Framingham State University

# MATH 226 Linear Algebra and Applications

## COURSE INFORMATION

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| Semester | : July 6, 2020 - August 7, 2020 |
| Credit | : 4 |
| Teaching Hours | : 50 Hours |
| Location | : Online |
| Professor | : Lun Yang |
| Email | : luny1985@gmail.com |

## DESCRIPTION

Linear algebra is the study of linear systems of equations, vector spaces, and linear transformations. Solving systems of linear equations is a basic tool of many mathematical procedures used for solving problems in science and engineering. In this class we will concentrate on the mathematical theory and methods of linear algebra. The student will become confident in solving linear equations, performing matrix algebra, calculating determinants, and finding eigenvalues and eigenvectors. On the theoretical side, the student will come to understand a matrix as a linear transformation relative to a basis of a vector space.

This course requires basic acquaintance with vectors and matrices, linear equations, eigenvalues, and determinants and studies these topics in more depth, in particular with regard to applications. Topics include Gram-Schmidt orthogonalization, eigenvalues and diagonalization, QR decomposition, and singular value decomposition. Prerequisite for this course is one semester of college calculus, however the mathematical maturity obtained from two semesters of calculus would serve you well and is recommended.

## REQUIREMENTS

1. Plan on spending at minimum of 1.5 hours of uninterrupted time preparing for each class (and possibly more for the first day of a new topic area) and absolute minimum of 3 hours per week doing homework, reviewing other class materials.
2. It is very important that you familiarize yourself with the entire semester class schedule now, so that you can plan your schedules ahead for weeks when you may have multiple exams or other due dates. Let your instructor know, in advance, if you will miss a class and the reason for missing the class.

NOTE: In order to perform well in this class, extensive preparation is required prior to each class meeting. In addition, over the course of the semester, students are expected to make their best efforts to follow the schedule listed in the syllabus. However, depending on class progress, the syllabus may be adjusted. Any changes of the syllabus will be announced in class.

## TEXTS AND MATERIALS

Strang, Gilbert. Introduction to Linear Algebra. Wellesley-Cambridge Press, 2009. ISBN: 9780980232714.

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## COURSE CONTENT

1. Solving Ax = b for square systems by elimination (pivots, multipliers, back substitution, invertibility of A, factorization into A = LU)
2. Complete solution to Ax = b (column space containing b, rank of A, nullspace of A and special solutions to Ax = 0 from row reduced R)
3. Basis and dimension (bases for the four fundamental subspaces)
4. Least squares solutions (closest line by understanding projections)
5. Orthogonalization by Gram-Schmidt (factorization into A = QR)
6. Properties of determinants (leading to the cofactor formula and the sum over all n! permutations, applications to inv(A) and volume)
7. Eigenvalues and eigenvectors (diagonalizing A, computing powers A^k and matrix exponentials to solve difference and differential equations)
8. Symmetric matrices and positive definite matrices (real eigenvalues and orthogonal eigenvectors, tests for x'Ax > 0, applications)
9. Linear transformations and change of basis (connected to the Singular Value Decomposition - orthonormal bases that diagonalize A)
10. Linear algebra in engineering applications (graphs and networks, Markov matrices, Fourier matrix, Fast Fourier Transform, linear programming

## GRADING CRITERIA

Your grade is based on homework, quizzes, three exams, and class participation.

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| Exam 1 | 15% | HomeWorks | 45% |
| Exam 2 | 15% | Professionalism & Participation | 10% |
| Exam 3 | 15% | Total | 100% |

**Exams:**

There will be three exams. As the dates for the three exams are specified in the syllabus, it is expected that all students will be at exams AS SCHEDULED. If a student fails to take the exam at the scheduled time, the student will receive a score of zero on that exam. Make-up exams will only be given under extreme circumstances and only if previously arranged with me. All illnesses must be documented. No make-up is permitted for reasons such as being late for the class, leaving class early, forgetting the exam date/time, car broken, traffic jams, work/travel related excuses, and conflicts with other classes/exams. If you know that you will not be able to take an exam at the time scheduled on this syllabus, please drop the course. The only materials that may be brought into a test are pencils, pens, an eraser, and a basic calculator. No books, cell phones, computers, translators, or programmable calculators will be permitted. If you do not bring an approved calculator to the test, you will end up having to do all calculations by hand. I will not supply students with calculators, and calculators cannot be shared under any circumstances. Students will not be permitted to leave the classroom for any reasons once a test has begun. Please plan accordingly.

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**Professionalism and Class Participation:**

Professionalism and class participation grades are based on the contributions, both positive and negative, that you make to the class.

I take attendance periodically. Excellent attendance is necessary, but not sufficient, to guarantee a high participation grade. Your questions, answers, comments, and insights over the course will contribute to this score. My expectation is that you will have read the assigned material prior to the class for which it is assigned. Thorough preparation will enable you to answer questions and join in class discussions.

