

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 Solutions Manual

Peter J. Olver



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Differential Equations: Techniques, Theory, and Applications Barbara D. MacCluer, Paul S. Bourdon, Thomas L. Kriete, 2019-10-02 Differential Equations Techniques Theory and Applications is designed for a modern first course in differential equations either one or two semesters in length The organization of the book interweaves the three components in the subtitle with

each building on and supporting the others Techniques include not just computational methods for producing solutions to differential equations but also qualitative methods for extracting conceptual information about differential equations and the systems modeled by them Theory is developed as a means of organizing understanding and codifying general principles Applications show the usefulness of the subject as a whole and heighten interest in both solution techniques and theory Formal proofs are included in cases where they enhance core understanding otherwise they are replaced by informal justifications containing key ideas of a proof in a more conversational format Applications are drawn from a wide variety of fields those in physical science and engineering are prominent of course but models from biology medicine ecology economics and sports are also featured The 1 400 exercises are especially compelling They range from routine calculations to large scale projects The more difficult problems both theoretical and applied are typically presented in manageable steps The hundreds of meticulously detailed modeling problems were deliberately designed along pedagogical principles found especially effective in the MAA study Characteristics of Successful Calculus Programs namely that asking students to work problems that require them to grapple with concepts or even proofs and do modeling activities is key to successful student experiences and retention in STEM programs The exposition itself is exceptionally readable rigorous yet conversational Students will find it inviting and approachable The text supports many different styles of pedagogy from traditional lecture to a flipped classroom model The availability of a computer algebra system is not assumed but there are many opportunities to incorporate the use of one

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Functional Differential Equations Constantin Corduneanu, Yizeng Li, Mehran Mahdavi, 2016-04-11 Features new

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Table of Contents Partial Differential Equations An Introduction Solutions Manual

1. Understanding the eBook Partial Differential Equations An Introduction Solutions Manual
 - The Rise of Digital Reading Partial Differential Equations An Introduction Solutions Manual
 - Advantages of eBooks Over Traditional Books
2. Identifying Partial Differential Equations An Introduction Solutions Manual
 - 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 Solutions Manual
 - User-Friendly Interface
4. Exploring eBook Recommendations from Partial Differential Equations An Introduction Solutions Manual
 - Personalized Recommendations

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

- 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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