CMDA 4604 · INTERMEDIATE TOPICS IN MATHEMATICAL MODELING

Fall 2015 · Virginia Tech

Lectures: Monday/Wednesday/Friday 9:05–9:55AM, Patton 215

Web Site: `http://www.math.vt.edu/people/embree/cmda4604`

Instructor: Mark Embree (embree@vt.edu), McBryde 575, (540) 231-9592
Office Hours: Monday 4:00–5:30PM, Thursday 3:30–5PM, or by appointment.
Informal office hours: join me for lunch on Wednesdays, 11:45AM-12:45PM, at Owens.

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.

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 Scholar site.

Text: *Partial Differential Equations: Analytical and Numerical Methods* by Mark Gockenbach
2nd ed., Society for Industrial and Applied Mathematics (SIAM), Philadelphia, 2010.
The first edition is also suitable; it is on reserve at the library: QA 377 .G65 2002.

Exams: Two closed-book exams will each account for 25% of the final grade.
The first exam will be held on the evening of Wednesday 14 October from 7–9PM (tentative).
The second exam will be held on Friday 11 December, 10:05AM–12:05PM.

Problem Sets: Problem sets will be assigned roughly once every 10 days, due by 5PM on the specified date. The last assignment will be an open-ended project that will count twice the weight of a normal problem set (and you will have an extended time to complete it).

Rigorous solutions are expected; strive for clarity and elegance. Unless it is specified that a particular calculation must be performed 'by hand,' you are encouraged to use MATLAB's Symbolic Math Toolbox (or Mathematica/Wolfram Alpha/Maple) to compute and simplify tedious integrals and derivatives on the problem sets.

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: If your work has been graded incorrectly, you may submit a re-grade request. Clearly explain the perceived error on a separate sheet of paper, staple it to the front of your graded paper, and give it to the instructor within one week of the paper's return.

Honor Code: 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.

Programming: 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.

Any student with special needs or circumstances requiring accommodation in this course is encouraged to contact the instructor during the first week of class, as well as the Dean of Students. We will ensure that these needs are appropriately addressed.

CMDA 4604, an advanced course in the new curriculum in Computational Modeling and Data Analytics, introduces students to partial differential equations, numerical methods, and uncertainty quantification. Some techniques we shall study are ancient, beautiful, and of enduring importance. Others are modern computational approaches that are both elegant and vital to nearly every science and engineering simulation. These techniques will be developed from the common theoretical language of (elementary) functional analysis.

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

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

1) appreciate how differential equations are derived from physical principles;
2) solve linear PDEs through eigenfunction expansions (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 Reading:

Carl Meyer, *Applied Matrix Analysis and Linear Algebra*
Gilbert Strang, *Introduction to Applied Mathematics*
Gilbert Strang, *Differential Equations and Linear Algebra*
Jorge Nocedal and Steven Wright, *Nonlinear Optimization*
Ralph Smith, *Uncertainty Quantification*
D. J. Higham & N. J. Higham, *MATLAB Guide*, 2nd ed.

The class website contains links to these books; more specific references will be provided on the website as the semester progresses.