

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:

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

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

(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:

- (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, $\frac{\partial u}{\partial t} = 5 \cos x \sin t$ 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.

Partial Differential Equations An Introduction

Günter Hellwig



Partial Differential Equations An Introduction:

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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** 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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Modern Methods in Partial Differential Equations Martin Schechter, 1977 *Numerical Solution of Partial Differential Equations* K. W. Morton, D. F. Mayers, 2005-04-11 This is the 2005 second edition of a highly successful and well respected textbook on the numerical techniques used to solve partial differential equations arising from mathematical models in science engineering and other fields The authors maintain an emphasis on finite difference methods for simple but representative examples of parabolic hyperbolic and elliptic equations from the first edition However this is augmented by new sections on finite volume methods modified equation analysis symplectic integration schemes convection diffusion problems multigrid and conjugate gradient methods and several sections including that on the energy method of analysis have been extensively rewritten to reflect modern developments Already an excellent choice for students and teachers in mathematics engineering and computer science departments the revised text includes more latest theoretical and industrial developments

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of solution methods mainly separation of variables for boundary value problems with constant coefficients 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 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 (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

Partial Differential Equations Aleksei A. Dezin, 2012-12-06 Let me begin by explaining the meaning of the title of this book In essence the book studies boundary value problems for linear partial differential equations in a finite domain in n dimensional Euclidean space The problem that is investigated is the question of the dependence of the nature of the solvability of a given equation on the way in which the boundary conditions are chosen i.e. on the supplementary requirements which the solution is to satisfy on specified parts of the boundary The branch of mathematical analysis dealing with the study of boundary value problems for partial differential equations is often called mathematical physics Classical courses in this subject usually consider quite restricted classes of equations for which the problems have an immediate physical context or generalizations of such problems With the expanding domain of application of mathematical methods at the present time there often arise problems connected with the study of partial differential equations that do not belong to any of the classical types The elucidation of the correct

formulation of these problems and the study of the specific properties of the solutions of similar equations are closely related to the study of questions of a general nature Partial Differential Equations Bernard Epstein,1962 **Partial Differential Equations** Nita H. Shah,Mrudul Y. Jani,2020-12-28 Differential equations play a noticeable role in engineering physics economics and other disciplines They permit us to model changing forms in both mathematical and physical problems These equations are precisely used when a deterministic relation containing some continuously varying quantities and their rates of change in space and or time is recognized or postulated This book is intended to provide a straightforward introduction to the concept of partial differential equations It provides a diversity of numerical examples framed to nurture the intellectual level of scholars It includes enough examples to provide students with a clear concept and also offers short questions for comprehension Construction of real life problems is considered in the last chapter along with applications Research scholars and students working in the fields of engineering physics and different branches of mathematics need to learn the concepts of partial differential equations to solve their problems This book will serve their needs instead of having to use more complex books that contain more concepts than needed *Numerical Solution of Partial Differential Equations* K. W. Morton,1994 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 mathematics physics and engineering

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Table of Contents Partial Differential Equations An Introduction

1. Understanding the eBook Partial Differential Equations An Introduction
 - The Rise of Digital Reading Partial Differential Equations An Introduction
 - Advantages of eBooks Over Traditional Books
2. Identifying Partial Differential Equations An Introduction
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Partial Differential Equations An Introduction
 - User-Friendly Interface
4. Exploring eBook Recommendations from Partial Differential Equations An Introduction

- Personalized Recommendations
- Partial Differential Equations An Introduction User Reviews and Ratings
- Partial Differential Equations An Introduction and Bestseller Lists
- 5. Accessing Partial Differential Equations An Introduction Free and Paid eBooks
 - Partial Differential Equations An Introduction Public Domain eBooks
 - Partial Differential Equations An Introduction eBook Subscription Services
 - Partial Differential Equations An Introduction Budget-Friendly Options
- 6. Navigating Partial Differential Equations An Introduction eBook Formats
 - ePub, PDF, MOBI, and More
 - Partial Differential Equations An Introduction Compatibility with Devices
 - Partial Differential Equations An Introduction Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Partial Differential Equations An Introduction
 - Highlighting and Note-Taking Partial Differential Equations An Introduction
 - Interactive Elements Partial Differential Equations An Introduction
- 8. Staying Engaged with Partial Differential Equations An Introduction
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Partial Differential Equations An Introduction
- 9. Balancing eBooks and Physical Books Partial Differential Equations An Introduction
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Partial Differential Equations An Introduction
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Partial Differential Equations An Introduction
 - Setting Reading Goals Partial Differential Equations An Introduction
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Partial Differential Equations An Introduction

- Fact-Checking eBook Content of Partial Differential Equations An Introduction
- Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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