

University of Waterloo, Fall 2020
AMATH740 / CM770 / CS770: Numerical Analysis
"Numerical Methods for Computational Science and Data Science"

Instructor: [Prof. Hans De Sterck](#), **email:** hdesterck@uwaterloo.ca

Lecture materials: will be delivered online (pdf board notes and course notes)

Live-streamed flipped-classroom sessions (Zoom, optional attendance, recorded):

Wednesdays and Fridays 10:00-11:20am (to be confirmed)

TA: Mohammad Aali, **email:** mohammad.aali@uwaterloo.ca

Instructor Office hours: Wednesdays 9:00-9:45am, Thursdays 11:00am-12:00 (Zoom, time to be confirmed)

TA Office hours: Tuesdays 11:00am-12:00, Thursdays 9:00-10:00am (MS Teams, time to be confirmed)

Course description and objectives:

The goal of this course is twofold. You will receive a solid introduction to the theory of several important classes of numerical methods for computational science and data science (with derivations of the methods and some proofs), and you will learn to implement the numerical methods efficiently in Matlab or another language of your choice, with applications to problems in several fields.

The course focuses on numerical methods for solving nonlinear algebraic equations, on ordinary differential equations, and on numerical linear algebra, with broad applications in many areas of science and technology. Applications covered include differential equation models from areas like heat conduction and structural mechanics; and matrix methods for deep neural networks.

This is a graduate-level numerical methods course that will be useful for students from Applied Mathematics, Computer Science, Computational Mathematics, Data Science, and other programs in Mathematics, Science and Engineering.

Prerequisites: A basic undergraduate course on numerical methods. (But: it is not recommended to take this course if you have previously taken a more specialized course focused on numerical linear algebra (such as CS475/675 at University of Waterloo).)

Tentative outline:

- some motivating applications from computational science and data science
- linear systems: LU decomposition (and floating point number system)
- linear systems: least-squares problems and QR decomposition
- linear systems: conjugate gradient method
- linear systems: GMRES method
- numerical methods for deep neural networks
- numerical methods for ordinary differential equations
- numerical methods for nonlinear equations

References:

- Numerical Mathematics, Quarteroni, Sacco and Saleri, Springer, 2007
(You can download pdf files for this book on campus at link.springer.com.)

For off-campus access, you first have to login via the library website, see <https://login.proxy.lib.uwaterloo.ca/login> which will allow you to use proxy URLs like <http://link.springer.com.proxy.lib.uwaterloo.ca/> .)

- Iterative methods for sparse linear systems (2nd edition), Yousef Saad, available online from www-users.cs.umn.edu/~saad/books.html

Course Website: the LEARN system will be used extensively for all course communications. Zoom and/or MS Teams will be used for live-streamed course components and office hours.

How the class will be taught:

- The class is fully online.
- The primary mode of delivery of the course materials is a combination of **hand-written “board notes” posted on LEARN** and **live-streamed “flipped-classroom sessions”** (these Zoom sessions will be recorded with the recordings posted on LEARN, and attendance is fully optional).
- The **handwritten “board notes”** are the notes the instructor would have written on the board in an on-campus offering, and contain all the primary course material. *You will be asked to read and study the relevant section of the board notes before the corresponding flipped-classroom session.* In the **flipped-classroom session** the instructor will go over the board notes highlighting the big lines and the important or tricky parts (at a faster speed than a regular board lecture), and students will have the opportunity to ask live questions (via video, voice or text chat) about the board notes and about other aspects of the course (like assignment questions etc.). These sessions are scheduled for a length of up to 80min, but it is expected they will often take substantially less time, since you will have studied the material beforehand, and some sessions will treat topics that are shorter than other sessions.
- **Typed course notes** will also be posted on LEARN (for most of the course), to complement the hand-written board notes and flipped-classroom sessions.
- **Note:** to increase social interaction with your classmates, we will start each flipped-classroom session 15 minutes early (from 9:45am) for a **15-minute social chat** during which you will be encouraged to switch on your camera and microphone. This will be an opportunity to chat about such diverse topics as the Raptors’ playoff run, world politics (US elections coming up ...), what you did over the weekend, the next Canadian team to win the Stanley cup, the latest movie releases, covid-19 vaccines, the weather, etc. ;-). There will also be such a **social chat** at the end of each flipped-classroom session.

