



Lecture 01 – Applied Linear Algebra Introduction



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

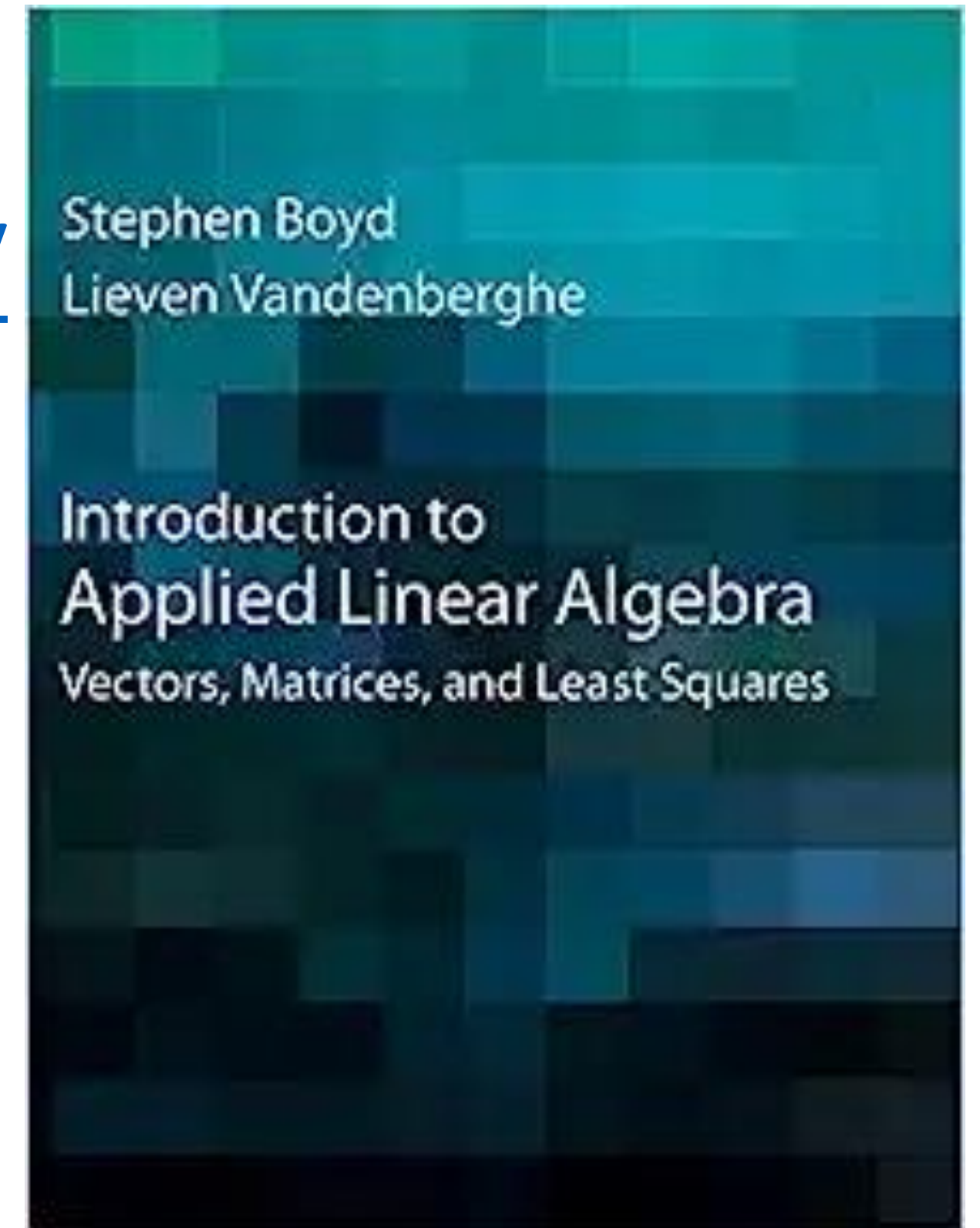
- Memorization not important for exams either
- Exam will test your
 - Core understanding & abstract thinking
 - Capability to apply Linear algebra to
 - Various scenarios & Machine Learning problems
- Objective type, True/False, Problems, 1-2 sentence
 - Negative marking for objective type, True/False
 - 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
- VMMLS exercise solutions pdf <https://tinyurl.com/ypbnwn44>



