MATH 415 AL1
Applied Linear Algebra

Tentative Syllabus (01/15/2021)

Lectures, Labs, Discussions.

- Lecture: Asynchronous online (optional synchronous review one hour/week)
- Discussion Sections: synchronous online, various times Tuesdays and Thursdays (Sections PDA - PDQ)
- TA office hours: TBA
- Instructor office hours: TBA

Instructors & TAs.

- Lecture instructor: Jer-Chin Chuang (jchuang@illinois.edu)
- TAs: Hung Cuu (hungchu2@illinois.edu), Mingyan (Simon) Lin (mlin39@illinois.edu), Ken Willyard (kenw2@illinois.edu), Yuji Yang (yujiy2@illinois.edu)

Introduction.

This is a first course in linear algebra. This covers basic definitions and algorithms of the subject needed in the higher level (engineering, science and economics) courses and more sophisticated mathematical techniques such as the Singular Value Decomposition.

Throughout the course, various applications to real life problems (for example Google's PageRank algorithm and JPEG image compression) will be introduced.

The AL section of MATH 415 differs from the PL section in that the latter has a laboratory component which considers Python implementations of the various applications discussed. MATH 415 PL is also pilot for a future course MATH 257 - Linear Algebra with Computational Applications which will eventually replace MATH 415.

Technical equipment. This course will be conducted entirely online. As such, each student will be assumed throughout the semester to have the necessary technical equipment to participate in course activities:

- a computer/laptop/tablet with a webcam and a microphone,
- a stable internet access, sufficient bandwidth and data allowance for using a webcam on Zoom.

Please contact the Student Assistance Center (helpdean@illinois.edu) immediately if you are missing any of required technology.

Other Linear Algebra courses. Be aware that course credit is not given for both MATH 415 and any of MATH 125, MATH 225, MATH 227, MATH 416 or ASRM 406. Any enrollment related questions should be sent to mathadvising@illinois.edu.

Two disclaimers and a request.

- ⚠ This is not a course that only teaches you how to compute stuff, and we know your computer will always be quicker. Modern applications of Linear Algebra require a sophisticated understanding of theory and methods, and learning these is the purpose of this course. Some of it might look like "abstract" Linear Algebra, but through the applications we present you will see that this is indeed "applied" Linear Algebra.
- ⚠ If you already know some Linear Algebra, this course might look very easy at the beginning. Don't be fooled into thinking it will stay easy. It is likely that even the material familiar to you will be covered in more depth here. It is also likely that the exams will require a deeper understanding of the concepts you already know something about. *So it is a good idea to take this course seriously from the beginning.*
- ⚠ If you find a typo or an error in any part of this course, please let us know by sending an email to the instructors. We appreciate your help, and are also happy to hear any further comments or suggestions. Thank you!

Learn@Illinois. This course has a page on Learn@Illinois:

TBA

All material will be available there. **You can check all your scores on this website.** Please note that if you have just registered for the course, you will automatically be given access to the Learn@Illinois website within a few hours. Only if you do not have access to the course site 48 hours after registering, contact your instructor.

Setup. This course consists of three hours per week of lecture and one hour per of week of active learning (paper-based) discussion sections.

Discussion section. Discussion sections are held synchronously online on Zoom on Tuesdays and Thursdays:

- Section ADA, Tuesdays 8am, Zoom ID: TBA, Password:TBA
- Section ADB, Thursdays 8am, Zoom ID: TBA, Password:TBA
- Section ADC, Tuesdays 9am, Zoom ID: TBA, Password:TBA
- Section ADD, Thursdays 9mm, Zoom ID: TBA, Password:TBA
- Section ADE, Tuesdays 10am, Zoom ID: TBA, Password:TBA
- Section ADF, Thursdays 10am, Zoom ID: TBA, Password:TBA
- Section ADG, Tuesdays 11am, Zoom ID: TBA, Password:TBA
- Section ADH, Thursdays 11am, Zoom ID: TBA, Password:TBA
- Section ADI, Tuesdays 12pm, Zoom ID: TBA, Password:TBA
- Section ADJ, Thursdays 12pm, Zoom ID: TBA, Password:TBA
- Section ADK, Tuesdays 1pm, Zoom ID: TBA, Password:TBA
- Section ADL, Thursdays 1pm, Zoom ID: TBA, Password:TBA
- Section ADM, Tuesdays 2pm, Zoom ID: TBA, Password:TBA
- Section ADN, Thursdays 2pm, Zoom ID: TBA, Password:TBA
- Section ADO, Tuesdays 3pm, Zoom ID: TBA, Password:TBA
- Section ADP, Thursdays 3pm, Zoom ID: TBA, Password:TBA
- Section ADQ, Tuesdays 10am, Zoom ID: TBA, Password:TBA

Only attend the discussion section you are signed up for.

