp->next != head) {
            prev = temp;
            temp = temp->next;
            i++;
        }
        if (temp->next == head) {
            std::cout << "Invalid position!" << std::endl;
        } else {
            prev->next = temp->next;
            delete temp;
        }
    }
    // Prints out the list
    friend std::ostream& operator<<(std::ostream& os, CircularLinkedList& myList) {
        Node* temp = myList.head;
        while (temp->next != myList.head) {
            std::cout << temp->data  << " -> ";
            temp = temp->next;
        }
        return os << temp->data;
    }
};

int main() {
    DoublyLinkedList list;

    list.insertAtEnd(1);
    list.insertAtEnd(2);
    list.insertAtEnd(3);
    list.insertAtEnd(4);
    list.insertAtEnd(5);
```

```
    std::cout << "< inserted 1,2,3,4,5 > Doubly Linked List :: \t" <<  list <<std::endl;

    list.deleteAtEnd();
    std::cout << "< delete at end > Doubly Linked List :: \t" <<  list <<std::endl;

    list.deleteAtBeginning();
    std::cout << "< delete at begin > Doubly Linked List :: \t" <<  list <<std::endl;

    list.deleteAtPos(1);
    std::cout << "< delete at pos=1 > Doubly Linked List :: \t" <<  list <<std::endl << std::endl;

    CircularLinkedList clist;

    clist.insertAtEnd(1);
    clist.insertAtEnd(2);
    clist.insertAtEnd(3);
    clist.insertAtEnd(4);
    clist.insertAtEnd(5);
    std::cout << "< inserted 1,2,3,4,5 > Circular Linked List :: \t" <<  clist <<std::endl;

    clist.deleteAtEnd();
    std::cout << "< delete at end > Circular Linked List :: \t" <<  clist <<std::endl;

    clist.deleteAtBegin();
    std::cout << "< delete at begin > Circular Linked List :: \t" <<  clist <<std::endl;

    clist.deleteAtPos(1);
    std::cout << "< delete at pos=1 > Circular Linked List :: \t" <<  clist <<std::endl;

    std::cout << "\nWritten By: Lakshay Sharma 02396402721";
    return 0;
}
```

Output ::


(base) c:\Users\Lakshay Sharma\College\DS\Experiment 4>.\"q3_Deletions.exe"
< inserted 1,2,3,4,5 > Doubly Linked List :: 1 ⇔ 2 ⇔ 3 ⇔ 4 ⇔ 5 ⇔
< delete at end > Doubly Linked List :: 1 ⇔ 2 ⇔ 3 ⇔ 4 ⇔
< delete at begin > Doubly Linked List :: 2 ⇔ 3 ⇔ 4 ⇔
< delete at pos=1 > Doubly Linked List :: 2 ⇔ 4 ⇔
< inserted 1,2,3,4,5 > Circular Linked List :: 1 -> 2 -> 3 -> 4 -> 5
< delete at end > Circular Linked List :: 1 -> 2 -> 3 -> 4
< delete at begin > Circular Linked List :: 2 -> 3 -> 4
< delete at pos=1 > Circular Linked List :: 2 -> 4
Written By: Lakshay Sharma 02396402721

Program 4

Aim :: Write a program for the reverse of a Doubly and Circular linked list.

Code ::

```
#include <iostream>

class DoublyLinkedList {
private:
   // Definition for a node in the linked list
   struct Node {
      int data;
      Node* next;
      Node* prev;
   };

   Node* head;
   Node* tail;
   int size;
public:
   DoublyLinkedList() {
      head = NULL;
      tail = NULL;
      size = 0;
   }
   // Insert a new node at the back of the list
   void insertAtEnd(int data) {
      Node* newNode = new Node;
      newNode->data = data;
      newNode->next = NULL;
      newNode->prev = tail;
      if (tail != NULL) {
         tail->next = newNode;
      }
      tail = newNode;
         if (head == NULL) {
      head = newNode;
      }
      size++;
   }

   void reverse(){
      Node* temp = head;
      Node* tempp = head->prev;
      Node* tempn = head->next;

      while (temp->next != NULL){
```

```
            temp = temp->next;
            tempp = temp->prev->prev;
            tempn = temp;
            temp->prev->next = tempp;
            temp->prev->prev = tempn;
        }
        tempp = temp->prev;
        tempn = temp->next;
        temp->next = tempp;
        temp->prev = tempn;
        head = temp;
    }
    // Prints out the list
    friend std::ostream& operator<<(std::ostream& os, DoublyLinkedList& myList) {
        Node* temp = myList.head;
        while (temp != NULL) {
            std::cout << temp->data << " " << char(29) << " ";
            temp = temp->next;
        }
        return os << "";
    }
};
class CircularLinkedList {
private:
    struct Node {
        int data;
        Node *next;
    };
    Node *head;

public:
    CircularLinkedList() {
        head = NULL;
    }
    void insertAtEnd(int data) {
        Node *newNode = new Node;
        newNode->data = data;
        newNode->next = NULL;

