Syllabus for POLI 783: Essential Mathematics and Statistics For Political Research

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Course Description

Effective use of modern quantitative and formal tools for political and social research requires familiarity with key mathematical concepts. This course focuses on fundamental ideas from three areas—calculus, linear algebra, and probability—that are especially relevant for the methods sequence.

Building on these foundations, the course introduces essential concepts in statistics, culminating in an introduction to linear regression, one of the most widely used methods in political science research.

POLI 783 is the first course in the graduate methods sequence. Its primary goal is to develop concepts and procedures that will be applied in later courses. You will also participate in a weekly lab to acquire practical skills in R. Mastery of these skills—including calculation, proof, and coding—is essential for becoming a competent producer and consumer of applied quantitative research in political science.

Time and Location

Classes: 9:30am-10:45am on Tuesdays and Thursdays, Room 0115 in Murphey Hall.
There will be no class on Oct. 7 (Well-being day), Oct. 14, Oct. 16 (Fall break), Nov. 25, or Nov. 27 (Thanksgiving).
Instructor: Ye Wang (yewang@unc.edu).
Office hours: 1:00pm-4:00pm on Tuesdays, Room 322 in Hamilton Hall. Labs: 10:10am-11:00am on Wednesdays, Room 351 in Hamilton Hall.
Teaching assistant: Jaime Lindh (jlindh@unc.edu).
TA Office hours: 11:15am-2.15pm on Wednesdays, Room 303 in Hamilton Hall.

Texts and Software

The course will draw a lot from the following textbooks:

[MS] Moore, W. and Siegel, D., A Mathematics Course for Political and Social Research. Princeton University Press, 2013.

[BH] Blitzstein, J.K., and Hwang, J. Introduction to Probability. CRC Press, 2014.

[DBC] Devore, J., Berk, K., and Carlton, M. Modern Mathematical Statistics with Applications. Springer, 2021.

[B] Blackwell, Matthew. A User's Guide to Statistical Inference and Regression.

We may also refer to other textbooks and research papers for certain topics. It is expected that students try to read materials listed as references before class.

We will working with R in this course, which is an open-source computing language that is very widely used in statistics. You can download it for free from www.r-project.org. You are also encouraged to use Rmarkdown for your homework.

Evaluations

The course grade will be determined by class participation (10%), lab exercises (10%), six homework assignments (40%), and two take-home exams (40%).

Short lab exercises

To help you solidify the techniques learned in lab, you will have to complete a very short exercise at end of each lab. Upload the completed documents to Canvas these prior to the following lab. They will be graded as check (when fully completed), half check (when completed unsatisfactorily), and no-check (when not completed). These will also help us help keep track of lab attendance.

Assignments

There will be six problem sets due throughout the semester, and the top five scores will count towards your final grade. These are time-intensive assignments that will typically take 2 weeks to complete. Submissions for each assignment, including both the write-up and the R script, must be uploaded to Canvas before the specified deadline, typically prior to the midnight on Sunday. A full solution key will be made available immediately after the due date, and you are welcome to use office hours to discuss questions related to these assignments.

Exams

There will be two take-home, non-cumulative exams. You will have one week to complete these, and you are prohibited from collaborating with others or with generative A.I. tools when generating your answers. You are, however, welcome to consult your books, notes, and other online materials as you see fit. You should feel free (in fact, encouraged) to come see me or our TA for clarification, but we will not "pre-grade" your work (i.e., don't ask us to check whether your answer is correct).

Class Policies

Attendance

Attendance is here understood to mean in-person. UNC's policy gives no right or privilege that allows a student to be absent from any class meetings, except for University Approved Absences. If you are not feeling in good health, please refrain from coming to class, and submit paperwork when appropriate. Lab attendance *is* mandatory (and expected), but also subject to the above guidelines.

Late submission and incompletes

As the assignment with the lowest score will be dropped from your grade, late submission will not be accepted without *prior* permission. Prior arrangements should be made with the instructional team at least **one week** in advance of the due date. For lab work, please contact your TA on the day the lab takes place to inform him of any circumstances that may prevent you from submitting work on time. No incompletes will be given for assignments or the course.

Technology in the classroom

Use your computers only for class-related purposes. Please put your phone away before class starts and don't bring it out. This class fully adheres to UNC's guidelines on the use of generative A.I., which you can review here. Failure to adhere to these guidelines may be a reportable violation to the UNC Honor Court.

Counseling and mental health services

Graduate school can be overwhelming. Counseling and Psychological Services (CAPS) at UNC is strongly committed to addressing the mental health needs of a diverse student body through timely access to consultation and connection to clinically appropriate services, whether for short or long-term needs. Go to their website: https://caps.unc.edu/ or visit their facilities on the third floor of the Campus Health Services building for a walk-in evaluation to learn more.

Harassment and discrimination – Title IX

Any student who is impacted by discrimination, harassment, interpersonal (relationship) violence, sexual violence, sexual exploitation, or stalking is encouraged to seek resources on campus or in the community. Reports can be made online to the EOC. Please contact the University's Title IX Coordinator (titleixcoordinator@unc.edu), Report and Response Coordinators in the Compliance Office (reportandresponse@unc.edu), Counseling and Psychological Services (confidential), or the Gender Violence Services Coordinators (gvsc@unc.edu; confidential) to discuss your specific needs. Additional resources are available at safe.unc.edu.

