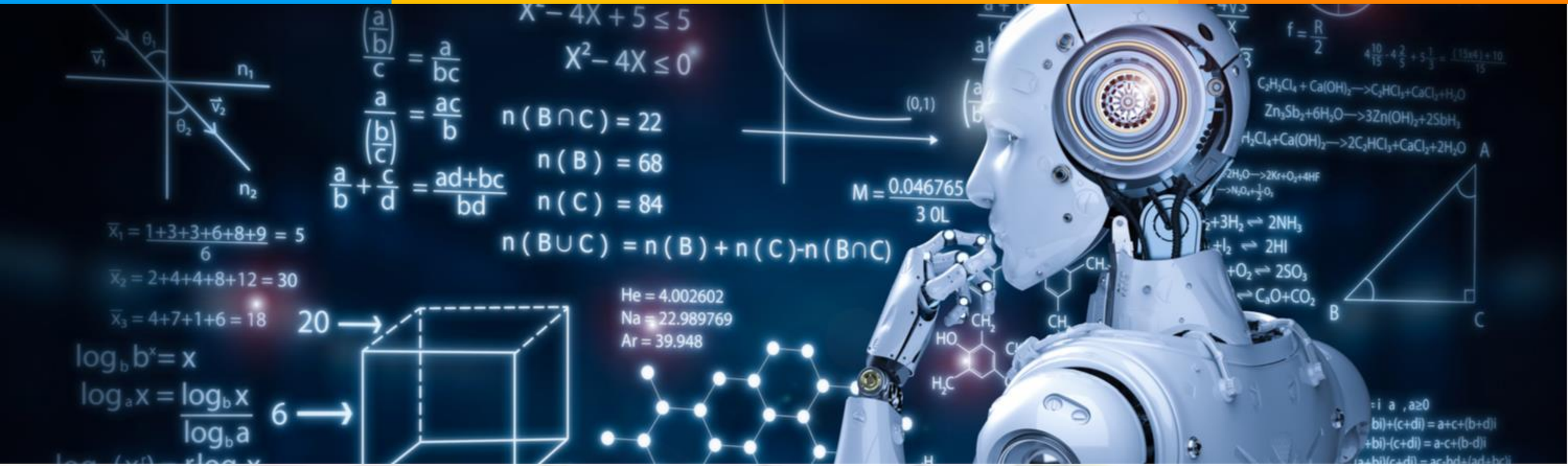


Lecture 01 – Applied Linear Algebra Introduction

1. Course plan & logistics

Logistics

- Course Name
  - Applied Linear Algebra – ALA 5101
- Hours per week: 3 lectures + 3 hours lab
- Total 36 hours theory + 36 hours lab

Course Objectives

- You can find the objectives in syllabus
- My unofficial objectives -
  - To make you shed the fear/aversion for Linear Algebra
  - To make you develop a liking for Linear Algebra
  - To help you become a better data scientist
- Not a comprehensive introduction to numpy, Pandas
  - Numerous videos available on youtube