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

```
            temp->next = newNode;
            newNode->next = head;
        }
    }
    void reverse() {
        if(head != NULL) {
            Node* prev = head;
            Node* temp = head;
            Node* curr = head->next;
            prev->next = prev;

            while(curr != head) {
                temp = curr->next;
                curr->next = prev;
                head->next = curr;
                prev = curr;
                curr = temp;
            }
            head = prev;
        }
    }
    // Prints out the list
    friend std::ostream& operator<<(std::ostream& os, CircularLinkedList& myList) {
        Node* temp = myList.head;
        while (temp->next != myList.head) {
            std::cout << temp->data  << " -> ";
            temp = temp->next;
        }
        return os << temp->data;
    }
};
int main(){
    DoublyLinkedList list;

    list.insertAtEnd(1);
    list.insertAtEnd(2);
    list.insertAtEnd(3);
    list.insertAtEnd(4);
    list.insertAtEnd(5);
    std::cout << "< original > Doubly Linked List :: \t" <<  list <<std::endl;

    list.reverse();
    std::cout << "< reversed > Doubly Linked List :: \t" <<  list <<std::endl << std::endl;

    CircularLinkedList clist;

    clist.insertAtEnd(1);
    clist.insertAtEnd(2);
```

```
    clist.insertAtEnd(3);
    clist.insertAtEnd(4);
    clist.insertAtEnd(5);

    std::cout << "< original > Circular Linked List :: \t" <<  clist <<std::endl;

    clist.reverse();
    std::cout << "< original > Circular Linked List :: \t" <<  clist <<std::endl;

    std::cout << "\nWritten By: Lakshay Sharma 02396402721";

    return 0;
}
```

Output ::

```
(base) c:\Users\Lakshay Sharma\College\DS\Experiment 4>.\"q4_Reverses.exe"
< original > Doubly Linked List ::      1 ⇔ 2 ⇔ 3 ⇔ 4 ⇔ 5 ⇔
< reversed > Doubly Linked List ::      5 ⇔ 4 ⇔ 3 ⇔ 2 ⇔ 1 ⇔

< original > Circular Linked List ::    1 -> 2 -> 3 -> 4 -> 5
< original > Circular Linked List ::    5 -> 4 -> 3 -> 2 -> 1

Written By: Lakshay Sharma 02396402721
```

Experiment 5

Program 1

Aim :: Write a program showing the implementation of Stack and Queue with Linked list.

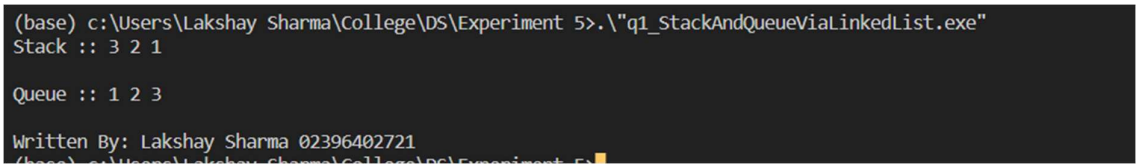
Code ::

```
#include <iostream>

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

// Stack class with push, pop, and peek operations
class Stack {
private:
   Node* top;

public:
   Stack() { top = NULL; }

   void push(int data) {
      Node* newNode = new Node;
      newNode->data = data;
      newNode->next = top;

      // Set the new node as the top of the stack
      top = newNode;
   }

   int pop() {
      // Return -1 if the stack is empty
      if (top == NULL) return -1;
      int data = top->data;

      Node* temp = top;
      top = top->next;
      delete temp;
      return data;
   }

   int peek() {
      // Return -1 if the stack is empty
      if (top == NULL) return -1;
      return top->data;
```

```
    }
};

// Queue class with enqueue, dequeue, and peek operations
class Queue {
private:
    Node* head;
    Node* tail;

public:
    Queue() { head = tail = NULL; }

    void enqueue(int data) {
        Node* newNode = new Node;
        newNode->data = data;
        newNode->next = NULL;

        // If the queue is empty, set the new node as both the head and tail
        if (tail == NULL) {
            head = tail = newNode;
        }
        // Otherwise, set the new node as the tail and update the tail pointer
        else {
            tail->next = newNode;
            tail = newNode;
        }
    }

    int dequeue() {
        // Return -1 if the queue is empty
        if (head == NULL) return -1;

        int data = head->data;
        Node* temp = head;
        head = head->next;

        // If the head is now null, set the tail to be null as well (queue is empty)
        if (head == NULL) tail = NULL;

        delete temp;
        return data;
    }

    int peek() {
        // Return -1 if the queue is empty
        if (head == nullptr) return -1;
        return head->data;
    }
```

```
};

int main() {
   // Create a stack and push some values onto it
   Stack stack;
   stack.push(1);
   stack.push(2);
   stack.push(3);

   // Pop and print the values from the stack
   std::cout << "Stack :: " ;
   std::cout << stack.pop() << " ";
   std::cout << stack.pop() << " ";
   std::cout << stack.pop() << std::endl << std::endl;

   // Create a queue and enqueue some values
   Queue queue;
   queue.enqueue(1);
   queue.enqueue(2);
   queue.enqueue(3);

   // Dequeue and print the values from the queue
   std::cout << "Queue :: " ;
   std::cout << queue.dequeue() << " ";
   std::cout << queue.dequeue() << " ";
   std::cout << queue.dequeue() << std::endl;

   std::cout << "\nWritten By: Lakshay Sharma 02396402721";
   return 0;
}
```

