What is this course about? Linear algebra is one of the most powerful and beautiful subjects in mathematics. It offers great insight into a myriad of disciplines, and has applications ranging all the way from economic theory to image compression to ecology. But beyond its great applicability, linear algebra is characterized largely by its elegance. One of the goals of this class is to give you a taste of the power of abstraction to take a concrete problem and illuminate its underlying structure.

In this class, we will start with a very concrete mathematical problem - how to find all solutions to a linear system of equations - and examine it again and again with new language and tools.

Learning Goals for Math 15a. Students in Math 15a will:

- Gain foundational knowledge for a broad variety of math and science courses, which they will draw on for their entire college career and beyond.

- Learn to think critically and logically about (mathematical) problems they encounter, both in this and other courses.

- Apply familiar techniques in unfamiliar settings, by relying on experience, intuition, and understanding.

Linear algebra is a challenging course. It’s worth saying up front that for many students this is a challenging course. It is the first exposure to abstract mathematics and reasoning, and switches away from the traditionally computation-heavy classes like Calculus. We will basically only learn two computational techniques in this course, one of them in the first week, but the point of the course is to keep rephrasing new questions we’re interested in in ways which can be answered by these techniques. Don’t be discouraged if it doesn’t make sense right away, it is only in struggling that we really learn!

Office Hours. Many students don’t understand what office hours are for. Office hours are not just for struggling with the course, but for learning more about the material and getting to know your professor. I strongly encourage every student to come to my office hours at least once in the semester, even if it is only to say hi and chat for a few minutes. If you would like to meet with me but cannot make the scheduled office hours, just send me an email and we will find a time to meet.

The book can be purchased from the University Bookstore, or bought online, but you are responsible for making sure you purchase the correct book. If you buy an older edition, it is your responsibility to make sure you’re reading the correct sections and doing the correct homework problems. I strongly recommend you try for a new or used version of this edition.

If you are having difficulty purchasing course materials, please make an appointment with your Student Financial Services or Academic Services advisor to discuss possible funding options and/or textbook alternatives.
**Prerequisites.** MATH 5a and permission of the instructor, placement by examination, or any mathematics course numbered 10 or above. Students may take MATH 15a or 22a for credit, but not both. If you HAVE NOT taken Math 10a and 10b (or the equivalent class in high school), you may feel slight discomfort in this class. If you do, feel free to meet with me (preferably at the beginning of the semester, rather than too late!).

**Exams.** There will be two midterm exams and a final exam.

- Exam 1: Thursday, February 27, in class.
- Exam 2: Thursday, March 26, in class.
- Final Exam: During exam week, precise time and place TBD.

**Grades.** Your grade in the course will be based on the following:

1. **Homework (20% of your grade)**
   - Homework assignments will be collected (approximately) once a week. It will be due every Thursday at the beginning of class.
   - **No late homework will be accepted**, but your *two* lowest homework grades will be dropped.
   - I encourage you to discuss homework problems with your classmates, but you must write up your own solutions.

2. **Quizzes (10% of your grade)**
   - Short quizzes will be given regularly. These will be (nearly) every Monday at the beginning of class.
   - The purpose of these quizzes is to make sure you are following the material. If you do poorly on multiple quizzes in a row, *this means you have fallen behind and are not understanding new material!* There’s no shame in this, but it means you have to work extra hard to catch up.
   - **No make-up quizzes will be given.** Missed quizzes count as zeroes. However, the *two* lowest of your quiz grades will be dropped.

3. **Two midterm exams (each 20% of your grade)**
4. **Final exam (30% of your grade)**

**Calculators.** Calculators are not allowed during exams or quizzes. In particular, you do not need a graphing calculator. You may use a calculator when working on homework; however, please keep in mind that simply entering a problem into a computer algebra system and recording its answer does not constitute a solution to that problem.

**LATTE.** All course materials for Math 15a will be available online on LATTE. Log in at [http://latte.brandeis.edu](http://latte.brandeis.edu) using your Unet username and password.

**Four-Credit Course (with three hours of class time each week).** Success in this 4 credit hour course is based on the expectation that students will spend a minimum of 9 hours of study time per week in preparation for class (readings, papers, discussion sections, preparation for exams, etc).

