FOSSEE Summer Fellowship Report

On

Mathematics With Python

Submitted by

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Under the guidance of

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Mentors

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Acknowledgment

Foremost, I would like to express my sincere gratitude to my mentors Purusharth Saxena and Sharanya Achut for making the notes lucid and error free, acquainting us with new tools to make our work easier & faster, and their continuous support for the project. Thanks to my teammates for fruitful discussions and maintaining the team spirit. Thanks to Prof. Prabhu Ramachandran for his precious overall guidance of the team.

I want to thank the selection committee for giving me a chance to work on this project. They envisaged my potential to select me, and I am extremely thankful for that.

Thanks to the whole FOSSEE team for providing us such a great hands-on learning experience and developing such a wonderful platform to improve skills.

Special thanks to Grant Sanderson for making the open-source graphics library "Manim". This library was extensively used to generate the animations for the Lecture notes of my project.

Grateful to the communication platforms like Slack, Gmail, Google Meet, Trello etc. for which we were able to complete the fellowship remotely in an organized way.

I am thankful to my parents, family members, and friends for constantly supporting me throughout this project.

With Regards,

Somnath

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Introduction

1.1 FOSSEE Animations and the Summer Fellowship

'**FOSSEE** (Free and Open Source Software for Education) promotes the use of FLOSS(Free/Libre and Open Source Software) tools to improve the quality of education in our country. The project aim to reduce dependency on proprietary software in educational institutes. This project also develop 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.'[1]

'**FOSSEE Animations** is a part of FOSSEE project at the Indian Institute of Techology, Bombay. FOSSEE Animations Project works on making seemingly complex Science and Mathematics topics feel natural and approachable through animations. Students across the country take part in this project to create animations on different topics.'[2]

After being selected for the fellowship based on the screening task I first met my team on April 20. After that the plan of work was set up with the help of my mentors. For first few days I learned "Git" and "Manim" then I have done the Orientation tasks. After selection of topics I was assigned to make lecture notes and animations on 5 different topics on May 6. In our team, there were about ten fellows assigned with their own topics. Before June 30 I had completed the notes.

The work done by us are significant in mainly three ways as I see -

- The created lecture notes will be very helpful for anyone who wants to learn the topics in a short time with great insights.

- While creating the notes we also learned the topic in a great detail and especially we learned how to create good animations with "Manim".

- "Manim" has no complete documentation till date. We used to learn by seeing other's work but they are also limited in number. The Git repository[3] containing our animation work will help future learners for sure.

1.2 Tools used for animations

1.2.1 Manim

'**Manim** is an animation engine written in python, created by Grant Sanderson. It is used to create precise animations programmatically'[4]. I used it to create animations for my lecture notes. It is a free and open source library, one can find it here[4].

1.2.2 Git

'**Git** is a free, open-source distributed version control system (Version control is a system that records changes to a file, or set of files, over time so that you can recall specific versions later). It keeps track of projects and files as they change over time with the help of different contributors.

Git helps keep track of changes made to a code. If at any point during coding one hit a fatal error and don't know what's causing it, Git allows to revert back to a stable state. It also helps to see what changes have been made to the code over time.'[5]

In our project we used Git and Github to maintain our codes and share them with other teammates to help each other.

Topic for the Fellowship - Integrals of Multivariable Functions

Multivariable calculus is the calculus of more than one variable as the name indicates. For most of the real-life application functions of several variables are dealt more frequently than the functions of a single variable. Integration and differentiation are the two important operations of Calculus. In this project I dealt mostly with the Integration part.

Multiple integral and line integral are the topics under integrals of multivariable functions. Double and triple integrals may be used to calculate areas and volumes of regions in the plane and in space. For evaluating multiple integrals as repeated single integrals we need Fubini's Theorem. Line integral is used to integrate along a curve in a field, and to calculate the length of a wire curved in space or work done along a path in a field. Two types of functions are are discussed here - scalar functions and vector functions. Vector functions are used to describe physical fields as vector fields.

