Math Workshop for Political Science
The Ohio State University
Syllabus: Autumn 2019

Instructor:	Daniel Kent	Class location:	2130 Derby Hall
Office:	2063 Derby Hall	Class time:	M–F, 09:00–12:30
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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. 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. Class sessions are tentatively scheduled to run from 9:00AM–12:30PM, with approximately a 20–30 minute break in between two 1.5 hour sessions.

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

- 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 "semi-flipped" format. For each module, I will provide links to a series of short videos, as well as some reading. Students will be responsible for covering these materials prior to class. Assignments and videos are due on the day they are noted. Class time will be divided into two sections. The first 1.5 hour section will either be a traditional lecture, or a guided discussion. After the break, students will split into groups and solve problem sets, the answers to which will be provided at the end of class.

R Introduction

The compressed nature of this class makes it impossible to give students an introduction to all of the tools they will need in the first year methods sequence. However, I provide a parallel curriculum that will give students a jump start on R programming. These readings and exercises are optional, but all students are encouraged to take advantage of these resources.

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)

- **Reading**: SM (3-21, Ch.2, Ch.3) & WG (Preface, Ch.1)
- Summation and product operators
- Factorials, permutations, and combinations
- Solving equations, inequalities, and for roots
    - Single and multiple variable
    - Quadratic formula

    - Factoring
- Logarithms and rules

Day 3: Linear Algebra (I)

- **Reading**: SM (275-288, 297-298, 304-309) & WG (Ch.2)
- 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)

- **Reading**: SM (289-297, 315-324) & WG (Chs.3-4)
- 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)

- **Reading**: SM (298-300, 310-315) & WG (Chs.5-6)
- 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)

- **Reading**: SM (81-92, 96-99, 103-113, Ch.6) & WG (Ch.7)
- 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)

- **Reading**: SM (113-114, 355-361) & WG (Ch.8)
- 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)

- **Reading**: SM (Ch.8) & WG (Ch.9)
- Definition of optimum and extreme values
- Relative maximum and minimum
- Second-derivative test
- Constrained optimization and Lagrange Multipliers
- Quadratic approximation and Taylor series expansion

Day 9: Calculus (IV – Integration)

- **Reading**: SM (133-143) & WG (Ch.10)
- Antidifferentiation
- Areas and Riemann sums
- Indefinite and definite integrals
- Fundamental Theorem of Calculus

Day 10: Calculus (V – More Integration)

- **Reading**: SM (144-150, 362-374) & WG (Ch.14)
- Integration by substitution
- Integration by parts
- Brief discussion of improper integrals
- Calculus on matrices: the general rules