

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

Peter Olver



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

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

Partial Differential Equations Walter A. Strauss, 2007-12-21 Our understanding of the fundamental processes of the natural world is based to a large extent on partial differential equations PDEs The second edition of *Partial Differential Equations* provides an introduction to the basic properties of PDEs and the ideas and techniques that have proven useful in analyzing them It provides the student a broad perspective on the subject illustrates the incredibly rich variety of phenomena encompassed by it and imparts a working knowledge of the most important techniques of analysis of the solutions of the equations In this book mathematical jargon is minimized Our focus is on the three most classical PDEs the wave heat and Laplace equations Advanced concepts are introduced frequently but with the least possible technicalities The book is flexibly designed for juniors seniors or beginning graduate students in science engineering or mathematics **Introduction to**

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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

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Introduction to Partial Differential Equations Peter Olver, 2013-11-20 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 solitons 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 Peter J Olver is professor of mathematics at the University of Minnesota His wide ranging research interests are centered on the development of symmetry based methods for differential equations and their manifold applications He is the author of over 130 papers published in major scientific research journals as well as 4 other books including the definitive Springer graduate text *Applications of Lie Groups to Differential Equations* and another undergraduate text *Applied Linear Algebra A Solutions Manual* for instructors is available by clicking on Selected Solutions Manual under the Additional Information section on the right hand side of this page

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

Introduction to Partial Differential Equations with MATLAB 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 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 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

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Table of Contents Introduction To Partial Differential Equations

1. Understanding the eBook Introduction To Partial Differential Equations
 - The Rise of Digital Reading Introduction To Partial Differential Equations
 - Advantages of eBooks Over Traditional Books
2. Identifying Introduction To Partial Differential Equations
 - 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 Introduction To Partial Differential Equations
 - User-Friendly Interface
4. Exploring eBook Recommendations from Introduction To Partial Differential Equations
 - Personalized Recommendations
 - Introduction To Partial Differential Equations User Reviews and Ratings
 - Introduction To Partial Differential Equations and Bestseller Lists
5. Accessing Introduction To Partial Differential Equations Free and Paid eBooks
 - Introduction To Partial Differential Equations Public Domain eBooks
 - Introduction To Partial Differential Equations eBook Subscription Services
 - Introduction To Partial Differential Equations Budget-Friendly Options
6. Navigating Introduction To Partial Differential Equations eBook Formats

- ePub, PDF, MOBI, and More
 - Introduction To Partial Differential Equations Compatibility with Devices
 - Introduction To Partial Differential Equations Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Introduction To Partial Differential Equations
 - Highlighting and Note-Taking Introduction To Partial Differential Equations
 - Interactive Elements Introduction To Partial Differential Equations
 8. Staying Engaged with Introduction To Partial Differential Equations
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Introduction To Partial Differential Equations
 9. Balancing eBooks and Physical Books Introduction To Partial Differential Equations
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Introduction To Partial Differential Equations
 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
 11. Cultivating a Reading Routine Introduction To Partial Differential Equations
 - Setting Reading Goals Introduction To Partial Differential Equations
 - Carving Out Dedicated Reading Time
 12. Sourcing Reliable Information of Introduction To Partial Differential Equations
 - Fact-Checking eBook Content of Introduction To Partial Differential Equations
 - 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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