MATH547: Linear Algebra for Applications

Course Info

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This course is an introduction to the many applications of linear algebra. Basic theoretical concepts are discussed, but the focus is on expressing these concepts in algorithms, and use of linear algebra algorithms to solve practical problems.

Course goals: Students will acquire an understanding of the fundamental role linear algebra has in mathematical modeling, become familiar with ways to formulate applications of interest as linear algebra problems, and proficient in using available computational tools to solve these problems.

Title	**MATH547: Linear Algebra for Applications**
Times	MWF 1:25PM-2:15PM, Greenlaw 101
Office hours	Mo 2:30-3:30PM, Th 10:30-11:30 AM, Chapman 451
Instructor	Sorin Mitran (mailto:mitran@unc.edu)
Assistant	Nuch Aminian (mailto:aminian@live.unc.edu) Wyatt Bridgman (mailto:whb@live.unc.edu) Andrew Ford (mailto:agford@live.unc.edu)

Honor Code:

- All work is individual. You may discuss various approaches to homework problems with students, instructors, but must draft your answers by yourself
- All exams are closed book

Grading

Required work

- Homework - 8 assignments x (4 1-point exercises + a 4-point computer application) = 64 points
- Midterm - 3 problems x 4 points = 12 points
- Final - 6 problems x 4 points = 24 points
- You will be given the opportunity during the Final Examination to answer one 4-point question from the midterm material (the question will be different from those given during the Midterm Examination). The score from this question will replace your worst score on a problem from the Midterm Examination.

Homework is designed such that each grade point requires 0.5 hours to complete, once basic concepts have been understood. All homework is organized around modules emphasizing practical applications of linear algebra concepts.

Examinations will test ~~understanding~~ of course concepts, as tested by problems that require insight rather than rote repetition of homework exercises.

Extra credit

You may use these extra credit questions to make up for missed homework or points lost on the examinations.

Turn in any of these before Fall break to receive extra credit points:
EC1 (2 points) (to be posted) EC2 (2 points) (to be posted)
* EC3 (2 points) (to be posted)

Turn in any of these before last day of class to receive extra credit points:
EC4 (2 points) (to be posted) EC5 (2 points) (to be posted)
* EC6 (2 points) (to be posted)

Extra credit is designed such that each grade point requires 1 hour to complete, double the effort required for homework grade points.

Mapping of point scores to letter grades

Grade	**Points**	**Grade**	**Points**	**Grade**	**Points**	**Grade**	**Points**
A*cum laude*	101-112	B+	86-90	C+	71-75	D+	56-60
A	96-100	B	81-85	C	66-70	D	50-55
A	91-95	B-	76-80	C-	61-65	F	0-49

Note: Students can obtain a grade of C- (64 points) by correct solution of the homework problems. Higher undergraduate grades require either doing some of the extra credit or dedicating effort to ~~understanding~~ the theoretical concepts of the course, as tested during the midterm and final examinations.

Course policies

- Course attendance is required
- Students are required to read posted lecture notes, sections from textbook, and complete exercises prior to class attendance. These assignments are posted at least one week in advance of class meeting time starting with Week 2.

- Late homework is not accepted.
- Homework and extra credits are submitted in electronic form through Sakai. Submission by email is not accepted.

Bibliography

Course textbook: *Linear Algebra with Applications* by Otto Bretscher. Additional recommendations:

- *[Linear Algebra and Its Applications]*(http://www.pearsonhighered.com/educator/product/Linear-Algebra-and-Its-Applications-plus-New-MyMathLab-with-Pearson-eText-Access-Card-Package/9780134022697.page} (http://www.pearsonhighered.com/educator/product/Linear-Algebra-and-Its-Applications-plus-New-MyMathLab-with-Pearson-eText-Access-Card-Package/9780134022697.page}) by David Lay, Steven Lay, and Judi McDonald, Pearson publishers
- *Linear Algebra and Its Applications* by Gilbert Strang.

Lectures, reading and exercise assignments

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The following lecture notes are meant as a synopsis of class discussions. For more details consult the corresponding sections within the textbook.

Week	Monday	Wednesday	Friday
1		1/11 Linear combinations Lesson01.pdf (http://mitran-lab.amath.unc.edu/courses/MATH547/lessons/Lesson01.pdf) Discussion01.pdf (http://mitran-lab.amath.unc.edu/courses/MATH547/Spring2017ClassDiscussions/Jan11.pdf)	1/13 Matrices Lesson02.pdf (http://mitran-lab.amath.unc.edu/courses/MATH547/lessons/Lesson02.pdf) Discussion02.pdf (http://mitran-lab.amath.unc.edu/courses/MATH547/Spring2017ClassDiscussions/Jan13.pdf)
2	(MLK holiday, no class)	1/18 Matrix products, transpose Lesson03.pdf (http://mitran-lab.amath.unc.edu/courses/MATH547/lessons/Lesson03.pdf) Discussion03.pdf (http://mitran-lab.amath.unc.edu/courses/MATH547/Spring2017ClassDiscussions/Jan15.pdf)	1/20 Measuring vectors: scalar products, norms Lesson04.pdf (http://mitran-lab.amath.unc.edu/courses/MATH547/lessons/Lesson04.pdf) Discussion04.pdf (http://mitran-lab.amath.unc.edu/courses/MATH547/Spring2017ClassDiscussions/Jan20.pdf)

Homework

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Homework should be started within 24 hours of it being posted. You should attempt upload of your completed assignment well ahead of the deadline, preferably to allow enough time for office hours consultation. The submission deadline and electronic submission procedure of typeset homework are strictly enforced.

