John Jay College of Criminal Justice CUNY
ECO 750 Mathematics for Economists
Syllabus

Instructor
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Pre-requisite
Pre-calculus

Rationale
Mathematics is a powerful approach to cognition in political economy and conventional economics. Increasingly, political economy and economics, theoretical and empirical, appear in a mathematical form. Historically, the development of political economy and economics, especially in modern times, has been accompanied by its increasing mathematical formalization. It is likely that the future development of logically coherent ideas in these fields will be associated with their further mathematization.

In particular, mathematics offers a concise language and a crisp logical framework by which economic reasoning can be pursued with greater precision and transparency, with a clearer specification of definitions, postulates, and consequences, which permit its more efficient peer and overall social validation, and cumulative development. (Abstraction and formalization are not without cost in that severing the relation with concrete phenomena impoverishes a framework, but there is a sense in which this cost is overwhelmed by the theoretical benefit.)

Furthermore, computing—which used to be an aspect of applied mathematics carried out personally by the mathematician, with the aid of simple artifacts—has in the last decades made use of interconnected physical devices of increasing sophistication. Modern day science, economic and financial activity—social life in general—are unthinkable without "smart" devices and their Internet. Mathematical formalism and computing, which are increasingly necessary in theoretical and empirical work in political economy and economics, are intimately related.

To grasp political economy and economics at a deeper and more general level, students need a stronger foundation in applied mathematics. To be sure, the concrete implementation of the course should be properly calibrated to the students' background, prior knowledge and skill, taking account of formative deficiencies and attitudes that may bias them against abstract and symbolic thought. However, this is a challenge common to any serious learning endeavor, even if it appears more formidable with respect to mathematics.

In this vein, a chief purpose of this introductory course is to help students to "slow down" and acquire familiarity and comfort with economic reasoning expressed in symbolic language structured by the rules of mathematical inference. This course will give students the tools and confidence to be better consumers of specialized political-economy, economics, and financial literature--readers of advanced books, journal articles, official reports and communications, which tend to be couched in mathematical and technical language. It may also spark the interest of students to themselves become producers of this type of work.

The focus of the course on formal reasoning complements and enriches the emphasis of the program on political economy as a social and historical discipline, intertwined with other social fields and approaches.

Course Description: Elementary set-theoretical concepts and useful number sets. Functional relations between sets commonly used in economics. Vectors and matrices (mathematical notions used to describe objects of economic interest), as well as the rules to manipulate them, with key applications in political economy and economics. Bivariate and multivariate calculus and their most common applications in economics and (less often) political economy.

In form, the course will be conducted online, asynchronously:

- Slides, short videos, Zoom meetings, and readings supplied by the instructor will introduce new concepts and illustrate their use in political economy and economics, and
- Nongraded exercise sets will be assigned for students to practice and build body memory for a more solid appropriation of concepts and applications.
- Gains in knowledge will be tested through periodic online quizzes, with several attempts allowed. The online format of the quizzes provides immediate feedback to students.
- There will be a midterm exam and a final exam, which may be cumulative or limited to a self-contained section of the course.
- The instructor will set up class activities and interactions in ways that encourage students to work as an academic community--individually responsible for their own learning, but also committed to assisting in their peers' development.

Goals

In this course, students will:

- gain confidence in using symbolic economic reasoning,
- improve their abstract intuition and logical-deductive skills through the patient study of basic economic and finance models and mathematical procedures on them,
- frame relevant questions in political economy and economics in a mathematical form.

More specifically, by the end of the course, students will be able to:

- demonstrate familiarity with basic concepts in set theory, linear algebra, and differential calculus;
- show competence operating with vectors and matrices, and interpreting their results being able to connect such operations to common applications in multi-variate econometrics;
- show proficiency in differentiating functions, without or with constraints;
- build, solve, interpret, and use simple micro-, macroeconomic, and financial economic models using the rules of linear algebra and differential calculus; and
- build, solve, interpret, and use economic models specifying optimizing agents subject to constraints by the method of Lagrange.