During the discussion sections, TAs will distribute worksheets to be completed collaboratively in small groups. At the end of the period, each group will submit one worksheet. Complete solutions to the worksheet will be posted afterwards on Learn@Illinois.

Attendance will be taken. You will be given a password at the beginning of each discussion section and you will have 15 minutes to mark yourself present on Learn@Illinois. *Note that it is not enough to just be present.* You have to be actively working with your group, and the worksheet submitted by your group must show that your group put in the necessary effort. If this is not the case, we will not consider you present and will not receive points for participation.

Unless there are special circumstances or you are told otherwise by the TA, we expect you to have your video and your audio active through the whole Zoom meeting.

Textbook. We will post extensive lecture notes for all lectures and practice problems online. For many students these notes are enough. If you still want to buy/download a book, here are four really good options (two of them free!):

- Philip N. Klein, *Coding the Matrix: Linear Algebra through Applications to Computer Science*, first edition, Newtonian Press
- Feryal Alayont, Steven Schlicker, *Linear Algebra and Applications:An Inquiry-Based Approach*, scholarworks.gvsu.edu/books/21/
- David Cherney, Tom Denton,Rohit Thomas, Andrew Waldron, *Linear Algebra*, www.math.ucdavis.edu/∼linear/
- Gilbert Strang, *Linear Algebra and its Applications*, fourth edition, Cengage.

You are not required to buy any of these textbooks.

Slides. Lecture notes have been on Learn@Illinois. An interactive version with fill-in boxes is also available.

Videos. We will post module videos on the Learn@Illinois page of this course. An interactive version of the slides with fill-in boxes is also available. If you would like to use this feature, print out the fill-in slides and fill them out on your own or while watching the videos.

There are many other great (free) videos about linear algebra. Here are some we recommend as an addition (not a substitute) for the lecture videos.

- *Essence of Linear Algebra* by 3Blue1Brown, on Youtube, highly recommended
- MIT lectures by Gilbert Strang, MIT Open Courseware
- *Coding the Matrix* videos by Philip Klein, on Youtube

Online homework. Each module comes with two sets of homework, both available through the Learn@Illinois website.

The Checkpoint quizzes consist of two to three easy conceptional questions. We recommend that you take the quiz immediately after watching the module video. These quizzes make sure that you have watched the video and have at least a basic

understanding of concepts covered in the video. *Note that you only have one attempt for each quiz.*

The PrairieLearn homework associated with each module focuses on the computations and algorithms covered in the module. In this homework you will have to do the computation we did in the video by yourself. See below for more information on PrairieLearn.

Either of the above two types of assessments in the first two weeks of the semester will not count towards the final grade due to changing enrollments during that period.

Weekly assignment schedule. Weekly assignments due dates are as follows:

- ⌛ Checkpoint Quizzes (covering modules from previous week), due Thursdays 11:59PM
- ⌛ PrairieLearn Homework (covering modules from previous week), due Mondays 11:59PM at 100% (see below)

For example, checkpoint quizzes 1-4 are due on Thursday 01/28 (Thursday of Week 1). PrairieLearn Week 1 homework is due on Monday 02/01 (Monday of Week 2).

Netiquette. Since this is an online course, please be respectful of your fellow classmates and teaching staff in all online communications. Fostering a helpful learning environment requires everyone's cooperation. Remember that forum posts are visible to all students and staff in the course (around 450 people). So please double-check your posts before submitting them.

PrairieLearn. We will use PrairieLearn for homework. You have to access PrairieLearn through the Learn@Illinois website.

Homework (at 100%) will be due on Mondays at 11:59PM. The first homework is due on Monday 02/01 (see Week 1 tab). The PraireLearn homework will focus on computations, while the worksheets in the discussion section will focus more on conceptual problems.

How points are given on PrairieLearn. PrairieLearn places emphasis on mastery. The idea is to keep doing questions until you master the underlying concept or method. Once you do, you should be able to answer these questions very quickly.

The way this works in PrairieLearn is that each question has a value, a point total, and a point maximum. If you answer a question correctly, two things happen:

- ▶ The point total increases by the value, until you reach the point maximum.
- ▶ The value increases.

If you answer a question incorrectly, one thing happens:

- ▶ The value goes back to what it was originally.

This system rewards repeated correct answers, which tend to demonstrate mastery. There is no penalty (other than resetting the value) for answering a question incorrectly, so don't be afraid to submit an answer. Similarly, don't be afraid to keep doing

a question after you reach the point maximum - your point total with never go down!