Evaluation policy

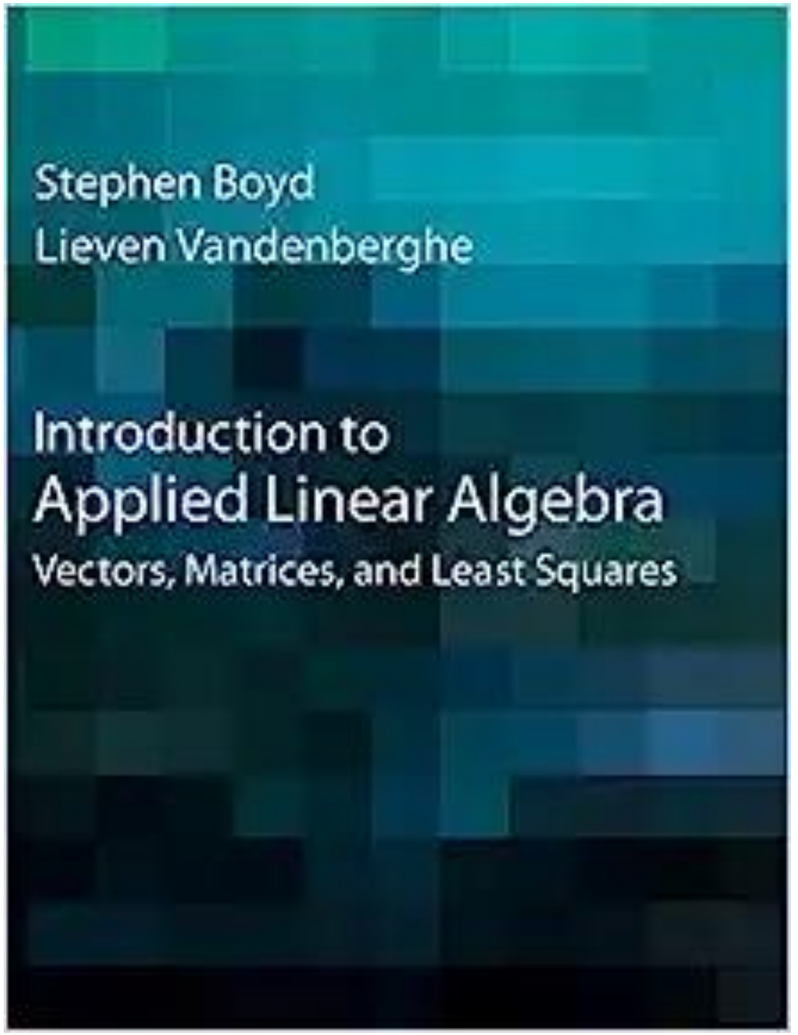
- Memorization not important for exams either
- Exam will test your
  - Core understanding & abstract thinking
  - Capability to apply Linear algebra to
    - Various scenarios & Machine Learning problems
- Objective type, True/False, Problems, 1-2 sentence
  - Negative marking for objective type, True/False
  - True/False will also need a 1-2 sentence reasoning.
  - Both have to be correct.

Grading policy

- 2 sessional + 1 end semester exam
- One big implication of chosen approach ☹
- Continuous assessment
  - 2-3 problem sets per semester
  - Many surprise quizzes
  - Daily summarization by randomly chosen student

Textbook

- https://web.stanford.edu/~boyd/vmls/
- Links for Boyd's
  - Textbook PDF
  - Entire course lecture in youtube
  - Slides
  - Python & Julia companion pdf
  - Python/Julia github repository
  - Additional exercises
- VMLS exercise solutions pdf https://tinyurl.com/ypbnwn44



Deviations from VMLS content

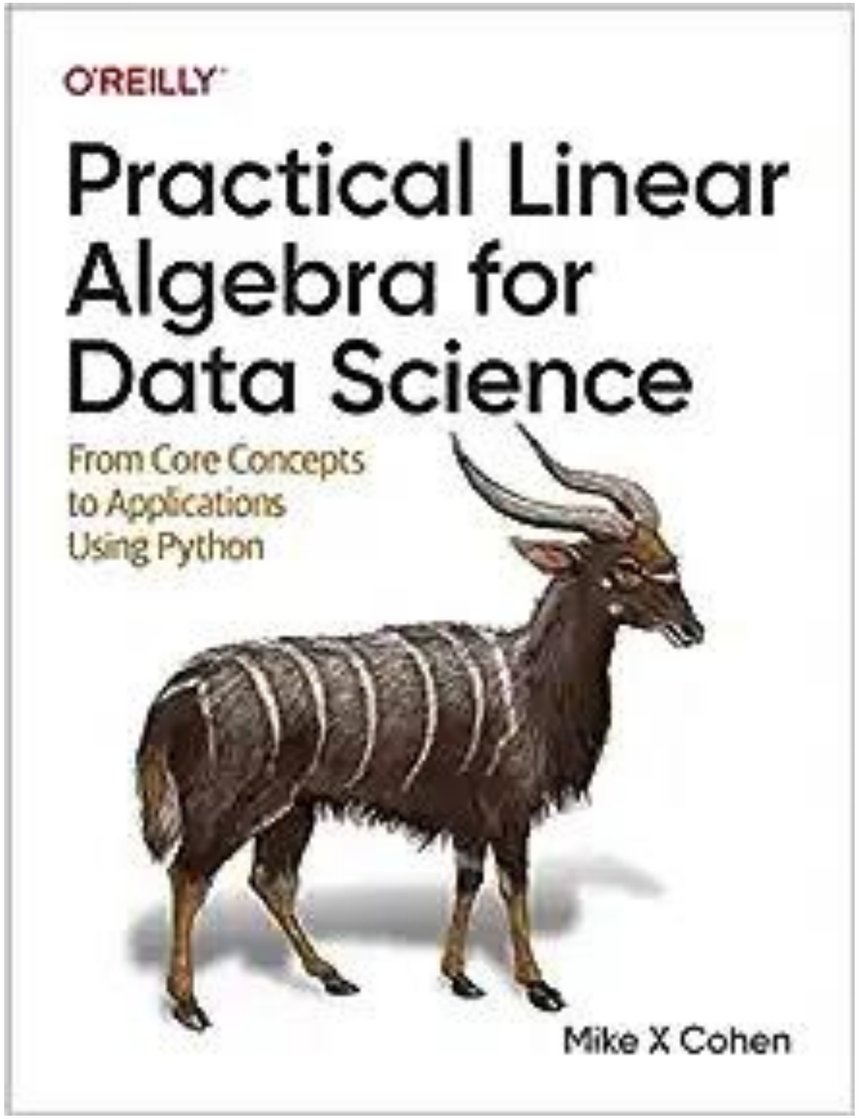
- Not included (tentative): Least Squares except OLS
- Alternate path: Linear Independence
- Additional materials
  - System of Equations
  - REF, RREF, Elimination Matrices
  - Matrix Factorization
  - Eigen Decomposition, PCA, SVD