Output ::


(base) c:\Users\Lakshay Sharma\College\DS\Experiment 5>.\"q1_StackAndQueueViaLinkedList.exe"
Stack :: 3 2 1
Queue :: 1 2 3
Written By: Lakshay Sharma 02396402721

Experiment 6

Program 1

Aim :: Write a program to create a Binary tree and perform traversal (pre-order, post-order, In-order).

Code ::

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

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

Node* createNode(int data) {
   Node *newNode = new Node;
   newNode->data = data;
   newNode->left = NULL;
   newNode->right = NULL;
   return newNode;
}

void preOrderTraversal(Node *root) {
   if (root == NULL) return;
   cout << root->data << " ";
   preOrderTraversal(root->left);
   preOrderTraversal(root->right);
}

void inOrderTraversal(Node *root) {
   if (root == NULL) return;
   inOrderTraversal(root->left);
   cout << root->data << " ";
   inOrderTraversal(root->right);
}

void postOrderTraversal(Node *root) {
   if (root == NULL) return;
   postOrderTraversal(root->left);
   postOrderTraversal(root->right);
   cout << root->data << " ";
}
```

```
int main() {
    Node *root = createNode(1);
    root->left = createNode(2);
    root->right = createNode(3);
    root->left->left = createNode(4);
    root->left->right = createNode(5);

    cout << "Pre-order traversal: ";
    preOrderTraversal(root);
    cout << endl;

    cout << "In-order traversal: ";
    inOrderTraversal(root);
    cout << endl;

    cout << "Post-order traversal: ";
    postOrderTraversal(root);
    cout << endl;

    std::cout << "\nWritten By: Lakshay Sharma 02396402721";
    return 0;
}
```

Output ::

/* Actual Tree →

```
   1
  /  \
 2    3
/ \
4  5
```

*/

```
c:\Users\Lakshay Sharma\College\DS\Experiment 6>.\"q1_BinaryTree.exe"
Pre-order traversal: 1 2 4 5 3
In-order traversal: 4 2 5 1 3
Post-order traversal: 4 5 2 3 1

Written By: Lakshay Sharma 02396402721
```

Program 2

Aim :: Write a program to create a Binary search tree and perform traversal (pre-order, post-order, In-order).

Code ::

```
#include <iostream>

using namespace std;

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

Node* createNode(int data) {
   Node *newNode = new Node;
   newNode->data = data;
   newNode->left = NULL;
   newNode->right = NULL;
   return newNode;
}

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

void preOrderTraversal(Node *root) {
   if (root == NULL) return;
   cout << root->data << " ";
   preOrderTraversal(root->left);
   preOrderTraversal(root->right);
}

void inOrderTraversal(Node *root) {
   if (root == NULL) return;
   inOrderTraversal(root->left);
   cout << root->data << " ";
   inOrderTraversal(root->right);
}

void postOrderTraversal(Node *root) {
   if (root == NULL) return;
```

```
    postOrderTraversal(root->left);
    postOrderTraversal(root->right);
    cout << root->data << " ";
}

int main() {
    Node *root = NULL;
    root = insert(root, 5);
    root = insert(root, 3);
    root = insert(root, 7);
    root = insert(root, 2);
    root = insert(root, 4);
    root = insert(root, 6);
    root = insert(root, 8);

    cout << "Pre-order traversal: ";
    preOrderTraversal(root);
    cout << endl;

    cout << "In-order traversal: ";
    inOrderTraversal(root);
    cout << endl;

    cout << "Post-order traversal: ";
    postOrderTraversal(root);
    cout << endl;

    std::cout << "\nWritten By: Lakshay Sharma 02396402721";
    return 0;
}
```

Output ::

