Introduction to Linear Algebra

Spring 2022 semester

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About: This class will cover the basic topics of linear algebra, including matrix equations, vector spaces, the rank-nullity theorem, projections, determinants. This includes the LU-, QR-, and singular value decompositions of matrices, as well as diagonalization for symmetric and non-zymmetric matrices. Extensions to some topics will also be covered, including graphs and clustering for large networks. Matrices and vectors will be reviewed in the first week. A full list of topics is given on the next page.

This class is based on several courses:

- 18.06 Linear Algebra (MIT)
- 18.065 Matrix Methods in Data Analysis, Signal Processing, and Machine Learning (MIT)
- MTH 309 Introductory Linear Algebra (SUNY Buffalo)

Textbook: There is no required texbook for this course, as all the material will be given in the lecture notes. Material will be taken in large part from the following two textbooks:

[1] (MIT) *Introduction to Linear Algebra*, Strang (2016)

[2] (MIT) *Linear Algebra and Learning from Data*, Strang (2019)

Other textbooks that may be useful:

[3] (SUNY Buffalo) *Linear Algebra and Its Applications*, Lay, Lay, McDonald (2016)

[4] *Linear Algebra Done Right*, Sheldon Axler (2015). Very abstract and theoretical

[5] *Linear Algebra Done Wrong*, Sergei Treil (2017). Very concrete and constructive

Format: The class will follow a split instructor-led / student-led format. Every session will be split into a 45 min lecture, 10 min break, 45 min group work. In the group work, students will follow learning prompts in small groups to formulate their understanding of concepts.

Grading: Your final grade will be:

- 60% homework questions: written assignments due (approximately) every two weeks
- 30% inquiries: submission of whiteboards on Miro
- 10% participation: quizzes, attendance, classroom interaction

If you cannot complete the homework on time, please inform me and I will give you an extension. Some assigned work will be coding, in which case Python $\geqslant 3$ is the preferred language, unless otherwise noted.

Academic integrity: You are encouraged to work together to complete assignments, but please write up your own solutions. The work you submit must be your own and should reflect your own understanding of the problem. Part of the RBS official stance on academic integrity is indcluded below.

RTU Riga Business School values intellectual integrity and the highest standards of academic conduct. To be prepared to meet societal needs as leaders and role models, students must be educated in an ethical learning *environment that promotes a high standard of honor in scholastic work. Academic dishonesty undermines institutional integrity and threatens the academic fame of RBS. Dishonesty is not an acceptable avenue to success. It diminishes the quality of RBS education, which is valued because of RBS high academic standards.*

Fostering an appreciation for academic standards and values is a shared responsibility among students, faculty, and staff. RBS prohibits dishonesty in connection with any RBS activity. [..] A commitment of acts of cheating, lying, and deceit in any of their diverse forms (such as the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated.

Class schedule: Strang [1] will be used as the main source. References to sections that are underlined refer to another Strang textbook [2].

Part	Date	Topic	Sections	Activities
I. Elimination	Jan 3	1: Vectors	1.1 - 1.2	HW 1 released
	Jan 5	2: Matrices	1.3	
	Jan 10	3: Elimination and inverses	2.1 - 2.7	
	Jan 12	4: The column space and nullspace	3.1, 3.2	
	Jan 17	5: Completely solving $A\mathbf{x} = \mathbf{b}$	3.3	HW 1 due
II. Vector spaces	Jan 19	6: Independence, basis, dimension	3.4	HW 2 released
	Jan 24	7: The rank-nullity theorem	3.5	
	Jan 26	8: Orthogonal spaces	4.1	
	Jan 31	9: Projections and least squares	4.2, 4.3	
	Jan 2	10: The Gram–Schmidt process	4.4	
	Feb 7	11: Inner products and distances	IV.10	HW 2 due
III. Eigentheory	Feb 9	12: Determinants, part 1	5.1, 5.2	HW 3 released
	Feb 14	13: Determinants, part 2	5.2, 5.3	
	Feb 16	14: Eigenvalues and eigenvectors	6.1	
	Feb 21	15: Diagonalization	6.2	HW 3 due
	Feb 23	16: Jordan form	8.3	HW 4 released
	Feb 28	17: Special matrices	6.4, 6.5	
	Mar 2	18: Singular value decomposition	7.1, 7.2	
	Mar 7	19: Principal component analysis	7.3, 7.4	HW 4 due
IV. Extensions	Mar 9	20: Linear transformations	8.1, 8.2	HW 5 released
	Mar 14	21: Complex numbers and matrices	9.1, 9.2	
	Mar 16	22: Fourier topics	IV.1, 8.3, 9.3	
	Mar 21	23: Graphs and networks	10.1	HW 5 due
	Mar 23	24: Markov matrices, spectral analysis, clustering	10.3, IV.6, IV.7	HW 6 released
	Mar 28	25: Large matrices and randomization	II.4	
	Mar 30	26: Optimization	10.4, VII.1	
	Apr 4	27: Extra lecture 1		
	Apr 6	28: Extra lecture 2		HW 6 due

Two extra lectures are reserved to account for difficult topics and / or topics relevant to the students. Some earlier lectures may be split up into two parts, so the schedule may shift slightly.