CMDA 4604: Intermediate Topics in Mathematical Modeling

Spring 2023 · Virginia Tech · CRN 13099

Professor: Dr. Paul Cazeaux **Office**: McBryde Hall 570 **Email:** cazeaux@vt.edu

Lectures: Tuesday/Thursday 2:00PM-3:15PM, McBryde Hall 204

Office Hours: Wednesday 1:30PM-3:00PM and Thursday 3:30PM-4:30PM, or by appointment

Web Site: Canvas

Announcements are made repeatedly and posted on Canvas. Students are responsible for checking Canvas regularly, and it is strongly advised that students turn on Canvas email notifications.

Prerequisites: You should know basic matrix concepts (Gaussian Elimination, subspaces, eigenvalues, etc.) and ordinary differential equations. MATLAB fluency will be helpful, but is not required.

Main text: *Partial differential Equations: Analytical and Numerical Methods, 2nd edition*, by Mark Gockenbach, Society for Industrial and Applied Mathematics (SIAM), Philadelphia, 2010.

Grade Policy: 50% exams, 50% problem sets.
Scores of at least 90, 80, 70 and 60 guarantee grades of at least A-, B-, C- and D-, respectively. Class participation and engagement in active learning activities will influence borderline grades. Improving performance over the course of the semester will also be considered. Homework and exam grades will be posted on the class Canvas site.

Exams: Two closed-book exams will each account for 25% of the final grade.
The first exam will be held in class on Tuesday, February 28, 2:00-3:15PM (tentative).
The second exam will be held on Wednesday, May 10, 1:05-3:05PM.

Problem Sets: Problem sets will be assigned roughly once every 10 days, due by 8PM on the specified date. Rigorous solutions are expected; strive for clarity, rigor and elegance. Unless it is specified that a particular calculation must be performed entirely 'by hand', you are encouraged to use MATLAB's Symbolic Math Toolbox, or another symbolic software (such as Mathematica, Wolfram Alpha, Maple) to compute and simplify tedious integrals and/or derivatives on the problem sets.

Project: The last assignment will be an open-ended project that will count twice the weight of a normal problem set; you will have an extended time to complete it.

Late Policy: You may turn in two problem sets one class period late without penalty. Further late assignments will be penalized 20% each. Work will not be accepted more than one class late.

Re-Grade Policy: Appeals for points, partial credit, incorrect score, missing scores on Canvas, etc., should be brought to the instructor's attention in a timely manner (within one week of the paper's return). For homework that has been submitted to Canvas, use the comments box to contest grades first.

Programming Assignments: Most problem sets will require a modest amount of MATLAB programming, often based on codes provided by the instructor for class demonstrations. Your programs should adhere to good programming standards, and must not be copied from another student (but you can edit codes the instructor posts to the class website). Consult the course website site for pointers to MATLAB resources.

 page 1 of 2 page 1 of 2

Course description: CMDA 4604 is an advanced course in the curriculum in Computational Modeling and Data Analytics. We will introduce partial differential equations, explore their solution using numerical methods, and look into uncertainty quantifications. Some techniques we shall study are ancient, beautiful, and of enduring importance. Others are modern computational approaches exploiting the power of computers, which are both elegant and central to most science and engineering simulations. The common language in which we will formulate these approaches is (elementary) functional analysis.

This course counts like an upper division Mathematics course for meeting Math minor requirements, and it counts as a math-related couse for Math majors.

Outcomes: Upon completing this course, students should be able to:

1. appreciate how differential equations are models derived from physical principles;
2. solve linear PDEs through eigenfunction expansions and Fourier series;
3. discretize and solve PDEs through the finite element method;
4. understand stability considerations for time-stepping methods;
5. apply basic techniques for optimizing nonlinear systems and quantifying uncertainty.

Supplemental readings:

Carl Meyer, *Applied Matrix Analysis and Linear Algebra*

Gilbert Strang, *Introduction to Applied Mathematics*

Gilbert Strang, *Differential Equations and Linear Algebra*

M. J. Gander and F. Kwok, *Numerical Analysis of Partial Differential Equations Using Maple and MATLAB*

Jorge Nocedal and Steven Wright, *Nonlinear Optimization*

Ralph Smith, *Uncertainty Quantification*

D. J. Higham and N. J. Higham, *MATLAB Guide, 3rd ed.*

More specific references will be provided on the website as the semester progresses.

Honor Code: The field of Computational Modeling and Data Analytics requires professionals who act with the highest ethical standards. CMDA teaches skills that empower you to have a tremendous impact upon the world. We teach you these skills with the expectation that you will exercise them responsibly.

The Undergraduate Honor Code pledge that each member of the university community agrees to abide by states:
"As a Hokie, I will conduct myself with honor and integrity at all times. I will not lie, cheat, or steal, nor will I accept the actions of those who do."

Virginia Tech's Honor Code applies to all work in this course. You are encouraged to discuss the problem sets with others, but your write-ups must be your own individual work. Transcribed solutions and copied MATLAB code are both unacceptable. The exams must be your own independent effort.

Accomodations: *If you require accommodations for the class, please arrange to meet with me as soon as possible to discuss them, as well as contact the Dean of Students. If for any reason you need special considerations please let me know as soon as possible. We will ensure that these needs are appropriately addressed. All requests must be approved by university. Feel free to visit www.ssd.vt.edu for additional information.*

 page 2 of 2 page 2 of 2