Students with disabilities

The University of North Carolina at Chapel Hill facilitates the implementation of reasonable accommodations, including resources and services, for students with disabilities, chronic medical conditions, a temporary disability or pregnancy complications resulting in barriers to fully accessing University courses, programs and activities.

Accommodations are determined through the Office of Accessibility Resources and Service (ARS) for individuals with documented qualifying disabilities in accordance with applicable state and federal laws. See the ARS Website for contact information or email ars@unc.edu.

Religious observances

If you have a religious observance that conflicts with your participation in the course, please complete the Request Form and send it to religiousaccommodations@unc.edu for consideration. Once you receive a response, please forward it to the instructor. You are expected to complete this process before the end of the second week of the semester.

Academic honesty

Plagiarism will not be tolerated in this course. This includes (but is not limited to) using other people's derivations and code in assignments, as well as using the output of any online resource, either based on a generative A.I. (e.g., ChatGPT) or crowd-sourced platforms (e.g., Chegg). You can review the University's policies regarding academic honesty for more information.

Course Outline

Section 1: Calculus

Lecture 1: Sets and Functions (August 19)

Operations on sets.
Classification of functions.

References: MS Chapters 1-3

Lecture 2: Limits (August 21)

Limits of sequences.
Series.
Limits of functions.
Continuity of functions.

References: MS Chapter 4

Lecture 3: Differentiation I (August 26)

Derivative.
Rules of differentiation.
Taylor expansion.

References: MS Chapters 5-6, 8

Lecture 4: Differentiation II (August 28)

Finding extrama.
Differentiation for multivariate functions.

References: MS Chapters 5-6, 8

Lecture 5: Integration I (September 2)

The Newton-Leibniz formula.
Calculating indefinite integral.

References: MS Chapter 7

Lecture 6: Integration II (September 4)

Calculating definite integral.
Integrable functions.

References: MS Chapter 7

Assignment 1 due (September 7)

Section 2: Probability

Lecture 7: Probability I (September 9)

Axioms of probability.
Properties of probability.
Conditional probability.

References: BH Chapters 1-2

Lecture 8: Probability II (September 11)

Law of total probability.
Bayes' rule.
Independence and conditional independence.

References: BH Chapters 1-2

Lecture 9: Random Variables I (September 16)

Probability mass functions.
Cumulative distribution functions.
Different discrete random variables.

References: BH Chapters 3, 5

Lecture 10: Random Variables II (September 18)

Probability density functions.
Quantiles.
Different continuous random variables.

References: BH Chapters 3, 5

Assignment 2 due (September 21)

Lecture 11: Moments I (September 23)

Expectation.
Properties of expectation.
Law of the unconscious statistician.

References: BH Chapters 4, 6

Lecture 12: Moments II (September 25)

Expectations of different random variables.
Variance.
Other moments.

References: BH Chapters 4, 6

Lecture 13: Multivariate Distribution I (September 30)

Joint distribution.
Marginal distribution.
Conditional distribution.

References: BH Chapters 7, 9

Lecture 14: Multivariate Distribution II (October 2)

Conditional expectation.
Properties of conditional expectation.

References: BH Chapters 7, 9

Assignment 3 due (October 5)

Section 3: Statistics

Lecture 15: Sampling and estimation I (October 9)

Estimand, estimator, and estimate.
Population and sample.
Sampling distribution.

References: DBC Chapter 6

Midterm exam due (October 12)

Lecture 16: Sampling and estimation II (October 21)

Unbiasedness.
Consistency.
Efficiency.

References: DBC Chapters 7-8

Lecture 17: Asymptotics I (October 23)

Asymptotics.
Cauchy-Schwarz inequality. Markov, Chebyshev, and Chernoff inequalities.

References: BH Chapter 10

Assignment 4 due (October 26)

Lecture 18: Asymptotics II (October 28)

Law of large numbers.
Central limit theorem.

References: BH Chapter 10

Lecture 19: Testing I (October 30)

Sharp null vs. weak null.
Testing errors.
Randomization tests.

References: B Chapter 4

Lecture 20: Testing II (November 4)

Confidence intervals.
p-values.

References: B Chapter 4

Section 4: Linear Algebra

Lecture 21: Basic Operations (November 6)

Vectors and matrices.
Operations on matrices.

References: MS Chapters 12

Lecture 22: Eigenvalue Decomposition (November 11)

Vector spaces.
Eigenvalue decomposition.

References: MS Chapters 13-14

Lecture 23: Mutivariate calculus (November 13)

Jacobian and Hessian.
Multivariate optimization.
Multivariate integration.

References: MS Chapters 15-16

Assignment 5 due (November 16)

Lecture 24: Regression I (November 18)

Bivariate regression.
Multivariate regression.

References: B Chapter 5

Lecture 25: Regression II (November 20)

Large-sample properties of OLS.

References: B Chapter 6

Lecture 26: Regression III (December 2)

Testing in regression.

References: B Chapter 7

Assignment 6 due (December 3)

Final exam due (December 10)