Political Science Math Prefresher
Last revised June 22, 2011

Dates: August 29- September 2, 2011
Location: E51-372
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Purpose

The Math Prefesher is designed to introduce and review core mathematics and probability prerequisites that you will need to be successful in the quantitative methods courses in the Political Science department and elsewhere at MIT. In an intense one-week course, we will cover key concepts from calculus, linear algebra, probability theory, and an introduction to statistical computing. The learning will proceed through lectures, hands-on exercises, and homework. The aim of the course is to give you an opportunity to practice some of the mathematics you may have previously learned and to introduce you to areas that may be new to you so that you will be ready to enter classes that presume prior familiarity with these concepts, such as 17.800 Quantitative Research Methods I.

Course Website and Online Resources

You can access the course website via Stellar (the online course platform used at MIT), accessible at https://stellar.mit.edu/S/project/mathprefresher/index.html. On the course website you will find useful materials including online computing tutorials, additional suggested readings, lecture notes, and more.

You should set up an MIT Athena account to get started with your MIT email and access the other MIT resources (see here for instructions http://ist.mit.edu/support/accounts/information).

Texts

There are no required textbooks for the course. However useful resources for your reference or to get a head start are:

- Dimitri Bertsekas & John Tsitsiklis, Introduction to Probability (2nd edition)
- Otto Bretscher, Linear Algebra with Applications (8th edition)
- James Stewart, Calculus (6th edition)

Note: The Bertsekas & Tsitsiklis book is excellent, and will be required for Quant I. So you may want to buy that book in particular.

For students looking for a single reference book covering a wide range of relevant material, we suggest:

- Carl Simon & Lawrence Blume, Mathematics for Economists (1st edition)
- Jeff Gill, Essential Mathematics for Political and Social Research (1st edition)

Computing

Students will be introduced to statistical computing with the computer package *R*.

R is freely available and can be downloaded from http://www.r-project.org/. The web provides many great tutorials and resources to learn *R*. A list of these is provided at http://wiki.math.yorku.ca/index.php/R:_Getting_started.

A nice way to get started in *R* is to look at the two video tutorials provided by Dan Goldstein at http://www.dangoldstein.com/flash/Rtutorial1/Rtutorial1.html and http://www.dangoldstein.com/flash/Rtutorial2/Rtutorial2.html, which take you all the way from downloading *R* to running the program. *R* runs on a wide variety of UNIX platforms, Windows and MacOS - you can download and use it even if your computer is 10 years old.

Another great resource is a series of handouts written by Teppei Yamamoto, who will be joining our faculty this fall. These can be found at http://www.princeton.edu/~tyamamot/teaching.html.

Evaluation

Attendance is mandatory and will be tracked. Problem sets will be graded in detail and discussed. No grades are assigned for this class, but your grades in subsequent classes such as Quant I are likely to improve significantly if you learn the math camp material well!

If you need to miss a class

Some students will have to miss classes for language proficiency tests or other unavoidable obligations. If you do have such an obligation sometime during the week of class, please let us know right away so we can try to schedule lectures and breaks accordingly to maximize attendance.

Topics

1. Notation and Functions
    - Set and interval notation
    - Functions: concept, notation.
    - Important functions: exponents, logarithms
    - Inverse functions
    - Properties of logs and exponentials
    - Using these properties to solve for variables
    - Taking limits
    - Maxima and minima

2. Introduction to *R*
    - Getting started with *R*
    - Working with objects
    - Loading and creating data
    - Descriptive statistics
    - Basic graphics

3. Calculus 1

What is a derivative (and why do you care)?
What is an integral (and why do you care)?
Rules for computing basic derivatives
Rules for computing basic integrals
Higher-order derivatives and multiple integrals

4. Calculus 2
   - More derivative rules: Chain rule, exponentials, logs
   - More integration rules: Integration by substitution, integration by parts
   - Using derivatives to find minima or maxima
   - Partial derivatives

5. Probability I
   - Probability models
   - Sample spaces
   - Probability laws and functions: The Probability Axioms
   - Marginal and Joint Distributions
   - Conditional probabilities
   - Baye's Rule and the False-Positive Problem
   - Independence
   - Conditional Independence

6. Probability related computing in *R*
   - Mean, median, mode, variance
   - Tabs and cross-tabs
   - Density estimates
   - Simulations
   - Writing functions

7. Probability II
   - Random variables
   - Discrete random variables: probability mass functions, cumulative distribution functions
   - Continuous random variables: probability distribution functions, cumulative dist. functions
   - Marginal, Joint, and Conditional Distributions
   - The expectation function with discrete and continuous random variable
   - Median and Mode
   - Variance

8. Key concepts in Linear Algebra
   - Getting comfortable with vectors and matrices
   - Matrix multiplication as convenient notation for linear systems
   - Inverse matrices: Solving linear systems
   - Colinearity, rank, singularity, and the existence of an inverse

9. Practicing Linear algebra in R
   - Review of vectors and matrices, how to create them
   - The most important matrix multiplication: multiplying a matrix by a vector
   - Matrix inverses and solving linear systems
   - Examples of non-invertible matrices
   - Covariance matrices, weighted sums, and other common matrix manipulations