For creating the lecture notes I took reference from several well-known books on those topics and online materials. As proposed by our mentors, I maintained the structure of notes like -

1. Definition
2. Motivation
3. Bird's Eye View
4. Context of Definition
5. Applications
6. History
7. Pause and Ponder
8. References
9. Further Reading

Several images and total of 23 animations were created for illustrating the 5 lecture notes. Questions-answer set for all the topics were also prepared for checking the understanding of the topics.

GitHub Link to the Animations: https://github.com/FOSSEE/FSF-mathematics-python-code-archive/tree/master/FSF-2020/calculus-of-several-variables/integrals-of-multivariable-functions
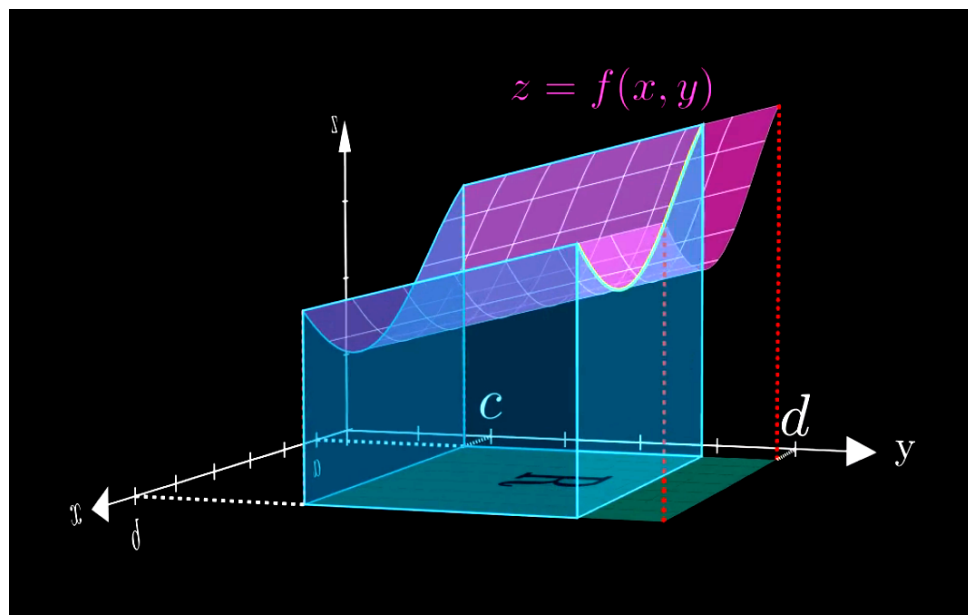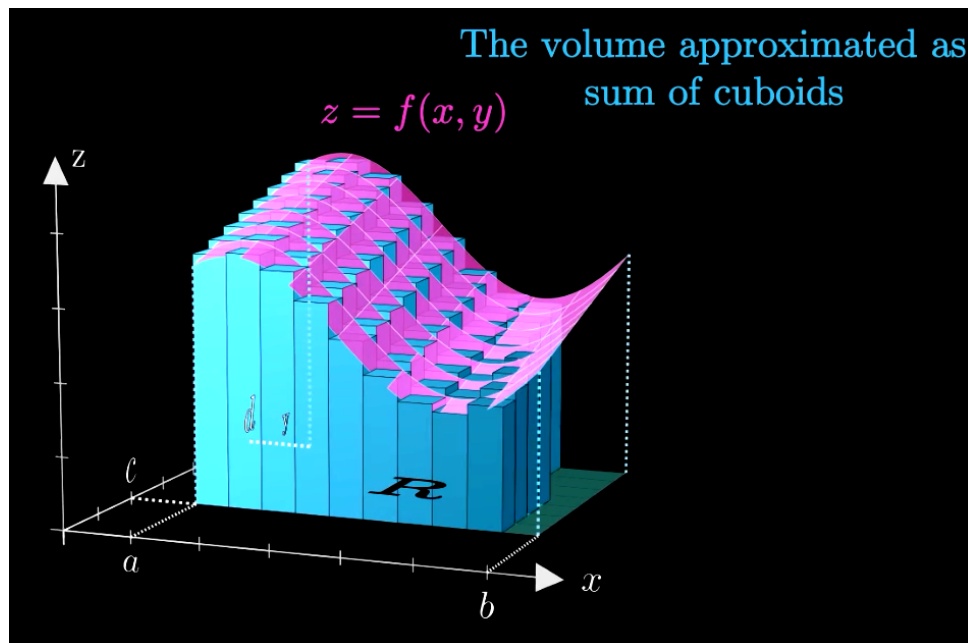
2.1   Double Integrals

