MATH 361S: Mathematical Numerical Analysis
Spring 2024 Syllabus

January 2024

Instructor Details

- Name: Shijun Zhang
- Email: shijun.zhang@duke.edu
- Office: Physics 034
- Office Hours: Monday 6-7 PM, Friday 4-6 PM, or by appointment.

Class times/Location

- Classes held every Monday and Wednesday, 4:40-5:55 PM.
- Location: Physics 227.

Textbook and Course Materials

- Uri M. Ascher & Chen Greif, A First Course in Numerical Methods, 2011.
- Timothy Sauer, Numerical Analysis, 3rd Edition, 2017.
- Excerpts from Cleve Moler's book Numerical Methods in MATLAB (free online at `https://www.mathworks.com/moler/chapters.html`).

Course Synopsis

Development of numerical techniques for accurate and efficient solutions of problems in science, engineering, and mathematics using computers. Topics include linear systems, nonlinear equations, optimization, interpolation, numerical integration, differential equations, and error analysis.

Prerequisites

A strong foundation in linear algebra, including linearity, solving linear systems, eigenvalues, and eigenvectors. Multi-variable calculus (e.g., Math 212) is required. Familiarity with ordinary differential equations is recommended. Basic programming knowledge (e.g., CS 101) is necessary, though no specific language experience is assumed. The course primarily uses Python, with support for Matlab.

Tentative Course Schedule

This schedule outlines the expected topics for each week, subject to updates and detailed elaboration via Sakai.

- Week 1: Overview and Basics of Floating Point Arithmetic.
- Weeks 2-3: Studying Error Analysis and Scalar Non-linear Equations.
- Weeks 4-5: Approaches to Linear Systems, Covering Both Direct and Iterative Methods.

- Weeks 6-7: Focus on Interpolation Techniques.
- Week 8: Exploring Numerical Differentiation.
- Week 9: Techniques in Numerical Integration (Quadrature).
- Weeks 10-11: Delving into Ordinary Differential Equations (ODEs).
- Weeks 11-12: Exploring Optimization Methods.
- Weeks 13-14: Covering Additional Topics and Course Conclusions, Including Student Presentations.

Additional topics may include Singular Value Decomposition, Least Squares Approximation, Discrete Fourier Transform/FFT, Boundary Value Problems in PDEs, and Numerical Analysis Applications in Deep Learning (e.g., Automatic Differentiation, Quantized Neural Networks).

Exams and Grading

There is no final exam in this course. Grades in this course will be based on the following components:

- **Midterm Exams (40%):** The two midterm exams are closed-book; however, students are allowed to bring two sheets of letter/A4 paper. These sheets can be used for summarizing key concepts or for note-taking purposes.
- **Final Project (30%):** This involves an in-depth study of a numerical analysis topic, culminating in a written report and a presentation.
- **Homework (30%):** Assignments will include both theoretical exercises and computational problems, requiring coding.

Homework

- Homework is assigned approximately weekly on Wednesday or Thursday, with each assignment typically due the following Monday.
- Collaboration in studying is encouraged, but each student must submit their own work, written in their own words.
- Late submissions are generally not accepted, except under Duke's policy for exceptional circumstances.
- Complete and well-argued solutions are crucial, emphasizing the process of arriving at the solution. Use complete sentences for explanations and support assertions with data and code where relevant.
- Organization and readability are important. Solutions should follow the order of the problem list.
- Computational problems will require coding. Python (using numpy) is the preferred language, but Matlab is acceptable. Original coding is essential, and online code sources should be avoided.

Final Project

The course's final project entails a deep dive into a numerical analysis subject, requiring a comprehensive LaTeX report and a presentation. The report should be structured like a scientific article, encompassing sections such as an introduction, methods, results, and conclusion, including code in an appendix. Students can select their project topic from a given list or propose their own, pending instructor approval. Further details will be shared on Sakai.

Ethics

Students at Duke University are required to adhere to the Duke Community Standard. In cases of academic dishonesty, if a student is adjudicated by the Office of Student Conduct, a zero grade will be assigned for the relevant assignment. However, if the issue is resolved through a faculty-student agreement approved by the Office of Student Conduct, the outcome of that agreement will determine the grading impact for the assignment involved.