

# Assignment 1

## COS 344



Department of Computer Science

Total: 38 Marks

Deadline: 17 March 2023 at 23:59

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

- Calculate  $\alpha \mathbf{x}$ . (2 marks)
- Calculate  $\mathbf{x} + \mathbf{y}$ . (2 marks)
- Calculate  $\mathbf{x} - \mathbf{y}$ . (2 marks)
- Calculate  $\mathbf{x} \cdot \mathbf{y}$ . (2 marks)
- Calculate  $\|\mathbf{x}\|_2$ . (3 marks)
- Calculate  $\alpha \mathbf{M}$ . (1 mark)
- Calculate  $\mathbf{M}^T$ . (3 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](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 XXXXXXXXX is your student/staff number.

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