Data Structure Algorithm & Application (CT-159)
Lab 02

Metrix (2D Arrays) in C++

Objective:

The objective of this experiment to get familiar with:

1. 2D Arrays (metrices) in C++.
2. Operations that can be performed on metrix in C++.
3. Implementation of OOP concepts (classes and functions).

Matrix multiplication is a fundamental operation in many areas, including computer graphics, physics simulations, and machine learning algorithms.

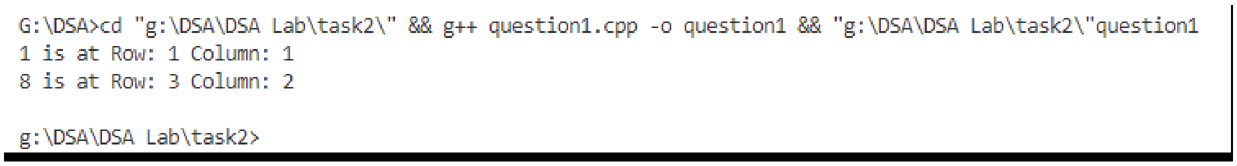
Exercise

1- Write a program in c++ that performs binary search on a 2D matrix. Implement OOP concepts (make a class and define function for searching an element in an array).

Code:

```
#include <iostream>
#include <vector>
using namespace std;
class BinarySearch{
public:
    void search(vector<vector<int>>& matrix, int targetValue){
        int rows = matrix.size();
        int columns = matrix[0].size();
        int left = 0;
        int right = rows * columns -1;

        while (left <= right) {
            int mid = left + (right - left)/2;
            int midValue = matrix[mid/rows][mid%rows];

            if (midValue == targetValue){
                cout << targetValue<< " is at "<<"Row: " << mid/rows + 1 << "
Column: " << mid%rows + 1 << endl;
                return;
            }
            else if (midValue > targetValue) {
                right = mid - 1;
            }
            else {
                left = mid + 1;
            }
        }
        cout << targetValue <<" is not found in matrix." << endl;
    }
};

int main(){
    vector<vector<int>> Matrix = {{1, 2, 3},
                                  {4, 5, 6},
                                  {7, 8, 9}};

    BinarySearch m;
    m.search(Matrix, 1);
    m.search(Matrix, 8);

    return 0;
}
```

Output:



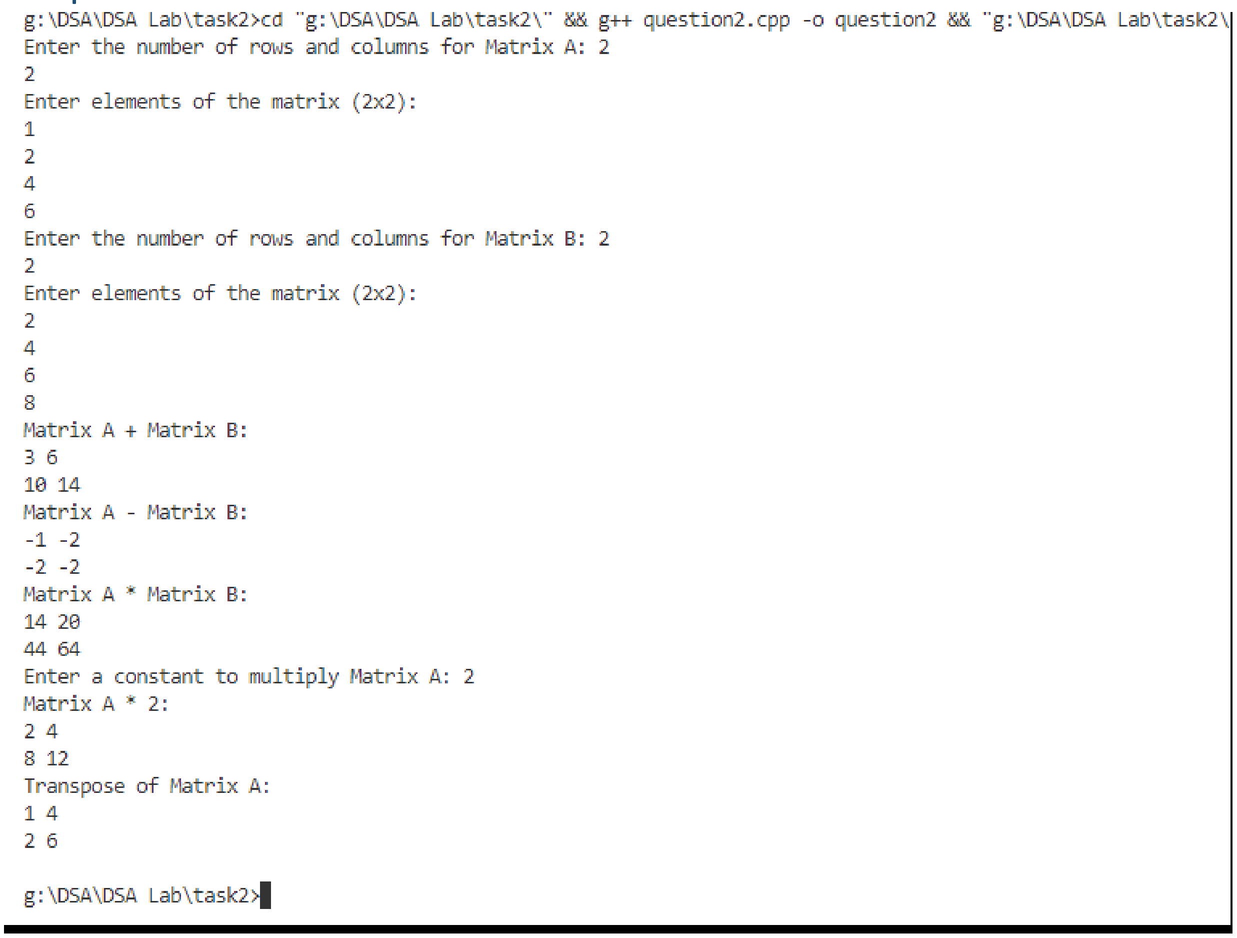
```
G:\DSA>cd "g:\DSA\DSA Lab\task2\" && g++ question1.cpp -o question1 && "g:\DSA\DSA Lab\task2\"question1
1 is at Row: 1 Column: 1
8 is at Row: 3 Column: 2

g:\DSA\DSA Lab\task2>
```

