Syllabus: DSCI 369

Dr. Eric R. Kehoe

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E-mail: ekehoe@colostate.edu
Office Hours: MR 11am - 12am
Office: Weber 16

Git: DSCI 369 Repository
Class Hours: MWF 10-10:50am
Class Room: ...

Lab Room: Weber 205

Lab Hours: R 10-10:50pm

Course Description

This is a 4 credit course in Linear Algebra with an emphasis on techniques and applications in Data Science.

Course Materials

- Linear Algebra for Data Science, M. Kirby (required text, free and available through Canvas)
- Introduction to Linear Algebra, Gilbert Strang (optional)
- Numerical Linear Algebra, Lloyd N. Trefethen and David Bau (optional)
- MATLAB, students can install with a student license via this link.
- `python` (optional, example code will not be provided for students and will have to be self-reliant)

Prerequisites

Prerequisites: M124 and M126.

Course Objectives

On completion of this course students will be able to:

- Perform basis matrix operations such as addition, multiplication by a scalar, and the multiplication of two matrices
- Explain the mathematical concepts of basis, matrix rank, linear independence and illustrate a change of basis
- Solve linear systems
- Define a vector space, vector subspace and demonstrate these properties, decompose a vector space into the direct sum of subspaces
- Fit data to a model using projections and describe the process geometrically
- Compute eigenvectors and eigenvalues and use them in applications such as the diagonalization of a matrix
- Describe the singular value decomposition and interpret singular values and singular vectors of a matrix

Course Structure

Weekly Problem Sets

Due at the beginning of class on Fridays for non-exam weeks, due by 5pm on Friday for exam weeks. Each student has a one week late pass for one assignment. **Additional late work will receive half credit**.

Examinations

There will three exams **in class** and a final examination. The examination dates are:

- Friday, February 14th
- Friday, March 13th
- Friday, April 17th

Lab

Each Thursday and the last Friday of class we will have lab in Weber 205. This will serve as a chance to ask questions and getting our hands dirty with coding in MATLAB applications of the theory. It is required that you read the FAQ (linked here) for information and rules regarding the lab in Weber 205. All example code will be placed in my `git` repository listed above and on Canvas as well. Topics for lab include:

- Basic Vector and Matrix Operations
- The Dot Product
- Reduced Row Echelon Form
- Rank
- Projections
- Novelty Detection

- Data Fitting
- The Fourier Transform
- Fisher discriminant analysis
- Difference equations
- PCA Lab
- SVD Lab

Grading Policy

The final grade will be calculated using the weighting:

- **50%** of your grade will be determined by the weekly problem sets.
- **30%** of your grade will be determined by the semester exams (10% each)
- **20%** of your grade will be determined by the final examination

Course Policies

Group Work and Collaboration

You may collaborate with other students (in our class) on problem sets and are encouraged to do so. However, if you choose to collaborate on assignments it is required that you adhere to these rules: You are required to write up your solutions independently, i.e., each student hands in his or her own work. Solutions that appear to be copies of each other will receive zero credit. Discussing assignments and exchanging ideas is recommended. There is no penalty for collaborating as long as you hand in your own work. Your mastery of the material will be evidenced by your own write-up of the problems as well as examination results.

Policies on Makeup Exams

Makeup exams will **only** be given under academically related or appropriate legal circumstances. If there is a conflict I must be told at least a week ahead of time to setup a new time for the exam. Makeup exams will **not** be given in any other circumstances so please do not ask.

Academic Integrity and Honesty

This course will adhere to the CSU Academic Integrity Policy as found on the Student' Responsibilities page of the CSU General Catalog and in the Student Conduct Code, link here. At a minimum, violations will result in a grading penalty in this course and a report to the Office of Conflict Resolution and Student Conduct Services

Accommodations for Disabilities

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, you must request them by first meeting with one of the SDC accommodation specialists. Appointments for this meeting are best made by calling the office at (970) 491-6385 and asking for one. Phone appointments are possible if you are not able to come to the office. Please visit this link for more details.