> (Note: the Jan 13 class lockout has delayed the homework schedule by a week from initial plans. First homework to be posted on Jan 22. Homework 0 is a test of submission procedures, and not included in course grade.)

Nr.	Issue Date	Due Date	Topic	Problems	Solutions
0	1/18	1/20	Test of homework submission procedure		
1	1/20	2/1	Vector spaces		
2	2/1	2/10	Fundamental matrix subspaces and applications to face recognition		
3	2/10	2/22	LU, QR factorizations		
4	2/22	3/3	Projections, permutations, least squares applied to analysis of electroenchephalograms (EEGs)		
5	3/20	3/29	Eigenvalue and eigenvector computation		
6	3/29	4/7	Eigensystem applications		
7	4/7	4/19	SVD computation		
8	4/19	4/28	Final preparation		

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Examinations

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- Midterm examination: 1:25-2:15 PM, Fr. Mar. 10
- Final examination: 12:00-3:00 PM, Th. May 4

- Midterm.SP.2016.pdf (http://mitran-lab.amath.unc.edu/courses/MATH547/exams/Midterm.SP.2016.pdf), MidtermSolution.SP.2016.pdf (http://mitran-lab.amath.unc.edu/courses/MATH547/exams/MidtermSolution.SP.2016.pdf)
- Final.pdf (http://mitran-lab.amath.unc.edu/courses/MATH547/exams/Final.pdf), FinalSolution.pdf (http://mitran-lab.amath.unc.edu/courses/MATH547/exams/FinalSolution.pdf)

Course materials

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Software

The utility of linear algebra can only be understood through practical applications on problems of realistic complexity. This requires use of computers and relevant software. Two options are available for students:

- For future users of linear algebra: install [TeXmacs](http://www.texmacs.org/tmweb/download/windows.en.html} (http://www.texmacs.org/tmweb/download/windows.en.html}) and use [Octave-online | http://octave-online.net/} (http://octave-online.net/})
- For future developers of computational applications: install [Virtual Box|https://www.virtualbox.org/wiki/Downloads} (https://www.virtualbox.org/wiki/Downloads}) and the [SciComp@UNC]

(http://scicomp.web.unc.edu/} (http://scicomp.web.unc.edu/}) Linux environment

Course examples will use both environments.

Users: TeXmacs and Octave

- TeXmacs is a freely available editor with excellent support for mathematical editing. Under OS/X and Linux TeXmacs supports interspersing computation and text editing
- Octave is a freely available system oriented towards linear algebra computations. The language is almost identical to the commercial Matlab system. Octave may be installed [locally | https://www.gnu.org/software/octave/download.html} (https://www.gnu.org/software/octave/download.html}), or used [online](http://octave-online.net/} (http://octave-online.net/}), and there are many tutorials available online, e.g. on [YouTube | https://www.youtube.com/watch?v=X0xLTKRWPgo} (https://www.youtube.com/watch?v=X0xLTKRWPgo}).

Developers: SciComp@UNC Linux environment

Scientific computation is typically carried out in a Un*x environment (e.g. OS/X, various Linux versions). This course uses a customized Linux environment named SciComp@UNC that is installed as a virtual machine on your laptop (assumed to satisfy [UNC laptop requirements](http://cci.unc.edu/new-students/minimum-laptop-requirement/} (http://cci.unc.edu/new-students/minimum-laptop-requirement/}). See [SciComp@UNC](http://scicomp.web.unc.edu/scicompunc-virtual-machine/} (http://scicomp.web.unc.edu/scicompunc-virtual-machine/}).

Here are some basic operations we carry out within the environment, as relates to Homework1:
[Navigating to Homework 1|https://www.youtube.com/watch?v=t3kx4u3y7i4} (https://www.youtube.com/watch?v=t3kx4u3y7i4}) [Basic editing within Homework 1|https://www.youtube.com/watch?v=5VYFhbK_TiM} (https://www.youtube.com/watch?v=5VYFhbK_TiM})

If you have difficulties with using the SciComp@UNC virtual machineon your laptop you can try to install the main programs ([Octave|https://www.gnu.org/software/octave/download.html} (https://www.gnu.org/software/octave/download.html}) and [TeXmacs](http://www.texmacs.org/tmweb/home/welcome.en.html} (http://www.texmacs.org/tmweb/home/welcome.en.html}) used in the course directly on your base operating system. You can also try to use the online version of [Octave](http://octave-online.net/} (http://octave-online.net/})

If you experience a hardware failure during the course, a temporary solution is to use the machine outside the Chapman 451 office.

Lecture notes, homework texts and solutions

Course materials (lecture notes, homework, quizzes) are distributed through Sakai and also through the subversion utility, available on all major operating systems. In the SciComp@UNC Linux environment the following will check out an initial copy of course materials:

- mkdir ~/courses
- cd ~/courses
- svn co http://mitran-lab.amath.unc.edu/courses/MATH547/ (http://mitran-lab.amath.unc.edu/courses/MATH547/)

Under Windows use [Tortoise SVN|https://tortoisesvn.net/downloads.html} (https://tortoisesvn.net/downloads.html}) or [SmartSVN](http://www.smartsvn.com/} (http://www.smartsvn.com/}). Under OS/X use [SmartSVN](http://www.smartsvn.com/} (http://www.smartsvn.com/}). Refer to the particular product for instructions on how to carry out the initial checkout of course materials.

In SciComp@UNC Linux you update the course materials before each lecture by:

- cd ~/courses/MATH547
- svn update

Similar procedures exist for svn under Windows or OS/X.