ENG EK 103: Computational Linear Algebra
Spring 2022

INSTRUCTORS

Section	Times	Room	Instructor	Office hours
A1	TTh 9:30 am - 10:45 am	PHO 211	Prof. Sean Andersson *sanderss@bu.edu*	110 Cummington Mall (Room 421) W, 10-11 am, F, 4:15-5:15 pm
A2	TTh 9:30 am - 10:45 am	PHO 203	Dr. Andy Fan *fana@bu.edu*	44 Cummington Mall (Room 707) T, 5-6 pm
A3	TTh 11:00 am - 12:15 pm	PHO 203	Prof. Tasso Kaper *tasso@bu.edu*	111 Cummington Mall (MCS 252) M, 2:30-4 pm, T, 12:30-1:45
A4	TTh 11:00 am - 12:15 pm	PHO 211	Prof. Andrew Sabelhaus *asabelha@bu.edu*	110 Cummington Mall (Room 305) M, 4-5 pm, T, 3:30-4:30 pm
A5	TTh 3:30 pm - 4:45 pm	KCB 101	Prof. Toshi Nishimura *toshi16@bu.edu*	725 Commonwealth Ave (Room 405) M 5:30-6:30
A6	TTh 5:00 pm - 6:15 pm	SAR 102	Prof. Kamal Sen *kamalsen@bu.edu*	44 Cummington Mall (ERB 414B) TBD

GRADUATE STUDENT TEACHERS

GST	E-mail	Primary section	Discussion sections	Office hours
Suhail Alsalhei	*alsalehi@bu.edu*	A1	B0, B1	Joint office hours M 5-8 pm (PSY B41) W 5-8 pm (ERA B11)
Yifan Peng	*ypeng9@bu.edu*	A2	B4, B5	
Xinyu Zhou	*xyz6@bu.edu*	A3	BB, BC	
Munib Hasnain	*munibh@bu.edu*	A4	B2, B3	
Wei Zhang	*wzhang1@bu.edu*	A5	B7, B8	
Debra Han	*debrahh@bu.edu*	A6	B9, BA	

INTRODUCTION, COURSE GOALS, AND LEARNING OBJECTIVES

This is a course on understanding, manipulating, and applying linear systems of equations and, more broadly, linear relationships between variables. The ideas and tools you will learn are immensely useful in a wide variety of application domains, including physics, engineering, big data, data visualization, and more. You will become familiar with vectors and matrices, linear systems of equations, vector spaces, inner products, eigenvectors and eigenvalues and the more general singular values. You will also learn to interpret matrices as linear transformations and to understand the geometrical interpretation for operations such as solving linear systems of equations and least-squares fitting of data to models. Throughout the course, the tools will be related to specific applications to show how linear algebra is used to solve real-world problems. Examples include Google's PageRank algorithm, cryptography, coding theory, genetics, bioinformatics, image compression, linear programming (optimization), networks, and Markov chains.

COURSE PREREQUISITES

EK 125. Matlab will be used. If you haven't done so already, you should download and install Matlab on your computer. Information on obtaining a copy of the software can be found at:

http://www.bu.edu/tech/support/research/software-and-programming/common-languages/matlab/

Computation and application

There will be a strong emphasis on how fundamental concepts in linear algebra are used to solve engineering problems. Solving small problems by hand definitely helps with understanding the concepts and is an important element of the course. However, practicing engineers often need to attack very large problems with a very large number of variables where doing things by hand is simply not feasible. As a result, and because this is a course for engineers, there will also be elements of the course aimed at helping students understand real-world use of the material. This will be done in a variety of ways. First, throughout the course examples will be presented of real world applications where linear algebra plays a major role and these applications will be connected to specific tools being learned in the course. Possible examples include Google's PageRank algorithm, cryptography, coding theory, genetics, bioinformatics, image compression, linear programming (optimization), networks, Markov chains, and more! Second, such examples will be drawn upon in the problems sets and other elements of the course. Finally, problem sets will include not just small but illustrative sample problems that are amenable to hand calculation, but (relatively) large scale problems that cannot be worked by hand but must be attacked using a computational platform such as Matlab.

Course expectations and grading

It is our firm belief that learning is an *active* experience. It is essential that prior to class you read the assigned material and organize your thoughts and questions. As an indication of the importance of properly preparing for lecture, there will be short "did you read" quizzes for each lecture.

In addition, while we hope there will be significant engagement with the material during lecture, there is simply no way to replace individual effort and practice. This is the role of homework. You are welcome to discuss the homework with others but each student must perform and submit their own work. Submitted work should be neat, organized, and legible and is to be turned in by the start of class on the due date. There will be two mid-term (third term?) exams and one final.

Your overall score will be assigned according to the following weighting:

Prep quizzes: 5% Homework: 15% Exam 1: 25% Exam 2: 25% Final exam: 30%

Note that while this formula applies to the entire course, each section is graded independently.

Regrading policy: We will do our best to return graded materials as quickly as possible. Because the specifics of grading any particular piece of work fade in a surprisingly short time, any requests for regrades must happen within **one week** of when the material is returned to you. Please note that during a regrade, we reserve the right to increase or to decrease your score, depending on what the work merits!