```
/*  Actual Tree
    5
   / \
  3   7
 / \ / \
2  4 6  8

*/
```

```
c:\Users\Lakshay Sharma\College\DS\Experiment 6>.\"q2_BST.exe"
Pre-order traversal: 5 3 2 4 7 6 8
In-order traversal: 2 3 4 5 6 7 8
Post-order traversal: 2 4 3 6 8 7 5

Written By: Lakshay Sharma 02396402721
```

Experiment 7

Program 1

Aim :: Write a program showing the implementation of Insertion sort?

Code ::

```
#include <iostream>
#include <vector>

// Function to sort an array using insertion sort
void insertionSort(std::vector<int>& arr)
{
   int n = arr.size();

   // Iterate over the array, starting from the second element
   for (int i = 1; i < n; i++) {
      // Get the current element
      int curr = arr[i];

      // Compare the current element with the elements to its left, until it is in the correct position
      int j = i - 1;

      while (j >= 0 && arr[j] > curr) {
         // Shift the elements to the right to make room for the current element
         arr[j + 1] = arr[j];
         j--;
         }

      // Insert the current element into its correct position
      arr[j + 1] = curr;
      std::cout << "Step " << i << " : \t" ;
      for (int x : arr) {
         std::cout << x << " ";
      }
      std::cout << std::endl;
   }
}

int main()
{
   // Test the insertion sort function
   std::vector<int> arr = { 4, 2, 1, 3, 6, 5 };

   std::cout << "Input : \t" ;
   for (int x : arr) {
```

```
        std::cout << x << " ";
    }
    std::cout << std::endl;

    insertionSort(arr);

    std::cout << "Output : \t" ;
    for (int x : arr) {
        std::cout << x << " ";
    }
    std::cout << std::endl;
    std::cout << std::endl;
    std::cout << "\nWritten By: Lakshay Sharma 02396402721";
    return 0;
}
```

Output ::

```
(base) c:\Users\Lakshay Sharma\College\DS\Experiment 7>.\"q1_InsertionSort.exe"
Input :         4 2 1 3 6 5
Step 1 :        2 4 1 3 6 5
Step 2 :        1 2 4 3 6 5
Step 3 :        1 2 3 4 6 5
Step 4 :        1 2 3 4 6 5
Step 5 :        1 2 3 4 5 6
Output :        1 2 3 4 5 6


Written By: Lakshay Sharma 02396402721
```

Program 2

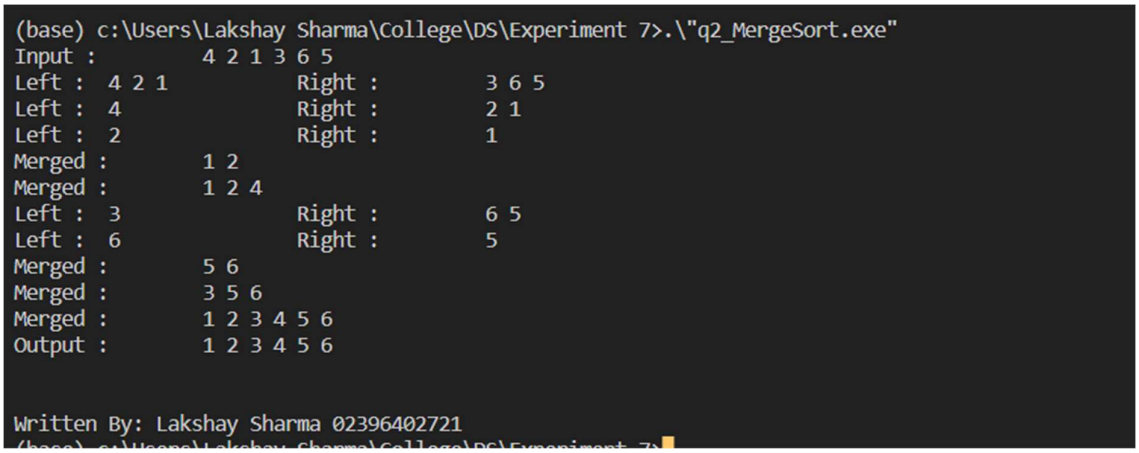
Aim :: Write a program showing the implementation of Merge sort?

Code ::

```
#include <iostream>
#include <vector>

// Function to merge two sorted arrays
std::vector<int> merge(const std::vector<int>& left, const std::vector<int>& right)
{
   // Create a result vector
   std::vector<int> result;

   // Set up two indices, one for each array
   int i = 0, j = 0;

   // Iterate until one of the indices reaches the end of its array
   while (i < left.size() && j < right.size()) {
      // Compare the elements at the current indices and add the smaller one to the result
      if (left[i] < right[j]) {
         result.push_back(left[i++]);
      }
      else {
         result.push_back(right[j++]);
      }
   }

