Instructor: Elden Elmanto, Science Center 231. elmanto@math.harvard.edu

Office Hours: T 9:30-10:30 AM, Th 2:00-3:00 PM and by appointment.

Course Assistant: Forrest flesher. forrestflesher@college.harvard.edu

What is this class about? While this class is called “Linear Algebra and its Applications,” our goal will be two-fold: 1) to gain exposure to the notion of a proof and understand how a mathematical theory is developed and built, and 2) to develop an appreciation for the practical aspects of linear algebra and its power as a fundamental tool in various branches of science, economics and, of course, mathematics itself. This class is most appropriate if you have a strong interest in pure mathematics, but have not had exposure to proofs and have not decided to concentrate in mathematics (yet). This is not a class about multiplying huge matrices together, even by means of a computer.

In order, we will cover: proof techniques, field theory, vector spaces and linear transformations (matrices), the rank-nullity theorem, tensor algebra, traces and determinants, eigenvalues and eigenspaces, the Riesz representation theorem and inner products, Jordan block decomposition, and the Cayley-Hamilton theorem. We will draw examples from (Euclidean and hyperbolic) geometry, quantum mechanics, linear programming, coding theory, machine learning, Markov processes. However, the narrative of the class will theorem-driven.

Textbook: We will not strictly follow any textbook, but Linear Algebra Done Right by Sheldon Axler is a good reference. I personally learned linear algebra from Linear Algebra by Kenneth Hoffman and Ray Kunze, which has a more theoretical bent. Exam/homework material will be drawn from class notes.

Prerequisites: None, although Math 21 is (somewhat) useful. Not to be taken in addition to Math 22b, 23a or 25a or 55a.

Grade Policy:

- (50% of grade) Weekly problem sets.
- (10% of grade) Midterm exam 1.
- (10% of grade) Midterm exam 2.
- (30% of grade) Final project.

*In other words, treated like a “math major class” where certain classic theorems in the subject will be our signposts.
†No calculus will be used in this class, for example.
**Homework:** You are highly encouraged to work collectively on the problem sets and scour various sources for hints and ideas. However, I demand two very important things:

- *properly cite* your sources (including your collaborators), and
- write up your solutions *in your own words.*

Failure to do so constitute plagiarism. In lieu of accepting late homework, I will drop the lowest problem set grade. Problem sets are due at the beginning of class every Tuesday and a new one will be assigned at the end of class. Starting week 5 I will expect homeworks to be TeXed.

**Project:** I will require you to write an end-of-year project. More on this towards the end of the semester.

**Academic Honesty:** Please refer to [https://handbook.fas.harvard.edu/book/academic-integrity](https://handbook.fas.harvard.edu/book/academic-integrity).

**Important Dates:**

- First Exam ................................................. September 26
- Add/drop deadline ................................. October 7
- Withdraw deadline ................................... October 21
- Second Exam ............................................. October 24
- Project topics deadline ............................ November 26
- Thanksgiving ........................................... November 28
- Last day of classes ................................. December 3
- Reading period ................................. Week of December 5
- Final project due ................................. Week of December 9