Political Science Math Prefresher

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Room E53-482

Faculty Sponsors:
Danny Hidalgo dhidalgo@mit.edu
In Song Kim insong@mit.edu
Teppei Yamamoto teppei@mit.edu

Course Instructors:
Matias Giannoni giannoni@mit.edu
Emilia Simison simison@mit.edu

Purpose

The Math Prefesher is designed to introduce and review core mathematics and programming 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/math-camp/. 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: https://ist.mit.edu/athena).

Policies and 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!

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.

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 program *R*.

R is free and can be downloaded from www.r-project.org. *R* can be run on computers using Windows, MacOS, and a variety of UNIX platforms. You can download and use it even if your computer is 10 years old!

We also recommend downloading RStudio, a free user interface for *R*, which is available at rstudio.com. We will be using RStudio during class and it provides an easier way to interact with the R environment, particularly for those of you with Windows.

While no *R* knowledge is needed prior to class, there are many great resources and tutorials available online. A list of these is available at http://scs.math.yorku.ca/index.php/R:_Getting_started_with_R. Some other resources are also listed on the Stellar site, including a free introduction to *R* by Data camp. If you prefer working with reference books, a nice one is Joseph Adler's *R in a Nutshell*.

It is also a good idea to start building good *R* habits right from the start. This link on style can be useful for that: https://google.github.io/styleguide/Rguide.html

Topics Covered

Notation and Functions

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

Introduction to *R*

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

Calculus I: Derivatives

- Review of limit
- What is a derivative (and why do you care)?
- Rules for computing basic derivatives
- Rules for more complex equations: chain rule, exponentials, logs
- Using derivatives to optimize functions (find maxima and minima)

Calculus II: Integrals

- Derivatives review
- What is an integral (and why do you care)?
- Rules for computing basic integrals
- Rules for more complex equations: integration by substitution and parts

Functions in *R*

- Coding functions
- Graphing functions
- Asymptotes
- Numerical optimization

Linear Algebra

- Vectors and matrices: dimensions, transposes
- Matrix multiplication
- Inverse matrices: solving systems of equations
- Collinearity, rank, singularity

Linear Algebra in *R*

- Review of vectors and matrices
- Multiplying a vector and a matrix
- Matrix inverses and solving linear systems
- Non-invertible matrices
- Covariance matrices, weighted sums, other common matrix commands

Probability

- Probability models
- Sample spaces
- Probability axioms
- Marginal and joint distributions
- Conditional probabilities
- Bayes' Rule and the false-positive problem
- Independence
- Conditional independence

Probability-related Computing in *R*

- Sampling
- Mean, median, mode, variance
- Tabs and cross-tabs
- Density estimates
- Simulations

Schedule

Day	**Morning Session**	**Afternoon Session**
Problem Set 0 (homework)	Notation	Introduction to R: scalars, vectors, and matrices
Monday 30	Functions	Introduction to R: data frames, basic functions
Tuesday 31	Calculus I	Graphs in R
Wednesday 1	Calculus II	Functions and loops in R
Thursday 2	Linear Algebra	Linear algebra in R
Friday 3	Probability Probability in R	