# Political Science 783: Introductory Statistics
# Political Science 891: Mathematics for the Social Sciences

*Fall 2007 — University of North Carolina at Chapel Hill*

## Instructor

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## Meeting Times

POLI 783: T-Th 9:30-10:45am, Saunders 322
POLI 891: Wed 4:00-4:50pm, Hamilton 150

## Course Description

Over the last five decades, political scientists have come to rely increasingly on quantitative methods for their research. This trend has occurred in virtually all subfields and is ongoing, as one can see in the publication of ever more complex quantitative analysis in the top tier journals. Given this development, statistical literacy has become indispensable for political scientists. Whether you just want to keep up with the literature in your field or want to be engaged in your own quantitative research program, a solid knowledge of statistical methods has become just as important as knowledge of the theories in your field. Learning statistics may not be what you had in mind when you decided to attend graduate school in political science, but the truth is that much of the substantive literature in the discipline will remain inaccessible without a thorough understanding of the language of statistics. POLI 783 teaches you that language, so that you can pursue more fruitfully your substantive interests.

The main emphasis in the course is on those concepts and procedures that lie at the heart of all statistical analysis. Thus, we discuss the key principles of statistical inference along with statistical measures that are widely used in political analysis. A thorough understanding

of this material is essential if you want to become a competent producer and/or consumer of quantitative research in political science.

## Course Objectives

Provided that you do the work that is required, you can expect to learn the following skills from POLI 783:

- You will learn fundamental concepts that underlie statistical analysis.
- You will learn the logic of statistical inference and discover how this logic can be used to draw inferences about the political world.
- You will learn how to translate substantive research questions into statistical terms, so that the language and procedures of statistics can inform your own research.
- You will obtain hands-on experience in data analysis, including statistical programming in Stata.
- You will be prepared for more advanced courses in statistics and data analysis.

In POLI 891, you will learn all of the mathematical skills you need to know in order to succeed in POLI 783 and POLI 784.

## Prerequisites

There are no prerequisites for POLI 783/891, except that basic knowledge of algebra is assumed. Prior course work in statistics is helpful, although it should be noted that POLI 783 goes considerably beyond the material covered in most undergraduate statistics courses.

Knowledge of basic calculus and set theory will be necessary for POLI 783. POLI 891 will cover all of the mathematics that you will need in this course and is required for all first-year UNC Ph.D. students enrolled in the course. Other students are strongly encouraged to sit in on the math section as I will *not* be covering calculus during the meeting times for POLI 783.

## Organization (POLI 783)

### Part I: Introductory Statistics

The first part of the course is an introduction to the use of statistics in political science. Starting with substantive research questions, we ask what statistical analysis can do to provide insights into the political world. You will also learn how to use the statistical software package Stata. This part of the class is pitched at the level of a typical undergraduate social statistics class: it provides a "cookbook" approach to statistics that requires little mathematics and no prior experience with statistics. The main text for Part I is Pollock's *Essentials of Political Analysis*. The *Stata Companion* will be used for homework assignments in this part of the course.

### Part II: Mathematical Statistics

The second part gets behind the "cookbook" statistics, so to speak. It delves into the mathematical statistical theory that underlies the techniques discussed in Part I, focusing in particular on the logic of statistical inference. To this effect, Part II addresses probability theory, sampling distributions, the theory of hypothesis testing, and estimation theory. This sketch of the statistical model of inference goes well beyond a typical undergraduate social statistics class; it is much more abstract and mathematically demanding. This part of the course lays the essential foundation for more advanced courses in applied data analysis. The main text for Part II is Wackerly, Mendenhall, and Schaeffer (WMS).

## Grading

In its graduate methods curriculum, the UNC political science department considers POLI 783/891 to be a single four-credit course. For bureaucratic reasons, they are officially listed as separate courses. However, only one grade will be calculated for your combined work in POLI 783 and POLI 891. Therefore, you will receive the same grade for both courses.

### Homework (50%)

You are expected to complete a series of homework assignments for POLI 783 during the semester. Some of these assignments involve data analysis using Stata, while others require you to solve analytical statistical problems. You are expected to submit each homework assignment by 9:30 a.m. on the day it is due.

There will be twelve homework assignments for POLI 891 over the course of the semester. Ten will be graded. The homework assignments will be rather small, and are intended to help you keep up a gradual study of these mathematical concepts rather than resorting to cramming sessions. After the first class, homework will be due at the beginning of each class, and a new homework will be assigned at the end of each class.

