

CS 475/675 – Spring 2021: Course Outline

Computational Linear Algebra

Instructor: Leili Rafiee Sevyeri
Course Material: Posted Mondays on Piazza and LEARN

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CS475/675 Website (Piazza): <https://www.piazza.com/uwaterloo.ca/summer2021/cs475675/home>

Piazza sign-up link: <https://www.piazza.com/uwaterloo.ca/summer2021/cs475675>

Calendar Description: <http://www.ucalendar.uwaterloo.ca/1516/COURSE/course-CS.html#CS475>

Schedule of Classes: <http://www.adm.uwaterloo.ca/infocour/CIR/SA/under.html>

Course Objectives

Numerical linear algebra is a basic part of many problems in scientific computation. This course provides an overview of algorithms and uses numerical linear algebra techniques for solving application problems. The course is structured around four major topics: (1) solving special linear systems, (2) least squares problems, (3) eigenvalue problems, and (4) singular value decomposition. Students will study the concepts of matrix factorization, implement algorithms using MATLAB, and apply numerical linear algebra techniques to solve application problems.

Tentative Schedule

Week of May 10	Introduction, LU Factorization Cholesky factorization, tridiagonal, banded matrices	
Week of May 17	1D, 2D Laplacian Sparse GE, graph representation	
Week of May 24	Ordering Methods Stability of Factorization	
Week of May 31	Image Denoising Iterative Methods	Assignment 1 Due Mon May 31
Week of June 8	Conjugate Gradient Least squares problems	
Week of June 7	Gram-Schmidt orthogonalization QR Factorization	
Week of June 14	Householder transformation Eigenvalue problems	Assignment 2 Due Mon June 14
Week of June 21	Reduction to Hessenberg	
Week of June 28	Power iteration, inverse iteration QR method with shifts, Applications	Midterm due Tue June 29
Week of July 05	Singular value decomposition Bidiagonalization	
Week of July 12	Application using SVD	Assignment 3 Due Tue July 13
Week of July 19	Convergence of iterative methods	
Week of July 26	Preconditioning techniques	Assignment 4 Due Tue July 27
Final Exam due August 13		

This schedule is tentative and subject to change.

- **Sources of Information.** The main source of information for the course is the material posted on Piazza under “Resources” tab. Course material will consist of lecture notes and demo videos. You may also wish to consult one or more of the optional textbooks below.

- **Optional Texts.**

- *Numerical Linear Algebra*, L.N. Trefethen and D. Bau III, SIAM, QA184.T74, 1997 (optional textbook, recommended, first 5 chapters on Trefethen’s webpage).
- *Iterative Methods for Sparse Linear Systems, 2nd edition*, Y. Saad, SIAM, QA188.S17, 2003 (free online).
- *Applied Numerical Linear Algebra*, J. Demmel, SIAM QA184.D455, 1997 (free online).
- *Matrix Computations*, G. Golub and C. van Loan, Johns Hopkins, QA188.G65x, 1989 (free online).

- **Piazza.** We will make use of Piazza for course management, news, and online discussion. Rather than emailing questions to the instructor or TA, you are encouraged to post your questions on Piazza so that everyone can benefit from the discussion and answers. Note however that you should *not* publicly post solutions (or proposed/partial solutions) to graded assessment questions on this forum. (It is okay to include solutions in private posts to instructors/TAs.)

The links to the Piazza page (and sign-up link) are at the top of this document.

- **Programming Languages.** MATLAB will be used for all programming assignments. Based on the course prerequisites you will likely already be familiar with MATLAB, but you can also find many resources online if you need to review.

- **Assignments.** Assignments will be posted on Piazza around two weeks before they are due. Check to make sure you are using the most recent version (corrections will be made to the posted assignment if necessary). There will be four assignments which are to be submitted **electronically by 1pm EDT on the due date**. Details of the electronic submission process (through Crowdmark and LEARN) will be provided with the assignment.

Students are welcome to discuss the assignment solutions with the instructor and TA after the assignments are returned. Assignment solutions will not be posted publicly.

Assignment marks will be posted on LEARN. Notify the instructor immediately if you believe the mark was recorded incorrectly. The marks recorded on LEARN are regarded as final two weeks after the assignments are returned.

- **Polls and Quizzes.** There will be a Piazza poll and a LEARN quiz weekly due on **Fridays at 1pm EDT**. The Piazza poll mark will be participation based, i.e., you receive full marks for any answer (correct or incorrect). LEARN quizzes provide two attempts and your highest mark is used in your grade.

- **Late Policy.** A late penalty of 25% per day will be applied to any submissions after the deadline (for example, if your assignment is submitted 47 hours after the deadline, your grade will be calculated and then multiplied by 50%). Late penalties are applied to the entire assignment (not individual components/questions). You may not hand in part of your assignment on time and part late; if this happens, the entire assignment will be marked as late.

No late days will be allowed for polls, quizzes, midterm, or final. A mark of 0% will be recorded if any of these components are late.

- **Assignment Help and Collaboration.** Students can discuss general concepts and problems with other individuals in class. However, the solution that you submit must be worked out by yourself and written in your own words. You can also post to Piazza or visit instructor or TA office hours.

Note that current Math faculty policy is that a mark of -100% can be recorded for the assignment in question in the case of cheating/copying.

- **Assignment Marking.** The assignments will consist of programming problems and analytic work. Your code is an important part of the assignment: it should be included with your submission and it should be readable and well-commented.

Assignment figures and graphs should be carefully thought out to present the data and your conclusions in an effective and clear manner. Poor presentation of your work will result in a poor mark. MATLAB has good plotting functions. Create figures with MATLAB to include in your assignments.

