

Syllabus

MATH 4650/CS 4650/MATH 5660 Numerical Analysis I, Fall 2023
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Numerical Analysis is a foundation of computational science and engineering, including new disciplines such as data science and machine learning. Anywhere you need to work with numbers on computers, accurate and efficient numerical methods matter, which is what Numerical Analysis is about.

Catalog description: A first semester course in numerical methods and analysis fundamental to many algorithms encountered in scientific computing, data science, machine learning, and computational models in science and engineering. Rounding errors and numerical stability of algorithms; solution of linear and nonlinear equations; data modeling with interpolation and least-squares; and optimization methods. This course assumes that students have the equivalent of differential and integral calculus (e.g., MATH 2411), linear algebra (e.g., MATH 3191 or 3195), and computer programming (e.g., MATH 1376 or CSCI 1410). Cross-listed with CSCI 4650, 5660, and MATH 4650.

Textbook:

- First Semester in Numerical Analysis with Python, by Yaning Liu and Giray Ökten, <https://yaningliucudenver.github.io/Numerical-Analysis-I> and in Jupyter notebooks format at <https://github.com/jmucdenver/Numerical-Analysis-I>
- Optional supplementary material:
 - Practice notebooks provided on Canvas
 - Numerical Analysis, by Timothy Sauer, 3rd edition, Pearson 2018
 - Lecture Notes on Essential Numerical Analysis, by Jan Mandel, <http://demo.openwfm.org/web/numer.pdf>

Time and location: Tuesday and Thursday 5:00-6:15PM, Student Commons Building 4125

Office hours: Tuesday 1:00-2:00, Thursday 3:30-4:30, Student Commons Building 4315, or by appointment. Zoom appointments will be possible.

Contact: Canvas, or email me at jan.mandel@ucdenver.edu

Required technology: Minimal requirement is a recent laptop with an internet connection. For optimal experience, laptop with Windows 10 or newer, or MacOS 12 or newer, with at least several GB free disk space. If possible, bring your laptop to the class to do exercises in the notebooks as they are being shown, and to participate.

Graduate section prerequisite: Graduate standing in Applied Mathematics includes analysis as an admission requirement. Other students may receive permission to register as graduate upon review of their Linear Algebra, Calculus, and Programming record. Students taking the class as graduate need to be able to use calculus theorems in simple proofs.

Topics and schedule:

Week 1: Computing environment, 1.1 Review of Calculus, 1.2 Python basics
Week 2: 1.2 Python basics, 1.3 Computer arithmetic
Week 3: 2.0 Solution of equations, 2.1 Error analysis of iterative methods, 2.2 Bisection method
Week 4: 2.3 Newton's method, 2.4 Secant method
Week 5: 2.5 Muller's method, 2.6 Fixed point iteration
Week 6: 2.7 High-order fixed-point iteration, 3.1 Gaussian Elimination
Week 7: 3.1 Gaussian Elimination
Week 8: Review of 1.1-3.1, midterm
Week 9: 3.2 iterative methods for linear systems, 3.3 Choleski decomposition
Week 10: 3.3 Choleski decomposition
Week 11: 4.1 Polynomial interpolation
Week 12: 4.2 High degree polynomial interpolation, 4.3 Hermite interpolation 4.4 Piecewise polynomial interpolation, splines
Week 13: 6.1 Discrete least squares, 6.2 Continuous least squares
Week 14: 7.1, 7.2 Numerical optimization
Week 15: Review of 3.2-7.2 for the final exam

Materials provided: Supplementary files will be posted on Canvas Modules. Any whiteboard pictures from the class will be posted in Files/whiteboards.

Learning outcomes: Students will understand numerical methods and their properties, and be able to describe them as well as express in correctly functioning code. Graduate students will also be able to do prove properties of numerical methods and analyze their behavior.

Assignments and tests: There will be **homework** given on Canvas weekly. You will have at least a week to complete the homework. **Computer homework** will be provided as Jupyter notebook files and the completed homework file needs to be uploaded on Canvas. **Written homework** needs to be submitted as a single pdf file on Canvas. Scan by a mobile app into pdf is fine, but the *scan must be clearly legible*. The lowest written homework score and the lowest programming homework score will be dropped. The score for late homework will be decreased automatically by 5% per day. Late submissions can be no longer accepted after the solution is posted. There will be **quizzes** at the beginning of most classes from the material of the previous one or two classes, **midterm** on 10/12, and **final** exam during the finals week as announced. All exams and quizzes will be on paper in class. The worst 3 quiz scores will be dropped. If you missed or know you will miss a quiz or an exam, contact me for alternative arrangements as soon as you can.