Credit. There is no need to "submit" your homework. The system will record whatever your score is at that time. However, you'll note the following line at the top of your screen:

Available credit: 110% until 11:59PM, Fri, 01/29

What this means is that if you reach 100% prior to 11:59AM on that Friday - i.e., complete the homework early - you will receive an extra 10% bonus. You will see this reflected in your score (the instant you reach 100%, it will jump to 110%).

If you click on the "?" just to the right of the line about available credit, you'll see all the dates associated with this homework. In particular, it says:

- you can receive 100% until 11:59PM, Monday, 02/01,
- you can receive 80% until 11:59PM, Monday, 02/08.

Note that your score will never go down. For example, if you achieve 90% by 11:59PM on Monday, 02/01, you won't be able to increase your score after that time, but you won't be penalized for not reaching 100% - your score will remain 90% forever. On the other hand, if you achieve only 70% by 11:59PM on Monday, 02/01, you will be able to increase your score after that time (to a maximum of 80%).

Please note that your overall PrairieLearn score is capped at 100%. So even if you score 110% on every assignment, you will only receive 100% overall.

Typos/Errors. If you believe there is a typo or an error in a question, or if you believe your answer was graded incorrectly, please take a screenshot and send an email to your instructor. We have access to all of your submissions and can easily check to see what, if anything, went wrong.

CampusWire. All announcements will be posted on CampusWire at

TBA

Please make sure you are signed up for CampusWire (PIN: TBA). Questions about the course material, or the organization of the course, that potentially are of interest to everyone in the class, should all be posted on CampusWire.

If you have a private question (for example about your grade or because you have to miss an exam), please contact your instructor via email. When posting on CampusWire, please use the subject line wisely. For example, if you ask something about matrix multiplication in Lecture notes 5, write "Lecture notes 5 - Matrix multiplication" and not just "Question about matrices". In addition, please post to the entire class whenever this is appropriate. No question will ever be held against you.

When you send an email to one of the instructors, please clearly write your name somewhere and please start the subject line with "MATH 415 AL". This will make sure that your mail isn't lost.

Syllabus Quiz. Because of the online format for this course, familiarity with course policies will be essential. All students will be required to complete by 5PM Central

Time Friday, February 12th a syllabus quiz on Learn@Illinois. This quiz covers basic course policies. It is open-notes and unlimited attempts are allowed.

Exams. There will be three midterm exams and a final exam, all administered through CBTF (see below). The midterms are from 7-7:50PM Central Time on the following Thursdays:

- **Midterm 1: Thursday, February 18**
- **Midterm 2: Thursday, March 18**
- **Midterm 3: Thursday, April 15**
- **Final: TBA.**

We are required to cancel three classes because of the evening exams. The canceled classes are:

- Friday, February 19
- Friday, March 19
- Friday, April 16

Conflict exams are available for each of the midterms. For a list of permissible reasons, see the CBTF website. Students must register directly with CBTF to request a conflict exam. Requests must be submitted **at least 48 hours** before the scheduled main exam time. Requests after this deadline will not be accepted. Please provide sufficient details in your request regarding your need for a conflict exam. *Requests with insufficient explanation will not be approved.*

There will be no make-up exams. Instead, if you miss an exam and have a valid excuse, we will mark the exam as 'excused'. An 'excused' exam means that this exam will not be taken into account in the computation of your grade. **Valid excuses must be documented** and must be reported to your instructor before the regularly scheduled exam times listed above.

CBTF. This course uses the College of Engineering Computer-Based Testing Facility (CBTF) for its quizzes and exams:

https://cbtf.engr.illinois.edu.

The policies of the CBTF are the policies of this course, and academic integrity infractions related to the CBTF are infractions in this course.

If you have accommodations identified by the Division of Rehabilitation-Education Services (DRES) for exams, please email your Letter of Accommodation (LOA) to CBTF Manager Carleen Sacris at sacris1@illinois.edu before you make your first exam reservation.

Any problem with testing in the CBTF must be reported to CBTF staff at the time the problem occurs. *If you do not inform a proctor of a problem during the test, then you forfeit all rights to redress.*

Cheating. No books, notes, calculators, cheat sheets or electronic devices are allowed during the exams. We take cheating very seriously! A more detailed description of the University policy on cheating and plagiarism may be found in the following link:

http://www.las.illinois.edu/students/integrity/

Grading. The course grade will be the average of your homework, worksheets, midterm exams, and final exam grades, weighted as follows:

- 2% syllabus quiz
- 7% discussion section attendance/completion (the two lowest scores will be dropped)
- 13% PrairieLearn homework (the two lowest scores will be dropped)
- 5% Check point quizzes (the two lowest scores will be dropped)
- 17% each Midterm exam (total 51%)
- 22% final exam

In addition: If your final exam score is higher than one of your midterm scores, then we will replace your lowest midterm score by your final exam score.

