

CASEC 505 Mathematics
Syllabus
Fall 2025

Course description

This is an introductory course in mathematics with applications in economics and econometrics, aimed at MA students with a solid background in elementary economics and mathematics. In our view, the most important branches of mathematics for applied economics and econometric analysis are linear algebra and (calculus-based) optimization. Many areas in economics and other social sciences are moving more towards large-scale data collection and analysis, prompting the use of machine learning techniques in addition to more traditional methods. Data are often stored in matrices and operations on those data are typically implemented via linear algebra operations. Economic agents (perfectly rational or not) are assumed to be optimizers, and one of the most useful applications of linear algebra and multivariate calculus is optimization theory. This course will introduce some of the mathematical background required to understand and use the basic tools for economic analysis. In the first part we discuss some elementary concepts in linear algebra and geometry, and the second part will provide an introduction to multivariate calculus and optimization.

Instructor

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Teaching fellow

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Blackboard website

Use your Kerberos password to access the course site on Blackboard Learn. Lecture notes and assignments will be posted on the course website.

Recommended texts

Austin: *Understanding linear algebra*, free textbook online:

<https://understandinglinearalgebra.org/frontmatter.html>

Simon and Blume: *Mathematics for Economists*, W. W. Norton 1994.

Pemberton and Rau: *Mathematics for Economists*, Manchester University Press 2025

Prerequisites

Students are expected to be comfortable with basic algebra, one-variable calculus and optimization, logarithmic and exponential functions and their derivatives, and basic trigonometry.

Academic conduct

It is a student's responsibility to know and understand the provisions of the CAS Academic Conduct Code:

<https://www.bu.edu/academics/policies/academic-conduct-code>

The CAS Academic Conduct Code is strictly enforced, and all cases of suspected academic misconduct will be referred to the Dean's Office.

Religious observance

This course follows BU's policy on religious observance, available

<http://www.bu.edu/ctl/university-policies/policy-on-religious-observance>

Class conduct and participation

Students are expected to attend and actively participate in all lectures and attendance will be taken at all lectures. Your regular attendance and participation are essential both to your own learning and to that of your fellow students. You may miss three classes for whatever reason without penalty. More than three absences will start affecting your grade negatively, and nine or more absences will lead to a failing grade. If you have a special obligation that will require you to miss several classes (e.g., varsity athletics, religious observances), please talk with me at the beginning of the semester. Please notify me of any foreseeable absence by email (preferably in advance) so I can try to help you make up what you miss.

Examination and grading policy

There will be two midterm exams and one final examination. Unless you have a documented health problem or family emergency, if you fail to take a test, your score for the missed test will be zero. There will be no make-up exams. Please observe that the final exam date cannot be changed so plan travel accordingly.

Problem sets

Problem sets will be distributed throughout the semester. They contain both theoretical and computational exercises. The problem sets need not be handed in and will not count towards the grade, but make sure to do them as they are essential to a successful completion of the course.

Exam dates

Midterm 1: 10/8 in class

Midterm 2: 11/12 in class

Final exam:

Grading weights

Midterm 1: 30%

Midterm 2: 30%

Final: 40%

Exam policy

Please note that the following rules apply in all exams:

- No phones, communication devices, or watches (of any type) may be accessible during an exam. Students must stash them in bags or leave them with the proctors before exams are distributed.

- Only *scientific* calculators are allowed - all others will be confiscated and returned after the exam.
- BUIDs are checked at every exam.
- Bathroom breaks are not allowed.
- The course instructor reserves the right to replace individual written exams with oral exams.
- Students may be moved during exams to ensure academic integrity.

Artificial intelligence

Generative AI tools are available and students are expected to learn how to use them. Note the following:

- All content produced must be critically analyzed - do not automatically assume the output provided is correct.
- Use of AI must be properly acknowledged. Failure to disclose and cite sources will be considered a violation of academic integrity.
- I reserve the right to put any material you hand in through plagiarism detection software.

Course outline

Below is a *preliminary* list of topics. Some deviations from the actual schedule may be necessary as the class progresses. Students are responsible for attending classes and learning of any changes in the schedule.

I. Linear algebra and geometry

Vectors and matrices

Linear systems of equations

Inner product and norms

Matrix algebra

Independence, basis, and dimension

The four fundamental subspaces

Orthogonality and projections

Ordinary least squares

The determinant function

Eigenvalues and eigenvectors

Linear transformations

Quadratic forms

Convex sets and convex functions

Level sets and hyperplanes

II. Calculus and optimization

Multi-variate calculus

Vector calculus and matrix differentiation

Implicit functions

Comparative statics

Convex optimization

Unconstrained and constrained quadratic programming (OLS/regularization/PCA)

Nonlinear programming

Karush-Kuhn-Tucker conditions

Gradient descent

Value functions

The envelope theorem