Kennesaw State University
College of Science and Mathematics
Department of Mathematics
Fall Semester 2022
MATH 4310 (Section 51): Partial Differential Equations

1. Basic Information

Instructor: Dr. Timothy Faver
Email: `tfaver1_AT_kennesaw.edu` (this is the best way to contact me)
Website: `https://tefaver.com/teaching/math-4310`
Lecture time/location: MWF 10:10 am – 11:00 am, D249
Office: D248
Office hours: (tentative) M 1:00 – 2:00 pm, W 3:00 pm – 4:00 pm

1.1. Learning outcomes. Upon completing this course, students will be able to

1. Know what a PDE is, understand the importance of initial and boundary conditions, know the classification of PDE (parabolic, elliptic, hyperbolic).

2. Derive a PDE as well as the initial and boundary conditions corresponding to problems which arise in the sciences and engineering.

3. Recognize Sturm–Liouville equations, be aware of the existence and uniqueness properties of boundary value problems, and demonstrate the orthogonality property of solutions of Sturm–Liouville equations.

4. Solve PDE using standard techniques including separation of variables, eigenfunction expansions, Fourier series, Fourier and other integral transforms.

The purpose of a course in *ordinary* differential equations (ODE) is to learn how to predict the future. One does so by casting a problem in the form of an ODE and then solving that ODE. This modeling process itself is a nontrivial challenge, the solution process (which may or may not involve finding an explicit formula) no less so. Our course in *partial* differential equations (PDE) likewise involves the distillation of physical phenomena into simplified models, and thence tractable equations, but the focus and available results will be somewhat different from what the ODE philosophy offers.

Instead of providing sweeping existence theories or broadly applicable techniques for finding solution formulas — neither of which is largely available for PDE — we will focus on very particular PDE and some (though not all) of their solutions, the rigorous study of which has driven the construction of much of modern analysis. The canonical examples of the transport equation, the heat equation, the wave equation, and Laplace's equation will occupy much of our study. The powerful theory and applications of Fourier analysis will arise from our study of the heat equation and be just as worthwhile as any of the specific PDE that we consider. Once we are sufficiently embiggened by this knowledge, we will see how the abstract perspective of linear analysis (as applied to Sturm–Liouville-type problems) can unite many seemingly disparate themes. Along the way, we will develop a deeper appreciation for many techniques of calculus, both of the single- and multivariable flavors, that we previously learned.

While this is not a course in "proof," it is also not a course in mechanically finding symbolic solutions to problems (although there will be plenty of those). Part of our learning will involve *asking* the right analytic questions and then understanding what the rigorous answers *say*, even if we don't *justify* all of those statements.

If there is a topic that you would like to study more deeply (perhaps because you find it interesting, or because it is challenging and you feel we need more time on it), please let me know. It is very likely that we can extend our coverage of the planned topics and also introduce particular topics beyond the common course description (such as the PDE governing nonlinear water waves).

1.2. Necessary background. The official prerequisite is Calculus III (and therefore I and II) and Ordinary Differential Equations. In particular, you should be comfortable with the following topics: methods for calculating ordinary and partial derivatives (e.g., the product rule); methods for calculating elementary antiderivatives, u-substitution, integration by parts; the multivariable chain rule, gradient, directional derivative; the definition of and properties of improper integrals that look like $\int_{-\infty}^{\infty} f(x)\ dx$; solving first-order ordinary differential equations via separation of variables and integrating factors; solving second-order constant-coefficient homogeneous ordinary differential equations; a nominal belief that if $i^2 = -1$, then $e^{ix} = \cos(x) + i\sin(x)$.

We will almost surely have time to review most of these topics along the way, depending on everyone's needs and interests. If you feel a bit rusty on some of them, don't panic (but don't be a slouch, either).

1.3. Course materials. Most material (notes, readings, exam solutions) will be posted to the course website. More sensitive information and grades will appear on D2L.

1. I will write comprehensive daily lecture notes and post them regularly on the course website. These notes will be the source that most accurately reflects our course content.

2. Our primary reference will be *Basic Partial Differential Equations* by David Bleecker and George Csordas (International Press 2003).

3. There are many, many good textbooks out there on PDE. Please let me know if you would like additional references throughout the term.