If you miss one midterm (**and have a valid excuse**), we will use the average of the two other midterms and the final exam as the score for the midterm you missed. We then apply the above calculation (including the potential replacement of your lowest midterm score).

If you miss more than one midterm, please contact your instructor.

Letter grades will be assigned according to (this is for the percentage, not for the absolute score!):

- 100.00 % - 98.00 % $\rightarrow$ A+
- 97.99 % - 93.00 % $\rightarrow$ A
- 92.99% - 90.00% $\rightarrow$ A-
- 89.99 % -87.00 % $\rightarrow$ B+
- 86.99 % - 83.00 % $\rightarrow$ B
- 82.99 % - 80.00 % $\rightarrow$ B-
- 79.99 % - 77.00 % $\rightarrow$ C+
- 76.99 % - 73.00 % $\rightarrow$ C
- 72.99 % - 70.00 % $\rightarrow$ C-
- 69.99 % - 67.00 % $\rightarrow$ D+
- 66.99 % - 55.00 % $\rightarrow$ D
- 54.99 % -0.00 % $\rightarrow$ F

Usually around 30% of the students get an A letter grade (including +/-) and around 70% score a B letter grade or higher. The median score is usually between 83% and 84%. The average GPA of this course over the last few years has been around 3.0. This will also be the case this semester.

We will renormalize each of the midterms and final exam such that the distribution of letter grades coincides with this historic distribution of the letter grades for MATH 415. No further curve will be applied at the end of the course.

There will be **no extra credit.** So make sure to work hard for every midterm!

Please check each week that your score was entered correctly on Learn@Illinois. With so many students it can happen that your grade is entered incorrectly. If, after an exam or a quiz, you find an error in the grading of your exam, please see us *immediately* before or after class/discussion section or during our office hours. It can always happen that we made a mistake while grading your exam, so we always encourage you to see us if you think that happened. *Rescoring requests will only be considered within a week after the posting of assessment scores.* So don't wait! With 500 students there are always many cases where students are close (sometimes even very close) to the next letter grade, and at the end of the semester make the case that they should receive higher grades. Unfortunately, in almost all cases we can not grant the request without being unfair to other students—even if we would like to!

Course Calendar

Date	Week	Lecture	Topic
01/25	1	1	Introduction to linear systems, Matrices
01/27	1	2	Echelon form of matrices, Gaussian Elimination
01/29	1		Review
02/01	2	3	Linear combinations, Matrix vector multiplication
02/03	2	4	Matrix multiplication, Properties of matrix multiplication
02/05	2		Review
02/08	3	5	Elementary matrices, Inverses of matrices
02/10	3	6	Computing an inverse, LU decomposition
02/12	3		Review
02/15	4	7	Solving linear systems using LU, Inner products
02/17	4		No class
02/18	4		Midterm 1; no class 02/19
02/22	5	8	Subspaces of $\mathbb{R}^n$, Column spaces and nullspaces
02/24	5	9	Abstract vector spaces, Linear independence
02/26	5		Review
03/01	6	10	Basis and dimension, The four fundamental subspaces
03/03	6	11	Orthogonal complements, Graphs
03/05	6		Review
03/08	7	12	Coordinates, Orthonormal bases
03/10	7	13	Linear transformations, Coordinate matrix
03/12	7		Review
03/15	8	14	Determinants, Cofactor expansion
03/17	8	15	Eigenvectors and Eigenvalues
03/18	8		Midterm 2; no class 03/19
03/22	9	16	Properties of eigenvectors, Markov matrices
03/24	9		No class
03/26	9		Review
03/29	10	17	Diagonalization, Powers of matrices
03/31	10	18	Matrix Exponential, Linear Differential Eq's
04/02	10		Review
04/05	11	19	Orthogonal projection
04/07	11	20	Least squares solutions, Linear Regression
04/09	11		Review
04/12	12	21	Gram-Schmidt process, QR decomposition
04/14	12	22	Spectral Theorem
04/15	12		Midterm 3; no class 04/16
04/19	13	23	SVD, Low rank approximations
04/21	13	24	Pseudo-Inverse, Least squares solutions via SVD
04/23	13		Review
04/26	14	25	Principal Component Analysis
04/28	14	26	Review complex numbers, Complex linear algebra
04/30	15		Principal Component Analysis
05/03	15	27	Leeway
05/05	15	28	Review