   // Add the remaining elements from the left array, if any
   while (i < left.size()) {
      result.push_back(left[i++]);
   }

   // Add the remaining elements from the right array, if any
   while (j < right.size()) {
      result.push_back(right[j++]);
   }
   std::cout << "Merged : \t" ;
   for (int x : result) {
      std::cout << x << " ";
   }
   std::cout << "\n" ;
   return result;
}

// Recursive function to sort an array using merge sort
std::vector<int> mergeSort(std::vector<int>& arr) {
```

```
    // Base case: If the array has 1 or fewer elements, it is already sorted
    if (arr.size() <= 1) {
        return arr;
    }

    // Split the array in half
    int mid = arr.size() / 2;
    std::vector<int> left(arr.begin(), arr.begin() + mid);
    std::vector<int> right(arr.begin() + mid, arr.end());

    std::cout << "Left : \t" ;
    for (int x : left) {
        std::cout << x << " ";
    }
    std::cout << "\t\t" ;
    std::cout << "Right : \t" ;
    for (int x : right) {
        std::cout << x << " ";
    }
    std::cout << std::endl;
    // Recursively sort the left and right halves
    left = mergeSort(left);
    right = mergeSort(right);

    // Merge the sorted left and right halves
    return merge(left, right);
}

int main() {
    // Test the merge sort function
    std::vector<int> arr = { 4, 2, 1, 3, 6, 5 };
    std::cout << "Input : \t" ;
    for (int x : arr) {
        std::cout << x << " ";
    }
    std::cout << std::endl;

    arr = mergeSort(arr);

    std::cout << "Output : \t" ;
    for (int x : arr) {
        std::cout << x << " ";
    }
    std::cout << std::endl;
    std::cout << std::endl;
    std::cout << "\nWritten By: Lakshay Sharma 02396402721";
    return 0;
}
```

Output ::


(base) c:\Users\Lakshay Sharma\College\DS\Experiment 7>.\"q2_MergeSort.exe"
Input : 4 2 1 3 6 5
Left : 4 2 1 Right : 3 6 5
Left : 4 Right : 2 1
Left : 2 Right : 1
Merged : 1 2
Merged : 1 2 4
Left : 3 Right : 6 5
Left : 6 Right : 5
Merged : 5 6
Merged : 3 5 6
Merged : 1 2 3 4 5 6
Output : 1 2 3 4 5 6
Written By: Lakshay Sharma 02396402721

Program 3

Aim :: Write a program showing the implementation of Selection sort?

Code ::

```
#include <iostream>
#include <vector>

// Function to sort an array using selection sort
void selectionSort(std::vector<int>& arr)
{
   int n = arr.size();

   // Iterate over the array, starting from the first element
   for (int i = 0; i < n - 1; i++) {
      // Find the index of the minimum element in the unsorted portion of the array
      int minIndex = i;
      for (int j = i + 1; j < n; j++) {
         if (arr[j] < arr[minIndex]) {
            minIndex = j;
         }
         std::cout << "Step " << i << "." << j << " : \t" ;
         for (int x : arr) {
            std::cout << x << " ";
         }
         std::cout << "\t<" << arr[minIndex] << ">" << std::endl;
      }

      // Swap the minimum element with the first element of the unsorted portion
      int temp = arr[i];
      arr[i] = arr[minIndex];
      arr[minIndex] = temp;
      std::cout << "Step " << i << "->" << " : \t" ;
      for (int x : arr) {
         std::cout << x << " ";
      }
      std::cout << std::endl << std::endl;
   }
}

int main()
{
   // Test the selection sort function
   std::vector<int> arr = { 4, 2, 1, 3, 6, 5 };
   std::cout << "Input : \t" ;
   for (int x : arr) {
      std::cout << x << " ";
```

```
    }
    std::cout << std::endl;

    selectionSort(arr);

    std::cout << "Output : \t" ;
    for (int x : arr) {
        std::cout << x << " ";
    }
    std::cout << std::endl;
    std::cout << "\nWritten By: Lakshay Sharma 02396402721";
    return 0;
}
```

Output ::

```
(base) c:\Users\Lakshay Sharma\College\DS\Experiment 7>.\"q3_SelectionSort.exe"
Input :         4 2 1 3 6 5
Step 0.1 :      4 2 1 3 6 5     <2>
Step 0.2 :      4 2 1 3 6 5     <1>
Step 0.3 :      4 2 1 3 6 5     <1>
Step 0.4 :      4 2 1 3 6 5     <1>
Step 0.5 :      4 2 1 3 6 5     <1>
Step 0-> :      1 2 4 3 6 5

Step 1.2 :      1 2 4 3 6 5     <2>
Step 1.3 :      1 2 4 3 6 5     <2>
Step 1.4 :      1 2 4 3 6 5     <2>
Step 1.5 :      1 2 4 3 6 5     <2>
Step 1-> :      1 2 4 3 6 5