Course components – final mark breakdown:

3 theoretical assignments (individual), 8% each	24%
3 computational assignments (in groups of 3 students), 12% each	36%
midterm test (Wednesday October 21, 10:00-11:30am, to be	20%

confirmed)	
final exam test (during final exam period)	20%

Midterm and final test formats: This is the first time this course will be offered online, so we will use some new exam formats. The current plan is to have **90-minute midterm and final tests** of equal value, that will be administered via the online Crowdmark system and that will be **life-video-proctored by the instructor and TA** (you dial into Zoom or MS Teams using your laptop and laptop camera). (Note that students who face technological restrictions can discuss alternatives (e.g., a fully oral exam), with the instructor.) The **midterm test is planned for Wednesday October 21, 10:00-11:30am** (to be confirmed) and the final test will occur during the exam period. Since the practicality of these exam formats may depend on factors like time zones and student numbers that are not fully known yet, the instructor may consider alternative exam formats if needed, including oral exam components, after consultation with students.

Assignments:

- There will be **three individual theoretical assignments** of equal value (3 x 8%), administered through the online Crowdmark system. Some problems may not be marked (solutions will be provided for these problems).
- There will be **three computational assignments of equal value** (3 x 12%). Since the semester is online and there will generally be less opportunities to get to know and interact with fellow grad students, the computational assignments will be completed in groups of three students, to promote your interaction with classmates. Groups of your preference will be formed after the first week of classes.
- You can take a three calendar-day extension on one theoretical assignment and on one computational assignment (no questions asked), but you have to notify the instructor of this ahead of the assignment due date.

Assignments	Due date (tentative)
theoretical assignment 1	Sep 25
computational assignment A	Oct 9
theoretical assignment 2	Oct 30
computational assignment B	Nov 18
theoretical assignment 3	Nov 27
computational assignment C	Dec 4

Office hours and student forum: Regularly scheduled **individual office hours** will be offered online via Zoom or MS Teams (using video, voice or chat). There will also be an active **piazza forum** where students, TA and instructor provide answers to student questions.

Recording of online course components:

- The **regularly scheduled flipped-classroom sessions** (optional attendance) will be **recorded and posted on LEARN**. Student questions will only be recorded when the student chooses to use video and/or voice when asking a question

- (questions via chat will not be recorded). During the flipped-classroom sessions you will normally mute your camera and microphone (except, if you wish, while asking a question).
- The 90-minute live-video-proctored tests will not be recorded. In case an oral exam component is needed due to missed tests or a change in exam format, the oral exam will be recorded (including voice of student, but not video) for record-keeping purposes (unless the student declines recording).
 - Of course, office hours will not be recorded.

Late Assignments/Missed Exams: Beyond the above-mentioned extension on one theoretical and one computational assignment, there will be no extensions for assignments except under extenuating (and documented) circumstances. If you are ill, please be prepared to provide a note from the health center or your doctor, see <https://uwaterloo.ca/math/vif> (but if you are affected by Covid-19, you can self-declare.). If your instructor decides that your circumstances warrant special accommodation, your final grade will be calculated based on your performance on the remaining assignments. When possible, advance notice must be given.

If you miss a test (due to illness, other documented and approved extenuating circumstances, or unexpected technical issues at the time of the test), the weight of the missed test will be shifted to the other test. If both tests are missed with valid reasons, the weight of the tests will be shifted to an oral exam during the final exam period.

Grade Appeals: We will make every effort to be fair and consistent in the marking. Grade appeals must be submitted to the TA via email within one week from the date the assignment was returned. For this reason, it is important that you look over all returned assignments on the day they are returned.