Deviations from VMLS content

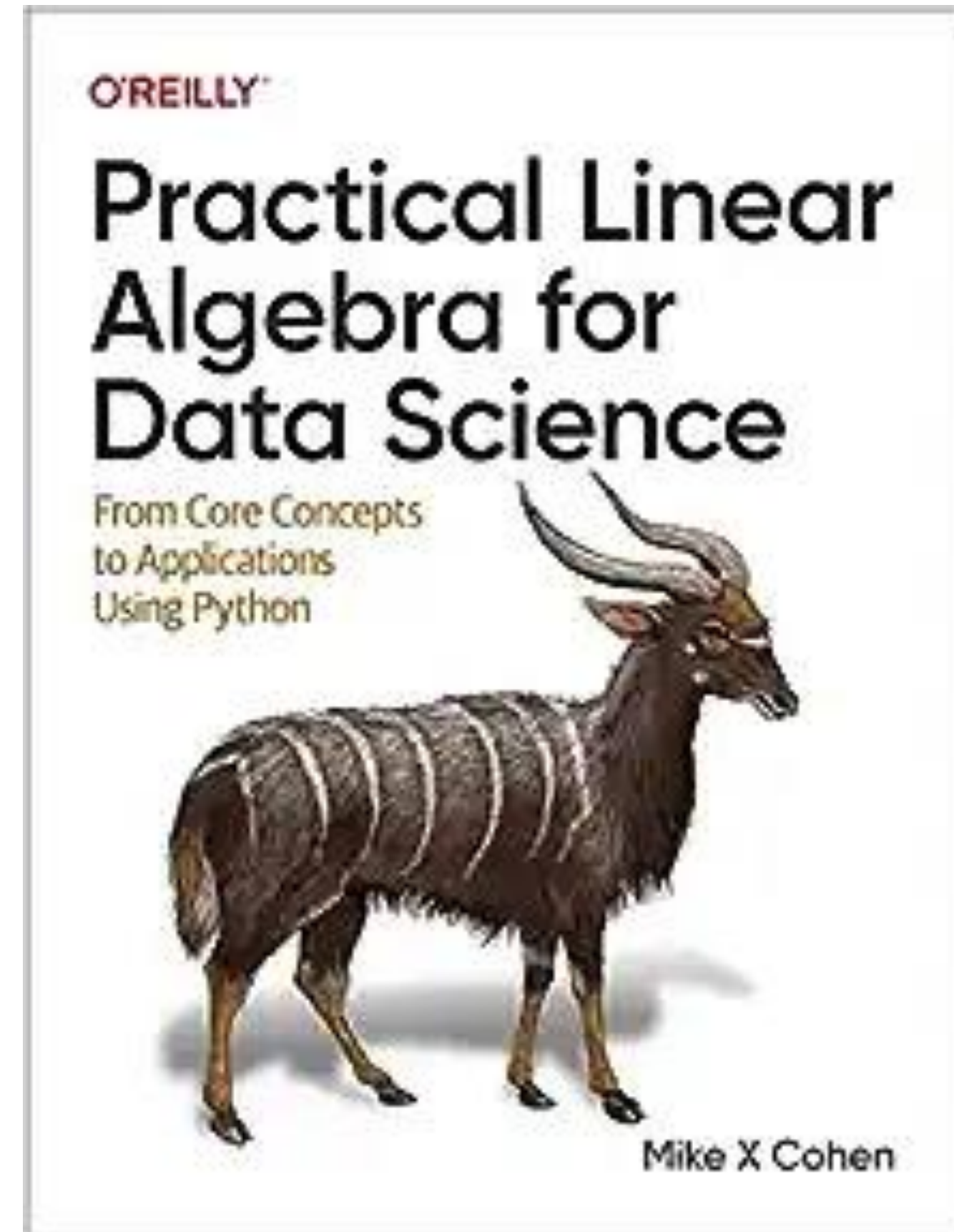
- Not included (tentative): Least Squares except OLS
- Alternate path: Linear Independence
- Additional materials
 - System of Equations
 - REF, RREF, Elimination Matrices
 - Matrix Factorization
 - Eigen Decomposition, PCA, SVD

