EE 441: Applied Linear Algebra for Engineers

Instructor: Mohammad Reza Rajati, PhD

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Instructor: Mohammad Reza Rajati, PhD
Web: **courses.uscden.net**
E-mail: `rajati@usc.edu`
Class Hours: MW 2-3:20
Class Location: OHE 136
Office Hours: Friday 11:30-1:30
Office: PHE 414

Teaching Assistant: Fatemeh Alishahi
E-mail: `falishah@usc.edu`
Discussion: Friday 2-2:50
Discussion Location: OHE 100D
Office Hours: Tue 4:00-6:00
Office TBD

Although the instructor does not expect this syllabus to drastically change, he reserves every right to change this syllabus any time in the semester.

Course Description

Introduction to linear algebra and matrix theory and their underlying concepts. Applications to engineering problems. This course is a pre-requisite for many courses in Signal Processing, Controls, and Communications, including: EE 512, EE 553, EE 559, EE 562, EE 564, EE 567, EE 585, and EE 660.

Course Objectives

After successful completion of this course, the student is expected to be able to:

1. describe the properties of vector spaces, linear independence, spanning sets, bases, and dimension.
2. describe the properties and importance of linear transformations
3. describe linear transformations using matrices.
4. relate the solutions of linear equations to fundamental subspaces of linear transformations.
5. describe the properties and importance of pseudo-inverse and singular value decomposition.

6. describe the properties and importance of normal and inner-product spaces.
7. formulate linear least squares problems using matrices and solve them.
8. formulate a wide range of problems in terms of eigenvalues and eigenvectors.
9. calculate canonical forms of matrices.
10. describe the concepts of similarity and congruence for matrices.
11. describe functions of matrices, especially the matrix exponential.
12. formulate optimization problems using linear algebra.
13. formulate linear difference and differential equations using linear algebra and describe the concepts of controllability and observability.
14. formulate vectorization problems using Kronecker products.
15. formulate engineering problems using linear algebra.

Prerequisites

This course has the following pre-requisites:

Formal pre-requisites: MATH 445 or graduate standing.

Strongly recommended preparation: Previous familiarity with basic concepts of linear algebra, including matrices, determinants, and vectors (e.g., EE 241), multivariable calculus, logic, and set theory

Credit Hours: 3.

Required Textbooks

- Laub, Alan J., Matrix analysis for scientists and engineers. SIAM, 2005.
- Meyer, Carl D., Matrix analysis and applied linear algebra. SIAM, 2000.

The organization and approach of the course resembles to those of the first textbook. The second textbook is used as a companion for detailed discussion of some concepts and as a source for sample problems for the students.

Recommended Textbooks

- Ortega, James M. Matrix theory: A second course, Springer Science & Business Media, 2013.
- Lang, Serge. Introduction to linear algebra. Springer Science & Business Media, 2012.
- Rosen, Keneth H., and Malo Hautus. Handbook of linear algebra, CRC Press, 2007.
- Strang, Gilbert, Linear algebra and its applications, 4th ed., Thomson Learning Co., 2006.

- Laub, Alan J. Computational matrix analysis, SIAM, 2012.
- Lay, David C., and Steven R. Lay, Linear algebra and its applications, 5th ed., Addison-Wesely, 2015.

Grading Policy

- Homework: **20%**.
- Midterm: **35%**
- Final: **45%**

Letter Grade Distribution

$\geq$ 93.00	A	73.00 - 76.99	C
90.00 - 92.99	A-	70.00 - 72.99	C-
87.00 - 89.99	B+	67.00 - 69.99	D+
83.00 - 86.99	B	63.00 - 66.99	D
80.00 - 82.99	B-	60.00 - 62.99	D-
77.00 - 79.99	C+	$\leq$ 59.99	F

Homework is assigned on Wednesdays and is due on the Wednesday of the next week. *No late homework will be accepted*.

