

Mathematical Foundations of Political Analysis

PSCI 8350 · Vanderbilt University · Fall 2026

Meetings	Tuesday and Thursday, 9:30–10:45am, Commons Center 349
Instructor	Professor Brenton Kenkel brenton.kenkel@vanderbilt.edu Office hours: Monday 10:30am–12:00pm, Commons Center 326
Teaching assistant	Addison Emig Office hours: Friday, 10:30–11:30am

Overview

This course will introduce you to the essential mathematical techniques necessary to understand and undertake research in political science. We will focus on math that has direct applications in statistics and causal inference, though many of the techniques we will cover are also useful for formal modeling.

Assessments

Problem sets (30%). I'll assign a problem set roughly every week, with a target completion time of 3–5 hours.

Midterm exams (2x, 20% each). These will be in-person exams held during the class period. They are closed-book and closed-notes, except you may bring a single, handwritten, two-sided “cheat sheet” to consult.

Final exam (30%). Your final exam will be a 45-minute oral exam administered by me and the TA. We will talk about key concepts from the course and ask you to work through some problems on the whiteboard.

Policies

Attendance. I expect you to attend every class session unless you are ill or experiencing an unanticipated emergency. You can assume that this expectation applies to all PhD courses.

Electronic devices. It's hard to learn if you're distracted. So this is a no-laptops, no-phones classroom, with exceptions only to meet documented ADA accommodations. That includes me—I'll be leaving my phone in my office during class.

You may use a tablet for note-taking, provided that you disable all notifications/distractions throughout the class and use the tablet solely for taking notes. If I get the sense that the tablet is serving as a distraction for *anyone*, I will remove this option for *everyone*.

Late assignments. I will neither accept late work nor grant extensions. Turn in whatever you have finished by the deadline. (This policy is in part for your own good, to prevent a cascade of extensions that results in you taking an incomplete in this or other courses.)

Artificial intelligence. On problem sets, I expect you to seriously attempt all problems on your own before consulting any outside source, including AI. I expect you to only turn in work that you personally authored and completely understand. You can only use AI as a supplement to your understanding and intellectual effort, not as a substitute for it.

On exams, you will not have access to electronic devices and therefore cannot use AI.

A violation of this policy is a violation of Vanderbilt's Honor Code. If I have reason to believe there has been a violation, I will follow the standard procedures for a suspected Honor Code violation by a graduate student. See <https://gradschool.vanderbilt.edu/academics/honor-council/> and <https://www.vanderbilt.edu/faculty-manual/part-iii-university-principles-and-policies/ch9-honor-system/>.

Topics and schedule

Your main source for readings will be the lecture notes at <https://bkenkel.com/mfpa>. I will also assign some chapters from Timothy Gowers' book *Mathematics: A Very Short Introduction* (Oxford, 2002). (Don't buy the book; I'll provide copies.)

Some useful, but optional, additional references:

- *Mathematics for Economists* by Carl P. Simon and Lawrence E. Blume (W. W. Norton, 1994).
- *The Cartoon Guide to Algebra* and *The Cartoon Guide to Calculus* by Larry Gonick (William Morrow, 2015 and 2011).
- *The No Bullshit Guide to Linear Algebra* by Ivan Savov (Minireference Co., 2017).
- *A First Course in Optimization Theory* by Rangarajan K. Sundaram (Cambridge, 1996).
- *The Nuts and Bolts of Proofs* by Antonella Cupillari (Academic Press, 2011).
- *How to Prove It: A Structured Approach* by Daniel J. Velleman (Cambridge, 2019).

Here is a tentative schedule of topic coverage. I may slow down (or speed up) depending on the needs of the class.

Date	Unit	Topics
Thu Aug 27	Set theory	Common sets, subsets, set equality, set builder notation
Tue Sep 1	Set theory	Combining sets, the empty set, complements, De Morgan's Laws
Thu Sep 3	Set theory	<i>(Will be rescheduled due to APSA travel, probably to the day before.)</i> Functions as mappings, compositions, one-to-one, onto
Tue Sep 8	Limits and continuity	Intuitive definition of function limit, properties of limits
Thu Sep 10	Limits and continuity	Continuity at a point and on the domain, common continuous functions, implications of continuity
Tue Sep 15	Limits and continuity	Logarithmic and exponential functions
Thu Sep 17	Intro calculus	Slope of a linear function, linear approximations, definition of the derivative
Tue Sep 22	Intro calculus	Rules of differentiation
Thu Sep 24	Intro calculus	Derivatives of common functions
Tue Sep 29	Intro calculus	Area under the curve, Riemann sums, second fundamental theorem of calculus
Thu Oct 1	Intro calculus	Integrals of common functions
Tue Oct 6	Midterm 1	
Thu Oct 8	Intermediate calculus	The chain rule
Tue Oct 13	Intermediate calculus	Applying the chain rule
Thu Oct 15	Intermediate calculus	Higher-order derivatives, partial derivatives
Tue Oct 20	Intermediate calculus	Optimization: first-order conditions
Thu Oct 22	<i>Fall break</i>	
Tue Oct 27	Intermediate calculus	Optimization: second-order conditions, convexity and concavity
Thu Oct 29	Linear algebra	Vector operations, linear independence
Tue Nov 3	Linear algebra	Matrix operations, special types of matrices
Thu Nov 5	Linear algebra	Matrix multiplication properties, inverse of a 2×2 matrix

Date	Unit	Topics
Tue Nov 10	Linear algebra	Solving linear systems
Thu Nov 12	Linear algebra	Solving linear systems
Tue Nov 17	Midterm 2	
Thu Nov 19	Catch up/flex day	
Tue Nov 24	<i>Thanksgiving break</i>	
Thu Nov 26	<i>Thanksgiving break</i>	
Tue Dec 1	Logic and proofs	Truth tables
Thu Dec 3	Logic and proofs	De Morgan's laws, necessity and sufficiency, deductive inference
Tue Dec 8	Logic and proofs	Proving a conditional, proof by contradiction
Thu Dec 10	Logic and proofs	Brief introduction to "for all" and "there exist" statements
Dec 15-ish	Oral final exam	<i>(Exact timing TBD, will not take place on same day as other in-person exams)</i>