MATH347
Linear Algebra for Applications

Course syllabus

Times	TuTh 8:00-9:15AM, Phillips 215
Instructor	Sorin Mitran
Office hours	M 2:00-3:30PM, Th 9:30-10:30AM, Chapman 451
Assistants	Justin Hager, Kin Yau James Wong
Office hours	

(*The instructor reserves the right to make changes to the syllabus. Any changes will be announced as early as possible.*)

Mathematics is a branch of knowledge dealing with abstract concepts such as quantity, structure, change, or patterns. A single number is sometimes sufficient to assess some quantities such as a person's height or weight. In such cases, once a unit of measurement has been established such as meter for height or kilogram for weight, arbitrary heights or weights are expressed as a multiple of the unit. An example is $h = 1.83$m, signifying that height h is 1.83 times the meter unit of length. Inspired by weight measurements on a scale, we say that h is a *scaling* of the meter unit by factor 1.83. However, for most objects encountered in nature a single number is insufficient. Some fundamental questions that then arise are:

- how many numbers are needed?
- how can we describe an arbitrary object?
- how can we define the generalization of units of memin$_{x\in\mathbb{R}^n}\|\boldsymbol{b}-\boldsymbol{A}\boldsymbol{x}\|_2$asurement?

One particularly useful approach is recognize that many objects can be described by m numbers, with m a fixed natural number, $m\in\mathbb{N}$. Some procedure must be introduced to describe an arbitrary object $\boldsymbol{b}$. One idea is to choose n objects each characterized by m numbers, $\boldsymbol{a}_1,\boldsymbol{a}_2,\ldots,\boldsymbol{a}_n$, to play the role of "units of measurement", scale them and then combine them is some way. In linear algebra the chosen combination procedure is *addition* leading to the formula,

$$\boldsymbol{b}=x_1\boldsymbol{a}_1+x_2\boldsymbol{a}_2+\cdots+x_n\boldsymbol{a}_n.$$

The above *linear combination* leads to a treasure trove of applications: balancing a chemical reaction, determining market equilibrium, finding genetic inheritence, analyzing social interactions, identifying faces in a crowd. Solutions to all these problems are found by linear combinations, and linear algebra provides the rigorous framework to determine answers to questions such as:

- can all objects of interest be reached by linear combination?
- what type objects cannot be reached by linear combination?
- if an object cannot be reached by linear combination, what's closest to it?
- are there special objects that do not get significantly changed by linear combination?
- can objects be more insightfully be described by a different linear combination?

The instructor reserves the right to make changes to the syllabus. Any changes will be announced as early as possible.

Course goals

Students will acquire proficiency in the formulation, theory and solution of finite dimensional linear algebra problems.

Honor Code

Unless explicitly stated otherwise, all work is individual. You may discuss various approaches to homework problems with students, instructors, but must draft your answers by yourself.

Grading

Required work

- Homework - Best 10 assignments x 5 = 50 points
- Midterm examination = 10 points
- Final examination = 40 points (optional questions to replace midterm score will be offered)
- Absence accomodation and/or extra credit - additional two homework assignments, 2 x 5 = 10 points

Mapping of point scores to letter grades

Grade	Points	Grade	Points	Grade	Points	Grade	Points
H+,A *cum laude*	101-110	H-,B+	86-90	P-,C+	71-75	L-,D+	56-60
H+,A	96-100	P+,B	81-85	L+,C	66-70	L--,D-	50-55
H,A-	91-95	P,B-	76-80	L,C-	61-65	F	0-49

Extra credit

- Various in-class announcements
- TBA

Examinations

- A midterm examination during normal class meeting time on Thursday, March 6.
- The final examination, Tuesday, May 6, 8:00AM.

Course policies

- Class attendance is expected and highly beneficial to understanding of course topics. There is no need to inform instructor of planned absences.
- Course grade is based upon accumulation of credit points (0-100). There is no "grading on a curve". Extra credit opportunities are offered for an additional 10 grade points, to allow for missed homework or tests.
- Homework is to be submitted electronically through Canvas. E-mailed homework is not accepted. Late homework is accepted only in the case of University approved class absences. Two supplementary homework assignments should provide sufficient flexibility for individual circumstances. E-mail messages requesting acceptance of late homework due to any other circumstance are deleted without review or response. Students are advised to prepare and submit homework well in advance of the Canvas deadline to allow for unforseen difficulties. Suspension of classes due to campus-wide events (weather, pandemic, etc.) will lead to modification of due dates or elimination of specific assignments for the entire class.

Accessibility resources and services. The University of North Carolina at Chapel Hill facilitates the implementation of reasonable accommodations, including resources and services, for students with disabilities, chronic medical conditions, a temporary disability or pregnancy complications resulting in barriers to fully accessing University courses, programs and activities.