Homework and final exams will be closed book and notes. One letter size crib sheet is allowed for the midterm. Two letter size crib sheets are allowed for the final.

Midterm Exam: Wednesday March 8, in class.

Final Exam: Monday, May 8, 2-4 pm.

Attendance: All students are required to attend all the lectures and discussion sessions and actively participate in class discussions. Use of cellphones and laptops are prohibited in the classroom. If you need your electronic devices to take notes, you should discuss with the instructor at the beginning of the semester.

Statement of Academic Integrity

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. SCampus, the Student Guidebook, contains the University Student Conduct Code (see University Governance, Section 11.00), while the recommended sanctions are located in Appendix A. See: http://scampus.usc.edu

Emergency Preparedness/ Course Continuity in A Crisis

In case of a declared emergency if travel to campus is not feasible, USC executive leadership will announce an electronic way for instructors to teach students in their residence halls or homes using a combination of Blackboard, teleconferencing, and other technologies. See the university's site on Campus Safety and Emergency Preparedness: http://preparedness.usc.edu

Statement for 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 accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.âĂŞ5:00 p.m., Monday through Friday.

DSP Contact Information

Website: http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html
(213) 740-0776 (Phone), (213) 740-6948 (TDD only), (213) 740-8216 (FAX) ability@usc.edu.

Tentative Course Outline

The weekly coverage might change as it depends on the progress of the class. However, you must keep up with the reading assignments.

Week	Content	Laub	Meyer
Week 1: MW Jan 9, 11	• Introduction and Review • Set Theory • Systems of Linear Equations	Chapter 1	Chapters 1, 2
Week 2: ~~MW Jan 16~~,18	• Martin Luther King Day • Determinants • Matrices	Chapter 1	Chapters 3, 6

Week 3: MW Jan 23, 25	• Algebraic Structures • Vector Spaces and Subspaces • Linear Independence, Bases, and Dimension	Chapter 2	Chapter 4
Week 4: MW Jan 30, Feb 1	• Linear Transformations	Chapter 3	Chapter 4
Week 5: MW Feb 6, 8	• Pseudo-inverse and Singular Value Decomposiion	Chapters 4, 5	Chapter 5
Week 6: MW Feb 13, 15	• Linear Equations Revisited	Chapter 6	Chapters 1, 2
Week 7: ~~MW~~ ~~Feb 20~~, 22	• President Day • Norms, Inner Product Spaces • Matrix Norms	Chapter 7	Chapter 5
Week 8: MW Feb 27, Mar 1	• Hilbert and Banach Spaces • Projections • Linear Least Squares Problems	Chapters 7, 8	Chapters 4, 5
Week 9: MW Mar 6, 8	• Eigenvalues and Eigenvectors • Midterm	Chapter 9	Chapter 7
Week 10: MW Mar 13, 15	• Spring Recess	–	–

Week 11: MW Mar 20, 22	• Eigenvalues and Eigenvectors • Introduction to Canonical Forms • Similarity and Congruence • Functions of Matrices	Chapters 9, 10	Chapter 7
Week 12: MW Mar 27, 29	• Canonical Forms • Similarity and Congruence • Functions of Matrices	Chapter 10	Chapter 2
Week 13: MW Apr 3, 5	• Quadratic Forms, Multilinear Algebra, and Optimization	–	Chapter 7
Week 14: MW Apr 10, 12	• Linear Difference and Differential Equations • Controllability and Observability	Chapters 6, 11	Chapter 7
Week 15: MW Apr 17, 19	• Kronecker Products • Tensors*	Chapter 13	–
Week 16: MW Apr 24, 26	• Applications**	–	–

*If time allows.

**Applications are selected from a list including but not limited to the following topics: Control System Design, Principal Component Analysis, Markov Chains, Deep Learning, Compressed Sensing, Spectral Clustering, Finite Fields and Coding. Applications may also be integrated into the previous lectures.