Poli 270: Mathematical & Statistical Foundations

Fall 2020

Instructors:	Kathryn Baragwanath, kbaragwa@ucsd.edu Luke Sanford lcsanford@ucsd.edu
Lectures:	9:00–12:00, Zoom
Office Hours:	By appointment

Description: This course serves as either a refresher or introduction to the core mathematical concepts that facilitate principled thinking about a probabilistic world. Because the scope of the course is sweeping, we will spend a limited amount of time on each topic. Both instructors will be widely available to help with difficult concepts.

This course is designed to be completed prior to *Poli204b*. Here we provide you with mathematical tools to think about political phenomena: calculus and optimization, linear algebra, an introduction to sets and logical operations, and probability theory. In *204b* you will learn how to identify systematic patterns in noisy data. Together, these tools provide a foundation for much of the work you will conduct throughout your career.

Finally, the course may be useful for non-academic reasons—this is an introduction to some of the friends and peers who will accompany you throughout your time in the program.

Structure: You should complete the assigned readings prior to the morning lectures. Grades are based on short homework assignments that are due at the beginning of each morning session. You should expect to spend several hours on the assignments each evening. There is also a comprehensive final exam that covers the course topics. You will have three hours to complete the exam. It is open book, open notes, and open internet.

Books for the Course: The primary text for the course is Moore and Siegel (2013) (although different texts are recommended for the first lecture; please consult the reading list for details). The interested student might also consider purchasing the texts we have used in previous years, Gill (2006) and Simon and Blume (1994). Both texts are written by political scientists and do a good job motivating and justifying concepts with relevant political science examples. Students interested in a high-level undergrad treatment should consult Larsen and Marx (2006).

- **Required Books**
  - Moore, Will H. and David A. Siegel. 2013. *A Mathematics Course for Political & Social Research*. Princeton University Press, Princeton, NJ.
- **Optional or Recommended Books**
  - Gill, Jeff. 2006. *Essential Mathematics for Political and Social Research.* Cambridge University Press, Cambridge, MA.
  - Larsen, Richard J. and Morris L. Marx. 2011. *An Introduction to Mathematical Statistics and its Applications, 5th Ed.* Pearson Prentice Hall, Upper Saddle River, NJ.
  - Simon, Carl P. and Lawrence Blume. 1994. *Mathematics for Economists.* W. W. Norton & Company, New York, NY.

Software: Throughout the course we will also focus on bringing you up to speed with the computing tasks that you will be expected to perform as a modern political scientist. Core emphasis is placed on two statistical packages: R and STATA. Both of these are used in *204b* as well as in other classes that you will take at UCSD. We recommend that you obtain a copy of each software package.

1. R can be obtained for free for all platforms at this link. Check that you install a "bit-version" that is compatible with your operating system. There are really two options: 32 or 64. If you're uncertain which type of system you have, you can check at the following links:
   - **Mac Users:** Follow this link.
   - **Windows Users:** Follow this link.
2. All graduate students can use STATA on the computer lab in the social science building (SSB 139). In addition, UCSD runs a virtual computing lab with STATA installed that you can access remotely. If you prefer to install a copy of STATA on your personal computer, you can request a license by emailing software@ucsd.edu, or you can purchase it for the low price of $395 here. If you decide to purchase, we suggest choosing the SE level. Finally, we understand that there are illicit means of obtaining this software, but they come at the risk of hackey-performance, computer viruses, and crippling lawsuits. We don't endorse this.

Finally, we encourage you to use an introductory text for R and Stata. The primary benefit of using a *good* book is that the concepts are presented with an underlying logic – something that frantic google searches and stackoverflow answers may not provide. We regularly consult the following books:

For an introduction to R we recommend Grolemund and Wickham (2017), available here. A non-tidyverse Introduction which is now a bit dated is given by Dalgaard (2008) and is available here. A less thorough introduction introduction by John Fox is available here. Kosuke Imai's new undergraduate text may also be of use to those looking for an applied introduction. It is listed here, but is available cheaper on Amazon. Finally, Stata publishes a good introduction by Acock here.

- **Additional Resources for R**
  - `https://stackoverflow.com/`
  - `https://www.rstudio.com/resources/cheatsheets/`
- **Additional Resources for STATA**
  - `https://www.statalist.org/forums/forum/general-stata-discussion/general`
  - `http://geocenter.github.io/StataTraining/portfolio/01_resource/`

Course Plan

Assumed Knowledge (We will assume that you are comfortable with these concepts before the course begins. If you are not, please come talk with us—we will be happy to work with you.)