Schedule and weekly learning goals

The schedule is tentative and subject to change. The learning goals below should be viewed as the key concepts you should grasp after each week, and also as a study guide before each exam, and at the end of the semester.

Week 01, 01/20 - 01/24: Vector and Matrix Operations

- M: No Class
- W: Vector Operations
- R: Lab 1 (Extra Help/ Logging on in Weber 205)
- F: Matrix Operations *(End of Restricted Drop)*

Week 02, 01/27 - 01/31: Solving Linear Systems

- Su: *End of Add Without Override*
- M: Elementary Row Operations
- W: RREF and Gaussian Elimination
- R: Lab 2 (Solving Linear Systems w/ MATLAB)
- F: Inhomogeneous Systems

Week 03, 02/03 - 02/07: Inverse Matrix

- M: Definition and Existence
- W: Computing the Inverse *(Registration Closes - end of period for adding courses - last day for dropping courses without record entry, changes in grade option, and tuition and fee adjustment)*
- R: Lab 3 (Inverses w/ MATLAB)
- F: LU Decomposition

Week 04, 02/10 - 02/14: Vector Spaces and **Exam 1**

- M: Introduction to Vector Spaces
- W: Subspaces and Direct Sum
- R: Lab 4 (Exam Extra Help)
- F: Exam 1 (Covering Weeks 01-03)

Week 05, 02/17 - 02/21: Range and Independence

- M: Span
- W: Range of a Matrix
- R: Lab 5
- F: Linear Independence

Week 06, 02/24 - 02/28: The Null Space and Bases

- M: Null Space of a Matrix
- W: Bases and Dimension
- R: Lab 6
- F: Change of Basis

Week 07, 03/02 - 03/06: Decomposition of $\mathbb{R}^n$

- M: Basis for the Row Space
- W: Basis for the Column Space
- R: Lab 7
- F: Orthogonality

Week 08, 03/09 - 03/13: Gram-Schmidt, Projections and **Exam 2**

M: Gram-Schmidt Orthogonalization

W: Projections

R: Lab 8 (Exam Extra Help)

F: Exam 2 (Covering Weeks 04-07)

Week 09, 03/16 - 03/20: Spring Break

Week 10, 03/23 - 03/27: Model Fitting

M: Intro to Model Fitting *(End of Course Withdrawal ("W") Period, Repeat/Delete Deadline)*

W: Lease Squares

R: Lab 9 (Model Fitting in MATLAB)

F: Hyperplanes and Dot Products

Week 11, 03/30 - 04/03: Classification: LDA and SVM

M: Fisher Linear Descriminant Analysis (LDA)

W: Support Vector Machines (SVM)

R: Lab 10 (LDA /w MATLAB)

F: Applications of SVM

Week 12, 04/06 - 04/10: SVM, Determinants, and Eigenvalues

M: Determinants

W: Eigenvalues and Eigenvectors

R: Lab 11 (SVM w/ MATLAB)

F: Eigenvalues and Eigenvectors cont.

Week 13, 04/13 - 04/17: Diagonalization and **Exam 3**

M: Diagonalization

W: Spectral Theorem

R: Lab 12 (Exam Extra Help)

F: Exam 3 (Covering Weeks 08-12)

Week 14, 04/20 - 04/24: The Spectral Theorem and PCA

M: Intro to Principal Component Analysis (PCA)

W: Solution of the Optimization Problem

R: Lab 13 (PCA /w MATLAB)

F: Eigenbases and data reduction

Week 15, 04/27 - 05/01: PCA cont. and SVD

M: Properties of PCA

W: Intro to Singular Value Decomposition (SVD)

R: Lab 14 (More PCA /w MATLAB)

F: Existence of SVD

Week 16, 05/04 - 05/08:

M: Image analysis and the SVD

W: Data interpretation of the SVD and subspaces

R: Lab 14 (SVD /w MATLAB)

F: Lab 15 (more SVD /w MATLAB) *(Last Day of Classes; University Withdrawal Deadline)*

Week 17, 05/11 - 05/15: **Final Exam**