Must read/watch

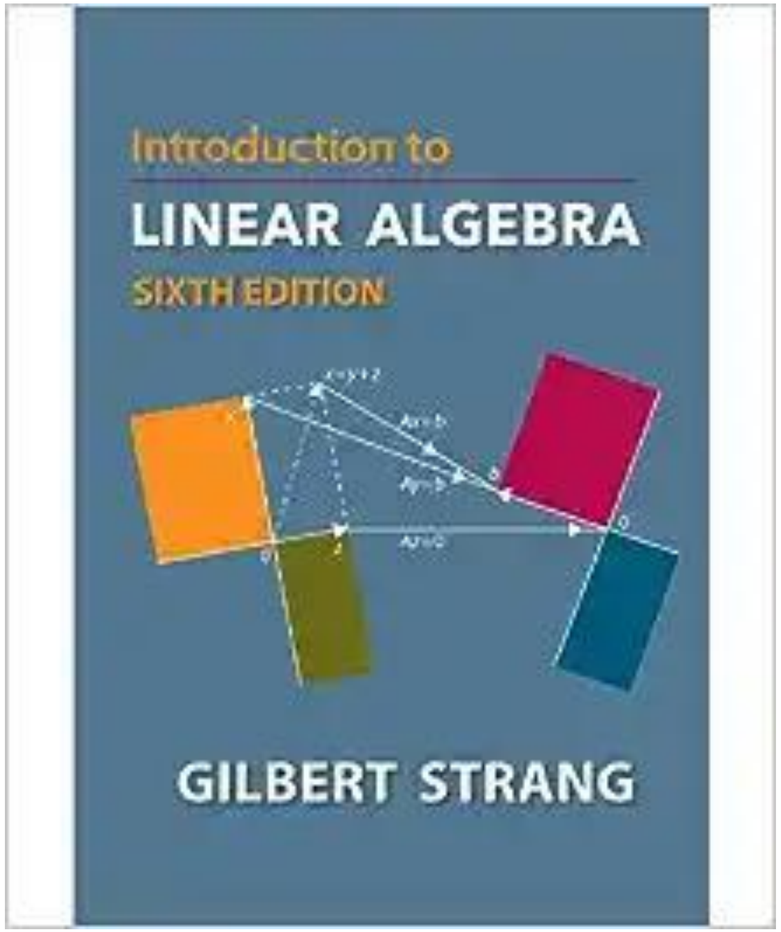
- 3Blue1Brown Youtube series “Essence of Linear Algebra”
- Slides from this course ALA
- Additional reading assignments & videos as provided

