Mathematics 2270— Linear Algebra

Dear Colleagues,

I will have the pleasure to serve as course coordinator for Math 2270 this coming semester. My idea of course coordination is that I provide you with some information, and make myself available for consultation and advice, but otherwise leave it up to you how you want to conduct your class.

Our task is to cover the first 7 chapters of the textbook, and in particular make sure that we cover the Singular Value Decomposition. This is a specific request from the College of Engineering and we should honor it. The SVD appears only at the end of Chapter 7, so you want to make sure that you do not run out of time before getting there.

I am attaching my syllabus from the last time I taught 2270, updated to show dates for the coming semester, and to show the current edition of our textbook. Please take this only as a suggestion, you can of course make your own choice of assignments, weights, deadlines, etc. Note that I covered a few extra topics (a practical way of solving linear systems in Lecture 4, the Gershgorin Theorem in lecture 38, and the QR factorization in Lecture 54.) Those topics are of course optional, but I recommend that you mention the Gershgorin Theorem in particular. I think it's a great candidate for being the most useful (largely) unknown theorem!

When I last taught the class (in the Fall of 2019) I had one home work per week, and a total of 4 midterm exams. I used MyLab that time (which is associated withe the textbook). However, we have not been using MyLab for Math 2270 since then.

I can provide you with pdf or (plain) TEX Files of my notes for each of my lectures if you are interested. I projected the notes with an iPad and annotated the notes in class. Those notes contain gaps that I filled in during class with calculations or proofs. Prior to class I published the notes on Canvas, and after class I published the annotated notes as well. As I keep saying, it's up to you what you do, but if you are interested I can provide you with those notes.

I can also send you copies of my exams and exam answers if you are interested.

A note on Grading: The University recently started to pay close attention to grading consistency across several sections of a specific course. While it is OK to have some variation across sections it is reasonable for students to expect that their grade will not depend greatly on the particular teacher from which they take their section of 2270. So for your information, here are the percentages for the grade distribution in Math 2270 during the Fall of 2022, the last time such information is available:

Section	A Range	B Range	C Range	DFWI Range
I	57%	19%	9%	15%
II	65%	21%	5%	9%
III	49%	31%	8%	12%
IV	79%	12%	2%	7%

"DFWI" means the grades of D, E, Incomplete, or withdrawal of the student. The University is particularly concerned about that rate if it gets too large. You can see that students in 2270 usually do rather well, and you want to make sure that your grading range is roughly consistent with the above data.

Please do not hesitate to contact me if you require any information or advice, or if I can help in any way. Linear Algebra is one of our most enjoyable classes to teach, in my humble assessment, and I wish you the best of success, and enjoyment, next semester.

