Analytical Methods in Electrical Engineering – EE 602

Schaefer School of Engineering & Science
Fall 2021

Meeting Times:	Mondays 6:30pm – 9:00pm
Classroom Location:	Gateway South GS 025
Instructor:	Serban Sabau
Contact Info:	Burchard 214, ssabau@stevens.edu, 201-216-5615
Office Hours:	Fridatys 6:30pm – 7:30pm
Prerequisite(s):	Freshman Year Calculus

COURSE DESCRIPTION

This course introduces the student to the fundamental concepts and methods from Linear Algebra and Linear Operators between Hilbert spaces, encompassing classical results pervasive not only to Electrical Engineering but also to Data Science, Economics and other scientific areas. After a thorough introduction to linear spaces and linear functions, a particular emphasis is put on the Orthogonal Projection Theorem due to its underlying applications to mainstream E.E. topics such as: Minimum Mean-Square Estimation, Linear Regression, linear expectation models and stationary covariance time series.

The course is specifically designed to be as self-contained as possible, while at the same time providing complete proofs for almost all the results taught in class. While mathematical rigor is not a scope in itself, it is intently embraced as an irreplaceable intellectual ability.

LEARNING OBJECTIVES

After successful completion of this course, students will be able to…

- Read and write rigorously mathematical proofs of a mild level of difficulty;
- Understand well the notions of linear spaces and linear functions, matrix representations and their fundamental subspaces, rank and singular values;
- Solve eigenvalue problems and get a basic understanding on how Matlab performs the numerical computations;
- Use ``least square'' techniques and understand the power and generality of the Orthogonal Projection Theorem in generic Hilbert spaces;
- Get a glimpse at a (linear) algebraic perspective on Machine Learning, subspaces clustering problems, high-dimensional statistics (*e.g*. covariance matrix estimation problems), principal component analysis *etc.*

FORMAT AND STRUCTURE

- This course is comprised of weekly lectures, periodic homework, a midterm and a final exam.

COURSE MATERIALS

Textbook(s): Gilbert Strang, ``Introduction to Linear Algebra'', 4th Edition, Wellesley-Cambridge Press, 2009. ISBN 978-0-9802327-1-4

Other Readings: P. Lancaster and M. Tismenetsky, ``The Theory of Matrices with Applications'', 2nd Edition, Academic Press, 1985. ISBN 0-12-435560-9

Materials: All other materials and instructor's handwritten notes will be uploaded to the course website (Canvas).

COURSE REQUIREMENTS

Attendance Students are not only strongly encouraged but required to attend all lectures. Several attendance signoffs will be performed at undisclosed dates. Excused absences (religious or medical, noted in via email to the professor prior to the absence occurring) must be accompanied by proper documentation.

Homework There will be at least seven homework written assignments throughout the semester. The due date of each assignment is usually one week after the date when the homework is posted on Canvas or assigned in class. Homework is due in hardcopy before the beginning of class.
Reading assignments must be treated just as thoroughly as written assignments.

Exams There will be a mid-term exam and a final exam for this course. The mid-term exam counts for 35% of the final grade, and the final exam will be 55% of the final grade. All exams will be administered as "take home" exams. The final exam is cumulative. There will be review sessions the week before each exam. There are NO makeup exams. Excused absence from any exam shall seek consent from the instructor prior to the exam day; rearrangement will be scheduled as appropriate.

GRADING PROCEDURES

Grades will be based on:

Class Participation	(5%)	50 points
Homework	(5%)	50 points
Mid-term Exam	(35%)	350 points
Final Exam	(55%)	550 points
Total	100%	1000 points

ACADEMIC INTEGRITY

Graduate Student Code of Academic Integrity

All Stevens graduate students promise to be fully truthful and avoid dishonesty, fraud, misrepresentation, and deceit of any type in relation to their academic work. A student's submission of work for academic credit indicates that the work is the student's own. All outside assistance must be acknowledged. Any student who violates this code or who knowingly assists another student in violating

this code shall be subject to discipline.

All graduate students are bound to the Graduate Student Code of Academic Integrity by enrollment in graduate coursework at Stevens. It is the responsibility of each graduate student to understand and adhere to the Graduate Student Code of Academic Integrity. More information including types of violations, the process for handling perceived violations, and types of sanctions can be found at www.stevens.edu/provost/graduate-academics.

