

Course Description

Math 60

Linear Algebra

What is Linear Algebra? Linear Algebra is the study of linear functions on higher dimensional spaces. In one variable calculus, you studied functions like $\sin(x)$, e^x , and $x^3 + x - 47$. For these functions, we plug in a real number and we get back a real number. For this reason, we say that these are functions from \mathbb{R} to \mathbb{R} . The symbol \mathbb{R} stands for the set of all real numbers and \mathbb{R} is a “one-dimensional space”. By analogy, a function that has 47 variables, could be a function on a 47-dimensional space. What makes calculus a powerful tool is that it allows you to locally approximate a complicated function with a linear one. In other words, from the derivative you get the tangent line which, for differentiable functions, is a very good approximation to your function near the point of tangency. In this formulation, linear algebra and calculus provide a one-two punch. Linear Algebra teaches you about high dimensional spaces and linear functions while multivariable calculus allows you to approximate other more complicated functions with these linear functions. It turns out—a fascinating story—that studying higher dimensional spaces and linear functions has a lot to do with solving systems of linear equations and with properties of matrices. As a result, matrices and linear equations play a central role in linear algebra classes. Watch [LA1 What is Linear Algebra?](#) for a brief intro to the subject.

Is Linear Algebra useful? Linear Algebra is the language for discussing phenomena that depends on many variables. As such, it becomes an essential ingredient of sophisticated discussions of not only mathematics of higher dimensions, but also of myriad other fields such as Statistics, Economics, Computer Graphics, and Analytics. When you studied calculus, you gained a whole new vocabulary (and the accompanying grammar), and this enabled you to do qualitatively different and new things. Similarly, Linear Algebra will give you a powerful new framework for tackling many problems.

What makes Math 60 different from my previous math classes? In Math 60, we not only learn the basics of linear algebra (the “what” and the “how”), we are also concerned with proofs and reasoning (the “why”). This focus on proofs is not just because we want to be rigorous. One of the purposes of Math 60 is to convince you that reasoning and proof lead to understanding. It is only by looking under the hood that we gain an appreciation of the more subtle parts of the theory and the limitations of the edifice that we built. Hence, Math 60 is “different” because it is a whole new language (the content is different) and because we approach it more rigorously than your previous encounters with mathematics. For these reasons, Math 60 provides a window into the craft of mathematics.

Are the different sections of Linear Algebra different? Yes and No. All sections of linear algebra will teach you linear algebra and they will all prepare you for future classes. But each instructor of linear algebra is faced with a number of choices. Some emphasize the concrete world of linear equations, \mathbb{R}^n , and matrices, and ground the more theoretical aspects in the intuition gained from these more familiar domains. Others will focus on applications. In my section of Math 60, while you will see plenty of applications, matrices, and linear equations, there is a particular emphasis on the development of the theory. One of my purposes is for you to appreciate the connection between the more abstract constructs and the concrete applications.

Is Linear Algebra the prerequisite for any other class? In our mathematics curriculum, Math 60 is the prerequisite for most transition level and upper division math classes. It is also very useful for students of Statistics, Economics, Computer Science, Physics, and Chemistry.

Do I need to know how to do “proofs” before starting linear algebra? No. One of the purposes of Math 60 is to get you started in becoming more versatile with proofs. The experience you have had with logical reasoning in your calculus classes will suffice.

Do I have to remember the techniques I learned in Calculus? No. Linear Algebra is a new language and so we start from the beginning. What we need from your study of calculus is not really any one particular technique or idea but something that we amorphously call “mathematical maturity”. Having studied calculus, you have seen mathematical and logical reasoning, and we will be building on your experience.

Should I take Math 31H or Math 32 or 60? If you have had the equivalent of AP Calculus BC (or some version of our Math 31) and done well, then you can take Math 60. If you have only had the equivalent of AP Calculus AB (or up to Math 30), then you are not yet ready for Math 32 or 60, and should consider some variant of Calc II. Students who have had some topics in AP Calculus BC (but have not taken Math 31 or 31S) can consider Math 31H. Linear Algebra and multivariable calculus can be taken in either order. You can either take Math 32 (multivariable calculus, a course that does not depend on linear algebra and continues your study of calculus) followed by Math 60, or take Math 60 and follow it by either Math 32 or Math 67 (vector calculus, a multivariable calculus class with linear algebra as a prerequisite). If you are planning to continue taking mathematics classes, then we generally suggest taking Math 60 followed by 32 or 67. (However, you may want to take 32 first, if you believe that a bit more mathematical experience before Math 60 will be useful.)

Structure. You learn best when you intellectually engage the material fully. Many of the topics in the course will be first presented in the readings and the videotaped lectures but quite a few will make their first appearance in homework. There will be ample support for your work, and collaborative learning will be emphasized. However, doing the regular (sometimes challenging) homework assignments will be at the core of this course. Reading the book &/or watching the videotaped lectures will be crucial in learning the material. In class, we will collaboratively work on worksheets to solidify your understanding of the topics, point out the subtle aspects of the material, and answer your questions.

What is the work load? There will be 3 homework assignments a week and each will consist of 5 problems. Some of the problems will be quite challenging but there will be ample resources to support you. When past students were asked “On average, how many hours per week, did you spend on this course outside of class?”, the median answer was 10, and fifty percent of the students reported working between 8 to 12 hours per week outside of class. (Twenty five percent reported spending between 4 and 8 hours a week, while another twenty five percent reported spending between 12 and 20 hours a week on this class.)

When is Math 60 offered next? Several sections of Math 60 are offered every semester.

Text. The textbook for my section of Linear Algebra—will be available free online—is Shahriar Shahriari, *Retro Linear Algebra, version 5.27*, 2021.

See my [Annotated Video List for Linear Algebra](#) or [Linear Algebra Playlist on YouTube](#) for the available videos for this course.