Math (P)refresher Syllabus 2014

Math (P)refresher for Political Scientists

Tuesday, August 19 - Thursday, August 28, 2014
Breakfast 9am - 9:30am
Lecture 9:30am - 12:00pm
Section 1:00pm - 4:00pm

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PURPOSE: Not only do the quantitative and formal modeling courses at Harvard require mathematics and computer programming — it's becoming increasingly difficult to take courses in political economy, American politics, comparative politics, or international relations without encountering game-theoretic models or statistical analyses. One need only flip through the latest issues of the top political science journals to see that mathematics have entered the mainstream of political science. Even political philosophy has been influenced by mathematical thinking. Unfortunately, most undergraduate political science programs have not kept up with this trend — and first-year graduate students often find themselves lacking in basic technical skills. This course is not intended to be an introduction to game theory or quantitative methods. Rather, it introduces basic mathematics and computer skills needed for quantitative and formal modeling courses offered at Harvard.

PREREQUISITES: None. Students for whom the topics in this syllabus are completely foreign should not be scared off. They have the perfect background for this course — the ones in most need of a "prefresh"ing before they take further courses with technical content. Students who have previously had some of this material, but have not used it in a while, should take this course to "refresh" their knowledge of the topics.

STRUCTURE & REQUIREMENTS: The class will meet twice a day, 9:00am – 12:00pm and 1:00pm – 4:00pm. This course is not for credit and has no exams. No one but the student will know how well he or she did. However, it still requires a significant commitment from students. Students are expected to do the reading assignments before the classes. Lectures will focus on major mathematical topics that are used in statistical and formal modeling in political science. Sections will be divided into two parts. During problem-solving sections, students are given exercises to work on (or as homework if not finished then) and students are encouraged to work on the exercises in groups of two or three. You learn more quickly when everyone else is working on the same problems! During computing sections, we will introduce you to the computing environment and software packages that are used in the departmental methods sequence. Math isn't a spectator sport — you have to do it to learn it.

COMPUTING: All of the methods courses in the department, and increasingly courses in formal theory as well, make extensive use of the computational resources available at Harvard. Students will be introduced to LaTeX (a typesetting language useful for producing documents with mathematical content) and R (the statistical computing language/environment used in the department's method courses). These resources are very powerful, but have something of a steep learning curve; one of the goals of the prefresher is to give students a head start on these programs.

TEXTBOOKS: The text for this course is the textbook by Jeff Gill. In previous years we've required students to purchase this book. This year we don't have such a requirement, although we strongly recommend that you acquire a copy for yourself since it is such a valuable resource.

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

There are several other recommended texts that you may wish to consult during the course. In particular, Simon and Blume is useful for those who will be taking formal modeling courses in the Government or Economics departments.

Simon, Carl P. and Lawrence Blume. 1994. *Mathematics for Economists.* New York: Norton.

Wackerly, Dennis, William Mendenhall, and Richard Scheaffer. 1996. *Mathematical Statistics with Applications,* 5th edition.

Hahn, Harley. 1996. *Harley Hahn's Student Guide to Unix,* 2nd edition.

Lecture Schedule:

Tuesday, August 19; CGIS Knafel K354

Lecture 1: Notation and Functions
R tutorial 1: Basics of R
LaTeX tutorial 1

Topics:	Dimensionality. Interval Notation for $\mathbf{R}^1$. Neighborhoods: Intervals, Disks, and Balls. Sets, Sets, and More Sets. Introduction to Functions. Domain and Range. Some General Types of Functions. Log, Ln, and e. Other Useful Functions. Graphing Functions. Solving for Variables. Finding Roots. Limit of a Function. Continuity.
Recommended Reading:	Gill Ch. 1, 5.2; SB 2.1-2, 12.3-5, 10.1, 13.1-2, 5.1-4

Wednesday, August 20; CGIS Knafel K354

Lecture 2: Linear Algebra
R tutorial 2: Working with data in R

Topics:	Working with Vectors. Linear Independence. Basics of Matrix Algebra. Square Matrices. Linear Equations. Systems of Linear Equations. Systems of Equations as Matrices. Solving Augmented Matrices and Systems of Equations. Rank. The Inverse of a Matrix. Inverse of Larger Matrices.
Recommended Reading:	Gill Ch. 3 & 4; SB 6.1, 7.1-4, 8.1-4. 9.1-2, 10.1-4, 11.1,

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Thursday, August 21; CGIS Knafel K354

Lecture 3: Calculus I
R tutorial 3: Logical statements and for loops

Topics:	Sequences. Limit of a Sequence. Series. Derivatives. Higher-Order Derivatives. Composite Functions and the Chain Rule. Derivatives of Exp and Ln. Maxima and Minima. Partial Derivatives. L'Hôspital's Rule. Derivative Calculus in 6 Steps.
Recommended Reading:	Gill Ch. 5.3-4, 6.4; SB 12.1-2, 2.3-6, 3.1-2, 3.5, 4.1-2, 5.5

Friday, August 22; CGIS Knafel K354

Lecture 4: Calculus II
R tutorial 4: Loops, apply, and other functions

Topics:	The Indefinite Integral: The Antiderivative. Common Rules of Integration. The Definite Integral: The Area under the Curve. Integration by Substitution. Integration by Parts.
Recommended Reading:	Gill Ch. 6.2-3, 5.5-6; SB 14.1, 14.3-4, Appendix 4.1-3

Monday, August 25; CGIS Knafel K354

Lecture 5: Unconstrained and Constrained Optimization
R tutorial 5: Graphics in R

Topics:	Taylor Series Approximation. Quadratic Forms. Definiteness of Quadratic Forms. Maxima and Minima in R^n. First Order Conditions. Second Order Conditions. Global Maxima and Minima.
Recommended Reading:	Gill 4.9, 6.7-8; SB 16.1-2, 17.1-4, 18.1-6; A1.3

Tuesday, August 26; CGIS Knafel K354

Lecture 6: Probability I
LaTeX tutorial 2

Topics:	Counting. Sets. Probability. Conditional Probability and Bayes' Rule. Independence.
Recommended Reading:	Gill Ch. 7; WMS 2.1-11

Wednesday, August 27

No PreFresher (GSAS orientation and DudleyFest)

Thursday, August 28; CGIS Knafel K354

Lecture 7: Probability II
R tutorial 6: Managing data in R and debugging code

Topics:	Levels of Measurement. Random Variables. Discrete Distributions. Continuous Distributions. Expectation. Special Discrete Distributions. Special Continuous Distributions. Joint Distributions. Summarizing Observed Data.
Recommended Reading:	Gill Ch. 8; WMS 3.1-4, 3.8, 4.1-5, 4.8