Format and Procedures

On the basis of experience, students prefer that the instructor offer lectures that gradually introduce mathematical concepts and methods of increasing levels of generality and power, showing their use through a number of simple economic applications. This has to be done now via videos and Zoom meetings, asynchronously.

In-class examples that students should follow closely, calculator in hand if needed. The following will be less frequent due to time constraints: in-class exercises for students to practice their grasp of mathematical concepts and methods, and their respective economic and finance applications.

Quizzes (or "exams" in Blackboard's terminology) that test the progress in the students' understanding of the material and provide them with immediate specific feedback and direction forward are to be solved outside of class. The instructor will provide general and -- time permitting -- personalized feedback on these quizzes.

Textbooks

Adequate textbooks, at the introductory level of this course, are:

- Kevin Wainwright & Alpha Chiang, Fundamental Methods of Mathematical Economics, McGraw Hill. [Required.]
- Carl P. Simon & Lawrence Blume, Mathematics for Economists, WW Norton.

More advanced textbooks:

- Akira Takayama, Mathematical Economics, Cambridge University Press.

- Kelvin Lancaster, Mathematical Economics, Dover.
- Avinash K. Dixit, Optimization in Economic Theory, Oxford University Press.
- Michael D. Intriligator, Mathematical Optimization and Economic Theory, Prentice Hall.
- Dean Corbae et al., An Introduction to Mathematical Analysis for Economic Theory and Econometrics, Princeton University Press.

There is a large amount of online resources that can help students overcome obstacles in their learning. Some of these materials are linked on Blackboard/Course Information.

Assignments/Grade Breakdown

- Quizzes (40%)
- Midterm exam (25%)
- Final exam (35%)

Course Topics

1. Numbers and sets. Most basic mathematical objects through which economic structure and activity can be represented abstractly for ease and rigor of logical manipulation.

2. Variables, relations, and functions. Economic theories postulate relations between variables or sets thereof. This section analyzes formal representations of these relations that are useful in political economy and economics, both basic (e.g. linear, quadratic, etc.) and transcendental (e.g. logarithmic, exponential, etc.).

3. Equilibrium analysis. When formalized as mathematical models, economic theories must meet consistency criteria or "equilibrium conditions." This section discusses the role of these conditions as they appear in the complementary approaches of partial and general equilibrium and in political economy under the rubric of “proportionate reproduction.”

4. Vectors and matrices (Definitions). The abstract representation of lists of variables as linear structures in space are extremely useful in economic thinking. This section introduces them.

5. Linear operations (1. Basic operations). An introduction to basic linear transformations.

6. Linear operations (2. Determinants). The computation of square-matrix determinants as a test to determine their invertibility.

7. Linear operations (3. Matrix inversion). One of the most important linear transformations, which allows us to solve systems of linear equations of an arbitrary size; a mathematical

machinery with a vast number of important applications in economic theorizing and econometrics.

8. Linear models (Leontief, Marx, Sraffa). Prototypical linear macroeconomic model with applications in industrial structure, management, and planning.

9. Differentiation (1. Introduction). Introduction of comparative statistics and the concept of a derivative as a measure of the rate of change (or "slope") of a function induced by a change in its independent variable.

10. Differentiation (2. Rules of differentiation). The core of differential bi-variate calculus. This section introduces it, as well as its use in the comparative statics of economic models.

11. Differentiation (3. Partial differentiation, implicit functions, expansion). Introduction to multi-variate calculus, partial differentiation, the implicit function theorem, and Taylor's polynomial expansion as a means to locally approximate highly nonlinear functions with simpler functions. This methodology is crucial in making complex economic relations amenable to analysis.

Time permitting:

12. Optimization 1. This section introduces economic models endowed with explicit agency of individuals or organizations (households, firms, government entities, etc.), where the agent seeks to maximize or minimize a function of her/his/its own actions.

13. Optimization 2. This section expands optimization to incorporate technological, wealth/income, or other social constraints on the actions of economic agents.