



# GEOMETRY OF VISION

## PROF. VIJAY RAVIKUMAR

Department of Mathematics

Chennai Mathematical Institute

**INTENDED AUDIENCE** : Any Interested Learners.

**PRE-REQUISITES** : None, but some experience with mathematical proofs will be useful. Linear Algebra will be useful in the fourth week, but not essential.

### ABOUT THE COURSE:

This course will explore how one of our senses -- our sense of sight -- relies on our brain's seemingly hardwired understanding of a fascinating geometric space. What's more, this space -- known as the two dimensional Projective Plane -- is surprisingly different from the familiar Euclidean plane.

By examining some basic questions related to perspective drawing, like why parallel lines appear to converge in our vision, we can identify and analyze the defining properties of this space — properties which are well known to our visual sense, but defy our logical intuition.

As the course progresses, we'll situate perspective drawing in the framework of Projective Geometry, and get familiar with the algebra of homogeneous coordinates, which will allow us to translate our sensory intuition into precise information we can easily communicate. Finally, we'll get to know the topological space known as the real projective plane, as well as the matrix group that governs its transformations.

Being a four-week long elective, this course will nicely complement standard courses on geometry and topology, by giving hands-on experience with several important mathematical objects you'll meet in those classes. But much of the course will also be interesting for artists, designers, or anyone else looking to understand deeper connections between math and art that humankind has been exploring for thousands of years.

The course is best experienced through the companion page: <https://this-vijay.github.io/vision-math/>  
Here you can easily navigate between videos, lectures, and chapters, understand the context of each video, and access interactive exercises that transition from one video to the next

### ABOUT THE INSTRUCTOR:

Prof. Vijay Ravikumar recently joined the faculty at Azim Premji University in Bangalore. He is interested in math communication and outreach, as well as visual art and puppetry. He was an Assistant Professor at the Chennai Mathematical Institute from 2016 to 2020. He received his PhD from Rutgers University in 2013.

### COURSE LAYOUT:

**WEEK 1:** The Power of Vanishing Points

**Lecture 1:** Why do images of parallel lines converge?

**Lecture 2:** Solving puzzles with vanishing points

**Lecture 3:** Using vanishing points to draw in perspective

**WEEK 2:** A Geometry of Coincidence

**Lecture 4:** The extended Euclidean plane

**Lecture 5:** Three coincidences in projective geometry

**Lecture 6:** Extending space to prove Desargues's Theorem

**WEEK 3:** The Shadow of a Square

**Lecture 7:** A closer look at perspectivities

**Lecture 8:** Projectivities and the Three-Fixed-Points Theorem

**Lecture 9:** The Fundamental Theorem of Projective Geometry

**WEEK 4:** The Analytic Framework

**Lecture 10:** Examining the cross ratio

**Lecture 11:** The Real Projective Plane

**Lecture 12:** Transformations of the Real Projective Plane