

ECE4501/6501: Matrix Analysis in Engineering and Science

(Spring 2022, 3 credits)

Course Description

In this senior-graduate course of *Topics in Electrical and Computer Engineering*, students are provided the opportunities to have an in-depth study and understanding of matrix analysis concepts, theory, algorithms, and applications, including eigenvalues and eigenvectors, linear transformation, similarity transformations, commonly used factorizations, canonical forms, Hermitian and symmetric matrices, and positive definite matrices. In addition, these concepts and theory will be illustrated by some engineering and science applications such as those in learning, control, signal processing, and optimization.

Some additional advanced assignments will be given to the group of graduate students.

Class information

The instruction mode of this class is “in classroom” (Thornton Hall, room E304), and the lectures will be recorded and made available on collab for the on-line section of ECE6501 and also for all students.

The class times are 2:00 - 3:15pm, *Tuesdays and Thursdays*.

Lecture recordings will be available in the class collab website, and you can access them in your own class collab account under “Lecture Capture”. The recordings are for your personal use only and may not be distributed in whole or in part through any other platform or to people outside of this class.

Instructor

Professor Gang Tao, ECE Department, gt9s@virginia.edu, 434-924-4586, room THN E311.

webpage: <http://www.ece.virginia.edu/~gt9s>

Textbook

Roger A. Horn and Charles R. Johnson, *Matrix Analysis*, 2nd Ed., Cambridge University Press, 2013.

Grading Plan

Homeworks (7 sets): 35%; Midterm Test: 30%; Project 1: 15%; Project 2: 20%.

Office Hours

Office hour activities can be conducted by in-person or zoom meetings during the office hours, or by emails or zoom meetings outside the office hours:

3:30 - 4:45pm, *Tuesdays and Thursdays*.

You are encouraged to contact the instructor by emails at any time if you have any questions about the assignments and any concerns about the coursework, and if you see any issues about teaching.

Class Policies

Coursework policy: Any possible rearrangement of homework, project and test schedules for some special situations should be discussed with the instructor ahead of time (however, being too busy for regular study, research or work should not be an excuse for such schedule changes).

Honor system policy: Honor pledge is required for all course work (see next page for more details).

Additional Information

Disability accommodations

UVA is committed to creating a learning environment that meets the needs of its diverse student body. If you anticipate or experience any barriers to learning in this course, please feel welcome to discuss your concerns with me. If you have a disability, or think you may have a disability, you may also want to meet with the Student Disability Access Center (SDAC), to request an official accommodation. You can find more information about SDAC, including how to apply online, through their website at

<http://sdac.studenthealth.virginia.edu>

If you have already been approved for accommodations through SDAC, please make sure to send me your accommodation letter and meet with me so we can develop an implementation plan together.

Violence and sexual assault prevention

The University of Virginia is dedicated to providing a safe and equitable learning environment for all students. For information about violence prevention and sexual assault prevention, please see

<https://notonourgrounds.virginia.edu>

<https://notonourgrounds.virginia.edu/greendot>

<https://uvapolice.virginia.edu/sexual-assault>

<https://eocr.virginia.edu>

Religious accommodations

It is the University's long-standing policy and practice to reasonably accommodate students so that they do not experience an adverse academic consequence when sincerely held religious beliefs or observances conflict with academic requirements.

Students who wish to request academic accommodation for a religious observance should submit their request to me by email as far in advance as possible. If you have questions or concerns about your request, you can contact the University's Office for Equal Opportunity and Civil Rights (EOCR) at UVAEOCR@virginia.edu or 434-924-3200. Accommodations do not relieve you of the responsibility for completion of any part of the coursework you miss as the result of a religious observance.

For information about accommodations for religious observance, please see

<https://eocr.virginia.edu/accommodations-religious-observance>

UVa honor system

For information about University of Virginia's honor code, please see

<http://honor.virginia.edu>

<https://honor.virginia.edu/frequently-asked-questions>

<https://engineering.virginia.edu/online/the-honor-system>

In this class, we follow the honor statement suggested in

<https://honor.virginia.edu/statement>

In particular, all graded assignments (homework, project and test) should be pledged, and for any homework, project or test, no old or new solution can be consulted before your own solution is turned in. Group discussion is allowed only for homeworks, not for projects and test.

Course Topics

Chapter 0

Basic properties of matrices

Inner product and special matrices

Homework 1

Chapter 1

Eigenvalues

Characteristic polynomials

Similarity

Eigenvectors

Homework 2

Chapter 2

Unitary matrices and QR factorization

Schur theorem

Singular value decomposition

Homework 3

Chapter 3

Jordan canonical form

Minimal polynomial

Other canonical forms

Generalized eigenvectors

Homework 4

Chapter 4

Hermitian matrices

Complex symmetric matrices

Diagonalizations

Homework 5

Chapter 5

Vector norms

Inner products

Matrix norms

Homework 6

Chapter 7

Positive definite matrix (I)

Positive definite matrix (II)

Homework 7

Applications

Application (I): Signal processing and optimization

Application (II): Learning theory

Application (III): Control systems