Approval: 8th Senate Meeting

Course Name: Introduction to Partial Differential Equations for Engineers

Course Number: MA555

Credit: 3-0-0-3

Prerequisites: IC 110: Engineering Mathematics

Intended for: UG/PG

Distribution: Elective

Semester: Odd /Even

Course Preamble: Many pure and applied scientific disciplines deals with two main issues: formulate a collection of mathematical laws (i.e., equations) that model the phenomena of interest, and analyze solutions to these equations in order to extract information and make predictions. The end result of the first issue is often a system of partial differential equations (PDEs). PDEs describe the relationships among the derivatives of an unknown function with respect to different independent variables, such as time and position. The second issue often entails the analysis of a system of PDEs. This course will provide an application-motivated introduction to some fundamental aspects of both the issues.

Course Outline: The objective of the course is to provide a broad overview of PDEs arising in the field of applied sciences and engineering. In this process, we shall study three important classes of PDEs that differ markedly in their quantitative and qualitative properties: elliptic, parabolic, and hyperbolic. In each case, we will discuss some fundamental analytical tools that will allow us to probe the nature of the corresponding solutions. Finally, our goal here is to develop the most basic ideas from the theory of partial differential equations, and apply them to the simplest models arising from applied sciences and engineering.

Modules:

Unit 1: Introduction [6 Lectures including Lab class]

Overview of PDEs, Classification of second order equations, Initial value problems, boundary value problems.

Unit 2: Parabolic Partial Differential Equations [**8 Lectures**]

Introduction to heat equation, uniqueness, Weak maximum principle, fundamental solution.

Unit 3: Hyperbolic Partial Differential Equations [**8 Lectures**]

Introduction to the wave equation, the method of spherical means, Kirchhoff's formula and Minkowskian geometry, geometric energy estimates.

Unit 4: Elliptic Partial Differential Equations [**8 Lectures**]

Introduction to Laplace's and Poisson's equations, fundamental solution, Green functions, Poisson's formula, Harnack's inequality, Liouville's theorem.

Unit 5: Fourier transform [**6 Lectures**]

Introduction to the Fourier transform; Fourier inversion and Plancherel's theorem.

Unit 6: Special Equations [**6 Lectures**]

Introduction to Schrödinger's equation; Introduction to Lagrangian field theories, Transport equations and Burger's equation.

Reference Books:

1. Sandro Salsa, *Partial Differential Equations in Action: From Modelling to Theory*. Springer, 2010.
2. Robert C. McOwen, *Partial Differential Equations - Methods and Applications*, Pearson Education Inc., Indian Reprint 2004.
3. S.J. Farlow, *Partial Differential Equations for Scientists and Engineers*, Dover Publications, New York, 1982.
4. E. C. Zachmanoglou and Dale W. Thoe, *Introduction to Partial Differential Equations with applications,* Courier Dover Publications, 1988.
5. Gerald B. Folland, *Introduction to Partial Differential Equations,* Princeton University Press, 1995.