

Assignment 2 - Euclidean Vector

Change Log

- 27/06: List and vector type conversion examples updated in spec and client.cpp
- 28/06: Fixed client.sampleout path

1. Overview

Write a Euclidean Vector Class Library in C++, with its interface given in `euclidean_vector.h` and its implementation in `euclidean_vector.cpp`.

1.1 Aims

- Familiarity with C++ Classes
- Constructors
- Uniform initialisation
- Value semantics (Copy Control)
- Function Overloading
- Operator Overloading
- Friends
- Exception handling
- Separation of Interface from Implementation

2. Your task

2.1 Constructors

Name	Constructor	Description and Hints	Examples	Exception: Why thrown & what message
Default Constructor	<code>EuclideanVector(int)</code>	A constructor that takes the number of dimensions (as a <code>int</code>) but no magnitudes, sets the magnitude in each dimension as 0.0. Hint: you may want to make this a delegating constructor to the next constructor below. This is the default constructor, with the default value being 1. You can assume the integer input will always be non-negative.	<pre>(1) EuclideanVector a{1}; (2) int i {3}; EuclideanVector b{i}; (3) EuclideanVector c; // or c{} // same as EuclideanVector c{1};</pre>	N/A
Constructor	<code>EuclideanVector(int, double);</code>	A constructor that takes the number of dimensions (as a <code>int</code>) and initialises the magnitude in each dimension as the second argument (a <code>double</code>). You can assume the integer input will always be non-negative.	<pre>(1) EuclideanVector a{2, 4.0}; (2) int x {3}; double y {3.24}; EuclideanVector b{x, y};</pre>	N/A
Constructor	<code>EuclideanVector(std::vector::const_iterator, std::vector::const_iterator)</code>	A constructor (or constructors) that takes the start and end of an iterator to a <code>std::vector</code> and works out the required dimensions, and sets the magnitude in each dimension according to the iterated values.	<pre>std::vector<double> v; EuclideanVector b{v.begin(), v.end()};</pre>	N/A
Copy Constructor	<code>EuclideanVector(const EuclideanVector&)</code>	<code>EuclideanVector aCopy{a};</code>	N/A	
Move Constructor	<code>EuclideanVector(EuclideanVector&&)</code>	<code>EuclideanVector aMove{a};</code>	N/A	

Example Usage

```
EuclideanVector a{1}; // a Euclidean Vector in 1 dimension, with default magnitude 0.0.
EuclideanVector b{2, 4.0}; // a Euclidean Vector in 2 dimensions with magnitude 4.0 in both dimensions

std::list<double> l;
l.push_back(5.0);
l.push_back(6.5);
l.push_back(7.0);
EuclideanVector c{l.begin(), l.end()}; // a Euclidean Vector in 3 dimensions constructed from a list of magnitudes
```

Notes

- You may assume that all arguments supplied by the user are valid. No error checking on constructors is required.
- It's **very important** your constructors work. If we can't validly construct your objects, we can't test any of your other functions.

2.2. Destructor

You must explicitly declare the destructor as default.

2.3. Operations

Name	Operator	Description	Examples	Exception: Why thrown & what message
Copy Assignment	<code>operator=(const EuclideanVector&)</code>	A copy assignment operator overload	<code>a = b;</code>	N/A
Move Assignment	<code>operator=(EuclideanVector&&)</code>	A move assignment operator	<code>a = std::move(b);</code>	N/A
Subscript	<code>operator[]</code>	Allows to get and set the value in a given dimension of the Euclidean Vector. Hint: you may need two overloaded functions to achieve this requirement. Note: It's a requirement you use asserts to ensure the index passed is valid.	<code>double a {b[1]}; b[2] = 3.0;</code>	N/A
Addition	<code>operator+=</code>	For adding vectors of the same dimension.	<code>a += b;</code>	Given: X = <code>a.GetNumDimensions()</code> , Y = <code>b.GetNumDimensions()</code> When: X != Y 0: "Dimensions of LHS(X) and RHS(Y) do not match"
Subtraction	<code>operator-=</code>	For subtracting vectors of the same dimension.	<code>a -= b;</code>	Given: X = <code>a.GetNumDimensions()</code> , Y = <code>b.GetNumDimensions()</code> When: X != Y Throw: "Dimensions of LHS(X) and RHS(Y) do not match"
Multiplication	<code>operator* =</code>	For scalar multiplication, e.g. <code>[1 2] * 3 = [3 6]</code>	<code>a *= 3;</code>	N/A
Division	<code>operator/=</code>	For scalar division, e.g. <code>[3 6] / 2 = [1.5 3]</code>	<code>a /= 4;</code>	When: b == 0 Throw: "Invalid vector division by 0"
Vector Type Conversion	explicit operator <code>std::vector<double>()</code>	Operators for type casting to a <code>std::vector</code>	<code>EuclideanVector a; auto vf = std::vector<double>(a);</code>	N/A
List Type Conversion	explicit operator <code>std::list<double>()</code>	Operators for type casting to a <code>std::list</code>	<code>EuclideanVector a; auto lf = std::list<double>(a);</code>	N/A