How to study: Review **all** material listed in the module after every class, if it was shown in class or not, unless I explicitly omit something and note it on Canvas. A quiz is coming soon! Do all coding exercises in the chapter notebook, then any supplementary material. Try to modify the code in the notebooks to see what happens. For algorithms and theory, solve the exercises in the

assigned chapters, repeat until you can do it reliably without looking things up. Start by writing down the exercise – that helps to upload it to your brain through your hand. Then close the book (here, the computer) and try to solve the exercise. Do all examples in the assigned chapter this way. If you can't do it, no worries, that's normal, try again until you can – miracles at exams do not happen. Then, do the same with any supplementary material provided in the module. Items from the supplementary material **will** be on the quiz.

It may not be possible to go through the entire notebook and supplementary materials .

Computer assignments: I will be happy to advise you on coding and debugging techniques, but I am sorry I cannot debug your code – this is just not manageable for a class. Debugging takes time, even for an experienced programmer, and it is an important skill for you to develop.

Office hours: I'll be happy to explain the homework to you but please do not expect me to do it for you in office hours. You would not learn anything that way.

Participation: I will call on students to demonstrate on the board or present on their computers. For a full participation credit, you need to come in front of the class at least twice.

Grading: In all written homework and exams, please:

- Show clearly all your work, but do not write irrelevant things. That will not help, just the opposite because more writing means more opportunity for errors.
- Do not write multiple solutions or multiple codes and expect me to select the right one – I will consider only the first one I see.
- Turn in the problems in the order given. In written assignments, number the pages.

All written work will be graded on the scale 0-4 as follows: 0=little relevant, 1=understands the problem, 2=some progress, but a significant error, 3=minor error, 4=OK.

Computer work will be graded on the scale 0-4 as follows: 0=crashes and won't run or code makes little sense. 1=not much progress 2=some progress 3=appears ok but a wrong result, a fixable error, 4=OK

The final score will be determined as 20% homework, 20% programming assignments, 20% quizzes, 15% midterm, 15% final, 10% participation. For this purpose, the points from all assignments of one type will be added together.

The letter grades are: A ≥ 90 , A- ≥ 85 , B+ ≥ 80 , B ≥ 75 , B- ≥ 70 , C+ ≥ 65 , C ≥ 60 , C- ≥ 55 , D+ ≥ 50 , D ≥ 45 , D- ≥ 40 , F < 40

Learning philosophy: My role is to bring the book alive. Yours is to use the lectures to help you understand the book when you study by yourself and solve problems and code, which is how you will spend most of your time.

Use of devices and AI policy: Future belongs to those who can use AI better. AI such as ChatGPT can write simple codes and it can be an invaluable productivity and learning tool. I will provide some instruction and demonstration of ChatGPT use. However, be aware that current

ChatGPT is just a language model: it produces random answer that sound right but may not be right. It makes errors, gets confused easily, and fails at more complicated tasks.

You can use AI tools for your homework, but you need to understand the code, verify that it is doing what it should be doing, and you are responsible for any errors. You need to be able to explain the code and repeat the exercise yourself if you need to.

Use of any electronic devices or AI is prohibited during in-class quizzes and exams. This includes but is not limited to phones, computers, smart watches, or calculators.

University, college, and department policies

Academic Calendar

For university deadlines and procedures (such as the last day to withdraw from a course), please see the Academic Calendar. <https://www.ucdenver.edu/student/calendars/academic/>

Academic Support

Instructor office hours or other appointments are the best way to get additional help. I'm happy to help with questions not answered during class, additional explanation, or homework assistance.

Other sources of support are

- The Math and Stat Support office is located in the Learning Commons Building Room 1225 and regularly offers CU Denver students free drop-in assistance. Hours of operation, zoom links for virtual options, and other forms of support for mathematics and statistics courses are available on the Math and Stat Support webpage.
<https://clas.ucdenver.edu/mathematical-and-statistical-sciences/math-and-stat-support>
- The Learning Resources Center (LRC) provides individual and group tutoring, Supplemental Instruction (SI), study skills workshops, and ESL support.
<https://www.ucdenver.edu/learning-resources-center>
- The College of Liberal Arts and Sciences has a summary of campus academic support and school/college advising offices.
<https://clas.ucdenver.edu/faculty-staff/content/clas-academic-policies-deadlines>

Recording of Class Meetings

Class meetings held on or streamed over a video conferencing platform (such as Zoom, Microsoft Teams, etc) may be recorded and posted for all members of the class. Student participation and interaction may be included in the recording. If you have any concerns about this, please contact the instructor.

