MATH 561: Numerical Analysis I

Instructor:	Prof. Wolfgang Bangerth Weber 214 bangerth@colostate.edu
Lecture:	Monday, Tuesday, Wednesday, Friday, 2:00–2:50 pm Weber 223
Office hours:	Tuesdays, 3–5pm; or by appointment.

Course Topics *Numerical methods* are the foundation for all approaches by which we *solve mathematical or engineering problems on computers*. They are typically formulated in terms of algorithms that can be implemented on computers, and include things like solving linear systems or nonlinear equations, but also how to solve ordinary or partial differential equations such as those in fluid dynamics, elasticity, and many other areas.

This course provides an introduction to the most basic techniques in this area, covering specifically the solution of linear systems of various kinds, as well as (linear and nonlinear) minimization. These techniques will re-appear over and over again when going to the more advanced methods that will be covered in Numerical Analysis II (MATH 651) and Advanced Numerical Methods for PDEs (MATH 652).

In contrast to a course only on numerical *methods*, numerical *analysis* is concerned not only with devising methods, but also analyzing their performance. For example, we will consider how *expensive* particular algorithms are, so that we can understand which ones can be implemented efficiently. We will also consider how *accurate* algorithms are – this is important because in most cases, algorithms for non-trivial problems can only give us *approximate* solutions, and we need to know how close these approximations are to the exact solution.

This course will cover the following, specific topics:

- Numerical linear algebra: solving linear systems through Gaussian elimination, fixed point iterations, and Krylov space methods; decompositions for square and rectangular matrices.
- Solving nonlinear systems: fixed point and Newton's methods.
- Least squares
- Minimization: solving nonlinear optimization problems; dealing with constraints; if time permits, linear optimization problems.

Textbook I do not require you to get any particular book, and in particular will not pose homework that references a book. That said, if you want to read up on some of the material we discuss in class, the following two books (in any edition you can find) cover essentially everything we do over the course of this semester:

- D. Kincaid and W. Cheney: *Numerical Analysis*, Brooks & Cole Publishing Co.
- J. Nocedal and S. J. Wright: *Numerical Optimization*, Springer.

Prerequisites (MATH 151 or CS 156 or CS 160 or CS 253) and (MATH 560).

Many of the homework assignments will require you to write small programs. In general, I leave the choice of programming language to you, but if your choice is somewhat exotic or outside the realm of what a typical programmer can be expected to read, you will need to provide sufficient commentary to make the code understandable.

Webpage Homework assignments and other course information will be posted at the course webpage
http://www.math.colostate.edu/~bangerth/teaching.html

Exams + Grading Final grades will be determined based on the following components:

- Homework and programming assignments: 30%
- Midterm 1, Monday February 27: 2–2:50pm, 15%
- Midterm 2, Monday April 10: 2–2:50pm, 15%
- Final, Tuesday May 9, 11:50am–1:50pm: 40%

Your minimum grade will be A, B, C, or D, for a score of 90%, 80%, 70%, and 60% over the course of the semester, respectively.
You must make arrangements in advance if you expect to miss an exam or quiz. Exam absences due to recognized University-related activities, religious holidays, verifiable illness, and family/medical emergencies will be dealt with on an individual basis. In all cases of absence from exams a written excuse is required. Ignorance of the time and place of an exam will not be accepted as an excuse for absence.

Learning Outcomes and Course Objectives Numerical methods are the foundation of computer simulations in all fields of the sciences and engineering. The goal of this class is to (i) provide a basic level of literacy in numerical methods, as well as (ii) to learn about their analysis. At the end of the semester, you will be able to identify and understand what methods to use depending on the situations; how they will likely perform; and analyze these methods in terms of properties such as approximation quality or speed of convergence. You will also have practice in implementing these methods on computers.

Policies *Academic integrity:* Academic integrity is integral to the success of the University and to you as a learner. Academic integrity is conceptualized as doing and taking credit for one's own work. Academic dishonesty undermines the educational experience at Colorado State University. Examples of academic dishonesty include (but are not limited to) cheating, plagiarism, and falsification. Plagiarism includes the copying of language, structure, images, ideas or thoughts of others and is related only to work submitted for credit. Cheating or any form of academic dishonesty will not be tolerated. The use of material from improperly cited or credited sources will be considered plagiarism. You are encouraged to collaborate with your classmates, unless otherwise directed, but all work intended for a grade must clearly be your work as an individual. Ignorance of the rules does not exclude any member of the CSU community from the requirements or the processes meant to ensure academic integrity.

Disabilities: Colorado State University, in compliance with state and federal laws and regulations, does not discriminate on the basis of disability in administration of its education related programs and activities. We have an institutional commitment to provide equal educational opportunities for disabled students who are otherwise qualified. Students with documented disabilities must contact The Office of Resources for Disabled Students (RDS; 970-491-6385) to make arrangements for class accommodations. It is the responsibility of the student to obtain accommodation letters from RDS and to make arrangements for the implementation of accommodations with faculty in advance. Students who believe they have been denied access to services or accommodations required by law should contact RDS (970-491-6385). Students who believe they have been subjected to discrimination on the basis of disability should contact the Office of Equal Opportunity (970-491-5836). For more information regarding disability grievance procedures, visit oeo.colostate.edu.