FOSSEE Summer Fellowship Report

On

Mathematics using Python

Submitted by

Simran Chhattani
St Joseph's College, Bangalore
simranchhattani1498@gmail.com

Under the guidance of

Prof. Prabhu Ramachandran
Department of Aerospace Engineering
Indian Institute of Technology, Bombay

Mentors

Mr. Purusharth Saxena
Ms. Sharanya Achut

July 20, 2020

Acknowledgment

The accomplishment and the outcome of the fellowship required a lot of guidance and assistance from many people and I am extremely grateful to have got this all along with the completion of my work.

I would like to thank the FOSSEE project for providing me with such a great learning opportunity. This fellowship helped me to learn and enhance my knowledge in Linear Algebra and Manim (a python animation library).
I am grateful to everyone who helped me during the fellowship.

I would like to especially acknowledge Prof. Prabhu Ramachandran, who despite being busy with his duties, took time to review my work. I am deeply thankful to him for giving me this opportunity to work under his esteemed guidance.

I also wish to express my profound gratitude to my mentors: Mr. Purusharth Saxena and Ms. Sharanya Achut for their constant support and supervision, and for patiently helping me with my doubts throughout the fellowship. This wouldn't have been possible without their support.

Finally, I would like to thank my co-fellows for their friendly encouragement and for making my experience fun and memorable.

Contents

Introduction

1.1 FOSSEE Animations and the Summer Fellowship

FOSSEE (Free/Libre and Open Source Software for Education) is a project that promotes the use of FLOSS tools to improve the quality of education in our country. The aim of the project is to reduce dependency on proprietary software in educational institutions and encourage the use of FLOSS tools through various activities to ensure commercial software is replaced by equivalent FLOSS tools. The project also involves the development of new FLOSS tools and upgrade existing tools to meet requirements in academia and research. The FOSSEE project is part of the National Mission on Education through Information and Communication Technology (ICT), Ministry of Human Resource Development (MHRD), Government of India.

FOSSEE Animations is a part of the FOSSEE project at the Indian Institute of Technology, Bombay. The FOSSEE Animations Project works on making seemingly complex Science and Mathematics topics feel natural and approachable through animations. The animations are created by students across the country. The students work with a mentor in creating a library of visualizations.

The task that was assigned to me in the fellowship was to create animations for the 5 topics in Linear Algebra and to make brief lecture notes for the same. The entire fellowship was focused on Mathematical topics with a distinct visual perspective. The animations created would help the students to understand and visualize the complex topics and make them more approachable. The animations were created using Manim, a Python animation library for creating explanatory mathematical videos.

1.2 Topic for the Fellowship - Linear Algebra

Linear Algebra is a branch of mathematics that concerns about the vector spaces and linear mappings between them. It further includes the study of matrix calculus, transformations etc. Linear Algebra is considered to be very powerful and it can solve the most important real life problems in an efficient way.
It is central to almost all the mathematical areas like geometry and functional analysis.
The 5 sub-topics assigned to me in Linear Algebra were Vector Spaces, Basis of a Vector Space and its Subspace, Polynomial and Functional Spaces, Inner Product Spaces and Dual of a space.

GitHub:

`https://github.com/FOSSEE/FSF-mathematics-python-code-archive/tree/master/FSF-2020/linear-algebra/vector-spaces/Vector-Spaces`