4. You should have paper (of any kind/size) available for in-class work each day.

2. Grading

Your final numerical grade will be based on your daily attendance, two projects, weekly problem sets, three in-class exams, and a cumulative final exam. Each component will be scored out of 100 points. The following weights will determine your final numerical grade.

Component	**Weight**
Attendance	5%
Essay	10%
Problem sets	30%
Lowest in-class exam*	10%
Middle in-class exam	15%
Highest in-class exam	15%
Final exam	15%

* *This grade can be replaced by your final exam score if your final exam score is higher. See details and exceptions to this possibility in Section 2.4.*

Your final letter grade will be determined by the interval to which your final numerical grade belongs.

Numerical grade	**[90,100]**	**[80,90)**	**[70,80)**	**[60,70)**	**[0,60)**
Letter grade	A	B	C	D	F

2.1. Attendance (5%). *Regular and engaged attendance is essential for your learning; failures in my classes are strongly correlated with low attendance or attendance with weak engagement.* I will take attendance on each of the days that we meet and do not have an exam, either by checking the course roster or by reviewing in-class work that you will submit. (This work will not be graded for correctness.) Each day that you are present will add a point to your final attendance score. At the end of the term, your attendance grade will be determined by

$$\max\left\{100 \times \frac{\text{Total number of attendance points}}{\text{Total number of meetings} - 6}, 100\right\}.$$

This allows you to miss several classes without penalty, including the first week if you join the course after the term begins.

An absence may or may not be "excused." Important family commitments, religious obligations, feeling ill, COVID exposure/infection, emergency car trouble, legal issues, an essential work commitment, and university-sponsored athletics, trips, or programs are all sufficient reasons for an excused absence. Making up work in another class, oversleeping, traffic, and vacations (...early Thanksgiving break...) are not.

If you feel that your absence merits an excuse, please read the posted lecture notes from that day and then email me (1) the reason for your absence and (2) a question about something that you don't understand from that day's discussion or, if you feel that you understand everything, a comment about something that seems interesting, or frustrating, or weird, or anything that evokes an emotional reaction in you. An excused absence will not receive attendance credit without the component (2).

2.2. Essay (10%). *The essay will enable you to explore in more intense and personal detail a PDE that we will not study in class, with a special focus on formal writing skills.* You will write a short, but carefully prepared, essay on some topic in PDE that you find interesting and that we will not discuss in (great detail in) class. Directions and suggestions for your essay are on the course website.

2.3. Problem sets (30%). *Regular work on problem sets will strengthen and reinforce your understanding of course concepts and techniques and occasionally expose you to important topics not discussed in class.* There will be 10 problem sets due throughout the term, mostly on Fridays. See the calendar (Section 4) for the exact (but perhaps tentative) dates on which problem sets are due. Problem sets will be posted to the course website (under `Problem sets and readings`) and due on D2L; specific instructions for the formatting and submission of solutions will be included in each assignment.

For each problem set, I will select a subset of problems to grade for "correctness" (i.e., you have the "right" answer with the "right" work), and I will grade the other problems for "completeness" (i.e., you have put in substantial work to reach, broadly, the desired conclusions). It is possible that this scheme will give you a higher problem set score than grading strictly for correctness would, and so it is incumbent on you to ensure your comfort and fluency with solutions to *all* problems, including those on which you will not receive direct feedback. Of course, you can ask me to review any problem with you during office hours or via email.

In general, I will not accept late problem sets, but I will drop your lowest two problem set scores. Incorporated into the problem set grade will be a syllabus quiz that is available on D2L and due by the Wednesday of the second week of the term. Your final problem set score will be given by

$$\frac{\text{Syllabus quiz score } + \text{ the sum of the 8 highest problem set scores}}{8}.$$

2.4. Exams (55%). *Exam preparation will help you connect discrete course topics; completing an exam under time constraints is one way of evaluating your fluency with course material and your intellectual independence.* There will be three in-class exams (Exams 1, 2, and 3) during the term and a cumulative final exam. The final exam will only be given at the university-specified time, which cannot be changed. See the calendar (Section 4) for the exam dates. I will provide a detailed study guide at least a week in advance of each exam. You will earn 5 points on each exam from a reflection activity that you will do based on the study guide; you can earn the other 95 points on the actual exam.

