Math 615 Numerical Analysis of Differential Equations

Spring 2017, UAF

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Times & Room: MWF 9:15 -- 10:15 am Gruening 401
CRN: 36278
Text: R. J. LeVeque, *Finite Difference Methods for Ordinary and Partial Differential Equations*, SIAM Press 2007

Course Content and Topics:

This course covers numerical approximations of partial differential equations (PDEs) and ordinary differential equations (ODEs) and related problems on computers. PDEs are the underlying structure for fluid flow, electric/magnetic fields, thermodynamics, elastic deformation, quantum mechanics and chemistry, finance, and so on. ODEs are even more universal, often as a part of a PDE problem. The course will include some nonlinear examples, for which one uses a sequence of approximating linear problems.

The emphasis will be on finite difference methods for PDEs, but also on understanding ODE numerical schemes more deeply than in an undergraduate course. We will do mathematical analysis of the numerical methods, with both practical and abstract approaches: How are these methods implemented? How are they verified and tested? When are they stable? Do we know in advance that they converge?

Homework assignments and a student-chosen project, tentatively in the form of a short slide-show, will include actual implementations in *Matlab/Octave* or another suitable language of your choice. (I will support *Matlab/Octave* but you may use other languages for assignments and the project.) Lectures will include *Matlab/Octave* demonstrations, plus help getting started with it, whenever I can fit it in. However, *you* must show initiative in learning actual numerical computation, especially if you have not done it before.

We will not be satisfied with seeing pretty pictures coming from the computer. Instead we will be concerned with the degree to which our numbers correctly approximate the PDE problem. We will seek the underlying linear algebra structure of these problems, in terms of vectors and matrices. Abstract and precise thought, that is, actual mathematics, is essential when making choices among numerical methods, and all homework assignments will have mathematical exercises. In these you will be asked to "show" and "prove", and, while formal proof style is not important, you will need to give clear and sufficiently-general logical arguments.

Goals and Outcomes:

At the end of the course you will be able to evaluate and use numerical tools for solving many scientific and engineering problems. You will be able to code some of the basic methods (i.e. for prototyping more serious solutions), and you will have the mathematical start needed for learning other approaches like the finite element method and spectral methods. Also, student competence with actual scientific computing is a goal of the course: You will be comfortable using *Matlab/Octave* both as a "supercalculator" and as a programming language.

Assigned Work:

Weekly homework forms 50% of your score for the class. The homework consists of by-hand computations, construction/comprehension of numerical algorithms, implementation of numerical algorithms in *Matlab/Octave*, including basic visualizations, rigorously-justified examples and counter-examples, and some proofs.

Homework assignments, and their due dates, will be regularly posted at the Course Website bueler.github.io/M615S17/. The site also has a daily schedule of topics which will be updated on an ongoing basis to reflect what topics were actually covered each day.

How Your Grade is Determined:

There will be **one in-class Midterm Exam**, covering basic concepts and definitions, and a **take-home Final Exam**. There will be a **project in two parts**, with the first part due midsemester and the second due before final exams:

Work	Percent of Grade	Dates
Homework	50%	weekly
Midterm Exam	15%	*in-class* Monday 27 February
Project part I	5%	*due in-class* Monday 10 April
Project part II	10%	*due in-class* Friday 28 April
Final Exam	20%	*due at 5pm* Friday 5 May

Based on your raw (homework, project, and exams) total, I guarantee grades according to the following schedule:

90 - 100 % = **A**, 79 - 89 % = **B**, 68 - 78 % = **C**, 57 - 67 % = **D**, 0 - 56 % = **F**.

This schedule is a guarantee. I reserve the right to increase your grade *above* this schedule based on the actual difficulty of the work and/or upon average class performance.

Policies:

The Dept of Mathematics and Statistics has reasonable policies on incompletes, late withdrawals, early final examinations, etc.; see www.uaf.edu/dms/policies. You are covered by the UAF Student Code of Conduct. I will work with the Office of Disabilities Services (208 WHIT, 474-5655) to provide reasonable accommodation to student with disabilities.

Prerequisites:

Officially, these are the *Prerequisites: CS F201 (Computer Science I); MATH F310 (Numerical Analysis); MATH F314 (Linear Algebra); MATH F421 (Applied Analysis); MATH F422 (Intro to Complex Analysis); or permission of instructor.*

In other words, this is an applied and computational mathematics course at the introductory graduate level. Students come from math, computer science, physics, geophysics, engineering, and indeed all over the technical subjects at UAF, and I am aware of this fact! I will devote substantial class time, especially at the beginning of the semester, to collecting together the many bits of needed prequisite knowledge. However, *you* must show initiative in recalling prerequiste knowledge in a meaningful and timely way, especially when I point out directly that certain prerequisite knowledge is needed. In all these aspects, this course is similar to MATH 614 Numerical Linear Algebra and MATH 661 Optimization.