Math 60650, Basic PDE – Description

MWF: TBA, Room: TBA

Instructor: Alex Himonas, Department of Mathematics, Hurley 274, Phone: 631–7583, Email: himonas.1@nd.edu

Office Hours: TBA and by appointment.

Textbook: Lawrence C. Evans, Partial Differential Equations (Second Edition). American Mathematical Society, Graduate Studies in Mathematics, Vol. 19, Providence RI, 2010.

Description: The goal of this course is to teach the basics of Partial Differential Equations (PDE), linear and nonlinear. It begins by providing a list of the most important PDE and systems arising in mathematics and physics and outlines strategies for their "solving." Then, it focusses on the solving of the four important linear PDE: The transport, the Laplace, the heat, and the wave equations, all in several space dimensions. In addition to deriving solution formulas, it also introduces "energy" methods involving L^2-norms, which foreshadow modern theoretical developments for studying PDE. Next, it continues with the solving of nonlinear first-order equations (like the Burgers equation) by using the method of characteristics. Also, it defines weak solutions, introduces several nonlinear concepts and phenomena, and demonstrates the point that nonlinear PDE are much more difficult to solve than linear PDE. The first (and major) part of the course concludes with the presentation of other ways for representing solutions, including the separation of variables, traveling waves and solitons, similarity and scaling, Fourier, Radon and Laplace transform methods, converting nonlinear PDE to linear by using transformations like the Cole-Hopf, asymptotics, power series methods and the Cauchy-Kovalevskaya Theorem. The second part of the course introduces function spaces like Hölder and Sobolev spaces together with their properties, including approximation, extensions, traces, important inequalities, and compactness. These spaces are used for designing appropriate solution spaces for a given PDE problem (initial or boundary value) inside which the solution resides. Proving this may require sophisticated theories that could involve many branches of mathematics as well as physics. Such theories are presented in the later part of the textbook, for which there is no time available in this course. However, this course will prepare the interested student to continue learning more about PDE and their applications to mathematics, the sciences, engineering and economics.

Prerequisites: Basic Analysis I and concurrently enrollment in Basic Analysis II. Some familiarity with Ordinary Differential Equations is desirable but not a prerequisite. Exposure to an undergraduate PDE course is helpful but not required.

Reference Books: For additional readings the following books are recommended:

[**1**] Fritz John, Partial Differential Equations, Springer-Verlag. (*A classic developping the basic theory of PDE, linear and nonlinear, concisely.*)

[**2**] David Gilbarg and Neil S. Trudinger, Elliptic Partial Differential Equations of Second Order, Springer Verlag. (*A classic on elliptic second order equations.*)

[**3**] Lars Hörmander, The Analysis of Linear Partial Differential Operators (4 volumes), Springer Verlag. (*The most comprehensive and advanced book on linear PDE. Volume 1 is a good place to learn Distributions and Fourier analysis.*)

[**4**] Felipe Linares and Gustavo Ponce, Introduction to nonlinear dispersive equations, Springer Verlag. (*A good book on a topic not included in most PDE books.*)

[**5**] Ivan Georgievich Petrovsky, Lectures on Partial Differential Equations, Dover 1991. (*A book describing the early developments in PDE clearly.*)

[**6**] Walter Strauss, Partial Differential Equations: An Introduction, John Wiley & sons, 2008. (*A good book for those with no exposure to PDE to build up experience by working with concrete examples of PDE.*)

[**7**] Michael E. Taylor, Partial Differential Equations (3 volumes), Springer Verlag. (*The most comprehensive and advanced book on both linear and nonlinear PDE.*)

Exam, Homework, Projects and course grade:

Midterm Exam	Date: TBA	Day: TBA	Time: TBA	Room: TBA	100 pts
Final Exam	Date: TBA	Day: TBA	Time: TBA	Room: TBA	100 pts
Homework	collected regularly				150 pts
Project	including class participation				50 pts
Course grade is based on the total points:					400

Project: The course project consists of a student (or a group of 2-3 students) reading a paper or an advanced topic form a book, typing up notes, and presenting it in class as a short lecture.

Homework: Homework problems will be assigned and collected regularly. Students are encouraged to work on homework problems in groups, but the assignments must be turned in individually. Also, it must be stressed that **no learning is achieved by copying another student's work**.

Honor Code: Examinations, homework and projects are conducted under the honor code. While collaboration in small groups in doing homework and projects is permitted (and strongly encouraged) in this course, copying is not.

Class Attendance and Participation: Students are expected to attend all classes. Also, they are encouraged to actively participate by answering and asking questions.