Step 2.3 :      1 2 4 3 6 5     <3>
Step 2.4 :      1 2 4 3 6 5     <3>
Step 2.5 :      1 2 4 3 6 5     <3>
Step 2-> :      1 2 3 4 6 5

Step 3.4 :      1 2 3 4 6 5     <4>
Step 3.5 :      1 2 3 4 6 5     <4>
Step 3-> :      1 2 3 4 6 5

Step 4.5 :      1 2 3 4 6 5     <5>
Step 4-> :      1 2 3 4 5 6

Output :        1 2 3 4 5 6

Written By: Lakshay Sharma 02396402721
```

Program 4

Aim :: Write a program showing the implementation of Quick sort?

Code ::

```
#include <iostream>
#include <vector>

// Function to partition an array around a pivot
int partition(std::vector<int>& arr, int low, int high)
{
   // Choose the pivot as the last element in the array
   int pivot = arr[high];

   // Set up two indices, one for the left side of the pivot and one for the right side
   int i = low - 1;
   for (int j = low; j < high; j++) {
      // If the current element is smaller than or equal to the pivot, swap it with the element at the
left index
      if (arr[j] <= pivot) {
         i++;
         int temp = arr[i];
         arr[i] = arr[j];
         arr[j] = temp;
      }
   }

   // Swap the pivot with the element at the left index + 1
   int temp = arr[i + 1];
   arr[i + 1] = arr[high];
   arr[high] = temp;

   // Return the index of the pivot
   return i + 1;
}

// Recursive function to sort an array using quick sort
void quickSort(std::vector<int>& arr, int low, int high)
{
   if (low < high) {
      // Partition the array around a pivot and get the pivot's index
      int pivotIndex = partition(arr, low, high);

      std::cout << "Step-> : \t" ;
      for (int x = 0; x < arr.size() ; x++) {
         if (x == pivotIndex) std::cout << "<" << arr[x] << ">" << " ";
         else std::cout << arr[x] << " ";
```

```
            // std::cout << arr[x] << " ";
        }
        std::cout << std::endl;
        // Recursively sort the left and right halves of the array
        quickSort(arr, low, pivotIndex - 1);
        quickSort(arr, pivotIndex + 1, high);
    }
}

int main()
{
    // Test the quick sort function
    std::vector<int> arr = { 4, 2, 1, 3, 6, 5 };
    std::cout << "Input : \t" ;
    for (int x : arr) {
        std::cout << x << " ";
    }
    std::cout << std::endl;

    quickSort(arr,0, arr.size()-1);

    std::cout << "Output : \t" ;
    for (int x : arr) {
        std::cout << x << " ";
    }
    std::cout << std::endl;
    std::cout << "\nWritten By: Lakshay Sharma 02396402721";
    return 0;
}
```

Output ::

```
(base) c:\Users\Lakshay Sharma\College\DS\Experiment 7>.\"q4_QuickSort.exe"
Input :         4 2 1 3 6 5
Step-> :        4 2 1 3 <5> 6
Step-> :        2 1 <3> 4 5 6
Step-> :        <1> 2 3 4 5 6
Output :        1 2 3 4 5 6

Written By: Lakshay Sharma 02396402721
```

Program 5

Aim :: Write a program showing the implementation of Bubble sort?

Code ::

```
#include <iostream>
#include <vector>

// Function to sort an array using bubble sort
void bubbleSort(std::vector<int>& arr)
{
   int n = arr.size();

   // Iterate over the array, starting from the second element
   for (int i = 0; i < n - 1; i++) {
      // Flag to track if any swaps were made in the current pass
      bool swapped = false;

      // Iterate over the unsorted portion of the array
      for (int j = 0; j < n - i - 1; j++) {
         // If the current element is greater than the next element, swap them
         if (arr[j] > arr[j + 1]) {
            int temp = arr[j];
            arr[j] = arr[j + 1];
            arr[j + 1] = temp;
            swapped = true;
         }
         std::cout << "Step " << i << "." << j <<" : \t" ;
         for (int x : arr) {
            std::cout << x << " ";
         }
         std::cout << std::endl;
      }
      std::cout << std::endl;

      // If no swaps were made, the array is already sorted
      if (!swapped) {
         break;
      }
   }
}

int main()
{
   // Test the bubble sort function
   std::vector<int> arr = { 4, 2, 1, 3, 6, 5 };
   std::cout << "Input : \t" ;
```

```
    for (int x : arr) {
        std::cout << x << " ";
    }
    std::cout << std::endl;

    bubbleSort(arr);

    std::cout << "Output : \t" ;
    for (int x : arr) {
        std::cout << x << " ";
    }
    std::cout << std::endl;
    std::cout << "\nWritten By: Lakshay Sharma 02396402721";
    return 0;
}
```

Output ::

