Honors Linear Algebra, Spring 2022

MATH-UA 148 / MA-UY 3054 A Syllabus, *Last Updated 1/24/2022*

Instructor	Norman Cao	**Email**	norman.cao@cims.nyu.edu
Lecture	Mon/Wed 11:00-12:15am	**Classroom**	CIWW 512
Office Hours	(refer to NYU Brightspace course page)	**Office**	CIWW 704

Important Notice

This honors version of Linear Algebra is intended for students who are more comfortable with mathematics. While the course will cover most of the material in the MATH-UA 140 (Linear Algebra) syllabus, this *course is different* from MATH-UA 140!

This course will move faster and go deeper; emphasis will be placed on rigorous proofs and abstract ideas. It will be assumed that you will be able to become comfortable with algebraic manipulations and computations on your own. We will also use a different textbook. You can check the official prerequisites of the course at https://math.nyu.edu/dynamic/courses/undergrad/math-ua-148/

Textbooks

We will make use of two texts throughout the course:

- (Required) *Linear Algebra Done Wrong*, by Sergei Treil, which is available for free in PDF form at https://www.math.brown.edu/streil/papers/LADW/LADW.html
- (Recommended) *Linear Algebra for Everyone*, by Gilbert Strang. Optionally you can substitute Strang's old book, *Introduction to Linear Algebra, 5th Edition*.

The course will mostly follow Treil's book. The book is proof-based, so I recommend you read chapters both *before and after lecture*. This will help you get the most out of lecture.

We will take occasional applications and examples from Strang's book. However, Strang's book is also a great supplement for building an intuitive understanding of the material, so I recommend reading it too.

Finally, I strongly recommend that you take advantage of various free online resources to supplement your learning. These can complement (but do not replace!) the more rigorous approach we will take in lecture. One great resource is the 3Blue1Brown Essence of linear algebra YouTube series.

Objectives

Honors Linear Algebra is aimed at students who want to develop a deeper and more rigorous understanding of linear algebra. The course will cover the basics of linear algebra, which has wide application in basically every scientific and mathematical discipline imaginable. The main course topics are:

- Vector spaces and linear transformations
- Matrices, solving linear systems of equations, LU decomposition
- Inner product spaces, orthogonality, Gram-Schmidt, least-squares solution and fitting
- Determinants, trace, eigenvalues and eigenvectors, spectral theory
- Singular value decomposition

This is a theoretical course that will focus on abstract ideas and developing mathematical reasoning. Students will learn how to read, write, and understand rigorous mathematical proofs, which will show up on homeworks and exams. These proofs, in addition to firmly establishing "what" is true, will also provide insight into "why" things are true.

Communication and Software

Currently, lectures are scheduled to be in-person this semester. Lectures will be recorded, and remote attendance will be available via Zoom. In addition, I will post a **weekly recap** at the end of each week which will summarize the most important points from lecture that week – this should help you keep up to date if you fall behind, e.g. due to absences.

The syllabus, course calendar, Zoom links, lecture recordings, homework solutions, and any announcements will be posted on NYU Brightspace. Homework will be submitted and graded electronically via Gradescope.

Any course-related questions should be asked via Campuswire. **Please follow the link and enter the code 4325 to join our course section**. Asking and answering questions can be done anonymously to other students if you wish. It is encouraged to answer each other's questions. I will check Campuswire regularly, and add to answers if needed.

Course Components and Grading

Homework (35%):

Homework will be assigned weekly via Gradescope, except during exam weeks. Solutions should be submitted online via Gradescope. Late homework will only be accepted either due to emergency circumstances, or if *prior notice at least 24 hours in advance* is given for non-emergency circumstances (refer to the sick and late policy below).

While collaboration is highly encouraged, each student is responsible for writing up their own solutions individually. Direct copying of another student's homework, even if both students contributed, is considered a violation of academic integrity.

Homework should be written clearly, and proper justification is required. For an idea of what constitutes a rigorous and complete proof for proof-based problems, consult the course textbook, homework solutions, or recitation sections. Even if you are unable to fully solve a problem, please submit your best attempt as partial credit will be awarded.

In order to allow the grader to give more detailed feedback on homeworks, not all exercises may be graded (you will not know which). The lowest homework score will be dropped from the final grade.

Exams (65%):

There will be two midterm exams and a cumulative final exam. The two midterms will be held **during lecture time** (see Calendar section), while the final exam will be held during finals week.

The 65% exam component will be determined from your three exam grades (two midterms + one final) by the following formula:

$$25\% \text{ (highest of three exam grades)} + 20\% \text{ (2nd highest of three exam grades)} + 10\% \text{ (lowest of three exam grades)} + 10\% \text{ (final)}$$

Sick and Late Policy

Extensions on homework will be granted in qualifying cases, such as religious holiday, family emergency, sickness that extends over several days, qualified academically related activity, or unavoidable circumstance which prevents you from working on the homework. I will generally try to be flexible and understanding with late homework, however, **non-emergency extensions will only be granted if requested at least 24 hours prior to the homework due date**. If you miss a homework or exam due to emergency circumstances, please contact me ASAP via email.

Other Course Policies

I expect students to contribute to our positive learning environment: **try to attend live classes**, **pay attention** for the duration of the class, **participate** meaningfully during class by asking questions or answering them. Students who disrupt our learning environment will be asked to leave the Zoom session. If you have questions related to the course, please ask them on Campuswire or send me an email. I will normally reply within 24 hours. If I do not, please send me a reminder.

This course will abide by NYU CAS academic policies and honor code.

Resources

I am available during **office hours and by appointment** to review course material or address any course related concerns. Peer tutoring is available at **University Learning Center** and **Undergraduate Mathematics Tutoring Center**. Students seeking accommodations must consult the **Moses Center for Student Accessibility**.

Tentative Course Calendar

See NYU Brightspace for most up-to-date calendar

Week	Dates	Required Reading List
1	Jan 24, 26	Vector spaces, bases, linear transformations Treil 1.1-1.4
2	Jan 31, Feb 2	Matrix operations, invertible transformations Treil 1.5-1.6
3	Feb 7, 9	Systems of linear equations, Gaussian elimination, LU factorization Treil 2.1-2.2, Strang 3.5
4	Feb 14, 16	Subspaces, dimension, general solutions Treil 1.7 and 2.3-2.6
5	Feb 23	Fundamental subspaces, rank nullity-theorem, change of basis Treil 2.7-2.8
6	Feb 28, Mar 2	Catch-up and review **Midterm exam 1**
7	Mar 7, 9	Inner product spaces, orthogonality and orthonormality, Gram-Schmidt Treil 5.1-5.3
8	Mar 21, 23	Least squares solutions, adjoints, QR factorization Treil 5.4-5.5, Strang 6.5
9	Mar 28, 30	Isometries and unitary operators, determinants Treil 5.6 and 3.1-3.4
10	Apr 4, 6	Eigenvalues and eigenvectors, diagonalization Treil 4.1-4.2
11	Apr 11, 13	Catch-up and review **Midterm exam 2**
12	Apr 18, 20	Schur representation, spectral theorem for self-adjoint and normal operators Treil 6.1-6.2
13	Apr 25, 27	Polar and singular value decomposition Treil 6.3-6.4
14	May 2, 4	Dual spaces, adjoint (dual) transformations Treil 8.1-8.3
15	May 9	Final review