53

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) $a \dfrac{\partial u}{\partial x} + b \dfrac{\partial u}{\partial y} = c$

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

(known as the heat conduction equation)

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

(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:

(a) partial integration,

(b) first and second order partial differentiation — as explained in Chapter 34, and

(c) 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, $\dfrac{\partial u}{\partial t} = 5 \cos x \sin t$ is integrated partially with respect to t, then the $5 \cos x$ term is considered as a constant,

and $u = \displaystyle\int 5 \cos x \sin t \, dt = (5 \cos x) \int \sin t \, dt$

$= (5 \cos x)(-\cos t) + c$

$= \mathbf{-5 \cos x \cos t} + f(x)$

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

then $\dfrac{\partial u}{\partial x} = \displaystyle\int 6x^2 \cos 2y \, dy = (6x^2) \int \cos 2y \, dy$

$= (6x^2)\left(\dfrac{1}{2} \sin 2y\right) + f(x)$

$= 3x^2 \sin 2y + f(x)$

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

$u = \displaystyle\int [3x^2 \sin 2y + f(x)] \, dx$

$= x^3 \sin 2y + (x)f(x) + g(y)$

$f(x)$ 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

J Dewey

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   **An Introduction to Partial Differential Equations** Michael Renardy,Robert C. Rogers,2004-01-08 Partial differential equations are fundamental to the modeling of natural phenomena The desire to understand the solutions of these equations has always had a prominent place in the efforts of mathematicians and has inspired such diverse fields as complex function theory functional analysis and algebraic topology This book meant for a beginning graduate audience provides a thorough introduction to partial differential equations   Introduction to Partial Differential Equations with Applications E. C. Zachmanoglou,Dale W. Thoe,1986-01-01 This text explores the essentials of partial differential equations as applied to engineering and the physical sciences Discusses ordinary differential equations integral curves and surfaces of vector fields the Cauchy Kovalevsky theory more Problems and answers   **Introduction to Partial Differential Equations** David Borthwick,2017-01-12 This modern take on partial differential equations does not require knowledge beyond vector calculus and linear algebra The author focuses on the most important classical partial differential equations including conservation equations and their characteristics the wave equation the heat equation function spaces and Fourier series drawing on tools from analysis only as they arise Within each section the author creates a narrative that answers the five questions What is the scientific problem we are trying to understand How do we model that with PDE What techniques can we use to analyze the PDE How do those techniques apply to this equation What information or insight did we obtain by developing and analyzing the PDE The text stresses the interplay between modeling and

mathematical analysis providing a thorough source of problems and an inspiration for the development of methods

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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 Matematica 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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mathematics has been shaped and fueled by the g eral availability of fast computers with large memories Their impact on mathematics both applied and pure is comparable to the role of the telescopes in astronomy and microscopes in biology Peter Lax Siam Rev Vol 31 No 4 Congratulations You have chosen to study partial differential equations <u>Introduction to Partial Differential Equations with MATLAB</u> Jeffery M. Cooper,2012-12-06 Overview The subject of partial differential equations has an unchanging core of material but is constantly expanding and evolving The core consists of solution methods mainly separation of variables for boundary value problems with constant coeffi cients in geometrically simple domains Too often an introductory course focuses exclusively on these core problems and techniques and leaves the student with the impression that there is no more to the subject Questions of existence uniqueness and well posedness are ignored In particular there is a lack of connection between the analytical side of the subject and the numerical side Furthermore nonlinear problems are omitted because they are too hard to deal with analytically Now however the availability of convenient powerful computational software has made it possible to enlarge the scope of the introductory course My goal in this text is to give the student a broader picture of the subject In addition to the basic core subjects I have included material on nonlinear problems and brief discussions of numerical methods I feel that it is important for the student to see nonlinear problems and numerical methods at the beginning of the course and not at the end when we run usually run out of time Furthermore numerical methods should be introduced for each equation as it is studied not lumped together in a final chapter *Introduction to Partial Differential Equations and Hilbert Space Methods* Karl E. Gustafson,1999-01-01 This volume offers an excellent undergraduate level introduction to the main topics methods and applications of partial differential equations Chapter 1 presents a full introduction to partial differential equations and Fourier series as related to applied mathematics Chapter 2 begins with a more comprehensive look at the principal method for solving partial differential equations the separation of variables and then more fully develops that approach in the contexts of Hilbert space and numerical methods Chapter 3 includes an expanded treatment of first order systems a short introduction to computational methods and aspects of topical research on the partial differential equations of fluid dynamics With over 600 problems and exercises along with explanations examples and a comprehensive section of answers hints and solutions this superb easy to use text is ideal for a one semester or full year course It will also provide the mathematically inclined layperson with a stimulating review of the subject s essentials **Introduction to Partial Differential Equations** K. Sankara Rao,2010-07-30 Provides students with the fundamental concepts the underlying principles and various well known mathematical techniques and methods such as Laplace and Fourier transform techniques the variable separable method and Green s function method to solve partial differential equations It is supported by miscellaneous examples to enable students to assimilate the fundamental concepts and the techniques for solving PDEs with various initial and boundary conditions **An Introduction to Partial Differential Equations with MATLAB** Matthew P. Coleman,Vladislav Bukshtynov,2024-08-01 The first two editions of An

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