6/25/20 revised 7/29/20, 8/22/20x

Math 51100: Linear Algebra with Applications (Class No: 23315)

Prerequisite: Math 26100; informal knowledge of matrix operations and solution of linear equations from earlier courses in engineering and math.

NOTE: Since we will NOT be able to have tests in a computer lab, all tests will be 'in class', with the questions being emailed to you shortly before 4:30p, and your solutions electronically submitted back to me by 5:50p and received by me by 6:00p. Since 'proctoring' and Matlab access will not necessarily be possible for all students, problems will be possible to be solved 'by hand' and we will use an 'open book/open notes' testing environment. (If circumstances regarding computer access for all students in the class, some policies may change during the semester.)

Meets: MW 4:30 – 5:45p online via Zoom Format: DO
Final Exam: Wednesday, November 18, 4:30-5:50p

Instructor: Carl Cowen **Office:** via Zoom **Phone:** 317-278-8846 (for messages)
Office Hours: M Tu 1:30-3:00p, W 12:00-1:30p, or by appointment
E-mail: ccowen@iupui.edu
URL: https://www.math.iupui.edu/~ccowen/Math511.html

General Information

This course might be subtitled "Applicable Matrix Analysis and Linear Algebra". Linear algebra is second only to calculus/differential equations in terms of mathematics of importance to engineering applications. The goal of this course is to enable you to recognize linear algebra problems when you see them and to use the linear algebra you know to solve them. Other goals are to enable you to read and understand descriptions of other people's solutions to problems that use linear algebra and to read the documentation for the linear algebra features of the mathematical software you need to use.

This is a course describing applicable mathematics. While we will occasionally mention some specific applications, direct applications are not the main focus of the course. Most of you already know or will soon learn the application material and need to better understand the tools.

Throughout, the course remains conscious of the reliance on computers for real world computation. Moreover, there is a formal computer component to the course: *some homework will be inconvenient to do without a machine of some kind.* UITS, the School of Science, and the School of Engineering and Technology make Matlab, an industry standard program for numerical linear algebra, available in some Macintosh and Windows labs administered by UITS for use in this course and many engineering departments have linear algebra software available on their machines. The Student Version of Matlab is recommended; student versions for Macintosh and Windows are available for about $100 online. (*GNU Octave* is a *free(!)* numerical linear algebra package very similar to Matlab.) In addition, many of you have calculators that do linear algebra calculations.

Stated more bluntly, engineers use computers and appropriate software to do their professional computations, and modern engineering could not exist without these computer computations. Many of the computations engineers do are linear algebraic in nature and this course is aimed at preparing students for using linear algebra professionally.

The stated prerequisite, Math 26100, is accurate in spirit in that students who know absolutely nothing about linear algebra and multi-dimensional mathematics are likely to have a hard time, but is not literally accurate because many students did not do their undergraduate work at IUPUI and much of the linear algebra learning that I expect you to know will have come informally from a variety of engineering sources. The course will be complete, but basic material on computational topics such as row operations will be covered quickly.

References

TEXT: *Linear Algebra for Engineering and Science,* second preliminary edition,
by Carl Cowen (ISBN 9780965071741).

Besides the official text, Strang's book *Linear Algebra and Its Applications* is a good reference and is on reserve in the library. The problems in Strang tend to be less difficult both computationally and theoretically than the text's, but Strang develops the subject very well and presents excellent intuition for the subject and its applications. Strang's book is difficult to use as a reference because it is written in a narrative style. Another book that covers the material for the course at a higher level is *Applied Linear Algebra,* by B. Noble and J. Daniel (third edition, 1988).

Communication

Email is a good way to communicate with me and there will be important course details emailed to you at your IUPUI email address. Besides communication in class, assignments and other course information will be posted on the course website

`https://www.math.iupui.edu/~ccowen/Math511.html`

and also posted on *Canvas*. It might be convenient at times to use the link "Math 511 Course Webpage" on the Canvas course page to get to the resources on the webpage.

Important! Since this is an online course, we will not be passing papers back and forth: I will post assignments and other course information on Canvas and on the course webpage. To 'hand in' your assignments and tests, you will create a .pdf file and email it to me or send it via Canvas to me. When I am sending you a test or quiz, I will send you a .pdf file for you to read with some device you have access to.