Accommodations are determined through the Office of Accessibility Resources and Service (ARS) for individuals with documented qualifying disabilities in accordance with applicable state and federal laws. See the ARS Website for contact information: https://ars.unc.edu or email ars@unc.edu.

Counseling and psychological services (CAPS). CAPS is strongly committed to addressing the mental health needs of a diverse student body through timely access to consultation and connection to clinically appropriate services, whether for short or long-term needs. Go to their website: https://caps.unc.edu/ or visit their facilities on the third floor of the Campus Health Services building for a walk-in evaluation to learn more.

Title IX resources. Any student who is impacted by discrimination, harassment, interpersonal (relationship) violence, sexual violence, sexual exploitation, or stalking is encouraged to seek resources on campus or in the community. Reports can be made online to the EOC at https://eoc.unc.edu/report-an-incident/. Please contact the University's Title IX Coordinator (Elizabeth Hall, interim – titleixcoordinator@unc.edu), Report and Response Coordinators in the Equal Opportunity and Compliance Office (reportandresponse@unc.edu), Counseling and Psychological Services (confidential), or the Gender Violence Services Coordinators (gvsc@unc.edu; confidential) to discuss your specific needs. Additional resources are available at safe.unc.edu.

Course materials

Course topics

- Vectors (VEC)

- Matrices (MAT)$\min_{x \in \mathbb{R}^n} \|\boldsymbol{b} - \boldsymbol{A}\boldsymbol{x}\|_2$
- Octave software (OCT)
- Linear combinations (COM)
- Vector spaces (SPC)
- Fundamental theorem of linear algebra (FTLA)
- Linear transformations (TRS)
- Matrix factorizations (FAC)
- Linear systems (SYS)
- Determinants (DET)
- Least squares (LSQ)
- Eigenvalues (EIG)
- Singular values (SVD)
- Application (APP)
- Course review (RVW)

Textbook

The following textbooks are freely available in electronic form from the UNC library.

- *Introduction to Linear and Matrix Algebra*, Nathaniel Johnson
- *Advanced Linear and Matrix Algebra*, Nathaniel Johnson

All course concepts are presented on slides below. Additional details can be obtained mostly from the first textbook with some additional topics from the second.

Class slides

Slides summarizing the main topics of each lecture are generally posted 48 hours prior to class time. It is useful to glance at these before class to better assimilate the material, ask clarifying questions during class time. Relevant sections from *Introduction to Linear and Matrix Algebra* are indicated as §1.2. Those from *Advanced Linear and Matrix Algebra* are indicated as §1.3.

Week	Date	Topic		
01	01/10	VEC	Lesson01 §1.1	Lesson02 §1.2
02	01/17	MAT	Lesson03 §1.3	Lesson04 §1.3
03	01/24	TRS	Lesson05 §1.4	Lesson06 §2.1
04	01/31	SYS	Lesson07 §2.1	Lesson08 §2.2
05	02/07	SPC	Lesson09 §2.3	Lesson10 §2.4
06	02/14	FTLA	Lesson11 §1.1	Lesson12 §1.4
07	02/21	FAC	Lesson13 §2.4, §1.C	Snow day cancellation
08	02/28		Lesson15	Lesson16 (eeg.mat, PN12-3.edf, seizures.txt)
09	03/06		Midterm review Practice Midterm	Midterm examination Solution
10	03/20	DET	Lesson17 §3.2	Lesson18 (ply.zip)
11	03/27	LSQ	Lesson19	Lesson20 (solved problems)
12	04/03	EIG	Lesson21 §3.3.1	Lesson22 §3.3.2-3
13	04/10	SVD	Lesson23 §2.3.1-2	Lesson24 §2.3.3
14	04/17	APP	Lesson25 §2.3	Wellness day
15	04/24	RVW	Lesson26 (art.zip)	Lesson27 (course review)
16	04/29			

Homework

Homework is assigned through Canvas.

Nr.	Issue Date	Due Date	Topic	Solution
01	01/17	01/24	VEC	
02	01/27	02/03	MAT	
03	01/31	02/07	OCT	
04	02/07	02/14	COM	
05	02/14	02/21	SPC	
06	02/21	02/28	FTLA	
07	03/25	04/04	LSQ	
08	04/08	04/08	EIG	
09	04/15	04/24	SVD	
10	04/21	04/23	REV	sol10
11	04/23	04/25	REV	
12	04/25	04/28	REV	

Software

The course will use the Octave/Matlab language to carry out vector and matrix operations. Students can install this software on their laptops, but they are large systems. For course purposes it is sufficient to use Octave-online. Very many tutorials are found through a web search.