Must read/watch

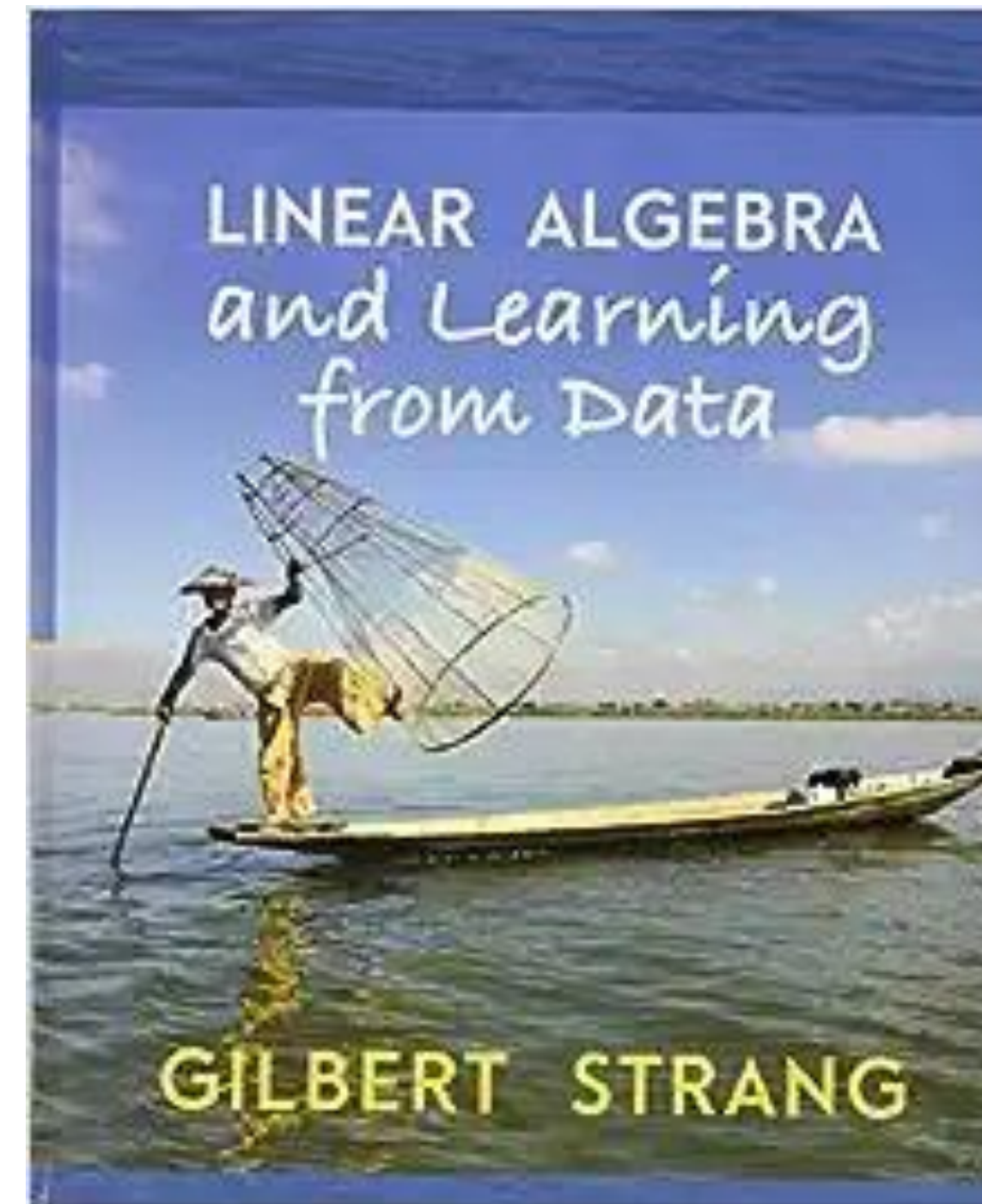
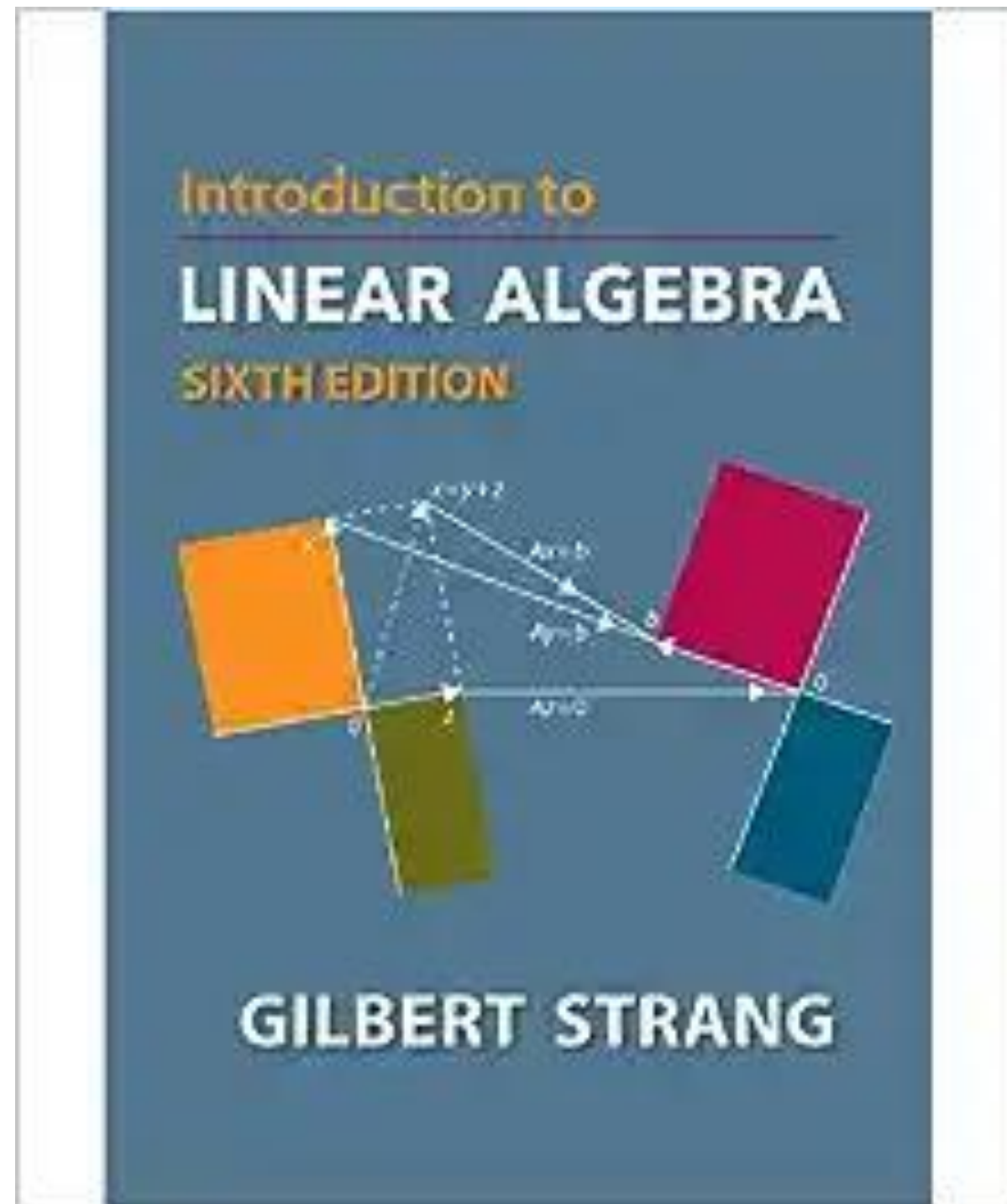
- 3Blue1Brown Youtube series “Essence of Linear Algebra”
- Slides from this course ALA
- Additional reading assignments & videos as provided