Grading Policies

There will be one 75 minute mid-term test counting about 40-45% of your grade and about 45-50% of your grade will come from the 75 minute final exam given November 18. The other 5-10% will come from an in-class quiz, probably September 2, and grades on the homework.

Weekly homework will be essential to your understanding of the course and will be submitted electronically. The quiz will rely *only* on hand calculations, but results of machine computations will be acceptable in **all** test problems in place of hand computation; "show your work" in this case means writing down the computation you asked the machine to do and giving the result of this computation. (You **WILL NOT** have the opportunity to attach a printout of your computer computations! That is, such attachments will be ignored···.)

As in the past, the grading scales for this course will be approximately A: 85%-100%;
B: 65%-85%; and C: 50%-65%.

General Academic Policies

The work you submit for homework, quizzes, tests, and exams must be your own. For homework, you will probably find it beneficial to consult with other students about the material and this kind of conversation and collaboration is encouraged. At the end of the consultation, however, each participant is expected to prepare their own summary of the discussion and their own solution to the problem. More information about student conduct can be found at

`https://studentcode.iu.edu`

Information concerning adaptive services for learning or other disabilities at IUPUI can be found at

`https://diversity.iupui.edu/offices/aes/index.html`

The policies for this class will be those derived from IUPUI's policies on academic conduct and adaptive services.

Information about withdrawal from a class or from IUPUI (with grade of 'W' if on or before October 13) can be found at

`https://registrar.iupui.edu`

and a description of administrative withdrawal can be found at

`https://studentcentral.iupui.edu/register/administrative-withdrawal.html`

Administrative Withdrawal: A basic requirement of this course is that you will participate in all class meetings and conscientiously complete all required course activities and/or assignments. Keep in touch with me if you are unable to attend, participate, or complete an assignment on time. If you miss more than half of the required activities within the first 25% of the course without contacting me, you may be administratively withdrawn from this course. Example: Our course meets twice per week; thus if you miss more than four classes in the first four weeks, you may be withdrawn. Administrative withdrawal may have academic, financial, and financial aid implications. Administrative withdrawal will take place after the full refund period, and if you are administratively withdrawn from the course you will not be eligible for a tuition refund. If you have questions about the administrative withdrawal policy at any point during the semester, please contact me.

After the conclusion of the 100% refund period for the relevant term or session

`https://studentcentral.iupui.edu/pay-bill/index.html`

all individuals attending classes on a regular basis MUST be officially enrolled in the class, attending the class based on formal arrangements to make up a prior grade of Incomplete, or enrolled as an auditor. One time visitors to classes may be allowed only on an exception basis with prior permission of the instructor. This policy does not apply to individuals who provide assistance to a student with a documented disability, such as Adaptive Educational Services sign language interpreters, individuals who are involved in the course in an instructional role, or administrative personnel.

Some Important Dates

September 7	Labor Day, *CLASS AS USUAL!!*
October 7(??)	Test 1, 4:30-5:45p
October 13	Last day to withdraw with adviser's signature and automatic "W" (Withdrawal after October 13 requires Dean's approval, which is rarely given)
November 18	Final Exam, 4:30-5:45p

Approximate Course Outline

Topic	*Text*	*Approx. No. of Lectures*
Matrix Algebra and Systems of Linear Equations matrix operations, linear systems, elimination, row echelon form and elementary matrices, determinants	1, 2	4
Spaces, Bases, and Coordinates vector spaces, subspaces, basis, dimension, rank–nullity theorem, coordinates and change of coordinates	3	6
Inner Products and Geometry inner products, orthogonality, Gram–Schmidt (and QR), sums and intersections of subspaces, Fund. Thm. Lin. Alg.	4.1–4.4	4
Norms norms of matrices, infinite series	5	1
Projections and Least Squares projections, inconsistent systems, least squares, QR (via Householder)	6.1–6.3, 6.5	3
Linear Transformations linear transformations and the matrix of a transformation	7	1
Eigenvalues, and Eigenvectors eigenvectors and eigenvalues, spectral mapping theorem, matrix exponential and application to systems of ODE's, diagonalization	8	4
Hermitian and Normal Matrices unitary similarity, Schur triangular form, spectral theorem for Hermitian matrices, SVD	9	2
Jordan Canonical Form Cayley–Hamilton theorem, Block Jordan Form, applications to differential equations	10.1, 10.2	2
	TOTAL	27