

# MATH 270A: Numerical Linear Algebra

## Introductory notes and course outline

Martin W. Licht

UC San Diego

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# Numerical Linear Algebra (NLA)

What is a numerical linear algebra?

- Computational Linear Algebra
- Numerical linear algebra involves mathematics and computer science.
- *The science of algorithms for solving problems in linear algebra*

Where does (numerical) linear algebra appear?

- **Answer:** everywhere.
- Linear algebra appears throughout computational science, data science, computational partial differential equations, etc.
- Linear algebra appears in auxiliary computations treating nonlinear problems.

# Typical problems in numerical linear algebra

A few examples:

- Implement operations of linear algebra.  
*e.g., Matrix-vector multiplication*
- Solve linear systems of equations.  
*e.g., numerical partial differential equations*
- Find eigenvalue and eigenvector of a matrix.  
*e.g., principal component analysis (PCA)*

Research focuses on a few central problems.

Major fields of applications:

- Statistics, Data Science
- Numerical Partial Differential Equations

# What do we do in numerical linear algebra?

- We develop computer algorithms for linear algebra problems and analyze their properties.
- Many problems solved in principle, but extreme demands requires extreme optimization.
- There are many computational resources:  
*time, memory consumption, energy, precision, number of processors, ...*
- Technical developments affect research:  
*faster processors, cache optimization, parallelism, stream processing, ...*
- **The more properties known about the problem class in advance, the more advantages we can use in specialized algorithms.**

# Goal of this class

**Goal:** Overview of the basic topics in numerical linear algebra

- Solving linear systems of Equations
- Linear Least-Squares problems
- Eigenvalue problems
- Direct/decomposition methods
- Iterative Methods
- Dense and Sparse Linear Algebra

**Metagoals:**

- Techniques to develop, analyze, and compare algorithms in numerical linear algebra (“Soft skills”)
- Prepare you for further (self-)study in the literature.

# Administrativa

**Lecturer:** Martin Licht

**Grader:** Minxin Zhang

## **Homework and Final exam:**

- There will be four homework assignments of equal importance.
- Final exam: December 12th, 3:00–5:59pm.
- Grading scheme: fifty-fifty.

# This is a Graduate level class

A piece of ~~warning~~ advice about graduate level classes:

- The level difficulty is much higher than in undergraduate classes.
- More theorems and proofs, less examples.
- More autonomous learning is ~~recommended~~ required.
- Feel free to ask, there are no dumb questions.