### Exams: Midterm (15%) and Final (35%)

Two closed-book in-class exams will be given during the semester. A mid-term exam will take place sometime in mid-to-late October, while a cumulative final exam will take place on Thursday, December 11 in Saunders 322 at 8:00am (as scheduled by the university). I will give you sufficient warning as to the exact date of the midterm. The exams will only cover the material from the statistics coursework, not the math section. However, the exam will require you to use the some of the math skills learned in POLI 891.

## Course Policies

I expect you to be aware of the following policies, as well as the UNC Honor's Code:

### Extensions and Incompletes

In general, incompletes are not granted for this course. Brief extensions on the homework assignments are debatable, but only before their due date. Otherwise, late submission of these assignments may result in a grade reduction.

### Collaboration

You can learn a great deal from your classmates and I encourage you to discuss the course materials, including the homework assignments. However, there is a fine line between accepting help and having someone else do the work for you, or between giving help and finishing someone else's work. For your own benefit you should avoid crossing this line. Plagiarism is a UNC Honor Code violation and will be prosecuted accordingly.

## Course Materials

The following books are required for POLI 783:

- Pollock, Philip H. 2005. *The Essentials of Political Analysis*, 2nd ed. Washington, DC: CQ Press.
- Pollock, Philip H. 2006. *A Stata Companion to Political Analysis*. Washington, DC: CQ Press.
- Wackerly, Dennis D., William Mendenhall III, and Richard L. Sheaffer. 2002. *Mathematical Statistics with Applications*, 6th ed. Duxbury Press.

The following book is recommended (but optional) for POLI 891:

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

## Schedule (POLI 783)

### Part I: Introductory Statistics

#### Key Elements of Data Analysis

- Measurement, process of hypothesis testing
- Pollock: Intro, Ch. 1–2

#### Data Description

- Measures of central tendency and dispersion, cross-tabulation, correlation
- Pollock: Ch. 3, plus pp. 155-157

**Controlled Comparisons**

- Controlled comparisons
- Pollock: Ch. 4

**Sampling**

- Population vs. sample, random sampling
- Pollock: Ch. 5

**Significance Testing**

- Significance tests, measures of association
- Pollock: Ch. 6

**Linear Regression**

- Simple regression, multiple regression, dummy variables
- Pollock: Ch. 7

## Part II: Mathematical Statistics

**Intro to Probability**

- Probability theorems, Bayes' rule
- WMS: Ch. 2 (some of this material will be covered in the math class)
- *You will need to know basic set theory at this point*

**Discrete Random Variables**

- Probability functions, expectation and variance, binomial and poisson distributions, moments
- WMS: Ch. 3.1–3.4, 3.8–3.9?

**Continuous Random Variables**

- Probability density functions, cumulative distribution functions, expectation and variance, uniform distribution, normal distribution
- WMS: Ch. 4.1–4.5
- *You will need to know basic calculus (i.e., integration) at this point*

**Multivariate Distributions**

- Multivariate distributions, marginal and conditional distributions, independence, expectation and covariance
- WMS: Ch. 5.1–5.8

**Sampling Distributions**

- Derivation of sample statistics, central limit theorem
- WMS: Ch. 7.1–7.3

**Estimation**

- Estimators, bias and mean squared error, confidence intervals, efficiency, consistency
- WMS: Ch. 8, Ch. 9.1–9.3

**Hypothesis Testing**

- Classical hypothesis testing, Type I & Type II error, common test statistics, power
- WMS: Ch. 10.1–10.10

**Methods of Estimation**

- Least squares, method of moments, maximum likelihood, Bayesian estimation
- WMS: Ch. 11.1–11.3, Ch. 9.6–9.7

## IMPORTANT DATES (POLI 783)

**No Class:**

- *Thursday, August 30 (APSA)*
- *Thursday, October 20 (Fall Break)*
- *Thursday, November 22 (Thanksgiving)*

**Exams**

- *Midterm exam: TBA (mid-to-late October)*
- *Final exam: Tuesday, December 11 at 8:00am in Saunders 322*

## Schedule (POLI 891)

***Relevant chapters from Gill in parentheses***

### Part I: Calculus

- Set theory and algebra review (1.1-1.6, 7.3)
- Probability theory (7.1-7.2, 7.4-7.9)
- Limits and continuity (5.2)
- Differentiation (5.3-5.4)
- Integration (5.5-5.6)
- Optimization (6.4)
- Exponential and logarithmic functions (1.7)

### Part II: Linear Algebra

- Types of matrices and vectors (3.1-3.3)
- Mathematical operations on matrices and vectors (3.4, 4.3-4.6)
- Systems of equations (4.7)
- Differentiation (special topic)
- Eigenvalues and eigenvectors (4.8)
- Vector geometry (4.1-4.2)
- Linear algebra in Stata (special topic)