



NED University of Engineering and Technology

Data Structures and Algorithms — Lab 1

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Date: November 22, 2025

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Question 1

Write a C++ program to copy data of a 2D array in a 1D array using Column Major Order.

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

class Array2D {
private:
    int **arr;
    int rows, cols;
public:
    Array2D(int r, int c) : rows(r), cols(c) {
        arr = new int*[rows];
        for (int i = 0; i < rows; i++) {
            arr[i] = new int[cols];
        }
    }
    int* operator[](int index) {
        return arr[index];
    }
    int getRows() { return rows; }
    int getCols() { return cols; }
    ~Array2D() {
        for (int i = 0; i < rows; i++) {
            delete[] arr[i];
        }
        delete[] arr;
    }
};

class Array1D {
private:
    int *arr;
    int size;
public:
    Array1D(int s) : size(s) {
        arr = new int[size];
    }
    // Copy constructor that takes Array2D and flattens it (column order)
    Array1D(Array2D &other) {
        size = other.getRows() * other.getCols();
        arr = new int[size];
        int index = 0;
        for (int i = 0; i < other.getRows(); i++) {
            for (int j = 0; j < other.getCols(); j++) {
                arr[index++] = other[j][i];
            }
        }
    }
    int& operator[](int index) {
        return arr[index];
    }
    ~Array1D() {
        delete[] arr;
    }
};
```

```

    }
};

int main() {
    cout << "Enter number of rows and columns for 2D array: ";
    int r, c;
    cin >> r >> c;
    Array2D arr2d(r, c);
    for (int i = 0; i < r; i++) {
        for (int j = 0; j < c; j++) {
            cout << "Enter element at arr[" << i << "][" << j << "]: ";
            cin >> arr2d[i][j];
        }
    }
    Array1D arr1d = arr2d;
    cout << "Flattened 1D array elements: \n";
    for (int i = 0; i < r * c; i++) {
        cout << arr1d[i] << " ";
    }
}

```

Output

```

Enter number of rows and columns for 2D array:
Enter element at arr[0][0]:
Enter element at arr[0][1]:
Enter element at arr[1][0]:
Enter element at arr[1][1]:
Flattened 1D array elements:

1 2 3 4
[Execution Time: 0.77s]
[INPUT PROVIDED]
2 2
1 3 2 4

```

Question 2

Write a program to calculate the GPA of students of all subjects of a single semester. Assume all the courses have the same credit hour.

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

class Table {
private:
    float **table;
    int rows, cols, curr_row;

public:
    Table(int r, int c) : rows(r), cols(c), curr_row(0) {
        table = new float*[rows];
        for (int i=0; i<cols; i++){
            table[i] = new float[cols];
        }
    }
    bool insert(float gpas[], int n){
        for (int i=0; i<n; i++){
            table[curr_row][i] = gpas[i];
        }
        curr_row++;
        return true;
    }
    void get_sem_gpas() {
        for (int i=0; i<rows; i++){
            float gpa=0;
            for (int j=0; j<cols; j++){
                gpa += table[i][j];
            }
            cout << "GPA for student " << i+1 << " is " << gpa/cols << endl;
        }
    }
};

int main(){
    int rows, cols;
    cout << "Enter number of students: "; cin >> rows;
    cout << "Enter number of subjects: "; cin >> cols;
    Table students(rows, cols);

    for (int i = 0; i < rows; i++) {
        float gpas[3];
        cout << "Enter " << cols << " GPAs for student " << (i+1) << ": ";
        for (int j = 0; j < cols; j++) {
            cin >> gpas[j];
        }
        students.insert(gpas, cols);
    }

    students.get_sem_gpas();
    return 0;
}
```

}

Output

```
Enter number of students:
Enter number of subjects:
Enter 3 GPAs for student 1:
Enter 3 GPAs for student 2:
GPA for student 1 is 3.63333
GPA for student 2 is 3.16667
[Execution Time: 0.75s]
[INPUT PROVIDED]
2 3
3.2 3.7 4
2.3 4 3.2
```

Question 3

Implement a MedianFinder class that has the functions addNum(int num) and findMedian() that will find the middle value in an ordered integer list.

