

# A brief syllabus of 21-670 Linear algebra for data science

Zecheng Zhang

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## 1 People and contacts

I am Zecheng Zhang. My office is Wean Hall 7216. My email is zechengz@andrew.cmu.edu.

The grader of the class is Zhijun Chen. His office is Wean Hall 7114. My office hours will be announced soon.

## 2 Targets of the course

This is a graduate-level class. We will discuss some topics in linear algebra. These are fundamental and very useful topics for data science.

## 3 Books and sources

We do not require a textbook, but the following books are good references. I will upload the class notes.

1. Linear Algebra and Its Applications, 6th Edition, Lay/Lay/McDonald
2. Numerical Linear Algebra, 1st Edition, Lloyd N. Trefethen and David Bau III
3. Matrix Analysis, 2nd Edition by Roger A. Horn, Charles R. Johnson
4. Introduction to Linear Algebra, 5th Edition, Gilbert Strang
5. Matrix Computations (Johns Hopkins Studies in Mathematical Sciences), 3rd Edition, Gene H. Golub, Charles F. Van Loan

We use Canvas, particularly Gradescope in Canvas (for homework). In addition, I create a website for the class. The website is here: [class homepage](#). You can also access the class homepage through my personal website in CMU math people.

## 4 Prerequisite

You need to have some basic knowledge of linear algebra. For example, what is a matrix? What are the elementary row operations? What is the REF of a matrix? How to solve a linear system by REF? How to compute the determinant of a square matrix? How to calculate the inverse of

the matrix? What is linear transformation? How to compute the eigenvalues? What is matrix diagonalization? I will provide you with notes to review some of the fundamental topics, but we may not have time to cover these topics in class.

## 5 Topics

Tentative topics of the class. Some topics may be removed, and some other topics will be added.

1. matrix, vector, linear combination, subspace, basis, linear transformation.
2. identity matrix, invertible, and invertible equivalence, matrix multiplication, column space, row space, dimension of column space.
3. range, null space, orthogonality, rank theorem, some rank inequalities, LU decomposition.
4. orthogonality, inner product, transpose of a vector, orthonormal, QR decomposition.
5. eigenvalue, diagonalizable, diagonalizable theorem.
6. finding eigenvalues and eigenvectors, the similarity of two matrices, a trace of a matrix, orthogonal complement, and singular value decomposition (SVD).
7. Gram–Schmidt (GS) process.
8. maximizes with a constraint, symmetric matrices, spectral theorem.
9. SVD theorem.
10. SVD another proof, symmetric matrix SVD, rank and the number of nonzero SV, rank  $r$  approximation.
11. symmetric positive definite matrix (SPD), a matrix is SPD iff ‘statements’. Simple SVD properties.
12. LU and SPD, quadratic form, the principle axis theorem, and SVD.
13. quadratic form and the principle axis theorem and SVD.
14. revisits SVD and prove one theorem.  $L_2$  norm, Eckart Young inequality, SVD and sum of low-rank approximation, Frobenius norm.
15. Kronecker product, Khatri-Rao product, tensor.
16. least square.

## 6 Course grading

### 6.1 Assessment methods

4 homework and NO exam, and I will NOT drop the lowest score. We do NOT accept late assignments. I will announce the homework due dates soon.

## 6.2 Grading criteria

Grading criteria. I may also curve the course and not precisely follow Table 1.

90% above	A
80% – 90%	B
70% – 80%	C
60% – 70%	D
50% – 60%	R (fail)

Table 1: Grading criteria

## 7 Course design and policy

### 7.1 Academic integrity

Any work you submit in this course must be your own, not copied from a friend, book, online resource, or anywhere else. The student handbook states that Carnegie Mellon’s academic integrity policies will be strictly enforced. See [here](#). In particular,

1. No collaboration on homework.
2. You need to write the solutions by yourself.

### 7.2 Electrical devices

1. Laptops, iPad are allowed in class as long as they don’t interfere with the class and affect other people.

### 7.3 Regrade requests

If you think the homework grading is incorrect, please submit a re-grading request within one week after you receive your graded homework.

### 7.4 Accommodations for students with disabilities

If you have a disability and have an accommodations letter from the Disability Resources office, I encourage you to discuss your accommodations and needs with me as early in the semester as possible. I will work with you to ensure that accommodations are provided as appropriate. If you suspect that you may have a disability and would benefit from accommodations but are not yet registered with the Office of Disability Resources, I encourage you to contact them at [access@andrew.cmu.edu](mailto:access@andrew.cmu.edu).

### 7.5 Student wellness

Many helpful resources are available on campus, and an essential part of the college experience is learning how to ask for help. Asking for support sooner rather than later is almost always helpful. If you or anyone you know experiences academic stress, complex life events, or feelings like

anxiety or depression, we strongly encourage you to seek support. Counseling and Psychological Services (CaPS) is here to help: call 412-268-2922 and visit their website. Consider reaching out to a friend, faculty, or family member you trust for help getting connected to the support that can help. You should always feel welcome to discuss sensitive issues with the course staff, but please bear in mind that (a) we are not counselors or therapists and will not attempt to provide such services (but we will listen to you and help however we can), and (b) we are required to report instances of suspected sexual misconduct to the Deputy Title IX Coordinator for Students.

## **7.6 Diversity and inclusion**

The Center for Student Diversity and Inclusion offers resources such as mentoring, advising, and coaching (and much more), particularly for students in historically underrepresented groups and first-generation students. More information can be found on the following website: Center for Student Diversity and Inclusion <https://www.cmu.edu/student-diversity/>. Phone: (412) 268-2150.

## **7.7 Discrimination, harassment and sexual misconduct**

We share a responsibility to make our community one where everyone feels safe and welcome inside and outside the classroom. Discrimination, harassment and abuse (sexual or otherwise) have no place in this course, at CMU, or anywhere else. Some resources for students regarding discrimination and harassment are as follows.

1. Office of Title IX Initiatives <https://www.cmu.edu/title-ix/> (412) 268-7125 / [tix@cmu.edu](mailto:tix@cmu.edu)
2. Hazing Prevention & Response <https://www.cmu.edu/hazingprevention/>
3. CMU University Police <https://www.cmu.edu/police/>. Phone: (412) 268-2323
4. Anonymous reporting <https://www.reportit.net/> (username: tartans, password: plaid). Phone: (877) 700-7050