MA 501, SP22, Advanced Mathematics for Engineers and Scientists I

TR, 11:45-1, SAS 1220, January 10 - April 25.
Final exam Tuesday May 3, 12 - 2:30. Final exam date and time are set by the university and cannot be changed.
Because the pandemic situation is continuously evolving (literally!), there may be changes to the delivery method or other logistical aspects of the course.

Professor: S. R. Lubkin, lubkin@ncsu.edu, 515-1904, http://www4.ncsu.edu/~lubkin
Office hours: (Zoom) M 3pm, F 2pm, or by appointment

Official listing: Survey of mathematical methods for engineers and scientists. Ordinary differential equations and Green's functions; partial differential equations and separation of variables; special functions, Fourier series. Applications to engineering and science. Not for graduate credit for mathematics majors.

Course Objectives: Upon successfully completing this course, you will be skilled in solving the fundamental linear PDE's that engineers use. You will be able to

I. identify the properties of the heat/diffusion equation, the wave equation, and the potential/Laplace equation.
II. find series and integral solutions to these PDE, in Cartesian and/or polar coordinates.
III. display and interpret solution curves and surfaces in space and time on the computer.
IV. interpret and implement different kinds of boundary conditions.

Other courses: MA 501 and 401 are almost identical. I teach both of them. However, I expect more from my students at the 500 level, so we cover more topics in the same amount of time. In particular, we cover integral transforms in 501 but not in 401. I do not have time in MA 501 to cover modeling with PDEs; that important topic is covered in MA 450, 451, 573, 574, and 774. Similarly, we do not cover nonlinear PDE in MA 501, but they are covered in various ways in MA 584, 587, 774, and others. A solid understanding of linear PDE from MA 501 or 401 gives a firm foundation for learning to work with nonlinear PDE such as the Navier-Stokes equations.

Text: Because textbook costs are a burden for students, I will not require purchase of a specific textbook. However, I do want you to read an appropriate textbook as the semester proceeds, because it will provide a complementary perspective, with emphases, examples, and details different from the class sessions. Suggested textbooks: *Boundary Value Problems and Partial Differential Equations, 5th edition*, 2006, by David Powers. Available online at NCSU libraries. This book does not cover Fourier transforms, so we will need some supplementary books, such as: Partial Differential Equations with Fourier Series and Boundary Value Problems, 3rd edition, 2016, by Nakhle Asmar, online at NCSU libraries; *Applied Partial Differential Equations with Fourier Series and Boundary Value Problems, 5th edition,* 2013, by Richard Haberman, on reserve at DH Hill. Other books on the subject may be useful; look in the table of contents for a focus on the wave, heat, and Laplace (or potential) equations, with Fourier series and Fourier transforms. There are online lectures on these subjects out there. Every professor, every textbook, has a somewhat different approach, and sampling a variety of approaches may be helpful to you.

Grades: final exam 35%, 2 midterms @ 20%, 15% HW and possibly quizzes (rare), 10% team "projects" (which are like in-depth HW problems).

- The main **purpose of HW** is give you **practice** using the individual methods through solving problems ranging from easy to hard. Through HW graphical implementation, you will also gain familiarity with the behavior of solutions of different equations with different IC and BC.
- The main **purpose of projects** is to give you experience applying the methods to **more complex** and/or **realistic problems** than on the HW. Your grade on the projects is some indication of your ability to understand and solve complex problems.
- The main **purpose of exams** is to determine your **fluency** with the essential techniques and underlying concepts. Note that **exams measure different aspects of your learning from HW and projects.** You will get practice tests to try at home the week before an exam.
- I cannot promise that your HW will be graded with great precision, but I can promise that your HW grade will be representative of your work. Projects are graded with more precision.
- Maple calculations will be required on most of the assignments. Nobody is expected to purchase Maple; it is available on campus computers and via VCL from your own computer. If you have another package that you prefer (such as Mathematica), you are free to use it, but I will not teach how to use other packages, nor should you expect my help with them.
- Midterm dates TBD. First midterm will be given and graded before the drop deadline 3/7.

Policies

- If you have a disability or conflict that I need to know about, let me know as soon as possible (not the week of the first exam). **Your final exam cannot be moved.** Make your travel plans for **after** the exam.

