

Linear algebra and multivariable calculus (Math 290)

Section 43, Fall 2018

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Section 1

Times, places and textbooks

- **Class** — MoWeFr 10:00–10:50am in Technological Institute L107
The focus of class will be on learning material and acquiring skills (see the learning objectives below). Classes will include a mixture of lecture and activities, including problem-solving exercises, group discussions and student-led presentations.
- **Discussion** — Th 10:00–10:50am in Technological Institute L107
Discussion sessions will be led by Grisha. They will be less formally structured than classes, and are intended to be an opportunity for you to review the material covered in class and to strengthen your learning.
- **Office hours.** These are times when I and/or Grisha will be available to discuss pretty much anything from the course—they are a great opportunity for us to get to know you better (and vice versa). Please see the guidelines for office hours in [Section 5](#) below.
Office hours will be announced during class.
If you can't attend the scheduled office hours, please contact me to schedule a meeting at another time.
- **Examinations.** There will be a midterm exam, which will be held during class, and a final exam—you might want to put the following dates in your calendar!
 - ◇ **Midterm exam #1.** Monday 22nd October at 6:30–7:30pm — location TBA.
 - ◇ **Midterm exam #2.** Monday 12th November at 6:30–7:30pm — location TBA.
 - ◇ **Final exam.** Wednesday 12th December at 9:00–11:00am — location TBA.
- **Textbook.** *Linear Algebra with Applications* (5th edition) by Otto Bretscher
ISBN 978-0-321-79697-4

Section 2

Course content

Upon successful completion of this course you should be able to:

- (1) Use matrices and vectors to translate between algebraic problems and geometric problems in linear algebra, and to solve such problems;
- (2) Perform algebraic manipulations with $m \times n$ real matrices, including addition, scalar multiplication, matrix multiplication, inversion and diagonalisation, as well as computing the trace, determinant, eigenvalues and eigenvectors of a matrix;
- (3) Interpret matrices and their associated algebraic manipulations geometrically as linear transformations and properties of linear transformations;
- (4) Identify when a set of vectors is linearly independent, spanning or a basis, and compute the basis of a subspace of \mathbb{R}^n ;
- (5) Compute the image and kernel of a matrix and interpret them geometrically.

Descriptions of some of the topics we will cover are as follows.

- **Linear systems.** These are algebraic problems in which every variable appears with degree ≤ 1 ; they arise frequently in the sciences and economics and can be interpreted as geometric problems involving intersections of hyperplanes. In the process, we will introduce the concepts of *vectors* and *matrices*.
- **Linear transformations.** We will interpret vectors and matrices geometrically, and see that matrices correspond with particular kinds of transformations of space relative to a given set of coordinates. With this connection made, we will perform algebraic manipulations of matrices and see how they correspond with operations of linear transformations.
- **Subspaces of \mathbb{R}^n and their dimension.** Subspaces correspond with (linear equational) restrictions on the variables involved. We will further expand the connections between matrices and linear maps by finding their *image* and *kernel*, and we will learn how to translate between different coordinate systems.
- **Determinants.** The determinant of a matrix gives us lots of geometric and algebraic information about the matrix—we will learn how to compute the determinant in several ways, and interpret this information geometrically.
- **Eigenvalues and eigenvectors.** Eigenvectors are vectors which a matrix scales by a factor, known as its eigenvalue, but does not rotate it. The eigenvalues of a matrix alone tell us lots of information about its behaviour (including its determinant!). We will develop methods for computing the eigenvalues and eigenvectors of a matrix.

Section 3

Assessment and grades

Below are descriptions of the course assessments and grade assignments.

- **Homework** (20% of total grade) (lowest score dropped).
 - ◇ **What?** Several challenging mathematical exercises based on material covered in class, graded for mathematical correctness and quality of proof-writing.
 - ◇ **Why?** To give you the opportunity to show off what you've learnt, and to allow me to give you individual feedback on your progress.
- **Quizzes** (10% of total grade) (lowest score dropped).
 - ◇ **What?** A fifteen minute quiz at the beginning of discussion on Thursdays.
 - ◇ **Why?** To help you stay on track and keep up with the pace of the course.
- **Midterm examinations** ($2 \times 20\% = 40\%$ of total grade).
 - ◇ **What?** Two fifty minute exams on Monday 22nd October and Monday 12th November.
 - ◇ **Why?** To solidify the knowledge and skills you acquired during the quarter, and to serve as milestones in the course.
- **Final examination** (30% of total grade).
 - ◇ **What?** A two hour exam from 9:00–11:00am on Wednesday 12th December.
 - ◇ **Why?** To test you on the knowledge and skills you have acquired throughout the quarter.

The grade borderlines will be determined at the end of the quarter, but they will not be lower than 90% for an A-, 80% for a B-, and 70% for a C-.

Section 4

Tentative class schedule

Please note that the following schedule is tentative, especially the homework deadlines—Hw 8 will definitely *not* be due on Friday 23rd November, but homeworks are generally due on Fridays.