Academic Integrity: All submitted assignment solutions should be strictly your own work or your group's work (for group computational assignments). For the theoretical assignments, you are allowed to discuss the assignment problems with your classmates at a general level (but not step-by-step). You are not allowed to copy any material. You are not allowed to show parts of your written assignment to another student. For the computational assignments, you are allowed to discuss issues you encounter with other groups, but you are not allowed to show other groups your computer code or copy computer code from other groups. You are not allowed to copy theoretical solutions or computer code from online resources. All assignment material you submit (including written documents, program code and graphical output) should be strictly your own work or your group's work (in the case of a group assignment). Compliance will be actively monitored. Instances of suspected cheating will be dealt with seriously, in accordance with Faculty and University policies.

More generally, 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. [Check [the Office of Academic Integrity](#) for more information.]

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](#). 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 an academic offence, and to take responsibility for his/her actions. [Check [the Office of Academic Integrity](#) for more information.] A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (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 offences and types of penalties, students should refer to [Policy 71, Student Discipline](#). For typical penalties, check [Guidelines for the Assessment of Penalties](#).

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](#).

Note for students with disabilities: [AccessAbility 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.

Mental Health: If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support.

UWaterloo Resources

- Campus Wellness: <https://uwaterloo.ca/campus-wellness/students>
- Counselling Services: counselling.services@uwaterloo.ca, 519-888-4567 ext 32655
- Health Services: 519-888-4096.

Off-Campus Resources

- Good2Talk (24/7): Free confidential help line for post-secondary students. Phone: 1-866-925-5454, <https://good2talk.ca/>
- Here 24/7: Mental Health and Crisis Service Team. Phone: 1-844-437-3247 or 519-821-3582, <https://here247.ca/>
- OK2BME: set of support services for lesbian, gay, bisexual, transgender or questioning teens in Waterloo. Phone: 519-884-0000, <https://ok2bme.ca/>

Remote Teaching and Learning: STUDENT NOTICE OF RECORDING

Activities for this course involve recording, in partial fulfillment of the course learning outcomes. You will receive notification of recording via at least one of the following mechanisms: within the Learning Management System (LEARN), a message from your course instructor, course syllabus/website, or other means. Some technologies may also provide a recording indicator. Video/audio recorded during flipped-classroom sessions will be made available to students of CM770/AMATH740/CS770 for the purpose of helping in the study of the course materials. If an oral exam is needed, video/audio of the exam will be recorded for record-keeping, unless the student declines recording. Recordings will be managed according to the University records classification scheme, [WatClass](#), and will be securely destroyed when no longer needed by the University. Your personal information is protected in accordance with the [Freedom of Information and Protection of Privacy Act](#), as well as [University policies and guidelines](#) and may be subject to disclosure where required by law.

The University will use reasonable means to protect the security and confidentiality of the recorded information, but cannot provide a guarantee of such due to factors beyond the University's control, such as recordings being forwarded, copied, intercepted, circulated, disclosed, or stored without the University's knowledge or permission or the introduction of malware into computer system which could potentially damage or disrupt the computer, networks, and security settings. The University is not responsible for connectivity/technical difficulties or loss of data associated with your hardware, software or Internet connection.

By engaging in course activities that involve recording, you are consenting to the use of your appearance, image, text/chat messaging, and voice and/or likeness in the manner and under the conditions specified herein. (In the case of a live stream event, if you choose not to have your image or audio recorded, you may [disable the audio and video functionality](#) (see: *Student privacy during live events*). Instructions to participate using a pseudonym instead of your real name are included where the feature exists; however, you must disclose the pseudonym to your instructor in advance in order to facilitate class participation.) This notice serves as confirmation that you can choose to participate in any course component without being recorded.

You are not permitted to disclose the link to/URL of an event or an event session recording or copies of recording to anyone, for any reason. Recordings are available only to authorized individuals who have been directly provided the above instructions/link for their use. Recordings for personal use, required to facilitate your learning and preparation of personal course/lecture notes, should not be shared with others without the permission of the instructor or event coordinator. Review the University's [guidelines for faculty, staff and students entering relationships with external organizations offering access to course materials](#) for more information on your obligations with respect to keeping copies of course materials. For more information about accessibility, connect with [AccessAbility Services](#).