POLS 60833: Math for Political Scientists (Fall 2016)

Course Information
Class Time: Mon./Wed., 11:00am–12:15pm
Classroom: DeBartolo Hall 113

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Course Description

This introductory course is one of the two mandatory research methods requirements for Political Science PhD students in their first semester at Notre Dame. But beyond preparing future political scientists for taking more advanced methodology courses (such as game theory, multiple regression, experimental and survey methods), I want you to learn a foreign language, the language of quantitative research. By mastering this language you will become an intelligent consumer of cutting edge substantive research across the social sciences. You may feel that you do not need the mathematical training because your research interests direct you intrinsically qualitative fields, such as transitional justice or social protest and political violence. This may be true. However, you should be aware that some of the most exciting research conducted in those fields also makes extensive use of mathematical methods. Thus, you should focus on focusing on getting as much out of this course as you can regardless of the directions in which your research interests develop.

Essentially, this is a course in probability, linear algebra, and calculus. But instead of spreading the instruction over five or more semesters, as one would for completing an undergraduate major in math, we have condensed into one semester all the material that future political scientists absolutely need to know to read the formal sections of articles in the top journals of our field.

It is typical for students to require repeated encounters with a concept or type of mathematical problem before they can actually master it. So if this is your first course in calculus or matrix algebra, it is natural that you will require repeated engagement with the basic operation in order to master the even the basic operations. That is why I encourage you to periodically revisit your notes and problem sets throughout the semester. Repetition leads to reinforcement.

Upon successfully completing the course, students will be able to:

- Understand and explain the logic of mathematical reasoning.

- Apply the rules of logic to prove mathematical theorems.

- Take derivatives and integrate to find maxima and minima of functions.

- Correctly apply the rules of logarithms and exponents.

- Perform basic matrix manipulation.

- Conduct operations using simple probabilities.

- Achieve a basic fluency in mathematical writing.

Software

At various points in this course, in an attempt to facilitate understanding, I will present results from some software programs. Mathematica will primarily be used in the calculus portion of the course, and R will be used in the matrix algebra and probability sections of the course. Students will not be expected to learn Mathematica (though it may be useful if students plan on using formal theory in their future work), though a familiarity with R will be encouraged, especially because it will be useful in later quantitative methods courses (including Quant I). To facilitate this understanding, I will include in my slides the code used when presenting simulations from R.

Using R for data analysis has a number of advantages. First and foremost, the software is free! Students can download their own copy of R (for Windows, OS X, or Linux) by going to the Comprehensive R Network (CRAN) webpage and selecting the appropriate version. Second, writing your own statistical code forces you to think carefully about the statistical assumptions that underlie your modeling decisions, in a way that using a point-and-click interface would not. Finally, if you find yourself needing to change software in the future, it is much easier to transition from R to more user-friendly statistical software (such as Stata or SPSS) than the other way around.

Books

There is one required book for this course:

A Mathematics Course for Political and Social Research by Will H. Moore and David A. Siegel.
· Errata
· Video Lectures

You should consider the video lectures to be (nearly) mandatory viewing.

Beyond these materials, however, you will be required to seek out materials that are best suited for **you** and **your learning style**. That said, I will incorporate into my lectures different materials from the following books. Furthermore, I will provide the relevant readings for those books that are not open-source. I suggest you ask around, look at other syllabi online, and just browse the shelves at the library and used bookstores to find books that make things clear to you.

A First Course in Linear Algebra by Robert A. Beezer.

Book of Proof by Richard Hammack.

Calculus by Gilbert Strang.

How to Prove It: A Structured Approach by Daniel J. Velleman.

Introduction to Probability by Charles M. Grinstead and J. Laurie Snell.

Probability and Statistics by Morris H. DeGroot and Mark J. Schervish.

Grading

Class attendance is not explicitly required, though there is little prospect of success without it. That said, ability in quantitative methods varies and not everyone will be able to "master" the material. If you need a particular methodological skill to conduct your work, I do not want grades to dissuade someone from taking a course that can help them. You will receive feedback along the way on problem sets and know how you are doing in the class, but the final grade submitted in the books will be uninformative, so long as you make a good-faith effort. My goal is to give you the skills to conduct your own research, not weed people out of the program or send signals about hiring.

Problem Sets

There will be four problem sets, which will collectively count for 50% of the course grade. **Absolutely no late assignments will be accepted without prior written permission of the instructor**. However, your homework grade will be skewed toward your highest grade—your highest individual homework grade will be worth 35% of your total homework grade, your lowest individual homework grade will be worth 15% of your total homework grade, and the remaining two individual homework grades will each be worth 25% of your total homework grade.

Two Exams

There will be a take-home midterm distributed electronically on **October 12**, which will be due on **October 16** by **11:59pm**, and a take-home final exam distributed electronically on **December 7**, which will be due on **December 11** by **11:59pm**. The final exam is cumulative. The midterm exam will count for 20% of the total course grade, and the final exam will count for 30% of your total grade. Any known scheduling problems should be brought to my attention as soon as possible. Both exams will be open book. However, you must work on them individually; unlike with the problem sets, there will be no collaboration allowed. **Unless you receive prior authorization from the instructor in writing, late exams will be penalized ten percentage points for each day—or fraction thereof—that they are late. There will be no exceptions.**

Typing Mathematical Notation

The most convenient way to write math is to use LaTeX, a system for preparing documents with mathematical symbols. If you learn LaTeX, you will be able to write mathematical formulae on your iPad, iPhone or any computing device with at least a text editor. Then, all you need to do

is upload your work to typesetting program and produce a camera ready PDF. Using LaTeXallows you to signal to your readers that you know the language of mathematics and that you take quantitative research seriously. Obviously, this is a good signal to send. (Nevermind the implications that follow from much of the discipline making judgments about the quality of one's work solely on one's choice of writing tool. But that is a rant for another time.)