Diversity Statement

It is my intent that students from all diverse backgrounds and perspectives be well served by this course, that students' learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. It is my intent to present materials and activities that are respectful of diversity: gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture, etc. I would like to create a learning environment for my students that supports a diversity of thoughts, perspectives and experiences, and honors your identities (including race, gender, class, sexuality, religion, ability, etc). To help accomplish this:

- If you have a name and/or set of pronouns that differ from those that appear in your official records, please let me know!
- If you feel like your performance in the class is being impacted by your experiences outside of class, please don't hesitate to come and talk with me. I want to be a resource for you. Remember that you can also submit anonymous feedback (which will lead to me making a general announcement to the class, if necessary to address your concerns). If you prefer to speak with someone outside of the course, the Office of Diversity, Equity and Inclusion, is an excellent resource.
- I (like many people) am still in the process of learning about diverse perspectives and identities. If something was said in class (by anyone) that made you feel uncomfortable, including by me, please talk to me about it. (Again, anonymous feedback is always an option).

Your suggestions are encouraged and appreciated. Please let me know ways to improve the effectiveness of the course for you personally or for other students or student groups. In addition, if any of our class meetings conflict with your religious or other cultural events, please let me know so that we can make arrangements for you.

Health and Wellness

As a student, you may experience a range of challenges that can interfere with learning, such as strained relationships, traumas, increased anxiety, substance use, feeling down, difficulty concentrating, and/or lack of motivation. These mental health concerns or stressful events may diminish your academic performance and/or reduce your ability to participate in daily activities. If you or someone you know is struggling, you can find supportive campus and community resources at the Health Center at Auraria or the CU Denver Counseling Center. On weekends, holidays or after-hours you can contact the 24/7 Mental Health Crisis and Victim Assistance Line at 303-615-9911.

The University of Colorado Denver is committed the health and well-being of all students. We recognize that diminished mental health, including significant stress, mood changes, excessive worry, or problems with eating and/or sleeping can interfere with optimal academic performance. The source of such symptoms can be quite varied, and include experiences of trauma (such as sexual and relationship violence, stalking, discrimination, crimes, and accidents), responses to course work, family worries, loss, personal struggle, or crisis. If you or someone you know is struggling, you can find supportive campus and community resources at

<https://www.ucdenver.edu/counseling-center>

or by calling the CU Denver Counseling Center (303-315-7270) or the Health Center at Auraria (303-615-9999). On weekends, holidays or after-hours you can contact the 24/7 Mental Health Crisis and Victim Assistance Line at 303-615-9911.

Disability Accommodation and Access

The University of Colorado Denver is committed to ensuring the full participation of all students in its programs, including students with disabilities. If you have a disability or think you have a disability and need accommodations to succeed in this course, I encourage you to contact Disability Resources and Services (DRS) and/or speak with me as soon as you can. DRS is located in Student Commons Building Suite 2116, and can be reached at disabilityresources@ucdenver.edu and online at <https://www.ucdenver.edu/offices/disability-resources-and-services>. I am committed to providing equal access as required by federal law, and I am interested in developing strategies for your success in this course.

Nondiscrimination and Sexual Misconduct

The University of Colorado Denver is committed to maintaining a positive learning, working and living environment. University policy and Title IX prohibit discrimination on the basis of race, color, national origin, sex, age, disability, pregnancy, creed, religion, sexual orientation, veteran status, gender identity, gender expression, political philosophy or political affiliation in admission and access to, and treatment and employment in, its educational programs and activities. University policy prohibits sexual misconduct, including harassment, domestic and dating violence, sexual assault, stalking, or related retaliation. If you have experienced any sort of sexual misconduct or discrimination, please visit the Office of Equity web site at <https://www.ucdenver.edu/offices/equity> to understand the resources available to you or contact the Office of Equity/Title IX Coordinator at equity@ucdenver.edu.