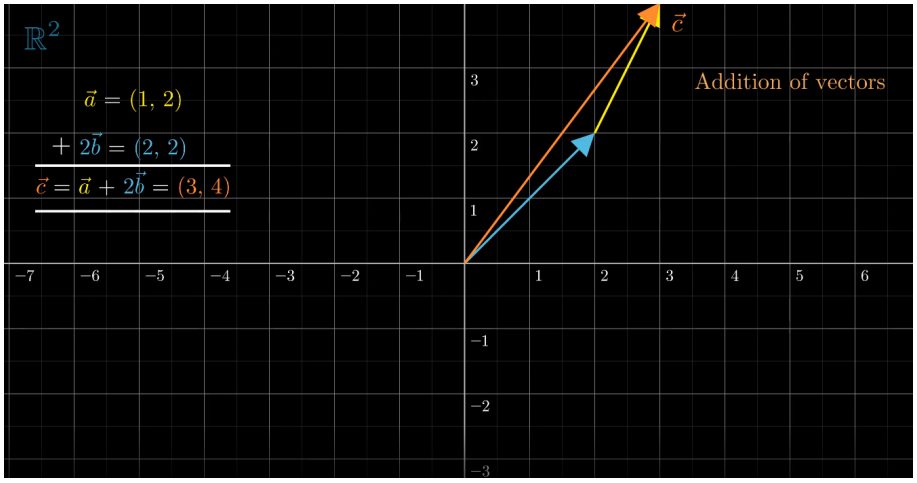
Vector Spaces

Link for the subtopic: `https://math.animations.fossee.in/contents/linear-algebra/vector-spaces/vector-spaces`

The topics covered in these lecture notes explains what exactly are vectors and vector spaces, how any vector space is populated by a similar kind of vectors, the two important linear algebraic operations: Vector Addition and Scalar Multiplication, Euclidean space as a vector space and some examples and non examples of vector spaces. It also includes how two or more vectors can be written as the linear combinations of each other.

There are 3 animations included in these notes.

The following screenshot of an animation depicts the vector addition and scalar multiplication in R^2 plane.



GitHub:

`https://github.com/FOSSEE/FSF-mathematics-python-code-archive/tree/master/FSF-2020/linear-algebra/vector-spaces/Vector-Spaces/Vector-Spaces`

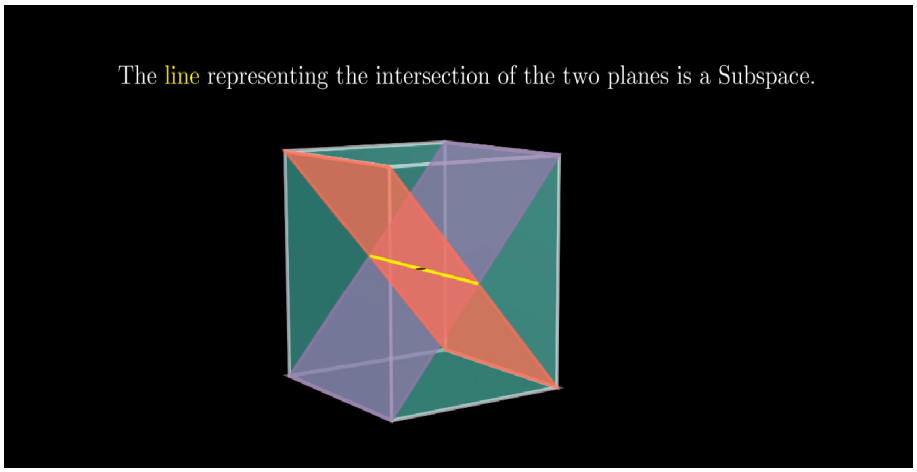
Basis of a Vector Space and its Subspace

Link for the subtopic: `https://math.animations.fossee.in/contents/linear-algebra/vector-spaces/basis-of-a-vector-space-and-its-subspace`

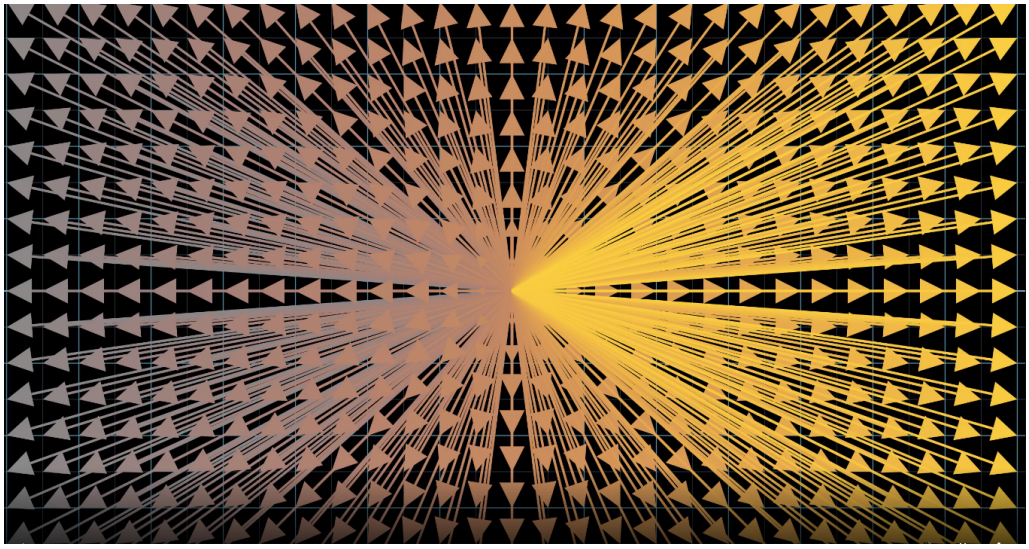
The topics covered in these lecture notes explains the concept of subspaces and how they are analogous to the concept of subsets, how the intersection of the two subspace is also a subspace, some examples and non-examples of subspaces. The other topics included are the concept of basis, how a basis is a minimum and enough information required to generate the whole vector space and the concept of linear dependence and independence.