Other readable books

- Easy to read & understand
- Not comprehensive

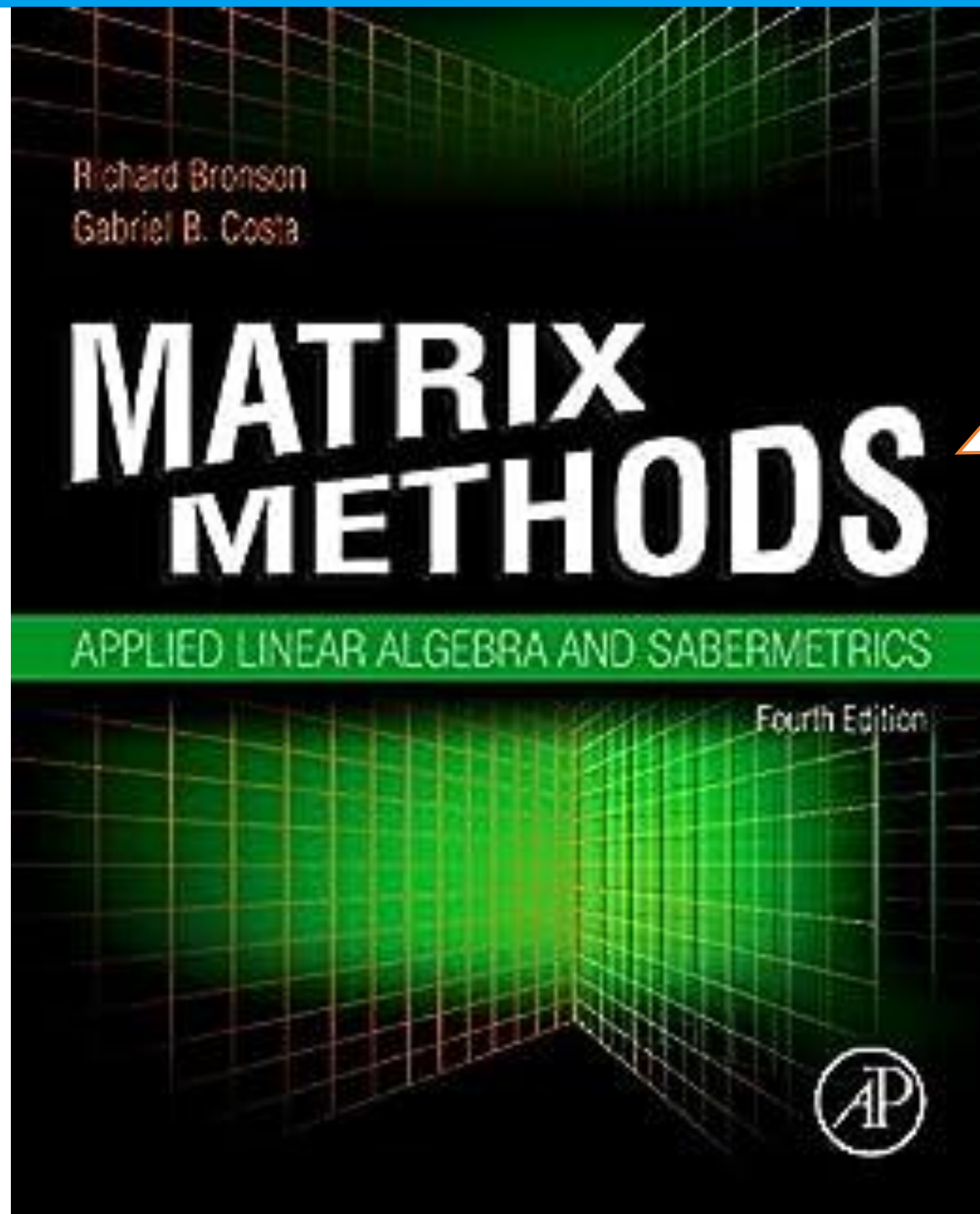


Books from Gilbert Strang (for adventurous)