Please note that I am a [Responsible Employee](#), which means that if I witness or receive information regarding possible prohibited protected characteristic discrimination or harassment, any form of sexual misconduct, and/or related retaliation, I am required to promptly report the information to the Office of Equity or their designee.

Religious Holiday Accommodation

Faculty in the University of Colorado system provide reasonable accommodations to students who must be absent from classes because of religious holidays. If you will miss class or graded assignments in order to observe religious holidays, you must contact me with all course conflicts by the end of the first week of classes.

Student Code of Conduct

As members of the University community, students are expected to uphold university standards, which include abiding by state civil and criminal laws and all University policies and standards of conduct. These standards are outlined in the student code of conduct, which can be found at <https://www.ucdenver.edu/student/wellness/student-conduct>

Academic Honesty

Students are expected to know, understand, and comply with the ethical standards of the university. A university's reputation is built on a standing tradition of excellence and scholastic integrity. As members of the University of Colorado Denver academic community, faculty and students accept the responsibility to maintain the highest standards of intellectual honesty and ethical conduct.

Academic dishonesty is defined as a student's use of unauthorized assistance with intent to deceive an instructor or other such person who may be assigned to evaluate the student's work in meeting course and degree requirements.

This course assumes your knowledge of the policies and [definitions](#). University policies allow the instructor to decide how to respond to an ethics violation, whether by lowering the assignment grade, lowering the course grade, and/or filing charges against the student with the campus Office of Student Conduct. For more information regarding the Office of Student Conduct policies and procedures, please refer to <https://www.ucdenver.edu/student/wellness/student-conduct/academic-integrity>. Violating the academic honor code can lead to expulsion from the University.

Examples of academic dishonesty include, but are not limited to, the following:

Plagiarism. Plagiarism is the use of another person's distinctive words or ideas without acknowledgment. Examples include:

1. Word-for-word copying of another person's ideas or words;
2. The mosaic (the interspersing of one's own words here and there while, in essence, copying another's work);
3. The paraphrase (the rewriting of another's work, yet still using their fundamental idea or theory);
4. Fabrication of references (inventing or counterfeiting sources);
5. Submission of another's work as one's own;
6. Neglecting quotation marks on material that is otherwise acknowledged.

Acknowledgment is not necessary when the material used is common knowledge.

Cheating. Cheating involves the possession, communication, or use of information, materials, notes, study aids or other devices not authorized by the instructor in an academic exercise, or communication with another person during such an exercise. Examples include:

1. Copying from another's paper or receiving unauthorized assistance from another during an academic exercise or in the submission of academic material;
2. Using a calculator when its use has been disallowed;
3. Collaborating with another student or students during an academic exercise without the consent of the instructor.

Note on use of Generative AI. Generative AI tools such as ChatGPT may not be used on exams, tests, or quizzes that do not permit the use of outside resources. The instructor will provide guidelines on whether such tools can be used for assignments and projects.

Fabrication and Falsification. Fabrication involves inventing or counterfeiting information, i.e., creating results not obtained in a study or laboratory experiment. Falsification, on the other hand, involves the deliberate alteration of results to suit one's needs in an experiment or other academic exercise.

Multiple Submissions. This is the submission of academic work for which academic credit has already been earned, when such submission is made without instructor authorization.

Misuse of Academic Materials. The misuse of academic materials includes, but is not limited to, the following:

1. Stealing or destroying library or reference materials or computer programs;
2. Stealing or destroying another student's notes or materials, or having such materials in one's possession without the owner's permission;
3. Receiving assistance in locating or using sources of information in an assignment when such assistance has been forbidden by the instructor;
4. Illegitimate possession, disposition, or use of examinations or answer keys to examinations;
5. Unauthorized alteration, forgery, or falsification;
6. Unauthorized sale or purchase of examinations, papers, or assignments.

Complicity in Academic Dishonesty. Complicity involves knowingly contributing to another's acts of academic dishonesty. Examples include:

1. Knowingly aiding another in any act of academic dishonesty;
2. Allowing another to copy from one's paper for an assignment or exam;
3. Distributing test questions or information about the materials to be tested before the scheduled exercise;
4. Taking an exam or test for someone else;
5. Signing another's name on attendance roster or on an academic exercise.

Incomplete Policy

When a student has special circumstances that make it impossible to complete course assignments, faculty members may choose to award an incomplete grade. All incomplete courses are assigned a grade of Incomplete (I). Incomplete grades are not awarded for poor academic performance or as a way of extending assignment deadlines. Faculty are not required to award an Incomplete.