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

class MedianFinder {
private:
    int* arr;
    int size;
    int capacity;
public:
    MedianFinder() {
        capacity = 100;
        arr = new int[capacity];
        size = 0;
    }
    void addNum(int num) {
        if (size == capacity) {
            capacity *= 2;
            int* newArr = new int[capacity];
            for (int i = 0; i < size; i++) {
                newArr[i] = arr[i];
            }
            delete[] arr;
            arr = newArr;
        }
        arr[size++] = num;
    }
    double findMedian() {
        sort(arr, arr + size);
        if (size % 2 == 0) {
            return (arr[size / 2 - 1] + arr[size / 2]) / 2.0;
        } else {
            return arr[size / 2];
        }
    }
    ~MedianFinder() {
        delete[] arr;
    }
};

int main() {
    MedianFinder* medianFinder = new MedianFinder();

    int choice;
    while (true) {
        cout << "1) addNum\n2) findMedian\n3) quit\n=> "; cin >> choice;

        switch (choice) {
```

```
        case 1:
            int num;
            cout << "Enter number: "; cin >> num;
            medianFinder->addNum(num);
            cout << endl;
            break;

        case 2:
            cout << "The median is: " << medianFinder->findMedian() << endl << endl;
            break;

        default:
            delete medianFinder;
            return 0;
    }

}

delete medianFinder;
return 0;
}
```

Output

```
1) addNum
2) findMedian
3) quit
=> Enter number:

1) addNum
2) findMedian
3) quit
=> Enter number:

1) addNum
2) findMedian
3) quit
=> Enter number:

1) addNum
2) findMedian
3) quit
=> The median is:
5

1) addNum
2) findMedian
3) quit
=>
[Execution Time: 0.84s]
[INPUT PROVIDED]
1
5
1
2
1
5
2
3
```


Question 4

Given an array of integers which is sorted in ascending order, and an integer target, write a function to search target in nums. If target exists, then return its index. Otherwise, return -1. You must write an algorithm with $O(\log n)$ runtime complexity.

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

class Array1D {
private:
    int *arr;
    int size;
public:
    Array1D(int s) : size(s) {
        arr = new int[size];
    }
    int& operator[](int index) {
        return arr[index];
    }
    // Binary search
    int find(int key) {
        int l=0, r=size-1;
        while (l <= r) {
            int mid = l + (r - l) / 2;
            if (arr[mid] == key) return mid;
            else if (arr[mid] < key) l = mid + 1;
            else r = mid - 1;
        }
        return -1;
    }
    ~Array1D() {
        delete[] arr;
    }
};

int main() {
    cout << "Enter size of 1D array: ";
    int s;
    cin >> s;
    Array1D arr(s);
    cout << "Enter elements in sorted order: ";
    for (int i = 0; i < s; i++) {
        cin >> arr[i];
    }
    cout << "Enter element to search: ";
    int key;
    cin >> key;
    int index = arr.find(key);
    if (index != -1) {
        cout << "Element found at index " << index << endl;
    } else {
        cout << "Element not found" << endl;
    }
    return 0;
}
```

}

Output

```
Enter size of 1D array:  
Enter elements in sorted order:  
Enter element to search:  
Element found at index 2  
[Execution Time: 0.80s]  
[INPUT PROVIDED]  
5  
2 13 16 23 35  
16
```

Question 5

Given a 2D array, return true if the target exists in the matrix and false if not. Each element is greater than the previous.

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

class Array2D {
private:
    int **arr;
    int rows, cols;
public:
    Array2D(int r, int c) : rows(r), cols(c) {
        arr = new int*[rows];
        for (int i = 0; i < rows; i++) {
            arr[i] = new int[cols];
        }
    }
    int* operator[](int index) {
        return arr[index];
    }
    int find(int key) {
        int l = 0, r = rows * cols - 1;
        while (l <= r) {
            int mid = l + (r - l) / 2;
            int mid_val = arr[mid / cols][mid % cols];
            if (mid_val == key) return true;
            else if (mid_val < key) l = mid + 1;
            else r = mid - 1;
        }
        return false;
    }
    ~Array2D() {
        for (int i = 0; i < rows; i++) {
            delete[] arr[i];
        }
        delete[] arr;
    }
};

int main() {
    cout << "Enter number of rows and columns for 2D array: ";
    int r, c;
    cin >> r >> c;
    Array2D arr2d(r, c);
    cout << "Enter elements in sorted order:\n";
    for (int i = 0; i < r; i++) {
        for (int j = 0; j < c; j++) {
            cin >> arr2d[i][j];
        }
    }
    cout << "Enter element to search: ";
    int key;
    cin >> key;
```

```
int index = arr2d.find(key);  
if (index) {  
    cout << "Element found" << endl;  
} else {  
    cout << "Element not found" << endl;  
}  
return 0;  
}
```

Output

```
Enter number of rows and columns for 2D array:  
Enter elements in sorted order:  
Enter element to search:  
Element found  
[Execution Time: 0.79s]  
[INPUT PROVIDED]  
2 2  
2 5 10 15  
5
```