Math Workshop for Political Science
The Ohio State University
Syllabus: Autumn 2020

Instructor:	Daniel Kent		Class location:	Online
Office:	Zoom Call		Class time:	M–F, 9:00 – 11:00 EST
Email:	*kent.249@osu.edu*		Office hours:	M–F, 14:00 – 15:00 EST

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 10th and run every weekday until Friday August 21st.

In the past, classes have met in person for an extensive lecture, followed by students completing problem sets after class on their own. However, due to current circumstances, this year the class is being held in a "flipped" format. Students will complete the previous day's problem set and review the current day's course materials before our daily Zoom call. During this Zoom call – from 9:00AM – 11:00AM EST – I will answers questions about the day's topics and we will work through the previous day's problem set as a group. These Zoom calls will be recorded and sent out to participating students so anyone can refer to the material if they are unable to attend or need additional clarification.

For the last three days of class, we will also cover some introductory programming in R from 1:00 – 2:00PM EST.

Textbook

Normally, these books are provided in person before we meet. Unfortunately, that will not be possible this year, but the books will be provided during the fall orientation and be available for reference subsequently throughout one's coursework.

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 "flipped" format. For each module, I will provide links to a series of short videos, lecture notes, and a daily problem set.

The day's preparatory videos and daily lecture notes are available on my website. I will email out the problem sets in advance.

There are 9 problem sets. During each day's Zoom call we will review the problem set from the previous day's material and then I will answer questions about the current day's material. For example, on day 2 we will review day 1's problem set and answer clarifying questions about day 2's topics.

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, I will provide brief R and computational social science lectures during the last three days of the course from 1:00 – 2:00PM.

Our R resource for these 3 lectures will be Quantitative Politics with R. 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 the qpolr book is well-suited.

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, qpolr ch 1**
  - Installing R and RStudio
  - Scripts vs. terminal
  - Coding best practices

Day 9: Calculus (IV – Integration)

- Antidifferentiation
- Areas and Riemann sums
- Indefinite and definite integrals
- Fundamental Theorem of Calculus
- **R Basics, qpolr ch 2 + 3**
  - Object types
  - Basic data manipulation
  - Tidyverse vs. base R

Day 10: Calculus (V – More Integration)

- Integration by substitution
- Integration by parts
- Brief discussion of improper integrals
- Calculus on matrices: the general rules
- **Data Visualization in R, qpolr ch 7-9**
  - `plot()` vs `ggplot()`
  - Descriptive statistics
  - Visualizing regression results