- You are welcome to work on HW and projects with other students, with some restrictions. Since **the point of HW is learning**, work with others only if it helps your learning and your partner's learning. Giving each other ideas: good. Explaining to each other: good. Finding each other's errors: good. Copying answers: bad. Letting your partner do the work: bad. **Don't let someone else do the learning for you.**
- You are welcome to use Maple or any other computer package to help on the HW and projects. Please say when you are using technological help. For instance, "Integrating this term by parts (Maple) yields...." In general, show your work, including computer work.
- You may not work with others on the exams. In accordance with the NCSU policy on academic integrity, found in the Code of Student Conduct, it is assumed that in turning in any assignment to the instructor, the student has thereby implicitly taken the honor pledge: "I have neither given nor received unauthorized aid on this test or assignment."
- I should not even have to say this (why isn't it obvious to everyone?), but **you may not copy any solutions from any source for any assignment**.

In-class behavior

- Until further notice, masks must be worn in class, covering your nose and mouth.
- If you are sick, stay home, rest up, and get the notes from a classmate.
- Ordinarily I would not care about eating and drinking in class, but because of the pandemic, this is too risky.
- If you are in class, I expect you to be paying attention and participating.
- If you have used a class laptop, when you are done, logout, shut down (saves the battery), and plug it back in to its charger.

Homework details

- Assignments will be turned in and graded as pdfs in Moodle. Before you upload, look over your pdf to make sure that all questions are there, in order, all questions are numbered, answers are boxed, and the image is readable. Files should be pdf. Do not turn in Maple (.m) files, or email me any as attachments. Instead, print all Maple files to pdf before uploading.
- If a solution has both hand-written work and Maple work, the pages should be next to each other. Do not cluster Maple outputs separate from handwritten work.
- Every graph must be labeled. Always label all axes. Arrowheads have a very specific meaning indicating the direction of motion or of a vector or time. Arrows do not belong on axes or curves unless they are intended to indicate time or motion or vectors.
- If you are asked to make an argument, or "show that..." then you need to use enough words to make that argument. Mathematical symbols without context make no sense. Look at your textbook: it is mostly words with symbols used within the sentences. That is how your homework should be written.
- If you do calculations in Maple (for instance) and hand in the Maple session, the "printout" should be edited for clarity and conciseness just as you would edit your handwritten notes (only giving me your best work). Show me all the necessary lines and don't show me failed lines. Do show me the results of calculations, unless they are very long. I can't grade properly unless I see your intermediate results. It is easy to make graphs in Maple, but you should only show those graphs which illustrate your point. Delete graphs which do not contribute to your discussion.
- If you are asked to show an animation, the ideal way to show it on "paper" is to use superimposed curves on the same axes, with some indication of the time sequence. Do not submit blank graphs. If I can't see them, I can't grade them.

Tips

- Look carefully at your Maple plots and animations. Do they satisfy the IC and BC? If they look wrong, then your solution is wrong.
- Your engagement with the homework should not stop when you hand it in. A lot of learning happens when you correct your own HW and find your own errors and misconceptions. That is why you will get HW solutions.
- You are expected to check your NCSU email daily. I often send reminders or explanations or assignments by email.
- Office hours are for me to help you with material you aren't understanding, despite coming to class, participating, reading the book, and working on the exercises. If you can't make the scheduled times, email me to set up a different time to meet.
- No one needs to purchase Maple. It is available on all campus computers, such as in the Mathematics Multimedia Center, SAS 2103/2105, where there is also free tutoring available.
- Did I mention that you should actually **read the book**?

Links

- Applets that show various phenomena that we model in this class (heat, waves, etc.): http://www.falstad.com/mathphysics.html
- Waves: http://www.kettering.edu/~drussell/demos.html
- Handbook of Mathematical Functions, Milton Abramowitz and Irene Stegun, courtesy of the US National Bureau of Standards has all the facts you need on special functions and not-so-special functions. This is what your grandparents had on their desk if they were engineers or physicists. Now it's online, and free.
- Khan Academy (www.khanacademy.org/math/differential-equations) is a great resource for review. It does not have material on PDE, but it does cover ODE and Laplace transform