2- Write a program in C++ with a class Matrix that performs addition, subtraction, multiplication of two matrices. Multiplies a matrix with a constant and calculates transpose matrix.

Code:

```
#include <iostream>
using namespace std;
class Matrix {
private:
    int rows;
    int cols;
    int** data;
public:
    Matrix(int r, int c) : rows(r), cols(c) {
        data = new int*[rows];
        for (int i = 0; i < rows; i++) {
            data[i] = new int[cols];
        }
    }
    ~Matrix() {
        for (int i = 0; i < rows; i++) {
            delete[] data[i];
        }
        delete[] data;
    }
    void inputElements() {
        cout << "Enter elements of the matrix (" << rows << "x" << cols << "):"
<< endl;
        for (int i = 0; i < rows; i++) {
            for (int j = 0; j < cols; j++) {
                cin >> data[i][j];
            }
        }
    }
    void display() const {
        for (int i = 0; i < rows; i++) {
            for (int j = 0; j < cols; j++) {
                cout << data[i][j] << " ";
            }
            cout << endl;
        }
    }
    Matrix add(const Matrix& B)  {
        Matrix result(rows, cols);
        for (int i = 0; i < rows; i++) {
            for (int j = 0; j < cols; j++) {
                result.data[i][j] = data[i][j] + B.data[i][j];
            }
        }
        return result;
    }
    Matrix subtract(const Matrix& B) {
        Matrix result(rows, cols);
        for (int i = 0; i < rows; i++) {
            for (int j = 0; j < cols; j++) {
                result.data[i][j] = data[i][j] - B.data[i][j];
            }
        }
        return result;
    }
    Matrix multiply(const Matrix& B) {
        Matrix result(rows, B.cols);
        for (int i = 0; i < rows; i++) {
            for (int j = 0; j < B.cols; j++) {
                result.data[i][j] = 0;
                for (int k = 0; k < cols; k++) {
                    result.data[i][j] += data[i][k] * B.data[k][j];
                }
            }
        }
        return result;
    }
    Matrix multiplyByConstant(int constant) {
        Matrix result(rows, cols);
        for (int i = 0; i < rows; i++) {
            for (int j = 0; j < cols; j++) {
                result.data[i][j] = data[i][j] * constant;
            }
        }
        return result;
    }
    Matrix transpose() {
        Matrix result(cols, rows);
        for (int i = 0; i < rows; i++) {
            for (int j = 0; j < cols; j++) {
                result.data[j][i] = data[i][j];
            }
        }
        return result;
    }
};
int main() {
    int rows, cols, constant;
    cout << "Enter the number of rows and columns for Matrix A: ";
    cin >> rows >> cols;
    Matrix A(rows, cols);
    A.inputElements();

    cout << "Enter the number of rows and columns for Matrix B: ";
    cin >> rows >> cols;
    Matrix B(rows, cols);
    B.inputElements();

    cout << "Matrix A + Matrix B:" << endl;
    Matrix C = A.add(B);
    C.display();

    cout << "Matrix A - Matrix B:" << endl;
    Matrix D = A.subtract(B);
    D.display();

    cout << "Matrix A * Matrix B:" << endl;
    Matrix E = A.multiply(B);
    E.display();

    cout << "Enter a constant to multiply Matrix A: ";
    cin >> constant;
    cout << "Matrix A * " << constant << ":" << endl;
    Matrix F = A.multiplyByConstant(constant);
    F.display();

    cout << "Transpose of Matrix A:" << endl;
    Matrix G = A.transpose();
    G.display();

    return 0;
}
```

