Math Workshop for Political Science

The Ohio State University

Syllabus: Summer 2024

Instructor:	Benjamin W. Campbell	Class location:	2130 Derby Hall
Email:	*campbell.1721@osu.edu*	Class time:	M–F, 9:00–11:30 EDT
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Description

The purpose of this workshop is to provide incoming first year Ph.D. students with some fundamental skills in various mathematical techniques that are used in political science, regardless of sub-specialty, and generally to prepare students for the first-year methods sequence. The workshop is also open to continuing students, who feel that they would gain from participating in the course.

This year the course will begin on Monday, August 5th and run every weekday until Friday, August 16th. Sessions are tenantively scheduled to run from 9:00—11:30 each day. In the past, there has also been an additional meeting on Saturday. We hope this will not be necessary this year, though if we fall behind in the material, we may need to reconsider.

Textbook

Moore, W.H. and Siegel, D.A., 2013. *A Mathematics Course for Political and Social Research*. Princeton University Press. (SM)

Wickham, H. and Grolemund, G., 2017. *R for Data Science*. O'Reilly. (WG)

General resources

- Another popular, but more technical, textbook is: Simon, Carl P. and Lawrence Blume., 1994, *Mathematics for Economists*. Vol. 7. New York: Norton.
- MIT Open Courseware (Mathematics): http://ocw.mit.edu/courses/#mathematics
- Khan Academy: http://www.khanacademy.org/
- Brightstorm: http://www.brightstorm.com/math/
- MathTV: http://www.mathtv.com/videos_by_topic

Class Format

The workshop will be taught in a lecture format. During each day's session we will review the problem set from the previous day before covering the current day's material. Before each session, it is expected that students will complete the previous day's problem set and review the current day's course materials. While the course will be presented as a lecture, student participation is strongly encouraged. For each module, links to a series of short videos, lecture notes, and a daily problem set will be provided.

The day's preparatory videos are available in the course's Github repository here. Problem sets and lecture notes will be posted immediately following the end of that day's session.

There are nine problem sets, each of which will be due the following morning at the start of class. Students should plan to spend 2–4 hours each day completing these assignments and preparing for the following session.

R Introduction

The compressed nature of this class makes it impossible to give students a comprehensive introduction to all of the tools they will need in the first year methods sequence. However, a brief introduction to R and computational social science will be provided during the last 3 lectures.

Our R resource for these 3 lectures will be a notebook that we will work through together. While the Wickham and Grolemund book is a fantastic resource for one's methods coursework, it is also quite thorough and extensive. For a brief introduction and overview of R this workshop will be helpful.

Class schedule

Day 1: Introduction, Pre-test, Notation and Definitions, and Some Basic Mathematics

- Definition of a variable and real number systems
- Set notation and relationships
- Definition of independent and dependent variables
- Discussion of interval notation
- Definitions of types of functions
- Commutative, associative, and distributive laws
- Concepts of inequality and absolute value
- Exponent rules

Day 2: Some Basic Mathematics (II)

- Summation and product operators
- Factorials, permutations, and combinations
- Solving equations, inequalities, and for roots
    - Single and multiple variables
    - Quadratic formula
    - Factoring
- Logarithms and rules

Day 3: Linear Algebra (I)

- Linear equations and linear systems
- Method of elimination
- Definition of matrices and vectors
- Matrix operators
- Transposes
- Dot product and matrix multiplication
- Matrix representation of systems of equations

Day 4: Linear Algebra (II)

- Linear dependence/independence
- Properties of matrix operators
- Definition of identity, zero, and idempotent matrices
- Reduced row/row echelon form and solving linear systems of equations Gauss-Jordan Reduction/Elimination

Day 5: Linear Algebra (III)

- Inverses
- Conditions for nonsingularity of matrix
- Definition of matrix rank
- Determinants
- Matrix inversion
- Trace of a matrix
- Eigenvectors and eigenvalues

Day 6: Linear Algebra (IV) and Calculus (I – Introduction to Differentiation)

- Limits
- The difference quotient
- The derivative
- Rules of differentiation for a function of one variable
- Rules of differentiation involving two or more functions of the same variable

Day 7: Calculus (II – More Differentiation)

- Derivative of exponential and log functions
- Rules of differentiation involving functions with different variables
- Partial differentiation
- Comments on differentiability and continuity
- Second and higher derivatives

Day 8: Calculus (III – Optimization and Constrained Optimization)

- Definition of optimum and extreme values
- Relative maximum and minimum
- Second-derivative test
- Constrained optimization and Lagrange Multipliers
- Quadratic approximation and Taylor series expansion
- **R Introduction**
    - Installing R and RStudio
    - Scripts vs. terminal vs. notebooks
    - Coding best practices

Day 9: Calculus (IV – Integration)

- Antidifferentiation
- Areas and Riemann sums
- Indefinite and definite integrals
- Fundamental Theorem of Calculus
- **R Basics**
    - Object types
    - Data storage
    - Functional programming
    - Data visualization

Day 10: Calculus (V – More Integration)

- Integration by substitution
- Integration by parts
- Brief discussion of improper integrals
- Calculus on matrices: the general rules
- **Data Analysis in R**
    - Exploratory data analysis on real data