In order to be excused from an exam, you must (1) notify me before the start of the exam (or as soon after as the circumstances allow) and (2) provide official documentation (a doctor's note, a quarantine notice or proof of COVID test, a note from your employer, etc.) excusing your absence in a timely manner. If your absence from an exam is excused, then you will take a make-up exam during finals week; if your absence is not excused, you will score a 0 on that exam. Dates and times for the make-up exam are also on the calendar. Valid (and invalid) reasons for missing an exam are, in general, the same as for missing class.

In the unlikely event that you first have an excused absence from Exam m and later have an excused absence from Exam n, where $1 \leq m < n \leq 3$, then you will take a make-up for Exam n within one week of returning to class. Failure to do so will result in a score of 0 on Exam n. This is to prevent you from having too much work at the end of the term.

To encourage and reward improvement throughout the term, your final exam grade can replace the lowest of your Exams 1, 2, and 3 grades. The final exam grade will not replace a score of 0 on Exams 1, 2, or 3 that results from an unexcused absence from the exam or from not taking the make-up exam in the event of an excused absence from the original exam.

2.5. Incomplete grades. The catalogue specifies that an "incomplete grade may be awarded only when the student was doing satisfactory work prior to the last two weeks of the semester but for nonacademic reasons beyond the student's control, was unable to meet the full requirements of the course." I define "satisfactory work" to mean the existence of a score (scores) on your remaining work that will allow you to pass the class.

The catalog subsequently states that a "grade of 'I' must be removed by completing the course requirements within one calendar year from the end of the semester in which the 'I' was originally assigned. In addition, should the student enroll in classes at KSU during the calendar year, the grade of 'I' must be removed by the end of the first semester of enrollment during that calendar year."

If you are awarded an incomplete for this course, it will be to your advantage to complete all remaining work as soon as possible. Based on your circumstances, we will agree on a mutually convenient and appropriate timeline for completing your work. Failure to follow this timeline without a justifiable excuse may result in failing grades for the missed work and possibly the course. Ideally, you would complete all work by the end of January 2023.

3. Strategies for Success and/or Failure

3.1. Class attendance and participation. Failures in my classes are strongly correlated with low attendance or attendance with minimal engagement; students who both attend class regularly and engage with me in and/or outside class tend to succeed. (This should be utterly unsurprising.) This is *your* education — seize every opportunity that you can to learn, and don't be content with mediocrity!

3.2. Office hours. During office hours, we can discuss specific examples, problems, or techniques from class, the lecture notes, or the textbook. More broadly, we can talk about your study habits, time management, and mathematical reading skills. Before coming to office hours, think carefully about what you want to discuss so that we use our time well.

If my office hours conflict with your other classes, we can make an appointment for a different time. If the currently scheduled office hours conflict with the availability of students who most frequently want to see me, I may change the weekly hours to accommodate the preferences of the majority.

An online option via Teams will always be available for office hours. The Teams link will be on D2L. I will attempt to hold office hours in person (please wear a mask).

3.3. Email communication. You are welcome to email me questions about any aspect of the course at any time. A short hint from me can make a big difference for you.

Please include the words "Math 4310" in the subject of your email. I filter emails and may not respond to your message promptly, or may miss it entirely, without these key words. Please use your "students" email, not D2L email.

Please begin your email with a salutation (e.g., "Hi, Dr. Faver") before the body of text; this is simply good manners (and will put me in a good mood, which will be helpful for you).

3.4. Problem sets. The problem sets represent the *minimum* amount of work that you will need to do to master the course material. You should start these assignments early each week and give yourself plenty of time to draft arguments, check calculations, and produce a clean and coherent submission. While each student must submit an individually written assignment, you are welcome to discuss and check your work with your classmates, provided that you write the final version solely by yourself.

3.5. Reading assignments and recommended problems. It is quite likely, and wholly natural, that you will not fully understand the material that we cover in a given class. The weekly readings from the textbook will offer different examples and perspectives that may be more conducive to your personal engagement with Math 4310. Part of your mathematical education is developing your reading comprehension; be prepared to invest time, and struggle, with the course's *written* materials (my lecture notes, the textbook) before seeking outside help or alternate media.

Doing the problem sets *alone* probably will not provide you with enough exposure to course material outside of class. Instead, you should attempt a variety of problems from the "Recommended Problems" lists that I provide each week; challenge yourself to do a certain number of these each week along with the problem sets. Recommended problems will enrich your Math 4310 experience by exposing you to topics beyond what we cover in class; they will also serve as additional, essential practice and review for exams. You are welcome to request particular kinds of recommended problems if there is a topic on which you want more practice (including topics from the course prerequisites).

