Fall 2022

Math 656: **Introduction to PDE**

MW 2:30 – 4:00 PM,

EH 4096

Instructor: Zaher Hani, (*Office:* 5834 East Hall (EH)), *Email:* zhani@umich.edu,
Website: https://sites.lsa.umich.edu/zhani/.*Office hours:* TBA.

Prerequisites: A strict requirement for this course is graduate real analysis at the level of Math 597 and a solid background in complex analysis.

Course Coordinates: MW 2:30–4:00 pm in EH 4096.

Textbook: No textbook is required. I will be supplying my own lecture notes.

Reference and resources: Here are some references for the material in the course.

1. L. C. Evans, *Partial Differential Equations.* Graduate Studies in Mathematics.
2. F. John *Partial Differential Equations.* Mathematical Notes, 102. Princeton University Press.
3. G. B. Folland, *Partial Differential Equations.* Applied Mathematical Sciences 1. Springer.

Homework: There will be (roughly bi-weekly) homework sets throughout the semester.

Grading: Grading will be based on homework (50%), a midterm (25%), and final (25%).

Course Description: Partial differential equations are at the core of models in science, engineering, economics, and related fields. It is a field of math that has been growing vigorously for over 400 years, while receiving a constant flux of new problems from inside and outside mathematics. This made PDE a field of immense breadth, diversity, and importance.

Attempts at classifying PDE into classes, and proving theorems applicable to all equations in each class have had limited success and utility. This is partly because of the immense diversity of PDE mentioned above, as well as the fact that each PDE often comes with its own character and complexities. As such, the modern study of PDE is more "equation specific". In this course, we will survey some of the powerful tools used to study some of the most important and representative equations. Each chapter below scratches the surface of a large field of mathematical research, and it is up to your interests to go deeper.

Rough Outline:

A) Preparations:

- The Fourier transform
- Tempered distributions

B) Introduction to First order systems.

- The method of characteristics
- Introduction to conservation laws.

C) General Considerations on local existence theory

- Non-characteristic hypersurfaces and the Cauchy problem.
- The Cauchy-Kowalevsky theorem.

D) Laplace's equation: maximum principle, mean-value property, regularity theory, construction of solutions.

E) The Heat Equation: Duhamel forumula, maximum principle, and regularity theory.

F) The Wave equation: Representation formula, finite speed of propagation, and estimates.

Important Dates

Aug 29	First day of classes
Sept 19	Drop/Add Deadline
October 26	Midterm (in class)
Oct 17-18	Fall Break- No Class
Dec 7	Last day of classes.