In this note I included the definition of the double integral as Riemann Sum and what it represents. How to calculate double integrals in rectangular and general regions, properties, double integral in polar coordinates, application, history.

Link to the Note : https://math.animations.fossee.in/contents/calculus-of-several-variables/integrals-of-multivariable-functions/double-integrals

Total 7 animations were created for this topic.
GitHub Link to the animations : https://github.com/FOSSEE/FSF-mathematics-python-code-archive/tree/master/FSF-2020/calculus-of-several-variables/integrals-of-multivariable-functions/double-integrals
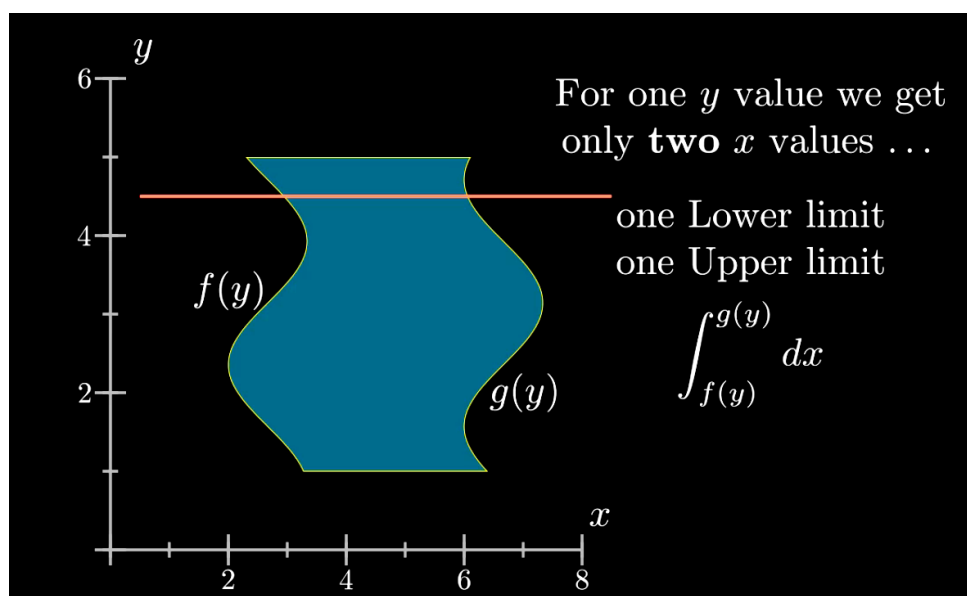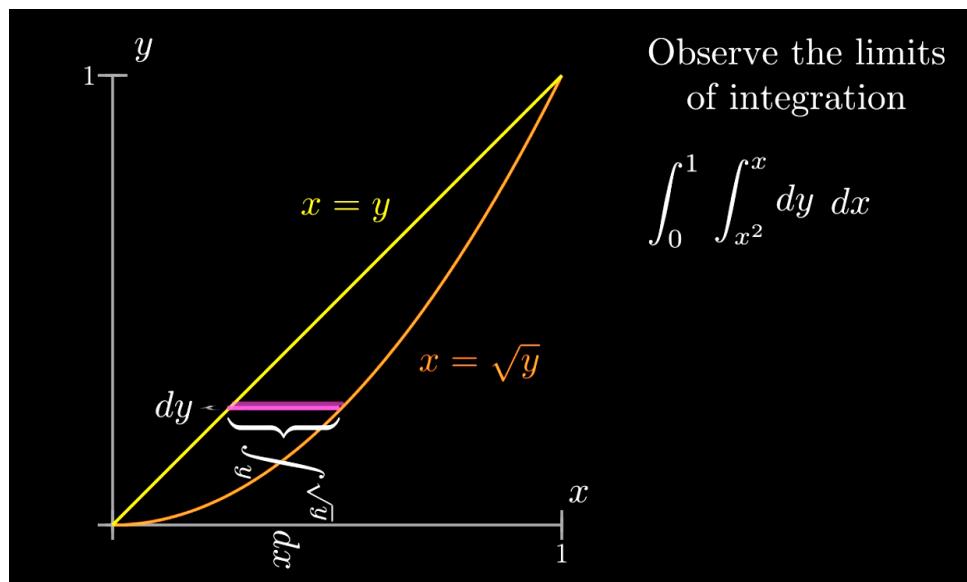
2.2 Fubini's Theorem