There are 6 animations included in these notes.

The following screenshot of an animation depicts that the intersection of two subspaces is a subspace.



The Basis vectors generating the entire 2-dimensional vector space.



GitHub:

`https://github.com/FOSSEE/FSF-mathematics-python-code-archive/tree/master/FSF-2020/linear-algebra/vector-spaces/Vector-Spaces/Subspaces`

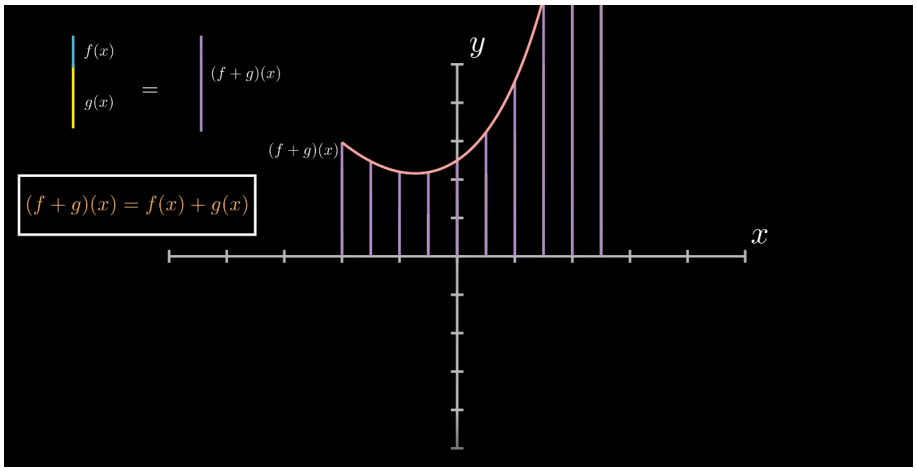
Polynomial and Function Spaces

Link for the subtopic: https://math.animations.fossee.in/contents/linear-algebra/vector-spaces/polynomial-and-functional-vector-spaces

The topics covered in these lecture notes explain how functions can also be treated as vectors, why a set of all the integrable functions over a real field forms a vector space, addition and scalar multiplication of functions, some examples of function spaces which includes a set of polynomials with real coefficients also forming a vector space and the concept of finite and infinite dimensional vector spaces.

There are 3 animations included in these notes.

The following screenshot of an animation depicts the addition of functions in R^2 plane.



GitHub:

https://github.com/FOSSEE/FSF-mathematics-python-code-archive/tree/master/FSF-2020/linear-algebra/vector-spaces/Vector-Spaces/Function-and-Polynomial-Spaces