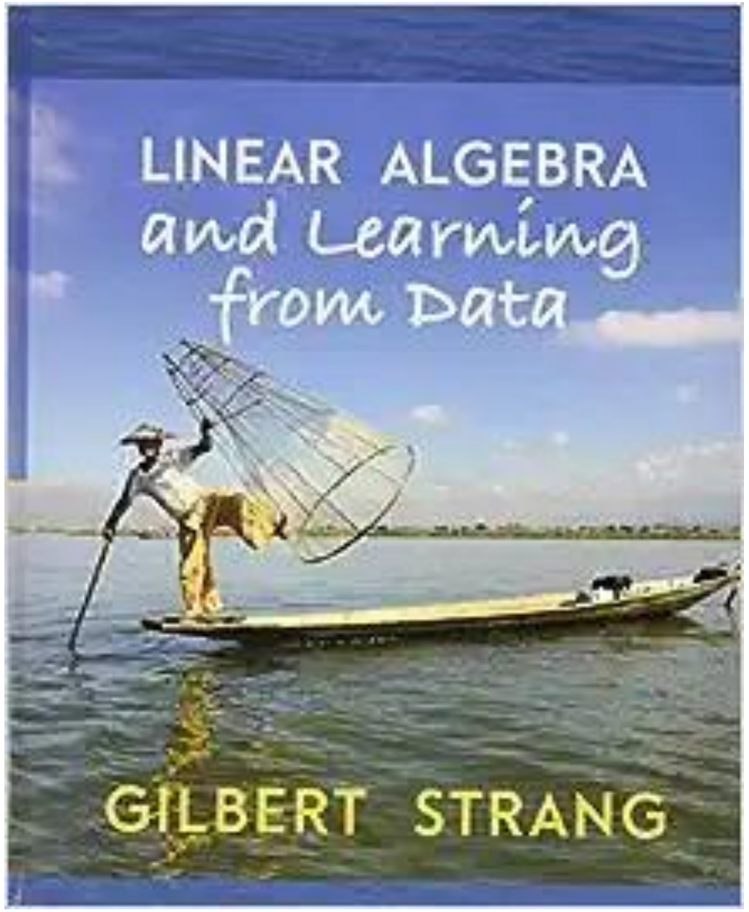
Other readable books

- Easy to read & understand 👍
- Not comprehensive 👎



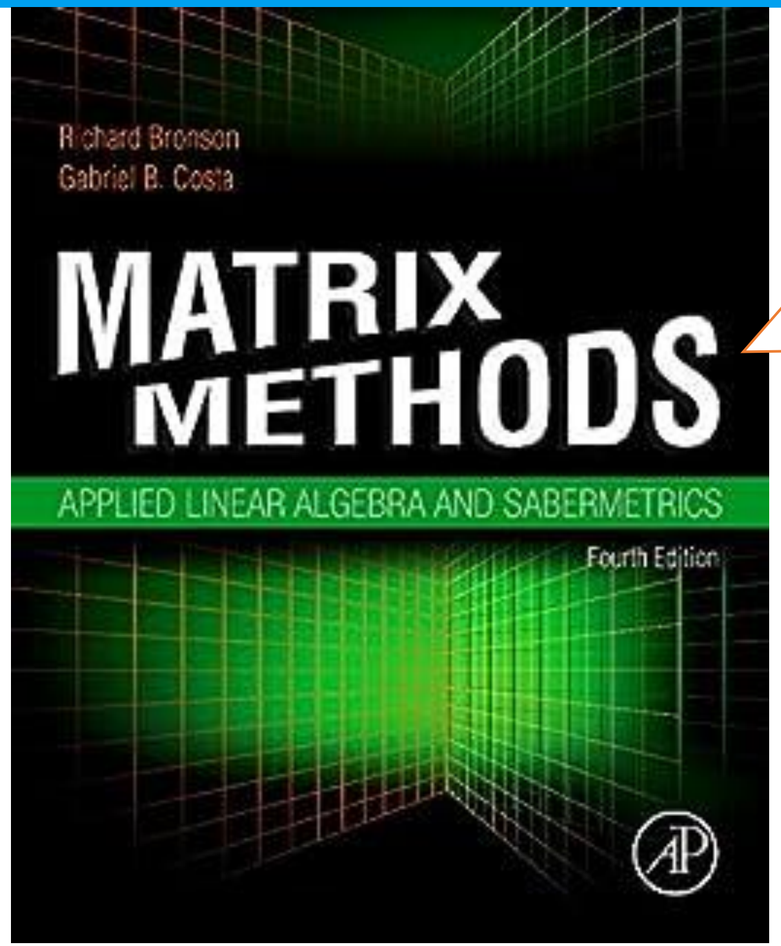
Books from Gilbert Strang (for adventurous)