	Date		Sec.	Topic	Notes
Week 1	Friday	28th September	1.1	Linear systems	
Week 2	Monday	1st October	1.2	Matrices and vectors	
	Wednesday	3rd October	1.2–3	Gauss–Jordan, linear systems	
	Friday	5th October	1.3	Linear systems, matrix algebra	Hw 1 due
Week 3	Monday	8th October	2.1	Linear transformations: intro	
	Wednesday	10th October	2.2	Linear transformations in geometry	
	Friday	12th October	2.3	Matrix products	Hw 2 due
Week 4	Monday	15th October	2.4	Inverses	
	Wednesday	17th October	2.4	Inverses	
	Friday	19th October	3.1	Image and kernel	Hw 3 due
Week 5	Monday	22nd October	—	<i>Midterm review</i>	Midterm 1
	Wednesday	24th October	3.2	Subspaces, bases, independence	
	Friday	26th October	3.2	Subspaces, bases, independence	Hw 4 due
Week 6	Monday	29th October	3.2–3	Dimension of a subspace	
	Wednesday	31st October	3.3	Dimension of a subspace	
	Friday	2nd November	3.4	Coordinates	Hw 5 due
Week 7	Monday	5th November	3.4	Coordinates	
	Wednesday	7th November	6.1	Determinants: intro	
	Friday	9th November	6.2	Determinants: properties	Hw 6 due
Week 8	Monday	12th November	—	<i>Midterm review</i>	Midterm 2
	Wednesday	14th November	6.3	Determinants and Cramer’s rule	
	Friday	16th November	7.2–3	Eigenvalues and eigenvectors	Hw 7 due
Week 9	Monday	19th November	7.2–3	Eigenvalues and eigenvectors	
	Wednesday	21st November	7.2–3	Eigenvalues and eigenvectors	
	Friday	23rd November	—	<i>No class</i>	Hw 8 due
Week 10	Monday	26th November	7.1	Diagonalisation	
	Wednesday	28th November	7.1	Diagonalisation	
	Friday	30th November	7.5	Complex eigenvalues	Hw 9 due
Reading period	Monday	3rd December	—	<i>Final review</i>	Optional
	Wednesday	5th December	—	<i>Final review</i>	Optional
	Friday	7th December	—	<i>Final review</i>	Optional
	Wednesday	12th December	—	Final examination 9:00–11:00am	

Section 5

Policies and guidelines

Academic honesty and integrity

My stance on academic honesty is simple: **all work you submit should accurately reflect your understanding**, and **any help you receive should be acknowledged**. This means that if someone were to ask you to explain your work, then you would be able to explain it and to say how you came to know it. What follows are some more specific descriptions of what this looks like in practice.

Collaboration. Speaking to each other about the course material and homework problems is one of the most effective ways to learn, so this is encouraged. What I ask is that you:

- **Cite your collaborators.** This means that you're giving them credit for their help, and avoids plagiarism issues. Just write a sentence at the end of your work saying who you worked with, e.g. 'I discussed Q4 with Carl Gauss, who showed me how to find the determinant of A'.
- **Write your work up independently.** If you made any permanent records (such as notes or photos) during collaboration sessions, these records should be destroyed well before you write up your solution. For example, any notes on whiteboards should be erased, notes on paper should be thrown away, and photos should be deleted. Direct copying is forbidden.

External resources. Sometimes you need a little more guidance than is available from your notes, and doing some research can give you the boost you need to understand the material in the course. If you do use external resources, then please:

- **Cite your sources.** If you used a book or website, other than the course textbook or other assigned reading, please say so—just the book title and author, or web page URL, is fine.
- **Write your work up independently.** Close the book or web page and make sure you've understood what you learnt before you start writing—otherwise, all you're really doing is copying, and then your work doesn't reflect your understanding.

Examinations. Exams are the main so-called *summative assessments* of the course, meaning that they are intended to be an opportunity for you to demonstrate the knowledge and skills you have acquired. The only resource you should have available to you going into an exam is your brain—this means you should not have your notes open, you should not speak to others during the exam, and you should not be looking at other people's answers. The same applies to quizzes.

Instances of suspected academic integrity violations will be reported to the Weinberg Assistant Dean for Academic Integrity for further investigation. If I believe academic integrity violations are widespread, then I may resort to using plagiarism detection software.

If you are ever in doubt about whether something you are doing is in violation of academic integrity, your safest bet is to ask me as soon in advance of turning in your work as possible.

Attendance

Classes will be both fun and intellectually stimulating, so you'll probably want to attend. If you know you're going to miss a class, **please let me know as soon as possible** so that I can tell you what to do in order to catch up.

Frequent absence from class is correlated with lower academic performance, as well as other issues including mental health concerns—with this in mind, if I notice that you have developed a pattern of absence, then I will contact the Weinberg Office of Undergraduate Studies and Advising (OUSA), who will then check in with you.

If you are absent from an examination, I will work with you and your academic advisor (and/or OUSA) to work out if, how and when you can make up the work. Please let me know during the first two weeks of the quarter if you know in advance that you must miss an examination for a legitimate reason.