Exams: There will be two midterms, each administered on a Friday evening (see the schedule). If you have a legitimate conflict, please inform your instructor at least **10 days in advance** so that alternate arrangements can be made. Note that for regular exams such as these, having multiple exams on the same day is not a conflict!

Exams will be open book, open notes

Course website

A website has been set up on Slack. All course materials will be disseminated there. Note that slack has a nice social networking feature allowing questions to be asked and answered among yourselves; We highly encourage you to make use of it! You can access it from the link below.

Slack sign-up link

Some sections may also make use of BU Learn (Blackboard) or other sites.

DROP AND WITHDRAWAL DATES

The last day to **drop** the class (without a W appearing on your transcript) is 02.24.2022.

The last day to **withdraw** from the class (with a W appearing on your transcript) is 04.01.2022.

TEXTBOOK AND REFERENCES

The primary textbook is D.C. Lay, S.R. Lay, and J.J. McDonald, Linear algebra and its applications, Sixth edition, Pearson, 2021.

Note that the fifth edition is also acceptable, though you may want to get a copy of the table of contents of the sixth edition to map the reading assignments properly.

There are many other textbooks on this topic. A couple of these are

1. G. Strang, Introduction to Linear Algebra, Fifth Edition, Wellesley-Cambridge Press, 2016.
2. Bernard Kolman and David R Hill, Elementary Linear Algebra with Applications, (9th edition), Pearson/Prentice Hall, 2008.

Prof. Strang (at MIT) offers his linear algebra course through the MIT OpenCourseWare sites. You can find lots of good videos, worked problems and exams, and other materials. Check it out at:

http://ocw.mit.edu/courses/mathematics/18-06-linear-algebra-spring-2010/

ACADEMIC INTEGRITY

BU takes academic integrity very seriously. Academic misconduct is conduct by which a student misrepresents his or her academic accomplishments, or impedes other students' opportunities of being judged fairly for their academic work. Knowingly allowing others to represent your work as their own is as serious an offense as submitting another's work as your own. More information on BU's Academic Conduct Code, with examples, may be found at http://www.bu.edu/academics/policies/academic-conduct-code.

COLLABORATION POLICY

In this class, when completing your homework you may use any textbooks, web sources, as well as human collaborators (from class), subject to the following enforced conditions:

- You must clearly acknowledge all your sources (including human collaborators) at the top of your homework.
- You must write all answers in your own words
- You must be able to fully explain your answers upon demand

Clearly these do not apply to exams; those cannot be done in collaboration with anyone.

Failure to meet any of the above conditions could constitute plagiarism and will be considered cheating in the class. If you are not sure whether something is permitted by the course policy, **please ask one of the faculty**. It is far more awkward to explain your actions after the fact to the college disciplinary committee.

ENG EK 103: Computational Linear Algebra: Spring 2022 (planned) schedule

Week	Topics	Reading	Notes
Week 1 (01/20)	Introduction and course overview		
Week 2 (01/25, 01/27)	Systems of linear equations, matrices as linear transforms	Ch. 1.1 and 1.9 (Example 3 and Tables 1-4 only)	
Week 3 (02/01, 02/03)	Row reduction, and echelon forms, vector equations, matrix equations	Ch. 1.2-4	PS 1 due 02/03
Week 4 (02/08, 02/10)	Solution sets, applications of linear systems, linear independence	Ch. 1.5-7	PS 2 due 02/10
Week 5 (02/15, 02/17)	Matrix operations, matrix inverse, matrix factorization	Ch 2.1-3, 2.5	PS 3 due 02/17
02.22.2022 (Tuesday): No class: Monday schedule			
Week 6 (02/24)	Subspaces of a matrix, dimension and rank	Ch. 2.8-9	
02.25.2022 (Friday) **EXAM 1 - Lectures 1-7, PS 1-3**			
Week 7 (03/01, 03/03)	Vector (sub)spaces, null and column space, bases, linearly independent sets/bases	Ch. 4.1-3, 4.5	PS 4 due 03/03
03. 08.2022 (Tuesday) and 03.10.2022 (Thursday): No class: spring break			
Week 8 (03/15, 03/17)	Determinants, volume and linear transforms, eigenvectors and eigenvalues	Ch. 3.1-3, Ch. 5.1	PS 5 due 03/17
Week 9 (03/22, 03/24)	Characteristic equation and more evals and evectors	Ch. 5.2-3, 5.8	PS 6 due 03/24
Week 10 (03/29, 03/31)	Diagonalization, iterative estimates for eigenvalues, discrete systems, Markov chains	Ch. 5.6, 5.9	PS 7 due 03/31
Week 11 (04/05, 04/07)	Inner products, length and orthogonality, orthogonal sets, orthogonal projections, Gram-Schmidt	Ch. , 6.1-4	PS 8 due 04/07
Week 12 (04/12, 04/14)	Least-squares, machine learning and linear models	Ch. 6.5-6	
04.15.2022 (Friday) **EXAM 2 - Lectures 1-18, PS 1-8**			
Week 13 (04/19, 04/21)	Diagonalization of symmetric matrices, quadratic forms	Ch. 7.1-2	PS 9 due 04/21
Week 14 (04/26, 04/28)	Applications to image processing and statistics Singular value decomposition	Ch. 7.4-5	PS 10 due 04/28
Week 15 (05/03)	SVD redux	None	PS 11 05/03