To be eligible for an Incomplete grade, students MUST:

- Have participated in the class for a significant proportion of the term.
- Have successfully completed a significant proportion of the course assignments.
- Have special circumstances (verification may be required) that preclude the student from attending class and/or completing graded assignments.
- Make arrangements to complete missing assignments with the original instructor by a mutually agreed upon date but within one calendar year.
- Both the instructor and student should complete and sign the incomplete form found at

<https://clas.ucdenver.edu/faculty-staff/content/incomplete-grade-policy>.

- The instructor gives a copy of the signed incomplete form to the department.

Incompletes cannot:

- require a student to repeat the entire course,
- repeat or replace existing grades,
- allow the student an indeterminate period of time to complete a course, or
- allow the student to repeat the course with a different instructor.

Student Grievances

Students who have concerns about the course or instructor should first contact the instructor to discuss the issue. If the issue is not resolved, the student should next contact the Associate Chair of the Department of Mathematical and Statistical Sciences (currently Stephen Hartke <stephen.hartke@ucdenver.edu>). If not satisfied, the student should then appeal to the appropriate Associate Dean of the student's home school or college (for CLAS, this is the Associate Dean for Student Success). No step in this process should be skipped.

STUDENT SUPPORT

CARE Team is there for you
Call 303-352-3579 if you
or a classmate needs extra help
Submit a concern at
<http://www.ucdenver.edu/care>

Call 911 in case of emergency
Auraria Campus Police: 303-556-5000

CAREER COUNSELING at LYNXCONNECT

ucdenver.edu/careercenter - Tivoli 339
303-315-7315 - CareerCenter@ucdenver.edu

COUNSELING CENTER

ucdenver.edu/counselingcenter - Tivoli 454 (4th floor)
303-315-7270 (Emergency After-Hours: 303-615-9911)

DISABILITY RESOURCES & SERVICES

ucdenver.edu/offices/disability-resources-and-services
Student Commons 2116
303-315-3510 - disabilityresources@ucdenver.edu

OFFICE OF EQUITY

ucdenver.edu/equity - Lawrence Street Center 12th floor
303-315-2567 – equity@ucdenver.edu

PHOENIX CENTER AT AURARIA

24/7 Free and Confidential Helpline: 303-556-2255
Info on interpersonal violence, referrals, options, & next steps
www.thepca.org - Tivoli 227 - 303-315-7250 - info@thepca.org

FREE TUTORING

Contact these services for academic assistance throughout the semester

LEARNING RESOURCES CENTER

ucdenver.edu/lrc – Learning Commons Suite 1231
303-315-3531 - LRC@ucdenver.edu

MATH AND STAT SUPPORT (MaSS)

Learning Commons Room 1225
clas.ucdenver.edu/mathematical-and-statistical-sciences/math-and-stat-support

WRITING CENTER

writingcenter.ucdenver.edu - Learning Commons First Floor

UNDERGRADUATE ACADEMIC ADVISING

ucdenver.edu/undergradadvising

Graduate students: contact your graduate program directly for advising information

ARCHITECTURE AND PLANNING (CAP) ADVISING

CU Building 2000
303-315-1000 - cap@ucdenver.edu

ARTS AND MEDIA (CAM) ADVISING

Arts Building 177
303-315-7400 - camadvising@ucdenver.edu

BUSINESS SCHOOL ADVISING

15th and Lawrence Street, 4th floor
303-315-8110 - undergrad.advising@ucdenver.edu

CENTER FOR UNDERGRADUATE EXPLORATION & ADVISING (CUE&A)

Student Commons 1113
303-315-1940 - cuea@ucdenver.edu

EDUCATION & HUMAN DEVELOPMENT (SEHD) ADVISING

Lawrence Street Center 701
303-315-6300 - education@ucdenver.edu

ENGINEERING, DESIGN & COMPUTING (CEDC) ADVISING

North Classroom 3034
303-315-7170 - engineering@ucdenver.edu

LIBERAL ARTS AND SCIENCES (CLAS) ADVISING

North Classroom 1030
303-315-7100 – clas_advising@ucdenver.edu

PUBLIC AFFAIRS (SPA) ADVISING

Lawrence Street Center 525
303-315-2228 – spa.advising@ucdenver.edu

Plan Ahead! Review Important Dates & Deadlines
at <http://ucdenver.edu/academiccalendar>