CSci 2033 Spring 2018

Elementary Computational Linear Algebra

General Information

Linear Algebra plays a central role in many computer science areas (computer graphics, data mining, robotics, networking, ...). This course is an introduction to linear algebra and matrix computations for computer scientists. It covers the fundamentals of linear algebra (vectors, matrices, determinants, rank, eigenvalues, ...), as well as standard algorithms for solving common matrix problems (linear systems, least squares systems, ...). The course aims at providing a solid foundation in linear algebra and matrix computations. It blends theory, algorithms, and applications.
The course involves three hours of lecture and one hour of discussion per week. In addition, you should expect to spend 10-15 hours per week on independent homework, reading assignments, and other studying.

- **Class Schedule:** MWF 10:10 – 11:00am (01/17/2018 - 05/04/2018) – Blegen hall 10.
- **Instructor:** Yousef Saad `http://www.cs.umn.edu/~saad`
  [e-mail: saad@umn.edu, Office: 5 -225B Keller Hall – Office Phone: (612) 624 – 7804.]

Prerequisites

Calculus I or equivalent, (e.g. Math 1271, 1371, or equivalent). Students are also expected to have had some programming experience, in any programming language. Note: students who have already taken MATH 2243/2373/2471/2574H, or need to take one of these as part of a double major, etc., may not need to take CSCI 2033. Please see the CS Undergraduate Guide page on course substitutions `https://www.cs.umn.edu/academics/undergraduate/guide/cs-requirements/acceptable-substitutes` or one of the CS undergraduate advisors for more information.

Textbook

- *Linear Algebra and its applications* David C. Lay, Steven Lay, Judi McDonald. 5th edition (4th edition also OK). Addison-Wesley 2012, 2016. ISBN 978-0-321-98261-2.
  The *Study guide* for this text is a nice addition that will help you ask the right questions when studying - but I will not refer to it in class.

Supplemental material

Matlab will often be used for writing short programs (in particular for homeworks). Matlab has extensive online documentation and there are many resources posted on the web, so a manual

is not really needed. Should you prefer to have a hard-copy manual, here are a couple you can consider:

- *" Matlab, Third Edition: A Practical Introduction to Programming and Problem Solving 3rd Edition"* by Stormy Attaway. (2013) Publisher: Elsevier, ISBN-13: 978-0124058767 ISBN-10: 0124058760
- *"Mastering Matlab"* by Duane Hanselman and Bruce Littlefield. Prentice Hall (2011) ISBN-13: 978-0136013303 ISBN-10: 0136013309. Excellent book.

You may also be interested in a few supplemental resources for studying:

- *Elementary Linear Algebra* by Howard Anton is another text (there is a paperback edition).
- *Introduction to Linear Algebra.* G. Strang. Wellesley Cambrdige Press, 2009.

Class Websites

The main class web-site is

`www-users.cselabs.umn.edu/classes/Spring-2018/csci2033-morning/`

There you will find a detailed schedule, the office hours of the instructor and TAs, homework assignments, latest announcements, etc.
We will use also moodle **for posting grades** and for all postings by the TAs – The link to moodle will be available on the cse class web-site.

Evaluation

The evaluation of your performance in this class will be based on the following :

- Homeworks: 26 % [4 HWs at 6.5% each]
- Quizzes 39 % $= 6 \times 6.5$ % (best 6 out of 8 quizzes)
- Final exam: 35%

Quizzes

There will be eight quizzes. These can be viewed as short versions of mid-term exams; in particular they are scheduled ahead of time. Each quiz will consist of 2 to 4 short problems and will take 20mn.
Your worst 2 scores out of the 8 quizzes – including any zeros that are due to absences – will be discarded so only your best 6 quizzes will count when calculating your total score for the class. *There will be no make-up quizzes (no exceptions)*. If you have more than 2 legitimate (documentation required) absences for illness or other emergencies you will need to talk to the instructor about alternate solutions.
On another note, the quizzes are *always* comprehensive: I can ask questions about any topic that has been previously seen – especially when the topic is important for the rest of the course and

we (TAs and instructor) feel that it is not yet quite well understood by *all* students. There will also be a final exam which counts for 35% of your final score. The final exam is comprehensive.
In-Class practice exercises. There will also be short in-class practice exercise sessions. These will be posted in advance and we will solve them in class – your participation will be important.