**Students with disabilities.** Brandeis seeks to welcome and include all students. If you are a student who needs accommodations as outlined in an accommodations letter, please talk with me
and present your letter of accommodation as soon as you can. In order to provide test accommodations, I need the letter more than 48 hours in advance. I am happy to arrange for your accommodations, but cannot do so retroactively. If you have questions about documenting a disability or requesting accommodations, please contact Student Accessibility Support (SAS) at 781.736.3470 or access@brandeis.edu.

**Academic Integrity.** You are expected to be honest in all of your academic work. Please consult Brandeis University Rights and Responsibilities for all policies and procedures related to academic integrity. Students may be required to submit work to TurnItIn.com software to verify originality. Allegations of alleged academic dishonesty will be forwarded to the Director of Academic Integrity. Sanctions for academic dishonesty can include failing grades and/or suspension from the university. Citation and research assistance can be found at LTS - Library guides.

**Privacy.** This class may require the use of tools that may disclose your coursework and identity to parties outside the class. To protect your privacy you may choose to use a pseudonym/alias rather than your name in submitting such work. You must share the pseudonym/alias with me and any teaching assistants as needed. Alternatively, with prior consultation, you may submit such work directly to me.

**Tentative Schedule.**

**January**

Mon. 13. Coordinates and $\mathbb{R}^n$. Vector addition and scalar multiplication.

Wed. 15. §1.1 Systems of linear equations.

Thu. 16. §1.2 Row reduction and echelon forms.

Wed. 22. §1.2 More on the row reduction algorithm.

Thu. 23. §1.3 The vector equation interpretation.

Mon. 27. §1.4-1.5 The matrix equation and solution sets.

Wed. 29. §1.7 Linear independence.

Thu. 30. §1.8 Definitions about general functions, and linear transformations.

**February**

Mon. 3. §1.8-1.9 More on geometry in $\mathbb{R}^2$ and $\mathbb{R}^3$ and examples of linear transformations.

Wed. 5. §1.8-1.9 Projections and reflections in $\mathbb{R}^2$ and $\mathbb{R}^3$.

Thu. 6. §1.9 Existence and uniqueness.

Mon. 10. §2.1, 2.2 Matrix operations and inverses

Wed. 12. §2.3 The invertible matrix theorem

Thu. 13. §2.8 Subspaces of $\mathbb{R}^n$.

Wed. 24. §4.1 Abstract vector spaces.

Thu. 26. §4.1-4.2 Subspaces, null and column spaces.

Mon. 27. **Midterm I**

**March**
Mon. 2. A weird construction: quotient spaces

Wed. 4. The first isomorphism theorem.

Thu. 5. §4.3 Bases of vector spaces.

Mon. 9. §4.3 More on bases.

Wed. 11. §4.5-4.6 Dimension, rank, rank-nullity.

Thu. 12. §4.4 Coordinates.

Mon. 16. §4.4, 4.7 More on coordinates, change of basis, and conjugation of matrices

Wed. 18. §3.1-3.2 Determinants of simple matrices and properties of determinants.

Thu. 19. §3.2 Row operations and determinants.

Mon. 23. §3.3 Computing the determinant.

Wed. 25. §3.3 More on the determinant

Thu. 26. **Midterm II**

Mon. 30. §5.1-5.2 Eigenvectors, eigenvalues, and the characteristic polynomial.

**April**

Wed. 1. §5.3-5.4 Diagonalization and linear transformations

Thu. 2. §5.3-5.4 Diagonalization, continued

Mon. 6. §5.5 Complex numbers and complex eigenvalues

Tue. 7. The PageRank Algorithm

Mon. 20. §6.1-6.3 Dot product, length, and orthogonality

Wed. 22. §6.1-6.3 Orthogonal sets, orthonormal sets. Symmetric and orthogonal matrices.

Thu. 23. §6.4 The Gram-Schmidt algorithm

Wed. 27. §7.1 Diagonalization of symmetric matrices and the spectral theorem

Thu. 29. §7.4 Singular value decomposition