Negative contributions to the class will have an adverse effect on your participation grade. Any behaviors that disrupt the learning environment will be considered negative contributions. These behaviors include (but are not limited to): chatting in class, eating in class, using cell phone in class, not turning off your cell phone before class, being late for class, poor attendance, leaving class early, moving around the classroom, sleeping in class, surfing the internet, talking to other students while someone else (either the professor or your fellow student) is speaking, and other unprofessional conduct.

Use of electronic equipment for any purposes other than the current topic of class discussion is extremely disruptive to your fellow students and to me. It also diverts your attention from class. There are only two permitted uses of electronic equipment in this class. First, laptop or tablet computers may be used to take notes, to read an e-textbook, to search for course-related data, and to do in-class exercises. They may not be used for any purpose unrelated to this course. Second, cellular phones and pagers may be left in silent mode if you inform me that it is imperative that you be reached during class. They may not be used to send text messages, to surf the internet, or to play games at any time. You will not be allowed to use a cell phone as a calculator. You will not be allowed to make recordings or take pictures in class without my permission. Any unpermitted uses of electronic equipment will be regarded as a negative contribution.

**Academic Integrity:**

It is expected that all students will uphold the academic integrity. All work submitted for this course should be completed only by the student being evaluated unless otherwise indicated in the assignment (e.g., group assignment). Students caught cheating or plagiarizing will, at my discretion, fail either the assignment/exam in question or the course, and the incident will be reported to the Dean's office for University Sanctions. Plagiarism includes copying someone else's words and claiming them as your own, paraphrasing someone else's words and/or ideas and claiming them as your own, or collaborating excessively with another person or persons and claiming the work as solely your own. Plagiarism on any assignment will, at minimum, result in an "F" for the assignment. I reserve the right to pursue further disciplinary action if appropriate.

## COURSE EXPECTATIONS

**Grading Scale:**

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| A 94% of total points | A- 90-93.99% of total points | |
| B+ 87-89.99% of total points | B 84-86.99% of total points | B- 80-83.99% of total points |
| C+ 77-79.99% of total points | C 74-76.99% of total points | C- 70-73.99% of total points |
| D+ 67-69.99% of total points | D 64-66.99% of total points | D- 60-63.99% of total points |
| F <60% of total points | Pass/Fail: need 60% or higher to pass. | |

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Any student not fulfilling his/her academic obligations for this course will receive a failing grade for the semester. Incompletes will only be granted under the most extreme of circumstances and only if agreed upon by the instructor before the completion of the semester. Any issues regarding such a situation will be referred to the Dean's office.

### Workload Expectations

For our accreditation, it is essential that all Framingham State University credit courses follow the Federal Definition of credit hour: for every one hour of classroom or direct faculty instruction, a minimum of two hours of out-of-class student work is required. Since the summer courses meet for two contact hours daily (10 contact hours of classroom time weekly), the expectation is that students spend 20 hours per week doing out-of-class work. For the five week 4-credit hour course, this reflects 50 hours of classroom time and 100 hours of out-of-class time since the credit hour is defined as 50 minutes.

## Daily Schedules

07/06 -- THE GEOMETRY OF LINEAR EQUATIONS
07/07 -- AN OVERVIEW OF KEY IDEAS
07/08 -- ELIMINATION WITH MATRICES
07/09 -- MULTIPLICATION AND INVERSE MATRICES
07/10 -- FACTORIZATION INTO A = LU

07/13 -- TRANSPOSES, PERMUTATIONS, VECTOR SPACES
07/14 -- COLUMN SPACE AND NULLSPACE
07/15 -- SOLVING AX = 0; SOLVING AX = B
07/16 -- ORTHOGONAL VECTORS AND SUBSPACES
07/17 – EXAM 1

07/20 -- PROJECTIONS ONTO SUBSPACES
07/21 -- PROJECTION MATRICES AND LEAST SQUARES
07/22 -- ORTHOGONAL MATRICES AND GRAM-SCHMIDT
07/23 -- PROPERTIES OF DETERMINANTS
07/24 -- EIGENVALUES AND EIGENVECTORS

07/27 -- DIAGONALIZATION AND POWERS OF A
07/28 -- DIFFERENTIAL EQUATIONS AND EXP(AT)
07/29 – EXAM 2
07/30 -- SYMMETRIC MATRICES AND POSITIVE DEFINITENESS
07/31 -- POSITIVE DEFINITE MATRICES AND MINIMA

08/03 -- SIMILAR MATRICES AND JORDAN FORM
08/04 -- SINGULAR VALUE DECOMPOSITION

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08/05 -- LINEAR TRANSFORMATIONS AND THEIR MATRICES
08/06 – CHANGE OF BASIS; IMAGE COMPRESSION
08/07 – EXAM 3

Topics for self-learning: will appear in exams as bonus points ☺

1. COMPLEX MATRICES; FAST FOURIER TRANSFORM (FFT)
2. LEFT AND RIGHT INVERSES; PSEUDOINVERSE
3. MARKOV MATRICES; FOURIER SERIES
4. DETERMINANT FORMULAS AND COFACTORS
5. CRAMER'S RULE, INVERSE MATRIX AND VOLUME
6. GRAPHS, NETWORKS, INCIDENCE MATRICES