7/25/17, revised 8/17/17

# Math 51100: Linear Algebra with Applications (Class No: 26461)

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

**Meets:** MW 3:00-4:15p in IT 162
**Final Exam:** Friday, December 15, 3:30-5:30p

**Instructor:** Carl Cowen **Office:** LD 224P **Phone:** 278-8846
**Office Hours:** MW 4:30-5:30 and Tu 10:00-11:30 or by appointment
**E-mail:** `ccowen@iupui.edu`
**URL:** `http://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 and the tests, which will held in a computer lab, 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 tests in this course will be timed and you will not be able to complete the problems in the allotted time if you try to use only hand calculations.

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

Besides communication in class, assignments and other course information will be posted on the course website `http://www.math.iupui.edu/~ccowen/Math511.html` and also posted on *Canvas* accessed through One.IU. Email is a good way to communicate with me and there will be important course details emailed to you at your IUPUI email address.

# Grading Policies

There will be two one–hour tests, each counting about 25% of your grade, and about 45–50% of your grade will come from the two–hour final exam given December 15. The two midterms and the final exam will be conducted in the computer laboratory in SL 070. You should reserve your seats for these tests **by August 28** using the links on the *Canvas* page or the webpage for the course.

You will not be permitted to have books, notes, calculators, phones, or watches during Tests in this class!

Weekly homework, assigned but not graded for credit due to problems in the past, will be essential to your understanding of the course. There will be a few in-class quizzes that will count as 5–10% of your grade. The lowest of your quiz scores will be dropped. Because of this policy, no make-up quizzes will be given except in the case of extended absence. You should show all your work on quizzes and tests. The quizzes 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!)

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

### Some Important Dates

| | |
|---|---|
| August 21 | First day of classes |
| August 27 | Last day to withdraw with no record |
| September 4 | Labor Day, no classes |
| October 4 | Test 1, SL 070, 3:00-4:30p, sign up by August 28 |
| October 16, 17 | Fall Break, no classes |
| October 22 | Last day to withdraw (automatic "W" on record) |
| November 15 | Test 2, SL 070, 3:00-4:30p, sign up by August 28 |
| November 22 | Thanksgiving Break!! no classes |
| December 11 | Last day of classes |
| December 15 | Final Exam, SL 070, 3:30p – 5:30p, sign up by August 28 |

## General Academic Policies

The work you submit for quizzes, tests, and the final exam 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 should prepare their own summary of the discussion and their own solutions to the problems because that will be required on quizzes and tests. The policies for this class will be those derived from IUPUI's policies on academic conduct and adaptive services. More information about IUPUI course policies can be found at

`http://registrar.iupui.edu/course_policies.html`

and

`http://registrar.iupui.edu/misconduct.html`

All students involved in a particular event of academic dishonesty will receive a zero on the item involved; a second infraction by an individual would usually mean receiving an 'F' for the course.

More information concerning adaptive services for learning or other disabilities at IUPUI can be found at `http://aes.iupui.edu/`

---

Students needing accommodations because of a disability will need to register with Adaptive Educational Services (AES) and complete the appropriate forms issued by AES before accommodations will be given. The AES office is located in Taylor Hall, UC 100. You can also reach the office by calling 274-3241. Visit `http://aes.iupui.edu/` for more information.

---

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 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.

---

This semester I will be using the FLAGS System to provide real-time feedback on your performance in this course. Periodically throughout the semester I will be entering data on factors such as your class attendance, participation, and success with coursework, among other things. This information will provide feedback on how you are faring in the course and offer you suggestions on how you might be able to improve your performance. You will be able to access this information in the student center:

One.IU >Student Services page>Student Center>My Academics and Grades>My Grades

---

## Approximate Course Outline

| *Topic* | *Text* | *Approx. No. of Lectures* |
|---|---|---|
| Matrix Algebra and Systems of Linear Equations<br>matrix operations, linear systems, elimination, row echelon form and elementary matrices, determinants | 1, 2 | 4 |
| Spaces, Bases, and Coordinates<br>vector spaces, subspaces, basis, dimension, rank–nullity theorem, coordinates and change of coordinates | 3 | 6 |
| Inner Products and Geometry<br>inner products, orthogonality, Gram–Schmidt (and QR), sums and intersections of subspaces, Fund. Thm. Lin. Alg. | 4.1–4.4 | 4 |
| **Test 1: October 4, SL 070, 3:00-4:30**<br>**sign up by August 28** | | |
| Norms<br>norms of matrices, infinite series | 5 | 1 |
| Projections and Least Squares<br>projections, inconsistent systems, least squares, QR (via Householder) | 6.1–6.3, 6.5 | 3 |
| Linear Transformations<br>linear transformations and the matrix of a transformation | 7 | 1 |
| Eigenvalues, and Eigenvectors<br>eigenvectors and eigenvalues, spectral mapping theorem, matrix exponential and application to systems of ODE's, diagonalization | 8 | 4 |
| **Test 2: November 15, SL 070, 3:00-4:30**<br>**sign up by August 28** | | |
| Hermitian and Normal Matrices<br>unitary similarity, Schur triangular form, spectral theorem for Hermitian matrices, SVD | 9 | 2 |
| Jordan Canonical Form<br>Cayley–Hamilton theorem, Block Jordan Form, applications to differential equations | 10.1, 10.2 | 2 |
| | **TOTAL** | 27 |

**Final Exam: December 15, SL 070, 3:30-5:30**
**sign up by August 28**