Output



```
g:\DSA\DSA Lab\task2>cd "g:\DSA\DSA Lab\task2\" && g++ question2.cpp -o question2 && "g:\DSA\DSA Lab\task2\
Enter the number of rows and columns for Matrix A: 2
2
Enter elements of the matrix (2x2):
1
2
4
6
Enter the number of rows and columns for Matrix B: 2
2
Enter elements of the matrix (2x2):
2
4
6
8
Matrix A + Matrix B:
3 6
10 14
Matrix A - Matrix B:
-1 -2
-2 -2
Matrix A * Matrix B:
14 20
44 64
Enter a constant to multiply Matrix A: 2
Matrix A * 2:
2 4
8 12
Transpose of Matrix A:
1 4
2 6

g:\DSA\DSA Lab\task2>
```

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Lab 02

3- Suppose A and B are n-elements vector array in memory and X and Y are scalars.
Write a program to find.

- XA + YB
- A . B

Test the program using A= (16, -6,7), B=(4,2,-3), X= 2, Y= -5

Code:

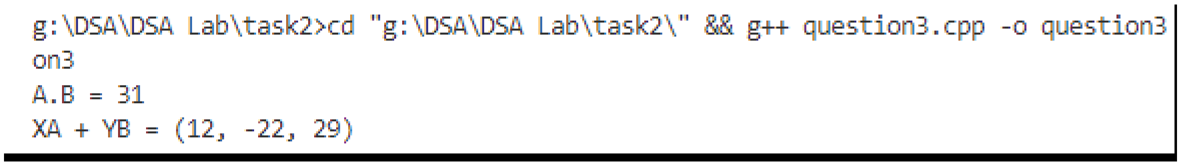
```
#include <iostream>
#include <vector>
using namespace std;

int scalarProduct(int a[], int b[], int size){
    int result;

    for (int i=0; i<size; i++){
        result += a[i] * b[i];
    }
    return result;
}
void vectorAddition(int a[], int b[], int x, int y, int size){
    int result[size];

    for (int i = 0; i < size; i++){
        result[i] = x*a[i] + y*b[i];
    }
    cout << "XA + YB = (";
    for (int i=0; i<size; i++){
        cout << result[i];
        if (i != size - 1){
            cout << ", ";
        }
    }
    cout << ")" << endl;
}
int main(){
    int A[] = {16, -6, 7};
    int B[] = {4, 2, -3};
    int vectorSize =sizeof(A)/sizeof(A[0]) ;
    int X = 2;
    int Y = -5;
    cout << "A.B = " << scalarProduct(A, B, vectorSize) << endl;
    vectorAddition(A, B, X, Y, vectorSize);
    return 0;}
```

Output:



```
g:\DSA\DSA Lab\task2>cd "g:\DSA\DSA Lab\task2\" && g++ question3.cpp -o question3
on3
A.B = 31
XA + YB = (12, -22, 29)
```

Lab 02 Evaluation		
Student Name: Adil Javed	**Student ID:**SESE-23025	**Date: 08-Sep-2024**
Rubric	**Marks (25)**	**Remarks by teacher in accordance with the rubrics**
R1		
R2		
R3		
R4		
R5		