EXAM ROOM CONDITIONS

The following procedures apply to quizzes and exams for this course. As the instructor, I reserve the right to modify any conditions set forth below by printing revised Exam Room Conditions on the quiz or exam, even though all exams will be "take home" during the Fall 2020 semester.

1. Students may use the following devices during quizzes and exams. Any electronic devices that are not mentioned in the list below are not permitted.

Device	**Permitted?**	
	Yes	No
Laptops	X	
Cell Phones		X
Tablets	X	
Smart Watches		X
Google Glass		X
Other (electrically powered devices)		X

2. Students may use the following materials during quizzes and exams. Any materials that are not mentioned in the list below are not permitted.

Material	**Permitted?**	
	Yes	No
Handwritten Notes	X	
Handwritten Cheat Sheet *Conditions*: one letter sized sheet (front and back),	X	
Textbooks		X
Readings		X

3. Students <u>are not</u> allowed to work with or talk to other students during quizzes and/or exams.

<u>TENTATIVE</u> COURSE SCHEDULE

The following is a <u>tentative</u> course schedule. Any changes to this schedule will be communicated to you 1) in class and/or 2) via email. The Canvas shell for this course will always be kept up-to-date so you can always reference the "Assignments" tab for accurate due dates.

Class Date	Topic(s)	Readings	Assignment
Lecture 1	*Introduction*		
Lecture 2	*Sets. One-to-one and onto functions. Invertibility of functions. Image and pre-image of a set through a function.*		
Lecture 3	*Linear (Sub)Spaces. Linear Independence. Spanning Sets. Bases. Linear Functions.*		Homework #1 due
Lecture 4	*Change of Bases. Similarity Transformations. Rank of a Matrix Eigenvalues. Eigenvectors*		
Lecture 5	*The Diagonalization Theorem. The Hamilton-Cayley Theorem. Glimpse at the Jordan Canonical Form.*		Homework #2 due
Lecture 6	*The Fundamental Subspaces of a Matrix. The Moore-Pennrose Pseudoinverse of a Matrix*		Homework #3 due
Lecture 7	Mid-term Exam		
Lecture 8	*Inner-Products and the Riesz Representation Theorem.*		Homework #4 due
Lecture 9	*Gram-Schmidt Orthogonalization (and the Karhunen-Loewe Transform)*		
Lecture 10	*The Orthogonal Projection Theorem. Oblique Projectors and Symmetries. ``Least Squares''.*		Homework #5 due

Lecture 11	*Bilinear Functionals and Quadratic Forms. Polynomial Data Fitting. Symmetric Matrices and a glimpse at convexity.*		
Lecture 12	*Singular Values and Subspaces Clustering. Introduction to Optimal Linear Estimation.*		Homework #6 due
Lecture 13	*Linear Operators and Contemporary Applications.*		Homework #7 due
Lecture 14	Final Exam		

LEARNING ACCOMMODATIONS

Stevens Institute of Technology is dedicated to providing appropriate accommodations to students with documented disabilities. The Office of Disability Services (ODS) works with undergraduate and graduate students with learning disabilities, attention deficit-hyperactivity disorders, physical disabilities, sensory impairments, psychiatric disorders, and other such disabilities in order to help students achieve their academic and personal potential. They facilitate equal access to the educational programs and opportunities offered at Stevens and coordinate reasonable accommodations for eligible students. These services are designed to encourage independence and self-advocacy with support from the ODS staff. The ODS staff will facilitate the provision of accommodations on a case-by-case basis.

Disability Services Confidentiality Policy

Student Disability Files are kept separate from academic files and are stored in a secure location within the Office of Disability Services. The Family Educational Rights Privacy Act (FERPA, 20 U.S.C. 1232g; 34CFR, Part 99) regulates disclosure of disability documentation and records maintained by Stevens Disability Services. According to this act, prior written consent by the student is required before our Disability Services office may release disability documentation or records to anyone. An exception is made in unusual circumstances, such as the case of health and safety emergencies.

For more information about Disability Services and the process to receive accommodations, visit https://www.stevens.edu/office-disability-services. If you have any questions please contact: Phillip Gehman, the Director of Disability Services Coordinator at Stevens Institute of Technology at pgehman@stevens.edu or by phone (201) 216-3748.