For Fubini's theorem we can change the order of integration of a multiple integral under certain criteria. Includes how different order of iteration can lead to different results of the integral; how to change the order of integrations its certain advantages and more.

Link to the Note : https://math.animations.fossee.in/contents/calculus-of-several-variables/integrals-of-multivariable-functions/fubini's-theorem

Total 4 animations were created for this topic.
GitHub Link to the animations : https://github.com/FOSSEE/FSF-mathematics-python-code-archive/tree/master/FSF-2020/calculus-of-several-variables/integrals-of-multivariable-functions/fubini's-theorem
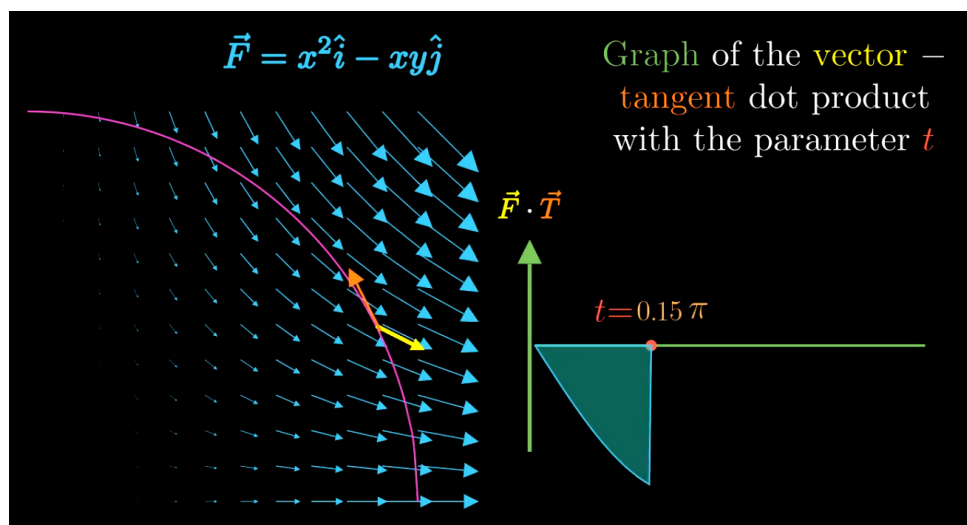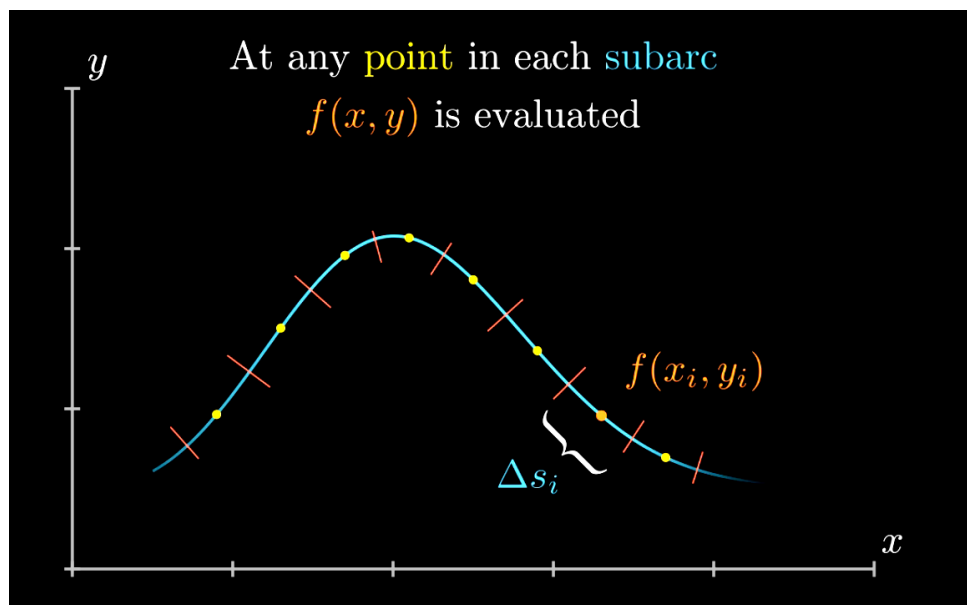
2.3   Line Integrals

