Math5332: Partial Differential Equations I

Section 001, Fall 2025.

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◇ **Lectures time and place:** MWF 2:00pm to 2:50pm in classroom MATH 012.

◇ **Office hours.** Monday 3:00pm to 5:00pm. If that time does not fit your schedule, please send me an e-mail so we can better coordinate. I can accommodate one-to-one meetings: M-W-F from 11:00am-1:00pm and 3:00pm-5:00pm.

◇ **Textbook:** The official textbook is "Partial Differential Equations", 2nd Edition (2010), authored by Lawrence C. Evans, published by the American Mathematical Society. Another excellent textbook is: "Partial Differential Equations in action", 3rd Edition (2016), by Sandro Salsa, published by Springer. The contents of the book by Salsa are almost the same as those by Evans. However, I find the book by Salsa (sometimes) easier to read. I will prepare my lectures using both books.

◇ **Contents of this class (PDE-I):** This class is meant to prepare graduate students to take their preliminary examination on Partial Differential Equations. The contents of the preliminary exam on PDEs are described in:

https://www.depts.ttu.edu/math/graduate/resources/prelims/PDE/PDETopics.pdf

PDE-I will focus on: classical solutions and representation formulas in relationship to Laplace equation, Heat equation, and Wave equation. We will also learn about first-order PDEs and Hamilton-Jacobi PDEs. Roughly speaking we will cover chapters 1, 2, 3, and 4 from the book of Evans. This is comparable to the contents of chapters 1 to 5 from the book of Salsa.

Note: PDE-I will NOT cover Sobolev Spaces, Hilbert-space methods, Galerkin method, and compactness methods. Those are the topics from Chapters 5, 6, 7 and 8 of the book of Evans. We will cover all those topics in PDE-II during Spring 2026.

◇ **Learning Outcomes.** By the end of the class the student should have knowledge and skills about the following topics:

- *Laplace and Poisson's equations:* fundamental solution, representation formula for Poisson's equation, mean-value formulas, properties of harmonic functions, strong maximum principle and uniqueness, regularity/smoothness, local estimates for harmonic functions, Liouville's theorem, Harnack's inequality, Green's function, energy methods.
- *Heat equation:* fundamental solution, representation formula, non-homogeneous problem and Duhamel's principle, mean-value formula, max/min principles and uniqueness, regularity, local estimates, energy methods, backward uniqueness.
- *Wave equation:* D'Alembert's formula ($d = 1$), Kirchhoff's and Poisson's formulas (spherical means, $d \geq 2$), nonhomogeneous problem and Duhamel's principle, energy methods, domain of dependence, range of influence, forward and backward characteristic cones.

- *First-order PDEs and Hamilton-Jacobi problems:* complete integrals and envelopes, characteristics, calculus of variations and Hamilton's ODE, Hopf-Lax formula, weak solutions.

◇ **Required background:** PDE-I requires minimal to no knowledge of real or functional analysis. I would go as far as saying that anyone with a solid knowledge of multi-variable calculus could actually take PDE-I and succeed. However, the fact that the pre-requisites for this class are elementary does not mean or imply that this class is easy (elementary $\neq$ easy). The level of intellectual difficulty builds up very quickly, which will be reflected by the homework.

◇ **Homework:** this class will have 5-6 homework assignments. You will be given 10-14 days to complete each homework assignment. Homework is the most important component of this class. It is your responsibility to do and latex/hand-write your own homework. Your homework is not merely for submission: it is a written record of things you have learned that you should use to study for the final exam. The goal of the homework is to teach you mathematical arguments and techniques that are standard and widely used in the scientific literature.

◇ **Exams:** there will be no midterms. Assuming that we have approximately a dozen students I will only take one oral (in-person) final exam. You will have to show-up to my office with your all your homework (either originals, or printed copies, or photocopy of your hand-written homework). I will pick 2-3 problems from the homework, I might introduce some modifications/variations to the problems, and you will have to either solve the problems on the blackboard, or explain to me what is a proper solution strategy (if the actual solution is deemed to lengthy).

◇ **Grade:** 50% of your grade will come from your homework, 50% will come from your final exam.

◇ **Important dates.** You can find the (full) official TTU's academic calendar at

`https://www.depts.ttu.edu/officialpublications/calendar/25-26_onepage_calendar.pdf`

Some important TTU dates I extracted from the official calendar:

- Classes Begin: Aug. 25 (Monday)
- Labor day: Sep. 1 (Monday)
- Thanksgiving Nov. 26-30 (Wednesday-Sunday)
- No Exams Except Makeup or Scheduled Lab Exams: Nov. 25-Dec. 4 (Tuesday-Thursday)
- Last Day of Classes: Dec. 3
- Individual Study day: Dec. 4
- Final Examinations: Dec. 5-10
- Semester Ends: Dec. 10

Note: these dates are provided for your convenience. This syllabus should NOT be used as your primary academic calendar reference. Always refer to the official academic calendar.

◇ **Grade posting:** in order to comply with state regulations and preserve your right of privacy, I will NOT communicate grades by e-mail or phone. I will strictly communicate and post grades using RaiderCanvas or in person during office hours.

◇ **Texas Tech Operating Policies and Procedures.** The complete policies are available at

`http://www.depts.ttu.edu/opmanual/`

The operaring policies are numerous but here are three that are particularly important:

- Academic Honesty (OP 34.12): It is the aim of the faculty of Texas Tech University to foster a spirit of complete honesty and high standard of integrity. The attempt of students to present as their own any work not honestly performed is regarded by the faculty and administration as a most serious offense and renders the offenders liable to serious consequences, possibly suspension. "Scholastic dishonesty" includes, but it not limited to, cheating, plagiarism, collusion, falsifying academic records, misrepresenting facts, and any act designed to give unfair academic advantage to the student (such as, but not limited to, submission of essentially the same written assignment for two courses without the prior permission of the instructor) or the attempt to commit such an act.
- ADA Accommodation (OP 34.22): Any student who, because of a disability, may require special arrangements in order to meet the course requirements should contact the instructor as soon as possible to make any necessary arrangements. Students should present appropriate verification from Student Disability Services during the instructor's office hours. Please note that instructors are not allowed to provide classroom accommodations to a student until appropriate verification from Student Disability Services has been provided. For additional information, you may contact the Student Disability Services office at 335 West Hall or 806-742-2405.
- Religious Holy Day Observance (OP 34.19): "Religious holy day" means a holy day observed by a religion whose places of worship are exempt from property taxation under Texas Tax Code §11.20. A student who intends to observe a religious holy day should make that intention known to the instructor prior to the absence. A student who is absent from classes for the observance of a religious holy day shall be allowed to take an examination or complete an assignment scheduled for that day within a reasonable time after the absence. A student who is excused may not be penalized for the absence; however, the instructor may respond appropriately if the student fails to complete the assignment satisfactorily.