Homework submission

Homework is designed not just to test your knowledge, but also to help you learn. I set deadlines because it's important that you understand the content on the homework before we move on to new material in class. As such, it is in your own interests to do the homework and submit it on time.

Late homework will typically not receive credit since the grading turnaround will be quick and the lowest score is dropped. If there are any special circumstances that mean you absolutely need to submit the homework late, please speak to me as soon as possible, and preferably well in advance of the deadline. If in doubt, ask—the sooner you ask, the easier it will be for us to find a solution.

Contesting a grading error

Grisha and I will grade a *lot* of your work throughout the quarter, but (just like you) we are mere humans, so it is entirely possible that we will make an error from time to time. If you believe a grading error has been made, then please do the following:

1. Write a note indicating what error(s) you believe has been made—be as specific as possible, and include the relevant question number(s).
2. Attach the note to your work and hand it in at the beginning of class within three working days of the return date—for example, if homework was returned on a Friday, you should turn it in on the following Monday or Wednesday.

I will then regrade the work in question from scratch and return it to you within a week—at this point, your homework grade is final.

Having a bad day/week: dropped scores and make-up work

Everyone has a bad day (or week) from time to time, but do not feel dejected if you don't do as well as you hoped on a homework assignment or quiz—keep in mind that your lowest scores will be dropped! There will not be opportunities for make-up work—however, I will be happy to discuss your homework solutions with you after they have been graded.

Accommodations

It is very important to me that my methods of instruction and assessment are fair to everyone. If you require any accommodations, including extra time on examinations, note-taking services, large-text format materials, alternative test locations, then you should register with AccessibleNU:

- **AccessibleNU**

<https://www.northwestern.edu/accessiblenu/>

(847) 467-5530 / accessiblenu@northwestern.edu

I am only able to make accommodations after I have received an accommodation notification from AccessibleNU—I cannot accept any other forms of evidence of need for accommodations, such as notes from doctors or emails from parents.

Mental health and wellness

It is likely that you will feel overwhelmed (with work or otherwise) at some point during the quarter. Please be aware that Northwestern University has a *lot* of resources available for helping you on your way, including:

- **Counseling and Psychological Services (CAPS)** (confidential resource)

<https://www.northwestern.edu/counseling/>

(847) 491-2151

- **Student Assistance and Support Services (SASS)**

<https://www.northwestern.edu/studentaffairs/dos/>

(847) 491-4582

- **Dean on Call** (if you don't know who else to call)

(847) 491-8430 (Mo–Fr 8:30am–5:00pm)

(847) 467-3022 (after hours)

More information and resources can be found on the university's Health and Wellness page:

<https://www.northwestern.edu/studentaffairs/dos/resources/health-wellness/>

Discrimination, harassment and sexual misconduct

We share a responsibility to make our community one where everyone has equal opportunities and feels safe, both inside and outside the classroom. I believe discrimination and harassment (sexual or otherwise) have no place in my classes or at Northwestern University, and I am committed to preventing such behaviour and taking action if it occurs. Some resources for students regarding discrimination and harassment are as follows.

- **Center for Awareness, Response and Education (CARE)** (confidential resource)
<https://www.northwestern.edu/care/>
(847) 491-2054
- **Deputy Title IX Coordinator for Students**
(847) 467-6571 / deputytitleixcoordinator@northwestern.edu
- **Office of Equity**
<https://www.northwestern.edu/equity/>
(847) 467-6165

Whilst I am willing to discuss sensitive issues, please bear in mind that I am required to report instances of suspected sexual misconduct to the Deputy Title IX Coordinator for Students.

Office hours

Office hours are quite simply times that I and Grisha have set aside to be available to meet with students. Make the most of them! Since office hours are entirely unstructured, please make sure that you follow the following guidelines.

- Have something in mind to discuss or ask, and be as specific as possible.
- Please take turns with other students—for example, if you ask a question, allow the other students present to ask a question before you ask a follow-up question.
- If office hours are busy, please avoid ‘camping out’—my office isn’t very big!
- Please don’t show me your written attempts at homework solutions. (I won’t look at them!) It is not fair for me to verify if your attempt is correct or to suggest how it can be improved ahead of the submission deadline.
- Please only come to the office hours for this course or ‘open office hours’—if you come to my Math 300 office hours, I will prioritise questions about Math 300 (and vice versa for Math 300 students attending Math 290 office hours).

Talk to me

I want you to learn a lot and I want you to enjoy taking this course. So that I can find out if this is happening, I encourage feedback—be it positive or negative—on all aspects of the course at any time during the quarter.

For example, if something I'm doing is making it difficult for you to learn, then say something before it's too late; or if you particularly enjoyed something we did in class, say so so that we can do it again.

You can do this by just speaking to me or Grisha, by sending one of us an email, or by using the anonymous comments form, details of which will be circulated in class. Please bear in mind that I cannot reply individually to anonymous feedback. Giving feedback will in no way affect your grade, positively or negatively.