1. "Preliminaries," Chapter 1. Moore and Siegel, pp. 1-26.
2. "Algebra Review," Chapter 2. Moore and Siegel, pp. 28-41.
3. "Functions, Relations, and Utility," Chapter 3. Moore and Siegel, pp. 44-78.
4. "Limits and Continuity, Sequences and Series, and More on Sets," Chapter 4. Moore and Siegel, pp. 81-100.

Meeting 1: (Guest Lecture - Professor David Wiens) Set theory, proofs and fallacies (September 8, 9:00am-12:00pm) The lecture will cover material that can be found in any of the following:

1. Velleman, *How to Prove It*, chaps. 1–3
2. Cunningham, *A Logical Introduction to Proof*, chaps. 1–5
3. Hammack, *Book of Proof*, chaps. 1, 2, 4–10

The suggested readings cover more or less the same material, although in differing levels of detail, different examples, etc. PDFs of each of these items can be found online (and the Hammack text is open source). My suggestion is that you download them all, have a look at chap. 1 of each, and then continue with the text that seems most intuitive to you.

Meeting 2: Linear Algebra (September 10, 9:00am-12:00pm)

1. "Fun with Vectors and Matrices," Chapter 12. Moore and Siegel, pp. 273-303.
2. "Vector Spaces and Systems of Equations," Chapter 13. Moore and Siegel, pp. 204-326

Meeting 3: Derivative Calculus (September 14, 9:00am-12:00pm)

1. "Introduction to Calculus and the Derivative," Chapter 5. Moore and Siegel, pp. 101-116.
2. "The Rules of Differentiation," Chapter 6. Moore and Siegel, pp. 117-132.

Meeting 4: Multivariate Derivative and Integral Calculus (September 16, 9:00am-12:00pm)

1. "The Integral," Chapter 7. Moore and Siegel, pp. 133-151.
2. "Multivariate Calculus," Chapter 15. Moore and Siegel, pp. 353-375.
3. "Unconstrained Optimization." Chapter 16.1, Moore and Siegel, pp. 376-382.
4. "Constrained Optimization: Equality Constraints," Chapter 16.2, Moore and Siegel, pp. 383-391.

Meeting 5: Introduction to Probability (September 18, 9:00am-12:00pm)

1. "An Introduction to Probability," Chapter 9. Moore and Siegel, pp. 173-197.
2. "Probability Theory," Chapter 7. Gill, pp. 284-330.

Meeting 6: Discrete Probability Functions (September 21, 9:00am-12:00pm)

1. Chapter 10. Moore and Siegel, pp. 198-229.
2. "Discrete Random Variables," Chapter 3. Larsen and Marx, pp. 148-161.
3. "Random Variables," Chapter 8. Gill, pp. 330-383.

Meeting 7: Continuous Probability (September 23, 9:00am-12:00pm)

1. Chapter 11. Moore and Siegel, pp. 242-272.
2. "Continuous Random Variables," Chapter 3. Larsen and Marx, pp. 161-173.

Meeting 8: An Introduction to Computing with R and Stata (September 25, 9:00am-12:00pm)

1. Install R from the CRAN website here.
2. Watch this video.
3. (*Recommended*) Read p. 1-95 in Dalgaard (2008).
4. (*Optional*) "Stata Tutorial," Princeton. Available here.
5. (*Optional*) "A Brief Introduction to Stata with 50+ Basic Commands," Tobias Pfaff. Available here.
6. (*Optional*) "Introduction to Stata," UNC at Chapel Hill. Available here.

Meeting 9: Review Session and advanced R and Stata (September 28, 9:00am-12:00pm)

Meeting 10: Final Exam (September 29, 12:00pm-3:00pm)

References

Acock, Alan. 2014. *A Gentle Introduction to Stata*. 4th ed. College Station, TX: Stata Press.

Dalgaard, Peter. 2008. *Introductory Statistics with R*. New York, NY: Springer-Verlag New York.

Gill, Jeff. 2006. *Essential Mathematics for Political and Social Research*. Cambridge, MA: Cambridge University Press.

Grolemund, Garrett and Hadley Wickham. 2017. *R for Data Science*. Sebastopol, CA: O'Reilly.

Larsen, Richard J. and Morris L. Marx. 2006. *An Introduction to Mathematical Statistics and its Applications*. 5th ed. Upper Saddle River, NJ: Pearson Prentice Hall.

Moore, Will H. and David A. Siegel. 2013. *A Mathematics Course for Political and Social Research*. Princeton, NJ: Princeton University Press.

Simon, Carl P. and Lawrence Blume. 1994. *Mathematics for Economists*. New York, NY: W. W. Norton & Company.