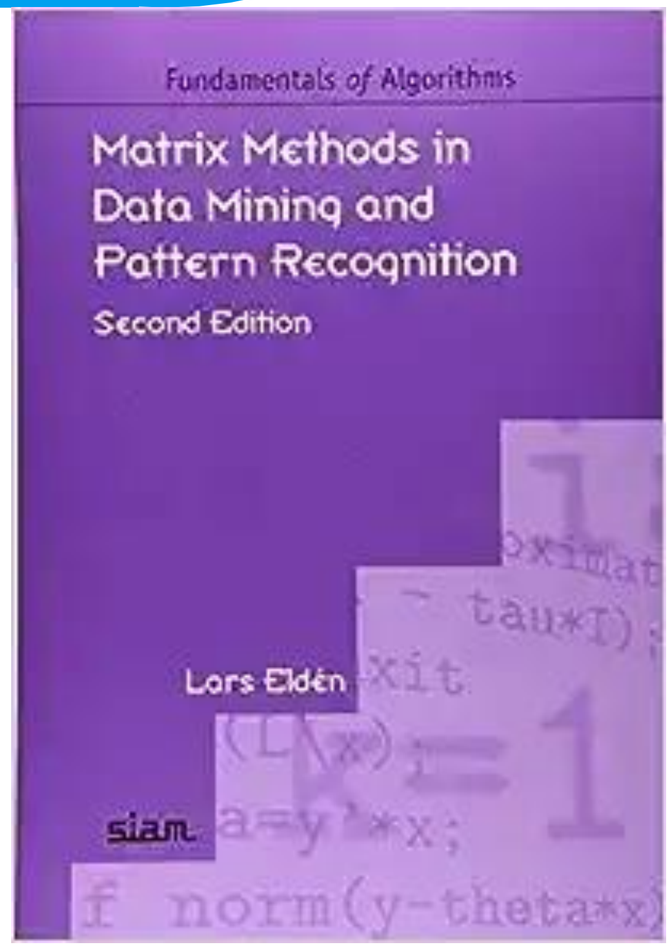


- Both books have lengthy & in-depth courses in MIT Open Courseware (How much time do you have?)

Additional references



4th edition:
Last 3 chapters on applying matrix methods in sports especially baseball



- After second sessional and those interested in going beyond the syllabus

2. Why Linear Algebra?

What is Linear Algebra

- Dealing with numbers en masse
  - Finding patterns in them
  - Using mathematical methods to process them and reduce computational time
- One of the four pillars of Machine Learning
- Four pillars
  - Linear Algebra
  - Calculus & Optimization
  - Probability & Statistics
  - Programming

Where is Linear Algebra used?

- Anything that involves numbers
- From physics to computational biology
- Computer Graphics
- Machine learning, Deep Learning, Data Science
- **Necessary** skill to be **good** data scientist

Applications in Machine Learning

- Feature Transformations during EDA
  - Transform/Inverse Transform: Log/antilog metaphor
  - What is a matrix vector multiplication?
  - Feature Scaling, Power Tx, Box-Cox Tx
  - Inverse transformation on y
- Regression, Classification, SVM, Deep Learning
  - Objective function minima - Multivariable calculus
  - Cannot solve analytically only numerically
  - Gradient Descent – Jacobian matrix, Hessian matrix

Applications in Machine Learning

- Probability Distributions in Generative AI
  - Variance and covariance matrix
- Separate mixed signals – ICA
  - Denoising images, audio
- Mix features for dimensionality reduction
  - Eigen decomposition & PCA
  - SVD

Applications in Machine Learning

- Image Processing
- Outlier detection
  - Mahalanobis distance
  - Minimum Covariance Determinant
- Natural Language Processing (NLP) –
  - Feature Transform with Matrix Factorization
  - Word embedding, Similarity Search
  - Attention mechanism
  - Topic Modeling

Applications in Machine Learning

- Linear System of equations
- Matrix decomposition/factorization
  - Recommender Systems
  - Molecular Dynamics
- Time series analysis

Applications in Machine Learning

- At the cusp of Linear Algebra & Graph Theory
  - Semi-supervised learning, Hierarchical clustering
  - NP-hard problems in polynomial time
- Graph Neural Networks


QUESTIONS


ThankYou!