Best wishes,

Peter

SYLLABUS — preliminary version

Week	Date	Lecture	Topic	Textbook	Assignment
1	M 01/08/24	1	Introduction and Technicalities		hw 1
1	T 01/09/24	2	Systems of Linear Equations	1.1	
1	W 01/10/24	3	Row Reduction and Echelon Forms	1.2	
1	F 01/12/24	4	How to solve a linear system		
2	M 01/15/24		**NO CLASS**		
2	T 01/16/24	5	Vector Equations	1.3	hw 2
2	W 01/17/24	6	The Matrix Equation $Ax = b$	1.4	
2	F 01/19/24	7	Solution Sets of Linear Equations	1.5	
3	M 01/22/24	8	Applications of Linear Equations	1.6	
3	T 01/23/24	9	Linear Independence	1.7	hw 3
3	W 01/24/24	10	Linear Transforms and their matrix	1.8-1.9	
3	F 01/26/24	11	Matrix Operations	2.1	
4	M 01/29/24	12	The Inverse of a Matrix	2.2	hw 4
4	T 01/30/24	13	Review		
4	W 01/31/24	14	Exam 1 on Chapter 1		
4	F 02/02/24	15	Characterizations of Invertible Matrices	2.3	
5	M 02/05/24	16	Partitioned Matrices	2.4	hw 5
5	T 02/06/24	17	Matrix Factorizations	2.5	
5	W 02/07/24	18	Subspaces of $\mathbb{R}^n$	2.8	
5	F 02/09/24	19	Dimension and Rank	2.9	
6	M 02/12/24	20	Review		hw 6
6	T 02/13/24	21	Exam 2 on Chapter 2		
6	W 02/14/24	22	Determinants	3.1	
6	F 02/16/24	23	Properties of Determinants	3.2	
7	M 02/19/24		**NO CLASS**		
7	T 02/20/24	24	Cramer's Rule	3.3	hw 7
7	W 02/21/24	25	Vector Spaces and Subspaces	4.1	
7	F 02/23/24	26	Null Spaces etc.	4.2	
8	M 02/26/24	27	Basis and Dimension	4.3, 4.5	
8	T 02/27/24	28	Isomorphisms	4.4	hw 8
8	W 02/28/24	29	Change of Basis	4.6	
8	F 03/01/24	30	Difference Equations	4.8	
9	M 03/04/24		**NO CLASS**		
9	T 03/05/24		**NO CLASS**		
9	W 03/06/24		**NO CLASS**		
9	F 03/08/24		**NO CLASS**		
10	M 03/11/24	31	Eigenvectors and Eigenvalues	5.1	
10	T 03/12/24	32	The Characteristic Equation	5.2	hw 9
10	W 03/13/24	33	Diagonalization	5.3	
10	F 03/15/24	34	More on Eigenvalues and Eigenvectors	5.4-5.5	
11	M 03/18/24	35	Review		
11	T 03/19/24	36	More Review		hw 10
11	W 03/20/24	37	Exam 3 on Chapters 3 and 4		
11	F 03/22/24	38	The Gershgorin Theorem		
12	M 03/25/24	39	Inner Product, Length, and Orthogonality	6.1	
12	T 03/26/24	40	Orthogonal Sets	6.2	hw 11
12	W 03/27/24	41	Orthogonal Projections	6.3	
12	F 03/29/24	42	The Gram-Schmidt Process	6.4	
13	M 04/01/24	43	Least Squares Problems	6.5	
13	T 04/02/24	44	Applications to Linear Problems	6.6	hw 12
13	W 04/03/24	45	Inner Product Spaces	6.7	
13	F 04/05/24	46	Applications of Inner Product Spaces	6.8	
14	M 04/08/24	47	Diagonalization of Symmetric Matrices	7.1	
14	T 04/09/24	48	Quadratic Forms	7.2	hw 13
14	W 04/10/24	49	Constrained Optimization	7.3	
14	F 04/12/24	50	The Singular Value Decomposition	7.4	

15	M 04/15/24	51	More on the Singular Value Decomposition	hw 14
15	T 04/16/24	52	Review	
15	W 04/17/24	53	Exam 4 on chapters 5 and 6	
15	F 04/19/24	54	The QR factorization	
16	M 04/22/24	55	Review	
16	T 04/23/24	56	More Review	

Notes

Linear Algebra: Linear Algebra is the mathematics of functions between **finite dimensional linear spaces**. The elements of those spaces are **vectors**, and the functions are **matrices**. That sounds pretty dry. But Linear Algebra is as central and fundamental to problem solving in Science and Engineering as is Calculus. That's why you need to learn about it. You will also see that it has a beautiful, rich, and *comprehensible* structure. I trust and hope that you will enjoy this class.

Grading: 13 home works (3% each), 4 exams (8% each), and one final exam (29%). There are actually 14 home works, but the first will give all of us a chance to get used to the My Lab system, and will not count for credit.

Textbook: David Lay, Linear Algebra and its Applications, 6th. ed. We will actually be using an electronic version via the University's Inclusive Access Program) which is much cheaper than the printed hard copy. See our home page for details.

