

EE 510: Applied Linear Algebra for Engineering (Fall 2020)

Objectives: To provide a fundamental understanding of concepts and techniques of linear algebra. The emphasis will be on developing the analysis and design tools needed to apply linear algebra to graduate electrical engineering courses and research.

Instructor: Ben Reichardt ben.reichardt@gmail.com
office hours: T 12:30-1:30pm, W 6-7pm, or by appointment
<https://usc.zoom.us/j/5141709632>

TA: Mohamed Ridha Znaidi znaidi@usc.edu
office hours: T 6-7:30pm, F 11-12:30, or by appointment
<https://usc.zoom.us/j/99704797263?pwd=YVlveE01MDZSZjJ0UDdscWx0Qk5ndz09>

Class websites:

Main webpage, for discussion, announcements, etc.: <https://piazza.com/usc/fall2020/ee510br>
Videos, and assignment *submission* via DEN: <https://courses.uscdcn.net/d2l/home/18915>

Lectures: TTh 1:30-3:20pm
<https://usc.zoom.us/j/98768828735?pwd=bjBTblVMdjg2T2xwMkhLcUdkMm5rUT09>

Discussion: Friday 9-9:50am

Please make an effort to attend live, with a camera. We appreciate your questions!

Exams: Final Thursday, Dec. 3, 2-4pm
Midterm 1: TBA, probably Oct. 8
Midterm 2: TBA, probably Nov. 12

Text: Gilbert Strang, "Linear Algebra and Its Applications" (4 ed.)

Optional text: Carl Meyer, "Matrix Analysis and Applied Linear Algebra"

Grading: 25% homework, 40% midterms, 35% final

Your lowest homework score will be thrown out before computing final grades.

No late homework will be accepted. No make-up exams will be given. You have one week from the date that a graded paper is returned to dispute the scoring of a problem.

You are encouraged to discuss homework problems among yourselves, but each person must do their own work. Copying or turning in identical homeworks is cheating.

Outline: (each item roughly corresponds to one week's material)

1. Solving simultaneous linear equations I
matrices, matrix-vector operations, Gaussian elimination, LU decomposition, Matlab, sparse matrices & examples (e.g., ODEs)
2. Vector spaces
abstract vector spaces, over \mathbf{R} , over finite fields, subspaces (and affine subspaces)
3. Linear transformations
correspondence to matrices, subspaces of a matrix
4. Bases
linear independence, basis, dimension, change of basis
5. Orthogonality
inner products (and vector norm), rank-nullity theorem, Gram-Schmidt orthogonalization, orthonormal bases, projections
6. Rotations and scaling
orthogonal matrices, isometries, matrix operator norm
7. Singular-value decomposition

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- pseudoinverses, principal component analysis with applications, stability of systems: condition number
8. Eigenvalues, eigenvectors
definition & significance, determinant, $\det(A - \lambda I)$ to find eigenvalues in theory, numerical: power method to find largest (or largest k) and smallest eigenvalues
 9. Diagonalizable matrices
similarity, normal matrices, simultaneous diagonalization of operators
 10. Special matrices
symmetric, skew-symmetric, orthogonal, positive (semi-)definite and quadratic forms, stochastic (corresponding to Markov chains), Hermitian & unitary matrices, applications to quantum mechanics
 11. Least squares
orthogonal projections and least-squares fitting, applications to data analysis
 12. Gradient descent iterative solving
sparse matrices, condition number, conjugate gradient, preconditioning, sparse diagonally-dominant systems, applications
 13. Linear programming
numerical examples, geometry and basic duality theory
 14. More applications
example topics: spectral graph analysis & clustering (Cheeger's inequality), compressed sensing, quantum physics, Page Rank, perturbation theory, infinite-dimensional Hilbert spaces, error-correcting codes (Hamming metric, basic coding theory), ...

Academic Responsibilities:

Academic Integrity

"The University, as an instrument of learning, is predicated on the existence of an environment of integrity. As members of the academic community, faculty, students, and administrative officials share the responsibility for maintaining this environment. Faculties have the primary responsibility for establishing and maintaining an atmosphere and attitude of academic integrity such that the enterprise may flourish in an open and honest way. Students share this responsibility for maintaining standards of academic performance and classroom behavior conducive to the learning process. Administrative officials are responsible for the establishment and maintenance of procedures to support and enforce those academic standards. Thus, the entire University community bears the responsibility for maintaining an environment of integrity and for taking appropriate action to sanction individuals involved in any violation. When there is a clear indication that such individuals are unwilling or unable to support these standards, they should not be allowed to remain in the University." (Faculty Handbook, 1994:20)

Academic dishonesty includes: (Faculty Handbook, 1994: 21-22)

Examination behavior - any use of external assistance during an examination shall be considered academically dishonest unless expressly permitted by the teacher. Fabrication - any intentional falsification or invention of data or citation in an academic exercise will be considered a violation of academic integrity. Plagiarism - the appropriation and subsequent passing off of another's ideas or words as one's own. If the words or ideas of another are used, acknowledgment of the original source must be made through recognized referencing practices. Other Types of Academic Dishonesty - submitting a paper written by or obtained from another, using a paper or essay in more than one class without the teacher's express permission, obtaining a copy of an examination in advance without the knowledge and consent of the teacher, changing academic records outside of normal procedures and/or petitions, using another person to complete homework assignments or take-home exams without the knowledge or consent of the teacher.

Students with Disabilities

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved

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accommodations can be obtained from DSP. Please be sure the letter is delivered to me as early in the semester as possible. Your letter must be specific as to the nature of any accommodations granted. DSP is located in STU 301 and is open 8:30 am to 5:30 pm, Monday through Friday. The telephone number for DSP is (213)740-0776.