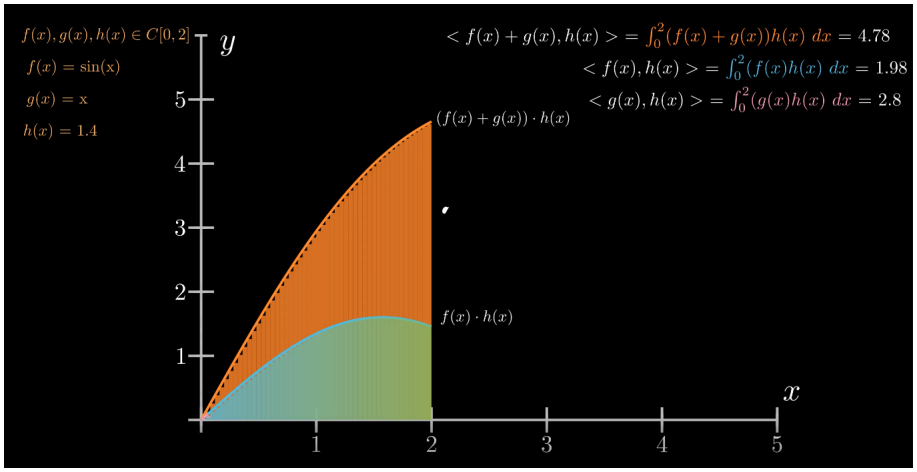
Inner Product Spaces

Link for the subtopic: https://math.animations.fossee.in/contents/linear-algebra/vector-spaces/inner-product-spaces

The topics covered in these lecture notes are dot product and its applications, the inner product as a generalization of the dot product, the concept of inner product spaces and some of its examples, the norm of a vector, and relationship between the topological, metric, normed and inner product spaces.

There are 7 animations included in these notes.

The following screenshot of an animation depicts example of an Inner Product Space.



GitHub:

https://github.com/FOSSEE/FSF-mathematics-python-code-archive/tree/master/FSF-2020/linear-algebra/vector-spaces/Vector-Spaces/Inner-Product_Spaces

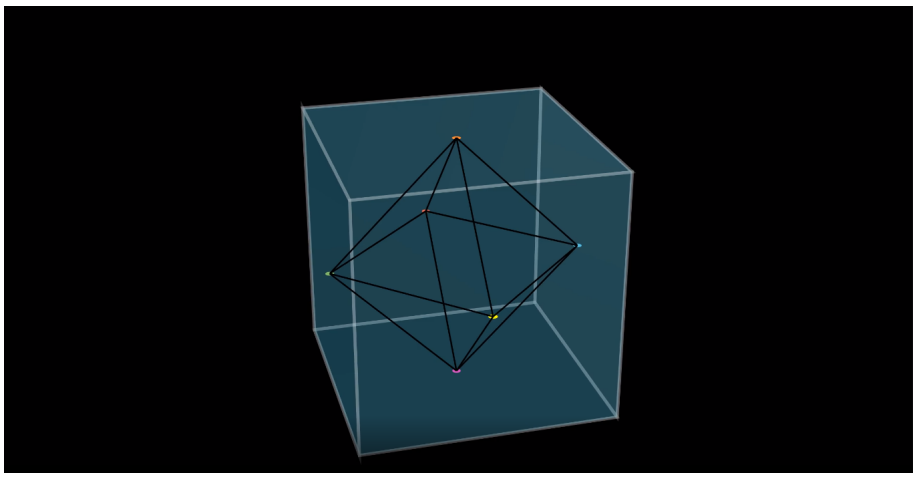
Dual of a Vector Space

Link for the subtopic: https://math.animations.fossee.in/contents/linear-algebra/vector-spaces/dual-of-a-vector-space

The topics covered in these lecture notes are the concept of duality, how a cube and an octahedron are duals of each other, duality in set theory, how the idea of duality arises in vector spaces and the dual of any vector space is also a vector space, linear functionals and the dual basis of a vector space.

There are 5 animations included in these notes.

The following screenshot of an animation depicts that a cube and an octahedron are the duals of each other.



GitHub:

https://github.com/FOSSEE/FSF-mathematics-python-code-archive/tree/master/FSF-2020/linear-algebra/vector-spaces/Vector-Spaces/Dual-Spaces

Conclusion

My experience of working with FOSSEE was very educative. Being an undergraduate student of Mathematics, I had theoretical knowledge about many topics but yet while making notes for other people I got the opportunity to learn deeper about the topics and get an idea of their applications as well. Also, the fellowship helped me a lot to visualize different mathematical concepts making them easier to understand and hard to forget. Through this fellowship, I met many individuals with great minds who helped me overcome all my challenges throughout. Having a balance between work and personal life is also one of the skills that I have acquired during this fellowship. All in all the experience was very productive, both in an academic as well as personal level.