2.4. Methods

Prototype	Description	Usage	Exception: Why thrown & what message
<code>double at(int)</code>	Returns the value of the magnitude in the dimension given as the function parameter	<code>a.at(1);</code>	N/A
<code>int GetNumDimensions()</code>	Return the number of dimensions in a particular EuclideanVector	<code>a.GetNumDimensions();</code>	N/A
<code>double GetEuclideanNorm()</code>	Returns the Euclidean norm of the vector as a double. The Euclidean norm is the square root of the sum of the squares of the magnitudes in each dimension. E.g, for the vector <code>[1 2 3]</code> the Euclidean norm is <code>sqrt(1*1 + 2*2 + 3*3) = 3.74</code> .	<code>a.GetEuclideanNorm();</code>	N/A
<code>EuclideanVector CreateUnitVector()</code>	Returns a Euclidean vector that is the unit vector of *this vector. The magnitude for each dimension in the unit vector is the original vector's magnitude divided by the Euclidean norm.	<code>a.CreateUnitVector();</code>	When: this->GetNumDimensions() == 0 Throw: "EuclideanVector with no dimensions does not have a unit vector"

not have a unit vector

3.5. Friends

In addition to the operations indicated earlier, the following operations should be supported as friend functions. Note that these friend operations don't modify any of the given operands.

Name	Operator	Description	Usage	Exception: Why thrown & what message
Equal	operator==	True if the two vectors are equal in the number of dimensions and the magnitude in each dimension is equal.	<code>a == b;</code>	N/A
Not Equal	operator!=	True if the two vectors are not equal in the number of dimensions or the magnitude in each dimension is not equal.	<code>a != b;</code>	N/A
Addition	operator+	For adding vectors of the same dimension.	<code>a = b + c;</code>	Given: X = a.GetNumDimensions(), Y = b.GetNumDimensions() When: X != Y Throw: "Dimensions of LHS(X) and RHS(Y) do not match"
Subtraction	operator-	For subtracting vectors of the same dimension.	<code>a = b - c;</code>	Given: X = a.GetNumDimensions(), Y = b.GetNumDimensions() When: X != Y Throw: "Dimensions of LHS(X) and RHS(Y) do not match"
Multiplication	operator*	For dot-product multiplication, returns a double. E.g., [1 2] * [3 4] = 1 * 3 + 2 * 4 = 11	<code>double c {a * b};</code>	Given: X = a.GetNumDimensions(), Y = b.GetNumDimensions() When: X != Y Throw: "Dimensions of LHS(X) and RHS(Y) do not match"
Multiply	operator*	For scalar multiplication, e.g. [1 2] * 3 = 3 * [1 2] = [3 6]. Hint: you'll obviously need two methods, as the scalar can be either side of the vector.	(1) <code>a = b * 3;</code> (2) <code>a = 3 * b;</code>	N/A
Divide	operator/	For scalar division, e.g. [3 6] / 2 = [1.5 3]	<code>a = b / 4;</code>	When: b == 0 Throw: "Invalid vector division by 0"
Output Stream	operator<<	Prints out the magnitude in each dimension of the Euclidean Vector (surrounded by [and]), e.g. for a 3-dimensional vector: [1 2 3]	<code>std::cout << a;</code>	N/A

3.6. Internal Representation

Your Euclidean Vector is **required** to store the magnitudes of each dimension inside of a unique_ptr. This is a unique_ptr to a C-style double array. This has been added as part of the stub to your euclidean_vector.h file.

To create a dynamically allocated C-style double array and add it to a unique pointer, but not require any *direct* use of the new/malloc call, you can use the following:

```
std::unique_ptr<double[]> magnitudes_ = std::make_unique<double[]>(8); // 8 is an example
```

3.7. Throwing Exceptions

You are required to throw exceptions in certain cases. These are specified in the tables above. We have provided a EuclideanVectorError exception class for you to throw. You are welcome to throw other exceptions if you feel they are more appropriate.

Note: while the particular exception thrown does not matter, you are required to pass the strings specified in the tables above.