In all cases, we expect you to clearly explain what you have done. You should also submit copies of your code (along with documentation) to the associated LEARN dropbox.

- **Assignment/Midterm Marking Appeals.** If you feel your assignment/midterm was marked incorrectly, write a clear explanation of what you would like reviewed, and communicate it to the course instructor or the appropriate TA. Reviews of assignment/midterm marking must be requested within one week of the time the assignments/midterm grades are returned.

- **Course Grade.**

For undergraduate students: Course grade is calculated from weekly Piazza polls and LEARN quizzes, four assignments, a midterm take-home exam, and a final take-home exam.

Mark breakdown:

- Weekly Piazza polls: $0.5\% \times 12 = 6\%$ (participation)
- Weekly Learn quizzes: $1\% \times 12 = 12\%$ (two attempts)
- Assignments: $10\% \times 4 = 40\%$
- Midterm: 18%
- Final: 24%

For graduate students:

- Weekly Piazza polls: $0.5\% \times 12 = 6\%$ (participation)
- Weekly Learn quizzes: $0.5\% \times 12 = 6\%$ (two attempts)
- Assignments: $10\% \times 4 = 40\%$
- Midterm: 16%
- Final: 20%
- Course project 12%

More information about the course project (for graduate students) will be announced by the end of the second week of classes.

- **Midterm.** Take-home midterm will be distributed Weds, June 23 and due **Tue, June 29 at 1pm EDT.**
- **Final Examination.** Take-home final will be distributed Sat, Aug 7 and due **Fri, Aug 13 at 1pm EDT.**

Students must inform the registrar's office if they have a conflict in the final examination schedule, by the date posted on the registrar's web site. Note that there is a precise definition of conflict as defined by the registrar. <http://www.registrar.uwaterloo.ca/exams/finalexams.html>

The course instructor will then be contacted by the registrar's office to make alternate arrangements. Under no circumstances will the instructor make alternate arrangements for a final examination unless given instructions by the registrar's office.

- **Plagiarism.** Plagiarism is representing the work of others as your own. Plagiarism on exams includes using unauthorized aids or communicating in any way with others during an examination. Plagiarism on assignments includes copying another student's solution and submitting it as your own, allowing another student to copy your solution, collaborating excessively with another student, or obtaining solutions from any other source. See the section on Discipline below for typical penalties.

All academic offenses are reported to the Associate Dean for Undergraduate Studies and are recorded in the student's file. Subsequent academic offenses in the same course or in other courses will lead to more severe penalties, up to and including suspension and expulsion.

As noted above, we encourage you to discuss *general* concepts and problems with classmates, tutors, TAs, and the instructor. However, the solution that you submit must be worked out by yourself and written in your own words. It is not acceptable to work on an assignment with somebody else and write it up individually. The only exceptions are assignments or projects (if any) which the instructor specifically designates as group activities. When discussing course matters, do not take notes, and do not look at another person's partial solutions, or show them yours.

- **Academic Integrity.** In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. Refer to the Academic Integrity website for details: <http://www.uwaterloo.ca/academicintegrity/>
- **Grievance.** A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4, <http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm> When in doubt please be certain to contact the department's administrative assistant who will provide further assistance.
- **Discipline.** A student is expected to know what constitutes academic integrity to avoid committing academic offenses and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offense, or who needs help in learning how to avoid offenses (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean. For information on categories of offenses and types of penalties, students should refer to Policy 71, Student Discipline: <http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm> For typical penalties check Guidelines for the Assessment of Penalties: <http://www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm>
- **Avoiding Academic Offenses.** Most students are unaware of the line between acceptable and unacceptable academic behaviour, especially when discussing assignments with classmates and using the work of other students. For information on commonly misunderstood academic offenses and how to avoid them, students should refer to the Faculty of Mathematics Cheating and Student Academic Discipline Policy <https://uwaterloo.ca/math/current-undergraduates/regulations-and-procedures/cheating-and-student-academic-discipline-gu>
- **Appeals.** A decision made or penalty imposed under Policy 70, Student Petitions and Grievances (other than a petition) or Policy 71, Student Discipline may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72, Student Appeals, <https://uwaterloo.ca/secretariat-general-counsel/node/99>
- **Note for Students with Disabilities.** AccessAbility Services <https://uwaterloo.ca/disability-services/>, located in Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with AccessAbility Services at the beginning of each academic term.
- **Intellectual Property.** Students should be aware that this course contains the intellectual property of their instructor, TA, and/or the University of Waterloo. Intellectual property includes items such as:
 - Lecture content, spoken and written (and any audio/video recording thereof);
 - Lecture handouts, presentations, and other materials prepared for the course (e.g., PowerPoint slides);
 - Questions or solution sets from various types of assessments (e.g., assignments, quizzes, tests, final exams); and
 - Work protected by copyright (e.g., any work authored by the instructor or TA or used by the instructor or TA with permission of the copyright owner).

Course materials and the intellectual property contained therein, are used to enhance a student's educational experience. However, sharing this intellectual property without the intellectual property owner's permission is a violation of intellectual property rights. For this reason, it is necessary to ask the instructor, TA and/or the University of Waterloo for permission before uploading and sharing the intellectual property of others online (e.g., to an online repository). Permission from an instructor, TA or the University is also necessary before sharing the intellectual property of others from completed courses with students taking the same/similar courses in subsequent terms/years. In many cases, instructors might be happy to allow distribution of certain materials. However, doing so without expressed permission is considered a violation of intellectual property rights.

Please alert the instructor if you become aware of intellectual property belonging to others (past or present) circulating, either through the student body or online. The intellectual property rights owner deserves to know (and may have already given their consent).