

# Object-Oriented Programming

Summer Semester 2023

Homework Assignment 2.

31/07/2023

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## Introduction

1. Try to provide clear and careful solutions.
2. You should provide comments for your code so it will be completely clear what you are trying to achieve. WARNING! Lack of comments might lead to points reduction.
3. Please note the following few points which may lead to points reduction during the submission check:
  - (a) Avoid using *magic numbers*. For example: “if (i>17)”, 17 is a magic number. If 17 is representing, for example, the number of shoes, then instead you should write: “if (i>shoesNumber)”.
  - (b) Try to avoid code duplication as much as possible.
  - (c) You should not globally enable *std* namespace usage or any other namespaces, e.g. *using namespace std;*

## Definitions

During the second homework, you will learn how to overload different operators in C++, as well you are going to practice your skills working with templates.

In this assignment you will implement a class that is capable to manage basic matrix manipulations (**Matrix** class), and a class that represents some container of matrices (**MatrixContainer** class).

Learning from past experience, please note that some (small) updates to the definitions and requirement of the assignment might be published in next few days and that following said updates and the HW forum is required.

Like in the last assignment, The methods signature is up to you, but :

1. Use the **const** keyword where possible and needed.
2. Use the **friend** functions where needed.
3. Use **reference** variables where possible and needed.
4. Use **static** variables and methods where possible and needed.

You need to understand where to use what, but if you'r unsure, feel free to ask me for help.

Your goals are:

- Having the main files, you should provide declaration and implementation while keeping in mind the basic *OOP* concept of *encapsulation*.

**Keep in mind that the included main files are very basic and do not cover all possible scenarios and end cases.**

- Make sure to manage correctly your dynamic memory. Be aware of both allocating and releasing resources.
- ☒ In this submission, you are **RESTRICTED** from using *STL* library regardless of prior knowledge you have.
- ☒ You **can** assume that all input for the functions you write will be legal.

## Matrix class

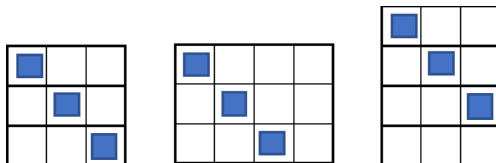
You have a free choice in the implementation of the class attributes and methods, but you must implement the following methods:

1. Operator+/- by scalar (same type as the matrix) or other matrix. Ex : `mat+5` : adds 5 to each cell in the matrix
2. Operator\* – for scalar multiplication
3. Operator\* - matrix by matrix (of the exact same shape) **5 BONUS POINTS**
  - Not mandatory, but if you do not wish to implement the function, write the appropriate signature and return the identity matrix.
  - Implement taken in account that it will only be used with square matrices
4. `getIdentityMatrix` – return the identity matrix of exact same size .
5. Operator++/-- – prefix and postfix. Same functionality as `mat+1`, `mat-1`.
6. `getDiag` – returning the matrix main diagonal (Example in the next page).
7. Operator==/!= - return if 2 matrices are not/equal (equal : if  $\forall i, j \text{ } mat1[i, j] == mat2[i, j]$  , more on floating point comparison in appendix 1)
8. To matrix type coercion – returning the trace of the matrix. Ex : `int trace = int(mat)`
9. `operator<<`
10. `operator()` – with arguments `i, j` should return a reference to cell `[i, j]` , example – `mat1(x, y)`

Hint – To save work and time (and code duplication) - use operators to implement different operators, for example : use `==` to implement `!=`, use `+` to implement `(-)` etc.

If you're unsure about the operator's signature should be, you can contact me or google it, there are a lot of guides.

main diagonals:



\*the class methods should be implemented only in the header file as inline methods. (to avoid troubleshooting that can appear with template and classes)

## MatrixContainer class

You have a free choice in the implementation of the class attributes and methods.

To be time and space complexity efficient- the data structure that holds the matrices should be a dynamic array (Explanation in appendix 2).

You must implement the following methods:

- addMatrix – add a matrix to the container (you can add an unlimited amount of matrices)
- removeLastMatrix – removing the last matrix from the container.
- operator[] – return a reference to the matrix at the index.
- operator<< – printing all the matrices in the container.
- size() – return the amount of matrices in the container.
- capacity() – return the size of the dynamic array (i.e, how many matrices the array **can** hold at the moment).

## Evaluation

Homework exercise provided with the following example program files and corresponding outputs:

1. matrix\_main.cpp
2. matrix\_output.txt
3. main\_matrix\_container.cpp
4. output\_matrix\_container.txt

You should be able to compile your code with “matrix\_main.cpp” and “main\_matrix\_container.cpp” files, and receive, respectively, the correct output which placed in “matrix\_output.txt” and “output\_matrix\_container.txt” file.

Submission should only include the following files :

1. Martix.h
2. MatrixContainer.h

## App1. Floating point comparison

Floating point comparison (`double==double`) can be inaccurate, this is due to the way decimal values are stored in the computer.

One way to compare floats is by **tolerance to difference**, i.e , checking to see if the difference is lower than known epsilon value (tolerance).

In this assignment, your matrix might hold floating point value, so you need to make a robust comparison.

Use the `DBL_EPSILON` (should already exist) defined value, and compare like so:

```
if((|val1 - val2|) < DBL_EPSILON) { return equal}
```

This compare will work in Integer values as well.

This is not the most robust way, there are more robust comparisons, but for this assignment, it will suffice.

For more information on floating point comparison : [Link](http://realtimecollisiondetection.net/blog/?p=89) - <http://realtimecollisiondetection.net/blog/?p=89>

## App2. Dynamic array data structure

Implementing a dynamic array should be as follows:

The size of the array starts from size = 1.

When full, that is,  $n$  (number of elements in the array) is equal to size: the array doubles his size by creating a new array twice as big, and copies his elements into the new array.

When  $= \frac{size}{4}$ , the array halves his size by creating a new array half as big , and copies his elements into the new array.

When implementing the array, don't forget to free allocated memory!

This guarantees amortized  $O(1)$  per insert/delete last operation.

**Make sure you keep the C++ syntax convention and submit the files exactly as described in the “Oop – Cpp – Conventions and Requirements” file in Moodle.**

**GOOD LUCK! 😊**