How to Succeed in this Class

- **Promise:** If you follow the suggestions in this section you will **save time** and **understand** the subject more **deeply and more effectively**.
- Mathematics in general, and Linear Algebra in particular, is **hierarchical**. Everything we do in an organized class like this is a small extension of what we did previously, often the day before. If you understand what we did yesterday you will **easily understand** what we do today. If you do not, what we do today will be confusing, and making sense of it will be **difficult and time consuming**.
- Read the relevant section in the textbook before each class. After class make sure you understand what we did in class.
- Pay careful attention to the precise language we will develop in this class. If you don't understand a word or phrase, **stop**, go back and review that word or phrase before going on. If you don't understand the language you can't effectively think about the subject, and you won't understand it.
- Do the home work problems corresponding to a certain textbook section after we cover the topic in class, and before you attend the next class.
- Nowadays most linear algebra problems are solved by computer. We need to understand linear algebra so that we can tell computers what to do, and to understand what they are doing. So this class is focused on understanding concepts, facts, properties, and connections. We will do some (small) computations to deepen our understanding, and it's in the nature of computer graded home work that much of it is computational. However, you want to concentrate your attention on the concepts, rather than acquiring computational facility.
- You will often need to read my or your notes, or the textbook, **repeatedly** before you understand what's happening.
- **Come to class.** I will cover much more verbally than what is written in the notes.
- I recommend that you form a **study group** with one or two class mates and meet on a regular basis to study together and to work on the home work together. The purpose of the home work is to help you understand the subject, so you should organize your team work so that every member of your group understands fully what is happening in each problem.
- **Seek help!** Talk with your class mates, ask tutors in the math center, and don't hesitate to contact me with your queries.

Student Information

The instructors in our department have access to the following information about the students registered in their classes: Name, preferred name (if entered in your CIS account), your student ID number, and your photograph (to help us learn your names) on your University ID card. We do not have access to other parts of your University Record.

The remaining items are standard syllabus items unrelated to Covid. Note, however, that some of the services described here may be available only on a modified or limited basis due to the Covid pandemic. Check online or call the relevant unit for up to date information.

Wellness Statement: Personal concerns such as stress, anxiety, relationship difficulties, depression, cross-cultural differences, etc., can interfere with a students ability to succeed and thrive at the University of Utah. For helpful resources contact the Center for Student Wellness at www.wellness.utah.edu or 801-581-7776. (Note: While I have no special expertise in these matters please don't hesitate to talk with me privately about your personal circumstances if you believe this may be useful.)

The Americans with Disabilities Act: The University of Utah seeks to provide equal access to its programs, services and activities for people with disabilities. If you will need accommodations in the class, reasonable prior notice needs to be given to the Center for Disability & Access, 162 Olpin Union Building, 801-581-5020, https://disability.utah.edu/. CDA will work with you and the instructor to make arrangements for accommodations. All written information in this course can be made available in alternative format with prior notification to the Center for Disability & Access.

Addressing Sexual Misconduct: Title IX makes it clear that violence and harassment based on sex and gender (which includes sexual orientation and gender identity/expression) is a Civil Rights offense subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, color, religion, age, status as a person with a disability, veteran's status or genetic information. If you or someone you know has been harassed or assaulted on the basis of your sex, office for equal opportunity and affirmative action including sexual orientation or gender identity/expression, you are encouraged to report it to the University's Title IX Coordinator; Director, Office of Equal Opportunity and Affirmative Action, 135 Park Building, 801-581-8365, https://oeo.utah.edu/contact-us/index.php or to the Office of the Dean of Students, 270 Union Building, 801-581-7066, https://deanofstudents.utah.edu/. For support and confidential consultation, contact the Center for Student Wellness, 426 SSB, 801-581-7776. To report to police, contact the Department of Public Safety, 801-585-2677(COPS), https://police.utah.edu/.

Campus Safety The University of Utah values the safety of all campus community members. To report suspicious activity or to request a courtesy escort, call campus police at 801-585-COPS (801-585-2677). You will receive important emergency alerts and safety messages regarding campus safety via text message. For more information regarding safety and to view available training resources, including helpful videos, visit safeu.utah.edu

University Counseling Center The UCC staff is committed to supporting the mental health needs of our campus community. Their phone number is 801-581-6826. Their hours are Monday-Friday, 8:00am-5:00pm. For after-hours emergencies, contact the 24/7 Crisis Line: 801-587-3000 . More information is at https://counselingcenter.utah.edu/ .

Office of the Dean of Students The Office of the Dean of Students is¡ dedicated to being a resource to students through support, advocacy, involvement, and accountability. It serves as a support for students facing challenges to their success as students, and assists with the interpretation of University policy and regulations. To contact the Office of the Dean of Students, please email deanofstudents@utah.edu or call 801-581-7066. There is more information at https://deanofstudents.utah.edu/ .