



## Course Information

**Course: MATH 442: Introduction to Partial Differential Equations**

## Course Description:

This course covers basic theory of partial differential equations, with a particular emphasize on the wave, diffusion, Laplace and Schrodinger equations. Topics include classification of PDEs in terms of order, linearity and homogeneity, finding the solutions of the PDEs using methods such as geometric, operator, Fourier, separation of variables and spherical means.

## Course Objectives

The course covers topics from the text book Partial Differential Equations by Walter A Strauss. Students would learn different methods for solving the PDEs along with some of the applications in the physical systems such as harmonic oscillator, special relativity and hydrogen atom. The main focus will be on understanding the physical meaning and mathematical properties of solutions of partial differential equations. It is important to recognize that reading ahead in the textbook before viewing class videos will make the lectures more comprehensible and writing your homework solutions in your own words improves your understanding.

## Course Content

1. First order linear partial differential equations, initial and boundary conditions, well-posed problems, geometric method and coordinate method for solving first order PDE.
2. Second order PDEs, types of second order PDEs, different methods for solving second order PDEs including operator method, Fourier coefficient method, separation or variables method, spherical means method, Green's function formula, Duhamel's principle.
3. Wave equation, principle of causality, diffusion equation, Maximum principle, reflection of waves, waves equation with a source, diffusion equation with a source, well posedness of the wave equation. Separation of variables with Dirichlet, Neumann and Robin boundary conditions. Heat and wave equation in higher dimensions, radial functions.
4. Fourier coefficient method for homogeneous and inhomogeneous wave, diffusion based on even, odd, periodic and complex functions, Orthogonality and convergence. Method of shifting data for inhomogeneous diffusion equation.
5. Laplace Equation with Robin BC, Energy problem, Eigen functions, homogeneous and inhomogeneous periodic differential equation, harmonic boundary problem.
6. PDE based modelling of simplest atom (Schrodinger equation), Harmonic oscillator, hydrogen atom, vibrations of drumhead, solid vibration in a ball.
7. Inner product spaces, Cauchy Schwarz inequality, Green Identity, Hilbert spaces, convergence and orthonormal systems, different types of convergence, harmonic function,

Bessel's inequality, Theorem on Continuous derivatives and pointwise convergence, divergence theorem, Weierstrass approximation theorem.

### Format

- This is an online course featuring video lectures from the UIUC Spring 2018 course taught by Professor Marius Junge.
- Required Text: Walter A Strauss. (2007). *Partial Differential Equations*. (2<sup>nd</sup> Edition). John Wiley & Sons, Inc.
- Students must be able to print out assignments, write out solutions, then scan their written work and upload it to Moodle.
- This course requires multiple paper-based exams that must be taken with an approved proctor. Exams may be taken on campus with NetMath proctoring; for off-campus options see <https://netmath.illinois.edu/offcampus>. Off-campus proctors must be able to scan completed exams and email them to NetMath for grading, as well as mailing the paper exam back for archival purposes.