Assignments

Assignments are due at the beginning of class on the due date unless otherwise stated. A 25% penalty will be applied to the grade for all assignments turned in up to 24 hours late. Those turned in between 24 and 48 hours late will receive a 50% penalty. Any assignments submitted more than 48 hours late will get a zero grade.
You are welcome to discuss the assignment problems in general terms with others, but you must work out and write your own solutions: any in-person or online discussion should stop before you start discussing or designing a solution. This means not only writing the final program, but also key preliminary and intermediate steps such as problem analysis, solution design, debugging, etc. Copying others solutions or letting another person copy your solutions is serious and can result in failing the course. If you have any doubts about what is and is not allowable in this class, please ask the course instructor.

Grading

Grades will be posted on moodle immediatly after each homework or quiz is graded. It will usually take about one week to grade a HW or a quiz. It is important that you check your grades regularly. If you see a discrepancy between your grades and the grades posted, you need to alert the instructor (cc. the TA responsible for that HW/quiz) immediatly. You have one week after the homework/ quiz is returned for requesting a change. Details on this can be found in the general **policy on homeworks and exams/quizzes** which is posted in the class web-site.

Final grades

Final grades will **not** be based on a competitive curve but will be decided based on the following scale, where T is the total score (out of 100) you achieved in the class.

A : $100 \geq T \geq 93$	**A-** : $93 > T \geq 87$	**B+** : $87 > T \geq 84$
B : $84 > T \geq 80$	**B-** : $80 > T \geq 75$	**C+** : $75 > T \geq 70$
C : $70 > T \geq 60$	**C-** : $60 > T \geq 55$	**D+** : $55 > T \geq 50$
D : $50 > T \geq 40$	**F** : $40 > T$	

For example, to get a B you will need a grade between 80 (inclusive) and 84 (exclusive).

EXEMPTIONS FROM THE FINAL EXAM: *Students with a (prorated) score of 95% or higher after the last quiz* will be exempted from the final and will get an A for the class.

Students taking the class on an S-N basis are expected to earn a total score of at least 60% to get an S grade. They will be exempted from the final exam and will receive an S for the class if their score after the last homework is 80% or better.
Everyone else *must* take the final exam.

Scholastic conduct and other policies

Standard University of Minnesota policies apply to this course on matters of:

- the student conduct code,
- use of personal electronic devices in the classroom,
- scholastic dishonesty,
- makeup work for legitimate absences,
- appropriate student use of class notes and course materials,
- grading and transcripts,
- sexual harassment,
- equity, diversity, equal opportunity, and affirmative action,
- disability accommodations,
- mental health and stress management, and
- academic freedom and responsibility.

For detailed information about these policies, please see:
`https://policy.umn.edu/education/syllabusrequirements-appa`

Cheating cases will be dealt with in a very strict manner. At a minimum, violators will fail the course and will have their names recorded. Please consult the `http://www1.umn.edu/regents/polindex.html#1` Regents' Student Conduct for additional information.

Overview of topics to be covered (tentative)

- Linear systems. Solving Linear systems (Gaussian eliminination, Gauss-Jordan elimination) [1.1]; Illustrations with matlab. Vectors and vector equations Linear combinations of vectors; Matrices; columns, rows; [1.3]; Row reduction and Echelon forms [1.2];
- The matrix equation $Ax = b$ [1.4] Solution sets of Linear Systems [1.5]; Application of linear systems [1.6]
- Linear independence [1.7]; Linear Transformations [1.8]; The matrix of a Linear Transformation [1.9]; Application: Linear models in business, sicence, engg. [1.10]
- Matrices and Matrix operations [2.1]; The identity matrix; Inverse of matrix; [2.2]
- Characterization of invertible matrices [2.3]; Matrix factorization [2.5];

- Determinants [3.1, 3.2, 3.3] Applications: area and volume.
- Vector spaces and subspaces [4.1]; Null Space, Column space, and linear transformations[4.2]; Linearly independent sets, bases [4.3]; Coordinate systems [4.4]; Dimension of a vector space [4.5] ; rank [4.6]; Change of basis [4.7].
- Eigenvalues and eigenvectors [5.1]; Characteristic equation [5.2]; Diagonalization [5.3] ; Application: Markov chains, page-rank; Recurrences.
- Inner Products. Lengths, Orthogonality. [6.1]; Orthogonal sets [6.2]; The Gram-Schmidt process [6.4]; Least Squares problems, Applications: regression, ... [6.5]
- Singular Value Decomposition. [7.4]; Applications: Principal Component Analysis; Image compression.