```
(base) c:\Users\Lakshay Sharma\College\DS\Experiment 7>.\"q5_BubbleSort.exe"
Input :         4 2 1 3 6 5
Step 0.0 :      2 4 1 3 6 5
Step 0.1 :      2 1 4 3 6 5
Step 0.2 :      2 1 3 4 6 5
Step 0.3 :      2 1 3 4 6 5
Step 0.4 :      2 1 3 4 5 6

Step 1.0 :      1 2 3 4 5 6
Step 1.1 :      1 2 3 4 5 6
Step 1.2 :      1 2 3 4 5 6
Step 1.3 :      1 2 3 4 5 6

Step 2.0 :      1 2 3 4 5 6
Step 2.1 :      1 2 3 4 5 6
Step 2.2 :      1 2 3 4 5 6

Output :        1 2 3 4 5 6

Written By: Lakshay Sharma 02396402721
```

Program 6

Aim :: Write a program showing the implementation of Heap sort (can be either min or max heap)?

Code ::

```
#include <iostream>
#include <vector>

// Function to heapify a subtree rooted at index i
// The subtree is assumed to already satisfy the max heap property, except for possibly the root node
void heapify(std::vector<int>& arr, int n, int i)
{
   // Set up variables to store the root node and its children
   int largest = i;
   int left = 2 * i + 1;
   int right = 2 * i + 2;

   // If the left child is larger than the root, set the largest value to the left child
   if (left < n && arr[left] > arr[largest]) {
      largest = left;
   }

   // If the right child is larger than the largest value so far, set the largest value to the right child
   if (right < n && arr[right] > arr[largest]) {
      largest = right;
   }

   // If the root node is not the largest value, swap it with the largest value and heapify the affected subtree
   if (largest != i) {
      int temp = arr[i];
      arr[i] = arr[largest];
      arr[largest] = temp;
      heapify(arr, n, largest);
   }
}

// Function to sort an array using heap sort
void heapSort(std::vector<int>& arr)
{
   int n = arr.size();

   // Build a max heap
   for (int i = n / 2 - 1; i >= 0; i--) {
      heapify(arr, n, i);
   }
```

```
    // Extract elements from the heap one by one, placing them at the end of the array
    for (int i = n - 1; i >= 0; i--) {
        // Swap the root node (maximum value) with the last element in the heap
        int temp = arr[0];
        arr[0] = arr[i];
        arr[i] = temp;

        // Heapify the remaining elements
        heapify(arr, i, 0);
    }
}

int main()
{
    // Test the heap sort function
    std::vector<int> arr = { 4, 2, 1, 3, 6, 5 };
    std::cout << "Input : \t" ;
    for (int x : arr) {
        std::cout << x << " ";
    }
    std::cout << std::endl;

    heapSort(arr);

    std::cout << "Output : \t" ;
    for (int x : arr) {
        std::cout << x << " ";
    }
    std::cout << std::endl;
    std::cout << "\nWritten By: Lakshay Sharma 02396402721";
    return 0;
}
```

Output ::

```
(base) c:\Users\Lakshay Sharma\College\DS\Experiment 7>.\"q6_HeapSort.exe"
Input :         4 2 1 3 6 5
Output :        1 2 3 4 5 6

Written By: Lakshay Sharma 02396402721
```

Experiment 8

Program 1

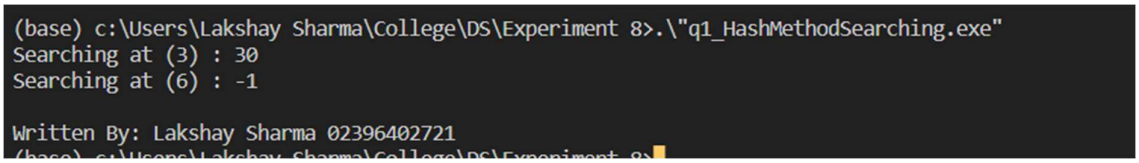
Aim :: Write a program to implement searching using hashing method?

Code ::

```
#include <iostream>
#include <vector>

using namespace std;

const int TABLE_SIZE = 128; // The size of the hash table

// A hash table element, which consists of a key and a value
struct Element {
   int key;
   int value;
};

// A hash table, which consists of an array of elements and a count of elements
struct HashTable {
   vector<Element> elements;
   int count;
};

// A hash function that returns a hash value for a given key
int hash_function(int key) {
   return key % TABLE_SIZE;
}

// A function to create a new hash table
HashTable* create_hash_table() {
   HashTable* table = new HashTable;
   table->count = 0;
   table->elements.resize(TABLE_SIZE);
   return table;
}