3.8. Other requirements

You must:

- Include a header guard in euclidean_vector.h
- Use C++17 style and methods
- Ensure methods will not throw exceptions are marked

```
noexcept
```

- Make sure that *all appropriate member functions* are const qualified

You must not:

- Write to any files that aren't provided in the repo (e.g. storing your vector data in an auxiliary file)
- Add a main function euclidean_vector.cpp

4. Getting Started

If you haven't done so already, clone the repository:

```
$ git clone https://github.com/cs6771/comp6771 comp6771
```

Then navigate to the **assignments/ev** directory

All of the files you need are in this directory. Here is a list of files that and a description of their purpose:

File	Description
client.cpp sampleout	A simple use case of a client using your euclidean_vector Note: Do NOT modify this file. We will potentially update it. If you want to modify it, make a local copy first.
euclidean_vector.cpp h	Your euclidean vector interface and implementation. The reference solution is around the 500 lines of code mark (to give you a sense of the size)
euclidean_vector_test.cpp	Your tests for your euclidean vector file
BUILD	Build file containing build, test, dependency instructions

4.2. Reference Solution & Time Limits

Due to the simple nature of this data type, there will be performance based measurements

Each test will still have a time limit to run (1 second max), but unless you do something completely insane this will be more than enough time for all of your operations to complete.

4.3. Running your assignment

4.3.1. Running a basic use case

You can run your code against a basic (non-testing) use case to get a better sense of the behaviour

From your project directory:

```
$ bazel build //assignments/ev:client
```

```
$ ./bazel-bin/assignments/ev/client | diff ./assignments/ev/client.sampleout -
```

4.3.2. Running your tests

```
$ bazel build //assignments/ev:euclidean_vector_test
```

```
$ bazel run //assignments/ev:euclidean_vector_test
```

4.4. Assessment

This assignment will contribute 15% to your final mark.

The assessment for the assignment recognizes the difficulty of the task, the importance of style, and the importance of appropriate use of programming methods (e.g. using while loops instead of a dozen if statements).

60%	Correctness The correctness of your program will be determined automatically by tests that we will run against your program. We will create a series of test files that contain their own main function and are compiled with your Euclidean vector file(s).
20%	Your tests You are required to write your own tests to ensure your program works. You will write tests in <code>euclidean_vector_test.cpp</code> . At the top of this file you will also include a block comment to explain the rational and approach you took to writing tests. Please read the Catch2 tutorial (https://github.com/catchorg/Catch2/blob/master/docs/tutorial.md) or review lecture/tutorial content to see how to write tests. Tests will be marked on several factors. These include, but are not limited to <ul style="list-style-type: none"> • Correctness - an incorrect test is worse than useless. • Coverage - your tests might be great, but if they don't cover the part that ends up failing, they weren't much good to you. • Brittleness - If you change your implementation, will the tests need to be changed (this generally means avoiding calling functions specific to your implementation where possible - ones that would be private if you were doing OOP). • Clarity - If your test case failed, it should be immediately obvious what went wrong (this means splitting it up into appropriately sized sub-tests, amongst other things).
15%	C++ style Your adherence to good C++ style. This is not saying that if you conform to the style guide you will receive full marks for this section. This 20% is also based on how well you use modern C++ methodologies taught in this course as opposed to using backwards-compatible C methods. Examples include: Not using primitive arrays and not using pointers.
5%	cpplint and clang-format In your project folder, run the following commands on all C++ files you submit: <pre>\$ clang-format -i /path/to/file.cpp && python cpplint.py /path/to/file.cpp</pre> If the program outputs the following, you will receive full marks for this section (5%). Otherwise you will receive no marks. <div> <pre>Done processing assignments/ev/euclidean_vector.cpp Total errors found: 0</pre> </div>

The following actions will result in a 0/100 mark for EuclideanVector, and in some cases a 0 for COMP6771:

- Knowingly providing your work to anyone and it is subsequently submitted (by anyone).
- Submitting any other person's work. This includes joint work.

- Submitting any other person's work that includes your work.
- Submitting another person's work without their consent.

The lecturer may vary the assessment scheme after inspecting the assignment submissions but it will remain broadly similar to the description above.

4.5. Originality of Work

The work you submit must be your own work. Submission of work partially or completely derived from any other person or jointly written with any other person is not permitted. The penalties for such an offence may include negative marks, automatic failure of the course and possibly other academic discipline. Assignment submissions will be examined both automatically and manually for such submissions.

Relevant scholarship authorities will be informed if students holding scholarships are involved in an incident of plagiarism or other misconduct.

Do not provide or show your assignment work to any other person — apart from the teaching staff of COMP6771. If you knowingly provide or show your assignment work to another person for any reason, and work derived from it is submitted, you may be penalized, even if the work was submitted without your knowledge or consent. This may apply even if your work is submitted by a third party unknown to you.

Note you will not be penalized if your work has the potential to be taken without your consent or knowledge.

4.6. Submission

This assignment is due **Saturday 13th of July, 22:59:59**. Submit the assignment using this *give* command:

```
give cs6771 euclideanvector euclidean_vector.cpp euclidean_vector.h euclidean_vector_test.cpp
```

4.7. Late Submission Policy

If your assignment is submitted after this date, each hour it is late reduces the maximum mark it can achieve by 1%. For example if an assignment worth 76% was submitted 5 hours late, the late submission would have no effect (as maximum mark would be 95%). If the same assignment was submitted 30 hours late it would be awarded 70%, the maximum mark it can achieve at that time.