3.6. How to fail. The following strategies have helped prior students fail my classes.

1. Don't come to class regularly; in particular, show up only for exams.

2. Be physically present but intellectually disengaged in class. Avoid talking with me.

3. Don't do the problem sets or any recommended practice problems.

4. Save all your Math 4310 work for only one day each week.

5. Ask for, but then completely ignore, my advice on improving your course performance.

4. Calendar

You are responsible for knowing all of the due dates for assignments and scheduled dates for exams listed below. D2L submissions are due at 11:59 pm on the stated day.

W August 24:	Syllabus quiz due on D2L
F August 26:	Problem Set 1 due on D2L
F September 2:	Problem Set 2 due on D2L
M September 5:	No class — Labor Day
F September 9:	Problem Set 3 due on D2L
M September 12:	Exam 1 reflection due on D2L
F September 16:	Exam 1
F September 23:	Problem Set 4 due on D2L
F September 30:	Problem Set 5 due on D2L
F October 7:	Problem Set 6 due on D2L
T October 11:	Last day to withdraw without academic penalty
F October 14:	Problem Set 7 due on D2L
M October 17:	Exam 2 reflection due on D2L
F October 21:	Exam 2
F October 28:	Essay due on D2L
F November 4:	Problem Set 8 due on D2L
F November 11:	Problem Set 9 due on D2L
M November 14:	Exam 3 reflection due on D2L
F November 18:	Exam 3
M November 21:	No class — Thanksgiving Break
W November 23:	No class — Thanksgiving Break
F November 25:	No class — Thanksgiving Break
T November 29:	Last day to withdraw without a WF
W November 30:	Final exam reflection due on D2L
F December 2:	Problem set 10 due on D2L
T December 6:	Make-up exams, 3:30 pm – 4:30 pm
W December 7:	Make-up exams, 3:30 pm – 4:30 pm
M December 12:	Final exam, 10:30 am – 12:30 pm

If something within or beyond Math 4310 is negatively affecting your Math 4310 experience, please come talk to me (in person, via email, during office hours — whatever you prefer). It is very likely that we can find a way to make your Math 4310 experience better. Waiting to discuss a Math 4310-related problem usually will not make that problem go away.

5. University Policies and Formal Matters

5.1. Federal, BOR and KSU Student Policies. You should be familiar with the policies detailed via the link below.

`https://cia.kennesaw.edu/instructional-resources/syllabus-policy.php`

5.2. KSU student resources. You should be familiar with the resources and rights available to you as detailed in the link below.

`https://cia.kennesaw.edu/instructional-resources/syllabus-resources.php`

5.3. Academic integrity statement. Every KSU student is responsible for upholding the provisions of the Student Code of Conduct, as published in the Undergraduate and Graduate Catalogs. Section 5c of the Student Code of Conduct addresses the university's policy on academic honesty, including provisions regarding plagiarism and cheating, unauthorized access to university materials, misrepresentation/falsification of university records or academic work, malicious removal, retention, or destruction of library materials, malicious/intentional misuse of computer facilities and/or services, and misuse of student identification cards. Incidents of alleged academic misconduct will be handled through the established procedures of the Department of Student Conduct and Academic Integrity (SCAI), which includes either an "informal" resolution by a faculty member, resulting in a grade adjustment, or a formal hearing procedure, which may subject a student to the Code of Conduct's minimum one semester suspension requirement.

5.4. Course catalogue description.
3 Class Hours 0 Laboratory Hours 3 Credit Hours
Prerequisite: MATH 2203 and MATH 2306
This course is an introduction to partial differential equations (PDE), their applications in the sciences and the techniques that have proved useful in analyzing them. The techniques include separation of variables, Fourier series and Fourier transforms, orthogonal functions and eigenfunction expansions, Bessel functions, and Legendre polynomials. The student will see how the sciences motivate the formulation of partial differential equations as well as the formulation of boundary conditions and initial conditions. Parabolic, hyperbolic, and elliptic PDE will be studied.

5.5. COVID-19 statements. You should be familiar with the most recent university policies and resources regarding COVID-19 as detailed in the link below.

`https://www.kennesaw.edu/coronavirus`