

Assignment 1

COS 344



Department of Computer Science

Total: 38 Marks

Deadline: 16 April 2021 at 17:00

Objectives:

- Getting to grips with 3D maths.

General instructions:

- This assignment should be completed individually, **no group effort** is allowed.
- Be ready to upload your assignment well before the deadline, as no extension will be granted.
- All calculations must be implemented using native JavaScript; no packages for the calculations can be included.
- You may however, utilize frameworks to make the HTML5 interface.
- The assignment should run solely on the client side.
- All the functionality must be accessible via an HTML5 interface to enter and display the required data.
- Marks for each of the listed tasks will only be awarded if they can be completely demonstrated via the interface.
- **All submissions will be checked for plagiarism.**

Plagiarism:

The Department of Computer Science considers plagiarism as a serious offence. Disciplinary action will be taken against students who commit plagiarism. Plagiarism includes copying someone else's work without consent, copying a friend's work (even with consent) and copying material (such as text or program code) from the Internet. Copying will not be tolerated in this course. For a formal definition of plagiarism, the student is referred to <https://www.library.up.ac.za/plagiarism/index.htm> (from the main page of the University of Pretoria site, follow the *Library* quick link, and then choose the *Plagiarism* option under the *Services* menu). If you have any form of question regarding this, please ask one of the lecturers, to avoid any misunderstanding. Also note that the OOP principle of code re-use does not mean that you should copy and adapt code to suit your solution.

After completing this assignment:

Upon successful completion of this assignment you will have implemented the basic 3D math operations and calculations that are needed in computer graphics.

Task 1 [30 Marks]

There are a number of mathematical operations and calculations that are fundamental to 3D graphics. In this task, you will need to implement the following functionality using JavaScript and HTML5.

Let $\mathbf{x}, \mathbf{y} \in \mathbb{R}^n$, $\alpha \in \mathbb{R}$, $\mathbf{M} \in \mathbb{R}^{n \times m}$ and $\mathbf{G} \in \mathbb{R}^{l \times j}$ (note 1)

- Calculate $\alpha \mathbf{x}$. (1 mark)
- Calculate $\mathbf{x} + \mathbf{y}$. (2 marks)
- Calculate $\mathbf{x} - \mathbf{y}$. (2 marks)
- Calculate $\mathbf{x} \cdot \mathbf{y}$. (2 marks)
- Calculate $\|\mathbf{x}\|_2$. (2 marks)
- Calculate $\mathbf{x} \times \mathbf{y}$ for $n = 1, 2$ and 3 (assume a right handed system). (3 marks)
- Calculate $\alpha \mathbf{M}$. (1 mark)
- Calculate \mathbf{M}^T . (2 marks)
- Calculate $\mathbf{M}\mathbf{x}$ and throw an error if not possible. (2 marks)
- Calculate $\mathbf{M}\mathbf{G}$ and throw an error if not possible. (3 marks)
- Calculate the determinant of a matrix \mathbf{M} and throw an error if not possible. (note 2) (5 marks)
- Solve for \mathbf{x} in the equation $\mathbf{M}\mathbf{x} = \mathbf{v}$, where \mathbf{M} and \mathbf{v} are given. If a unique solution does not exist, throw an error. (note 3) (5 marks)

Note 1: $\mathbb{R}^{l \times j}$ represents a matrix with l rows and j columns.

Note 2: The following will be helpful: <https://www.geeksforgeeks.org/determinant-of-a-matrix/>

Note 3: There exist a number of algorithms, the simplest is: https://en.wikipedia.org/wiki/Gaussian_elimination. I recommend doing this calculation last.

Task 2 [8 Marks]

Let $\mathbf{p} \in \mathbb{R}^3$ be the location of a character, looking in direction $\mathbf{d} \in \mathbb{R}^3$, with $\mathbf{u} \in \mathbb{R}^3$ as the *up* vector of the character. If an enemy is placed at location $\mathbf{e} \in \mathbb{R}^3$ your system must be able to answer the following questions:

- Is the enemy in front or behind the character? (3 marks)
- Is the enemy to the right or left of the character? (5 marks)

Your system could be able to toggle between working in a right or a left hand system.

Submission instructions

For your submission, you need to place all your source files in a zip or tar/gzip archive (you need to compress your tar archive) named uXXXXXXXXX.zip or uXXXXXXXXX.tar.gz where XXXXXXXXXX is your student/staff number.

Submit your code for marking under the appropriate item on ClickUP (*Assignment 1*) before the deadline.