

An introduction to partial differential equations

53.1 Introduction

A partial differential equation is an equation that contains one or more partial derivatives. Examples include:

$$(i) \quad a \frac{\partial u}{\partial x} + b \frac{\partial u}{\partial y} = c$$

$$(ii) \quad \frac{\partial^2 u}{\partial x^2} = \frac{1}{c^2} \frac{\partial u}{\partial t}$$

(known as the heat conduction equation)

$$(iii) \quad \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$$

(known as Laplace's equation)

Equation (i) is a **first order partial differential equation**, and equations (ii) and (iii) are **second order partial differential equations** since the highest power of the differential is 2.

Partial differential equations occur in many areas of engineering and technology; electrostatics, heat conduction, magnetism, wave motion, hydrodynamics and aerodynamics all use models that involve partial differential equations. Such equations are difficult to solve, but techniques have been developed for the simpler types. In fact, for all but for the simplest cases, there are a number of numerical methods of solutions of partial differential equations available.

To be able to solve simple partial differential equations knowledge of the following is required:

- partial integration,
- first and second order partial differentiation — as explained in Chapter 34, and
- the solution of ordinary differential equations — as explained in Chapters 46–51.

It should be appreciated that whole books have been written on partial differential equations and their

solutions. This chapter does no more than introduce the topic.

53.2 Partial integration

Integration is the reverse process of differentiation. Thus, if, for example, $\frac{\partial u}{\partial t} = 5 \cos x \sin t$ is integrated partially with respect to t , then the $5 \cos x$ term is considered as a constant,

$$\begin{aligned} \text{and } u &= \int 5 \cos x \sin t \, dt = (5 \cos x) \int \sin t \, dt \\ &= (5 \cos x)(-\cos t) + c \\ &= -5 \cos x \cos t + f(x) \end{aligned}$$

Similarly, if $\frac{\partial^2 u}{\partial x \partial y} = 6x^2 \cos 2y$ is integrated partially with respect to y ,

$$\begin{aligned} \text{then } \frac{\partial u}{\partial x} &= \int 6x^2 \cos 2y \, dy = (6x^2) \int \cos 2y \, dy \\ &= (6x^2) \left(\frac{1}{2} \sin 2y \right) + f(x) \\ &= 3x^2 \sin 2y + f(x) \end{aligned}$$

and integrating $\frac{\partial u}{\partial x}$ partially with respect to x gives:

$$\begin{aligned} u &= \int [3x^2 \sin 2y + f(x)] \, dx \\ &= x^3 \sin 2y + (x)f(x) + g(y) \end{aligned}$$

$f(x)$ and $g(y)$ are functions that may be determined if extra information, called **boundary conditions** or **initial conditions**, are known.

Introduction To Partial Differential Equations

Vladimir A. Tolstykh



Introduction To Partial Differential Equations:

Introduction to Partial Differential Equations Peter J. Olver, 2013-11-08 This textbook is designed for a one year course covering the fundamentals of partial differential equations geared towards advanced undergraduates and beginning graduate students in mathematics science engineering and elsewhere The exposition carefully balances solution techniques mathematical rigor and significant applications all illustrated by numerous examples Extensive exercise sets appear at the end of almost every subsection and include straightforward computational problems to develop and reinforce new techniques and results details on theoretical developments and proofs challenging projects both computational and conceptual and supplementary material that motivates the student to delve further into the subject No previous experience with the subject of partial differential equations or Fourier theory is assumed the main prerequisites being undergraduate calculus both one and multi variable ordinary differential equations and basic linear algebra While the classical topics of separation of variables Fourier analysis boundary value problems Green s functions and special functions continue to form the core of an introductory course the inclusion of nonlinear equations shock wave dynamics symmetry and similarity the Maximum Principle financial models dispersion and solutions Huygens Principle quantum mechanical systems and more make this text well attuned to recent developments and trends in this active field of contemporary research Numerical approximation schemes are an important component of any introductory course and the text covers the two most basic approaches finite differences and finite elements

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Partial Differential Equations Vladimir A. Tolstykh, 2020-06-08 This is a clear rigorous and self contained introduction to PDEs for a semester based course on the topic For the sake of smooth exposition the book keeps the amount of applications to a minimum focusing instead on the theoretical essentials and problem solving The result is an agile compendium of theorems and methods the ideal companion for any student tackling PDEs for the first time Vladimir Tolstykh is a professor of mathematics at Istanbul Arel University He works in group theory and model theoretic algebra Dr Tolstykh received his Ph D in Mathematics from the Ural Institute of Mathematics and Mechanics Ekaterinburg Russia in 1992 and his Doctor of Science degree in Mathematics from the Sobolev Institute of Mathematics Novosibirsk Russia in 2007 Partial Differential Equations: An Introduction With Mathematica And Maple Ioannis P Stavroulakis, Stepan A Tersian, 1999-12-13 This textbook is a self contained introduction to partial differential equations It is designed for undergraduate and first year graduate students who are mathematics physics engineering or in general science majors The goal is to give an introduction to the basic equations of mathematical physics and the properties of their solutions based on classical calculus and ordinary differential equations Advanced concepts such as weak solutions and discontinuous solutions of nonlinear conservation laws are also considered The material is illustrated with model examples Mathematics software products such as Mathematica and Maple in ScientificWorkPlace are used in both graphical and computational aspects *Introduction to Partial Differential Equations* Donald Greenspan, 2012-05-04 Designed for use in a 1 semester course by seniors and beginning graduate students this rigorous presentation explores practical methods of solving differential equations plus the unifying theory underlying the mathematical superstructure Topics include basic concepts Fourier series 2nd order partial differential equations wave equation potential equation heat equation and more Includes exercises 1961 edition **Introduction To Partial Differential Equations (With Maple), An: A Concise Course** Zhilin Li, Larry Norris, 2021-09-23 The book is designed for undergraduate or beginning level graduate students and students from interdisciplinary areas including engineers and others who need to use partial differential equations Fourier series Fourier and Laplace transforms The prerequisite is a basic knowledge of calculus linear algebra and ordinary differential equations The textbook aims to be practical elementary and reasonably rigorous the book is concise in that it describes fundamental solution techniques for first order second order linear partial differential equations for general solutions fundamental solutions solution to Cauchy initial value problems and boundary value problems for different PDEs in one and two dimensions and different coordinates systems Analytic solutions to boundary value problems are based on Sturm Liouville eigenvalue problems and series solutions The book is accompanied with enough well tested Maple files and some Matlab codes that are available online The use of Maple makes the complicated series solution simple interactive and visible These features distinguish the book from other textbooks available in the related area **An Introduction to Partial Differential Equations** Yehuda Pinchover, Jacob Rubinstein, 2005-05-12 A complete introduction to partial differential equations this is a textbook aimed at students of

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