MATH 361S: Mathematical Numerical Analysis
Spring 2019 Syllabus

Instructor: Jeffrey Wong

Office: Physics 029B (Office hours: see Piazza)

Class times/Location: WF 3:05-4:20, Physics 227

Website: Piazza (`https://piazza.com/duke/spring2019/math361s/home`), and course Sakai site (for grades and assignment submission)

Textbook: Uri Ascher & Chen Greif, *A First Couse in Numerical Methods* and excerpts from Cleve Moler's book *Numerical Methods in MATLAB* (free online).

Other suggested texts: T. Sauer's *Numerical Analysis* is a good, approachable introduction. *Numerical Recipes* is a useful (somewhat more advanced) reference, with details on implementation, design and practical perspective.

Course synopsis: Development of numerical techniques for accurate, efficient solution of problems in science, engineering, and mathematics through the use of computers. Linear systems, nonlinear equations, optimization, numerical integration, differential equations, error analysis.

Preqrequisites: A solid understanding of fundamental concepts from linear algebra is essential, including linearity, solving linear systems, eigenvalues and eigenvectors. A course in multi-variable calculus (e.g. Math 212) is also required. Experience with ordinary differential equations is recommended, but not necessary.

Some exposure to basic programming is required in some language (e.g. CS 101). Matlab will be used for the course (you may also use python), but no prior experience with any specific language will be assumed.

Schedule: Below is a tentative schedule with expected topics. A detailed schedule and further information about the topics will be posted and updated on Piazza.

- Week 1: Introduction, floating point arithmetic
- Week 2-3: Error analysis, non-linear equations (scalar)
- Week 4-5: Linear systems: direct and iterative methods
- Week 6-8: Interpolation, differentiation and integration
- Week 9-10: Ordinary differential equations
- Week 11: Nonlinear systems and more
- Week 12: Additional topics (linear algebra)
- Week 13-15: Additional topics, wrap-up, presentations

Some possible additional topics (we may cover one or two briefly) are:

- Continuous or discrete optimization
- Least squares and deficient rank linear systems
- Boundary value problems, PDEs
- Discrete Fourier transform / FFT

Course Logistics

Exams and Grading: Grades will be assigned based on several components:

- Midterms (40%): Two closed-notes, closed-book exams in class. Tentative dates are listed in the schedule. A formula sheet will be provided.
- Final project (30%): An in-depth exploration of a topic in numerical analysis with two components: a written report and an oral presentation to the class.
- Homework (20%): Regular assignments comprised of two parts: theoretical exercises and computational problems (which involve writing code). There will be at least one in-depth homework assignment that is more project-like (details TBA). The lowest regular homework score will be dropped
- Participation (10%): Your are expected to be an active participant in the class. For example: discuss the material, ask/answer questions in class or on the Piazza site, attend office hours, discuss the project(s). Some homeworks may include questions that count towards participation for thoughtful answers (feedback, reflections on what you have learned).
- **There is no final exam for the course**.

Homework:

- Homework will be assigned (roughly) weekly and will typically be due the following Wednesday. Consult the schedule for due dates.
- Working and studying in groups is encouraged. However, you should write your own solutions to each problem in your own words.
- **Late assignments will not be accepted**, barring exceptional circumstances as per Duke policy.
- Solutions should be complete arguments; the process by which you arrive at the solution is far more important than a correct answer. When appropriate (which is often), use complete sentences to develop your arguments. Assertions should be supported by computed data and code when it is needed.
- Make sure homework pages are stapled together and the work is organized and readable. Solutions should be in the same order as in the list of problems.

Computational problems:

- Some homework problems will require writing and running code. The official choice of language for this course is Matlab; most examples/solutions will also include python code. You may write your code in Matlab or python (for python, use the `numpy` package).
- Collaboration is encouraged but the code you submit should be your own, which includes not copy-pasting code from other sources. Avoid looking up code online because it is difficult to un-see it when writing your own.
- Expectations for computational problems are detailed in the *Guidelines for computational problems* document (on Piazza).

Final project: The final project is a research project exploring a topic in numerical analysis in depth and some key applications. Examples include calculation of dominant eigenvectors as used in Google's search algorithm (PageRank) or simulation of chaotic systems. Tentative due dates are listed in the schedule at the course website and exact due dates will be announced at a later time.

- The final project has two components: a written report and a presentation. The report **must be written in LaTeX** and will take the form of a scientific article, including an introduction, description of numerical methods, discussion of your results, conclusions, references, and an appendix containing your code.
- A list of topics will be provided. You may also choose your own topic, subject to instructor approval. A one page abstract of the topic will be due about halfway through the course.
- A draft of the report and presentation will be due at a time to be announced later (near the end of the semester). Presentations will occur around the last week of classes; the written report will be due during Finals week.

Ethics: Students are expected to follow the Duke Community Standard. If a student is found responsible for academic dishonesty through the Office of Student Conduct, the student will receive a score of zero for that assignment. If a students admitted academic dishonesty is resolved directly through a faculty-student resolution agreement approved by the Office of Student Conduct, the terms of that agreement will dictate the grading response to the assignment at issue.