If all this is not enough to convince you to invest in the time to learn LaTeX, keep in mind that it is very easy to prepare a presentation in Beamer out of a document written in LaTeX. You can literally copy and paste the mathematical formulas from the paper version into the presentation. **Finally, keep in mind that all material you turn in must be typed and in PDF format. There will be no exceptions**. You do not have to use LaTeX (Microsoft's Equation Editor is also reasonable, and there are other options as well), but you need to make an investment in *something*.

Collaboration

One of the best ways that people learn is by teaching and collaborating with others. In this class we facilitate collaboration by allowing you to work on the homework assignments in groups of no larger than three. That does not mean, however, that students are allowed to turn in identical assignments. Work out the solutions together and then write up the final answer separately. Identical assignments will result in failure of the assignment.

Policy on Plagiarism

According to University of Notre Dame's Academic Code of Honor for Current Graduate Students, "any activity that compromises the pursuit of truth and the advancement of knowledge may undermine confidence in the academic enterprise. Violation of integrity in research includes, but is not limited to plagiarism; deliberate fabrication or fabrication in proposing, conducting, reporting, or reviewing research." To learn more about where to draw the line between misjudgment and academic misconduct, I encourage you to consult the website above. To avoid engaging in plagiarism make sure that you never use words that are not your own without proper attribution. According to our Academic Code of Honor for Current Graduate Students, "those who appropriate the words or ideas of another, and who attempt to present them as their own without proper acknowledgment of the source, whether intentional or not, are committing plagiarism or intellectual theft."

Policy on Disabilities

Any student who has a documented disability and is registered with Disability Services should speak with the professor as soon as possible regarding accommodations. Students who are not registered should contact Sara Bea Disability Services.

Policy on Technology

This course relies heavily on access to computers, specific software, and the Internet. At some point during the semester you WILL have a problem with technology: your laptop will crash,

a file will become corrupted, a server will go down, or something else will occur. These are facts of life, not emergencies. Technology problems will not normally be accepted as excuses for unfinished work. Count on "stuff" happening and protect yourself by doing the following:

- Plan ahead — start early, particularly if scarce resources are required.

- Save work often — at least every ten minutes.

- Make regular backups of files in a different location from the originals.

- Save drafts of work at multiple stages.

- When editing an image, set aside the original and work with a copy.

- Practice safe computing when surfing the web and checking email.

- On your personal computer, install and use software to control viruses and malware.

When submitting any assignment electronically in this course, you are responsible for any technological problems (*e.g.*, internet connection difficulties, corrupted files, etc.). To prevent problems along with the associated lateness penalties, you should submit papers well before the deadline and take proactive steps to ensure that the file was not corrupted (*e.g.*, check it after uploading to Sakai or copy yourself on emails and check the attached file). Again, please do not trust your computer to function correctly at the last minute.

Calendaring Concerns

There will be no class on the following days:

- August 31: Annual Meeting of the American Political Science Association

- October 17 and 19: Midterm Break

- November 23: Thanksgiving Holiday

Course Topics

Note: The course syllabus is a general plan for the course; deviations announced to the class by the instructor may be necessary. We may not cover all of these topics. Conversely, time permitting, other topics might be covered in this course.

Topic 0: Introduction and Overview

- Achen, Christopher H. 2002. "Advice for Students Taking a First Political Science Graduate Course in Statistical Methods." *The Political Methodologist* 10(2): 10–12.

Topic 1: Set Theory and Functions

- Moore and Siegel — Chapters 1, 2, and 3

- DeGroot and Schervish — Chapter 1.4

- Hammack — Chapter 1

Topic 2: Formal Logic and Proofs

- Moore and Siegel — Chapter 1.7 (reread!)

- Hammack — Chapters 2, 4, 5, and 6

- Velleman — Chapter 1, 2, and 3

Topic 3: Limits and Derivatives

- Moore and Siegel — Chapters 4, 5, and 6

- Strang — Chapters 2 and 6

Topic 4: Applications of the Derivative

- Moore and Siegel — Chapter 8

- Strang — Chapter 3

Topic 5: The Chain Rule

- Moore and Siegel — Chapter 6.1.2 (reread!)

- Strang — Chapter 4

Topic 6: Integral Calculus

- Moore and Siegel — Chapter 7

- Strang — Chapters 5 and 8

Topic 7: Multivariate Calculus

- Moore and Siegel — Chapter 15

- Strang — Chapters 13 and 14

Topic 8: Matrix Arithmetic

- Moore and Siegel — Chapter 12

- Beezer — "Matrices," "Vectors," "Vector Spaces," and "Determinants"

Topic 9: Systems of Equations in Matrix Algebra

- Moore and Siegel — Chapter 13

- Beezer — "Systems of Linear Equations" and "Linear Transformations"

- Strang — Chapter 11

Topic 10: Probability and Bayes Rule

- Moore and Siegel — Chapter 9

- DeGroot and Schervish — Chapters 1.7, 1.8, and 2

- Grinstead and Snell — Chapters 1, 2, 3, and 4

Topic 11: Distributions and Densities

- Moore and Siegel — Chapters 10 and 11

- DeGroot and Schervish — Chapters 3 and 4

- Grinstead and Snell — Chapters 1, 2, and 5

Topic 12: Introduction to Statistical Inference

- Grinstead and Snell — Chapters 8 and 9