// A function to insert a new element into a hash table
void insert(HashTable* table, int key, int value) {
   Element e;
   e.key = key;
   e.value = value;

   // Find the index at which to insert the element
```

```
    int index = hash_function(key);
    while (table->elements[index].key != 0) {
        index = (index + 1) % TABLE_SIZE;
    }

    // Insert the element
    table->elements[index] = e;
    table->count++;
}

// A function to search for an element with a given key in a hash table
int search(HashTable* table, int key) {
    // Find the index at which the element with the given key should be located
    int index = hash_function(key);
    while (table->elements[index].key != key) {
        index = (index + 1) % TABLE_SIZE;
        if (table->elements[index].key == 0) {
            // The element was not found
            return -1;
        }
    }

    // The element was found
    return table->elements[index].value;
}

int main() {
    HashTable* table = create_hash_table();

    insert(table, 1, 10);
    insert(table, 2, 20);
    insert(table, 3, 30);
    insert(table, 4, 40);
    insert(table, 5, 50);

    cout << "Searching at (3) : " << search(table, 3) << endl; // 30
    cout << "Searching at (6) : "<< search(table, 6) << endl; // -1 (not found)

    std::cout << "\nWritten By: Lakshay Sharma 02396402721";
    return 0;
}
```

Output ::


(base) c:\Users\Lakshay Sharma\College\DS\Experiment 8>.\"q1_HashMethodSearching.exe"
Searching at (3) : 30
Searching at (6) : -1
Written By: Lakshay Sharma 02396402721

Program 2

Aim :: Write a program to create a graph and perform DFS and BFS?

Code ::

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

using namespace std;

// A graph node, which consists of an id and a list of neighboring nodes
struct Node {
   int id;
   vector<Node*> neighbors;
};

// A graph, which consists of a list of nodes
struct Graph {
   vector<Node*> nodes;
};

// A function to create a new graph
Graph* create_graph() {
   Graph* g = new Graph;
   return g;
}

// A function to create a new node
Node* create_node(int id) {
   Node* n = new Node;
   n->id = id;
   return n;
}

// A function to add an edge between two nodes
void add_edge(Node* a, Node* b) {
   a->neighbors.push_back(b);
   b->neighbors.push_back(a);
}

// A function to perform DFS on a graph
void dfs(Graph* g, Node* n, vector<bool>& visited) {
   // Mark the current node as visited
   visited[n->id] = true;

   // Print the node's id
```

```
    cout << n->id << " ";

    // Recursively visit the unvisited neighbors
    for (Node* neighbor : n->neighbors) {
        if (!visited[neighbor->id]) {
            dfs(g, neighbor, visited);
        }
    }
}

// A function to perform BFS on a graph
void bfs(Graph* g, Node* n) {
    queue<Node*> q;
    vector<bool> visited(g->nodes.size(), false);

    // Mark the current node as visited and enqueue it
    visited[n->id] = true;
    q.push(n);

    while (!q.empty()) {
        // Dequeue a node and print its id
        Node* node = q.front();
        q.pop();
        cout << node->id << " ";

        // Enqueue the unvisited neighbors
        for (Node* neighbor : node->neighbors) {
            if (!visited[neighbor->id]) {
                visited[neighbor->id] = true;
                q.push(neighbor);
            }
        }
    }
}

int main() {
    Graph* g = create_graph();

    // Create some nodes
    Node* a = create_node(0);
    Node* b = create_node(1);
    Node* c = create_node(2);
    Node* d = create_node(3);
    Node* e = create_node(4);
    Node* f = create_node(5);

    // Add the nodes to the graph
    g->nodes.push_back(a);
```

```
    g->nodes.push_back(b);
    g->nodes.push_back(c);
    g->nodes.push_back(d);
    g->nodes.push_back(e);
    g->nodes.push_back(f);

    // Add some edges
    add_edge(a, b);
    add_edge(a, c);
    add_edge(b, d);
    add_edge(c, d);
    add_edge(d, e);
    add_edge(e, f);

    // Perform DFS on the graph, starting from node 0
    cout << "DFS: ";
    vector<bool> visited(g->nodes.size(), false);
    dfs(g, a, visited);
    cout << endl;

    // Perform BFS on the graph, starting from node 0
    cout << "BFS: ";
    bfs(g, a);
    cout << endl;

    cout << "\nWritten By: Lakshay Sharma 02396402721";
    return 0;
}
```

Output ::

```
/*

   b
 /  \
a     d -- e --- f
 \  /
   c

*/
```

```
(base) c:\Users\Lakshay Sharma\College\DS\Experiment 8>.\"q2_Graphs.exe"
DFS: 0 1 3 2 4 5
BFS: 0 1 2 3 4 5

Written By: Lakshay Sharma 02396402721
```