

PLSC 30600 - Causal Inference (Winter 2026)

Math Section Syllabus

Location: Pick Hall 407

Course Time: Thursday 2:00-3:00

Supplemental Math TA: Sophia Lipkin, slipkin@uchicago.edu

Office Hours: TBD

Course Overview. This supplemental math section for causal inference is attempting to help graduate students bridge the gap between math education among PhD students. Attendance at this supplementary section is entirely optional, but it is designed to support students who would benefit from additional mathematical foundations for causal inference and estimation. We strongly recommend it for doctoral students, as well as for masters students who plan to continue on to Bobby Gulotty's estimation course in the spring.

If you are planning on taking Bobby's class and cannot attend the section, please contact me.

Prerequisites. The course covers Linear Algebra and continuous probability, as well as some multivariate calculus. Because of the limited time frame, I am assuming that students have attended or familiarized themselves with the content of the Math Camp for PhD students run by Ryan Gibbons and Luke Cain in the fall. I will flag what you should review as the course progresses so you don't have to rush to review everything at once.

Resources. There are multitude of resources on the internet to help you learn these concepts, from people who have been thinking about how to teach math for far longer than me, for many different types of learners. I will make available videos, practice problems, and relevant textbook chapters on Mondays before class.

- **Math Camp Slides:** <https://ryankgibbons.com/resources/>

Course text.

- Available on Github:
 - Bretscher, Otto. *Linear Algebra with Applications*. 5th ed. Boston: Pearson Education, 2013, (*solutions manual also available on Github*)
 - Hansen, Bruce. *Probability for Economists*. 2021
- Calculus 1:
https://www.asherbroberts.com/teaching/2025_fall_calculus_i/Calculus_I_Notes_2025.pdf

- Calculus 2:
https://www.asherbroberts.com/teaching/2025_spring_calculus_ii/Calculus_II_Notes_2025.pdf
- Calculus 3 (Multivariate Calculus):
https://www.asherbroberts.com/teaching/2025_fall_calculus_iii/Calculus_III_Notes_2025.pdf

Course resources. There are many great calculators and step-by-step resources to help with your math understanding that are passed down informally among math students. Here are a few. You should use these before checking ChatGPT or another AI


- [Matrix Calculator](#) - any sort of computation with matrices
- [Integral Calculator](#)
- [Derivative Calculator](#)
- [Wolfram Alpha](#)
- [Math Stack Exchange](#) - this is what retired math professors do in their free time, it is infinitely better for conceptual questions than Reddit or ChatGPT and your question has probably already been answered

Course outline.

Week 2. Introduction to Proofs

- Proof: Law of Iterated Expectations
- Matrix notation for systems of linear equations



Resources:

- https://www.fsb.miamioh.edu/lij14/411_proof.pdf - *Proof here*
- Video (preview of the class):  ALL of linear algebra in 7 minutes.
- Math camp slides review: Days 1 & 2 (set and number theory, functions and operations)

Week 3. Introductory Matrix Algebra

- systems of linear equations, matrix notation and solving
- matrix multiplication

Resources:

- Video:  Linear Algebra 1.1 Introduction to Systems of Linear Equations **, corresponding textbook chapter
- Video:  Linear Algebra 1.3 Matrices and Matrix Operations , corresponding textbook chapter

- Students may want to review some of the videos from week 6, particularly Chapter 4, if they are highly visual learners

Week 4. *Sophia in Colombia, no class*

- additional office hours Tuesday Jan 27th (*TBD time*)
- review problems: calculus: solving derivatives and integrals

Week 5. Linear algebra continued – Matrix Inverses & Determinants

- Video: [Linear Algebra 1.4 Inverses; Algebraic Properties of Matrices](#) , corresponding textbook chapter
- [Eigenvectors and eigenvalues | Chapter 14, Essence of linear algebra](#)
- Students may want to review the Chapter 6 video from week 6 if they want to understand determinants visually
- Visualizing linear regression through linear algebra: (*this is the essence of Bobby's class, NOT necessary for this class!*)
 - [Linear Regression in 3 Minutes](#)
 - [Simple Linear Regression Formula, Visualized | Ch.1](#) – chs 1-4!

Week 6. Linear algebra continued – Vectors, projection matrices

- dot product on unit vectors
- span, basis, coordinates
- eigenvalues

Resources:

- SL note: this is a very difficult week conceptually, but it is one of the most important things you learn for understanding how we compute regression models. I will add a bunch of additional videos for this
- Visually understanding everything we did in weeks 3-5
 - [Vectors | Chapter 1, Essence of linear algebra](#) (MUST WATCH!!)
 - [Linear combinations, span, and basis vectors | Chapter 2, Essence of linear algebra](#)
 - [Linear transformations and matrices | Chapter 3, Essence of linear algebra](#)
 - Visual explanation of matrix multiplication:
 - [Matrix multiplication as composition | Chapter 4, Essence of linear algebra](#)
 - [Three-dimensional linear transformations | Chapter 5, Essence of linear algebra](#)
 - [The determinant | Chapter 6, Essence of linear algebra](#)
 - [Dot products and duality | Chapter 9, Essence of linear algebra](#) (MUST WATCH!!)
- Visually understanding projection matrix:
 - [Projection Matrix Properties - Projection, Part 1](#)
 - [Orthogonal Projection Formulas \(Least Squares\) - Projection, Part 2](#)

Week 7. Continuous random variables

- Continuous probability, integrals and fundamental theorem of calculus
- expectation properties for continuous RVs

Week 8. Multivariate random variables

- Multivariate functions, partial derivatives
- Marginal densities, conditional distributions
- Gamma integrals
- joint PDFs & CDFs, visualizing in 3D

Week 9. Review, no new content

- additional office hours Tuesday March 3rd (*TBD time*)