

# 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.

# Partial Differential Equations An Introduction David Colton

**Arthur James Wells**

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some background in numerical methods for ODE systems and basic finite difference and finite volume discretization of evolutionary PDEs along with a basic understanding of the relevant mathematical models The book is suitable for students who have had a basic course in numerical analysis and are familiar with partial differential equations **Ordinary and Partial Differential Equations** ,1982 **Numerical Solution of Partial Differential Equations** James H. Bramble,Bert Hubbard,1971 **Canadian Mathematical Bulletin** ,1969 **Qualitative Properties of Differential Equations** W. Allegretto,Geoffrey James Butler,1987 *Inverse Problems and Applications* Plamen Stefanov,András Vasy,Maciej Zworski,2014-05-05 This volume contains the proceedings of two conferences on Inverse Problems and Applications held in 2012 to celebrate the work of Gunther Uhlmann The first conference was held at the University of California Irvine from June 18 22 2012 and the second was held at Zhejiang University Hangzhou China from September 17 21 2012 The topics covered include inverse problems in medical imaging scattering theory geometry and image processing and the mathematical theory of cloaking as well as methods related to inverse problems **Notices of the American Mathematical Society** American Mathematical Society,1990 Journal of Mathematics and Mechanics ,1969 The British National Bibliography Arthur James Wells,2006 **Reviews in Partial Differential Equations, 1980-86, as Printed in Mathematical Reviews** ,1988

*Differential Equations and Applications* Wiktor Eckhaus,Eduardus Marie de Jager,1977 **American Book Publishing Record** ,1992 *Duke Mathematical Journal* ,1970 Without specializing in a small number of subject areas this journal emphasizes the most active and influential areas of current mathematics Mathematical Reviews ,2008 *Book Review Index* ,2006 Every 3rd issue is a quarterly cumulation

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