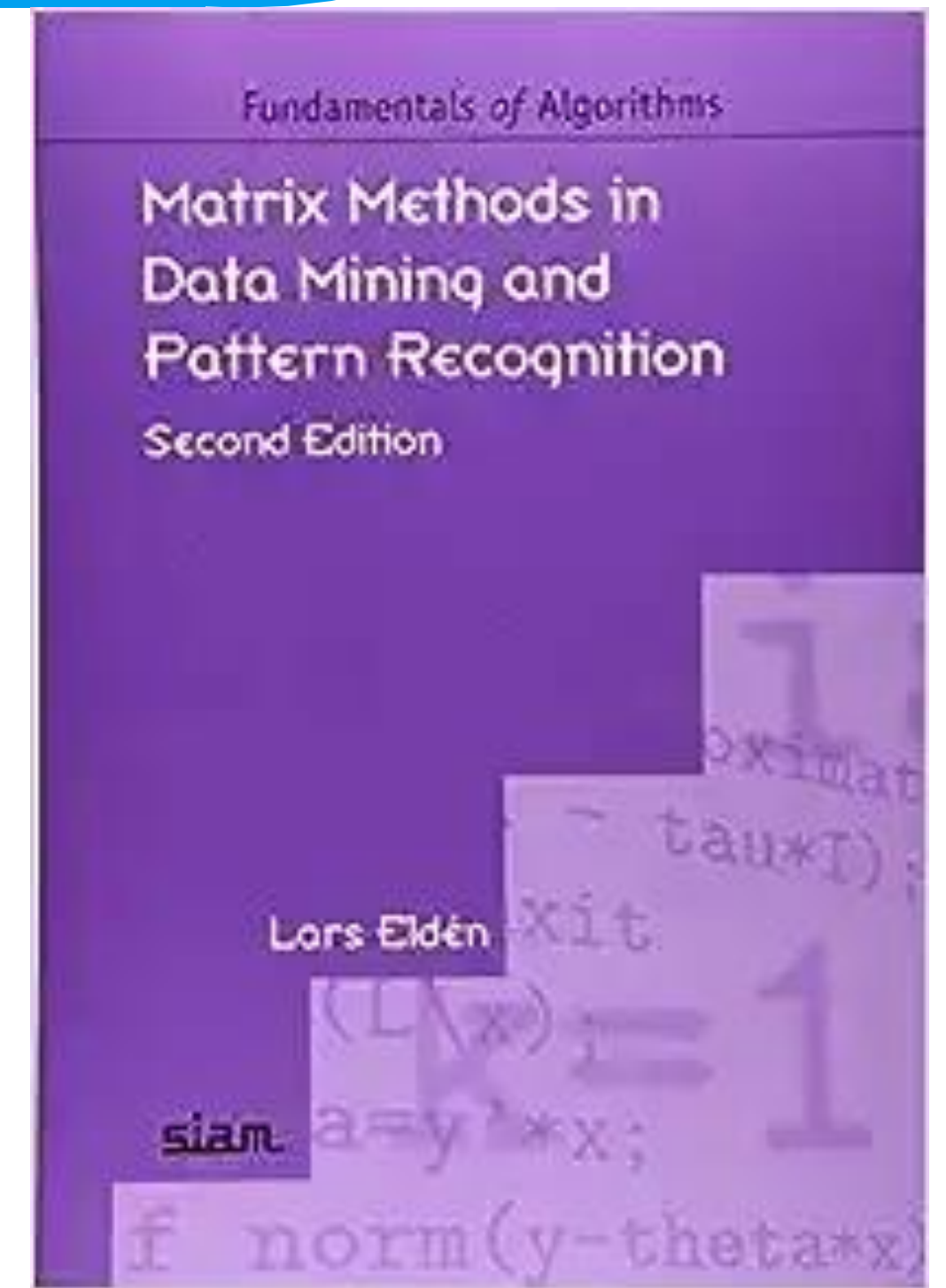


- Both books have lengthy & in-depth courses in MIT Open Courseware (How much time do you have?)

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



Thank You!