This note includes Scalar and Vector line integrals. Shows the need of parameterization in line integral. Definition of scalar and vector line integrals as a limit of sum, examples, properties and applications and more.

Link to the Note : https://math.animations.fossee.in/contents/calculus-of-several-variables/integrals-of-multivariable-functions/line-integrals

Total 5 animations were created for this topic.
GitHub Link to the animations : https://github.com/FOSSEE/FSF-mathematics-python-code-archive/tree/master/FSF-2020/calculus-of-several-variables/integrals-of-multivariable-functions/line-integrals
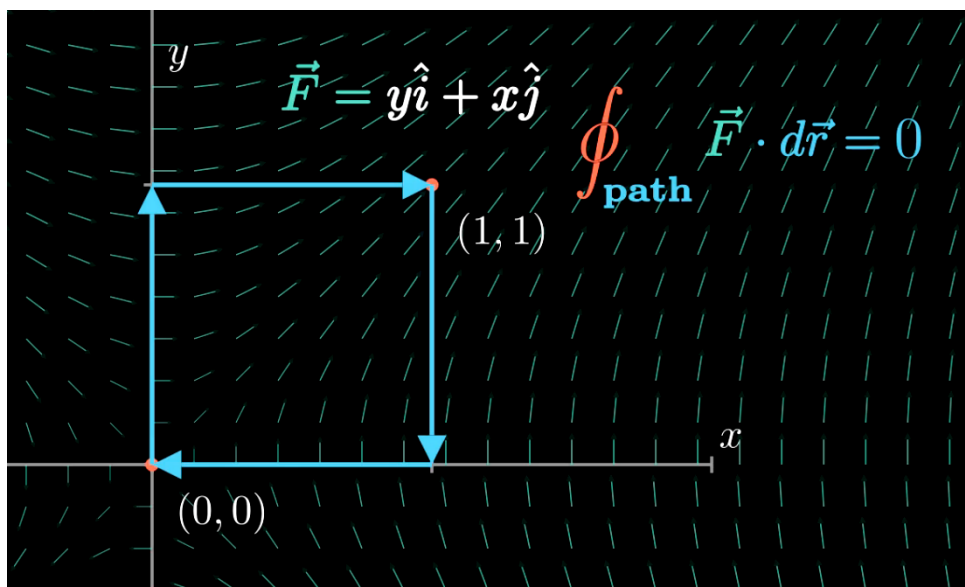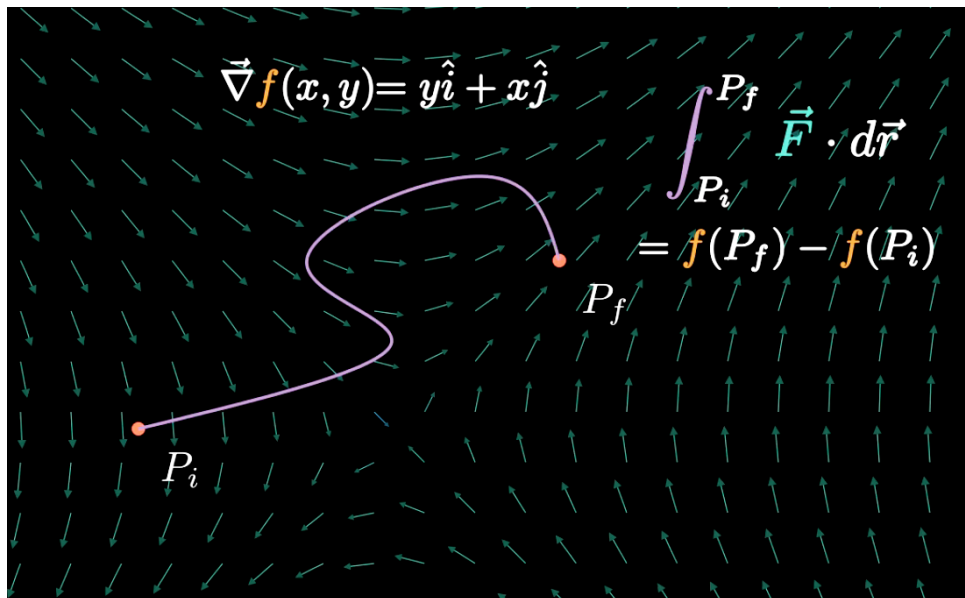
2.4 Fundamental Theorem of Line Integrals

Definition of Fundamental Theorem of Line Integrals and its relation with fundamental theorem of calculus. How it simplifies certain vector line integrals – conservative fields and how to find conservative fields and use this theorem to calculate line integrals and more.

Link to the Note : https://math.animations.fossee.in/contents/calculus-of-several-variables/div,-grad,-curl-and-all-that/the-fundamental-theorem-of-line-integrals

Total 3 animations were created for this topic.
GitHub Link to the animations : https://github.com/FOSSEE/FSF-mathematics-python-code-archive/tree/master/FSF-2020/calculus-of-several-variables/integrals-of-multivariable-functions/fundamental-theorem-of-line-integral
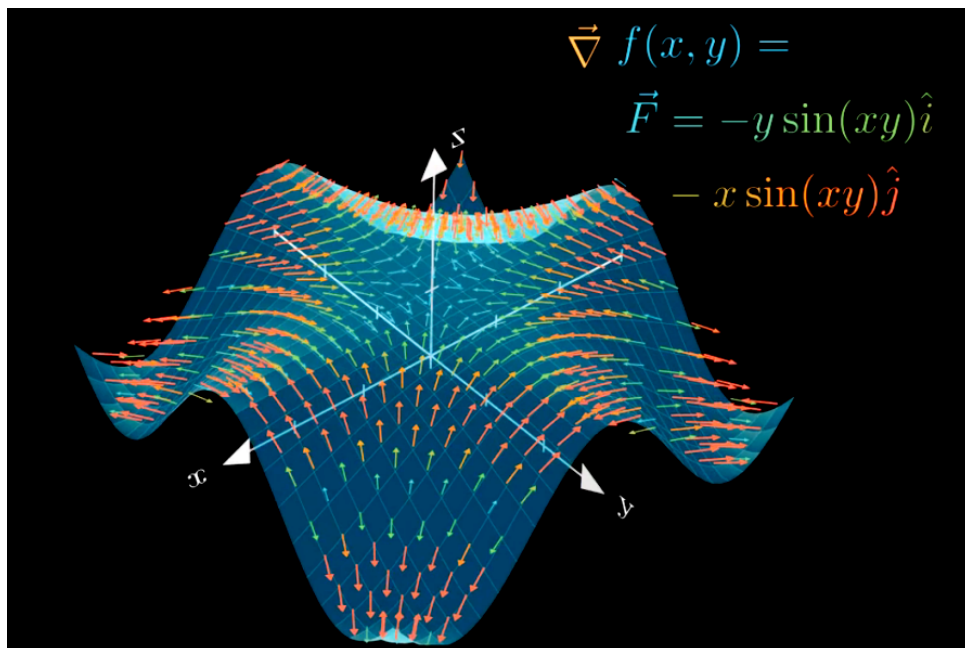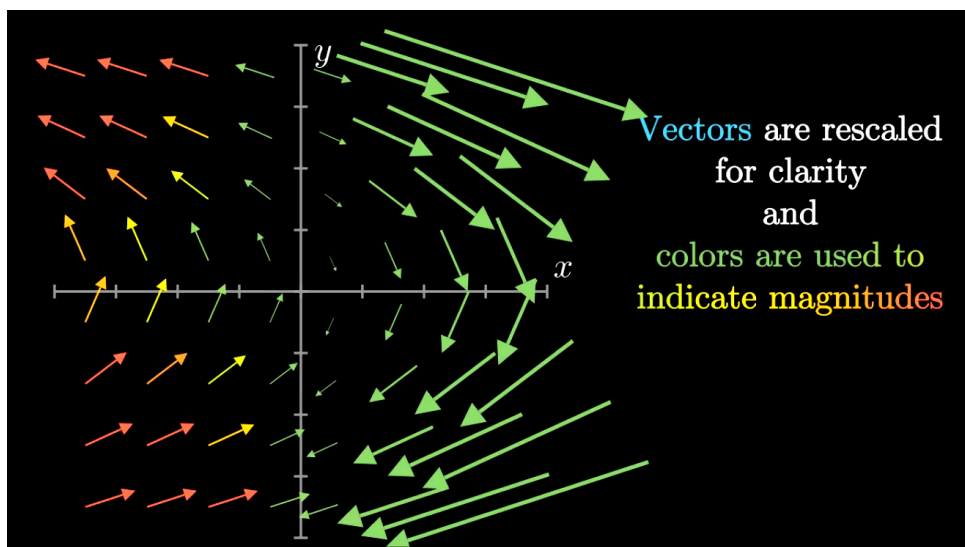
2.5   Vector Fields

This note introduces the concept of vector field and how they are represented. it Includes gradient of a scalar field, construction of a vector field. Application of vector field in fluid flow, wind maps, slope fields and more.

   Link to the Note : https://math.animations.fossee.in/contents/calculus-of-several-variables/integrals-of-multivariable-functions/vector-fields

   Total 4 animations were created for this topic.
GitHub Link to the animations : https://github.com/FOSSEE/FSF-mathematics-python-code-archive/tree/master/FSF-2020/calculus-of-several-variables/integrals-of-multivariable-functions/vector-fields

Conclusion

"It was quite a journey". For the first time I was working with people from different corners of India as a team which was indeed a great experience. This project pushed me to take a grip on my communication skills. Being a Physics major student I used Python for numerical methods, data plots and so on but for the first time in this project I was generating animations using Python. I can recall how I put all my effort to make the animations using "Manim" and about two months of lockdown for COVID-19 flew away. In this time I came to know more about visual tool kit, Git and Open Source software.

During this fellowship I got an understanding about how such projects are executed in an organized way. I got an idea of the amount of work needed to create a lecture note which is clean and understandable to everyone. We used to set deadlines for each lecture note and rush to complete it in time. While making the first notes I was under immense stress as the animations ate so much time but eventually I learned to manage stress and made SMART plans to achieve the goals - no doubt it was a big lesson for me.

Eventually, I loved to do animations despite they took time. As I had to finish the project in time, I suppressed my desire to make extra animations to further illustrate the topics.

It was a beautiful experience and I will be more happy if my work help and influence others.

References

1. https://fossee.in/about

2. https://animations.fossee.in/about/

3. https://github.com/FOSSEE/FSF-mathematics-python-code-archive

4. https://github.com/3b1b/manim

5. https://www.educative.io/edpresso/what-is-git