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

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

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

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 Differential Equations Matht

Jicheng Xie

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   An Introduction to Differential Equations, with Difference Equations, Fourier Series and Partial Differential Equations N. Finizio,G. E. Ladas,1982   **A Friendly Introduction to Differential Equations** Mohammed K A Kaabar,2015-01-05 In this book there are five chapters The Laplace Transform Systems of Homogenous Linear Differential Equations HLDE Methods of First and Higher Orders Differential Equations Extended Methods of First and Higher Orders Differential Equations and Applications of Differential Equations In addition there are exercises at the end of each chapter above to let students practice additional sets of problems other than examples and they can also check their solutions to some of these exercises by looking at Answers to Odd Numbered Exercises section at the end of this book This book is a very useful for college students who studied Calculus II and other students who want to review some concepts of differential equations before studying courses such as partial differential equations applied mathematics and electric circuits II   *An Introduction to Differential Equations and Their Applications* Stanley J. Farlow,2006-03-11 This introductory text explores 1st and 2nd order differential equations series solutions the Laplace transform difference equations much more Numerous figures problems with solutions notes 1994 edition Includes 268 figures and 23 tables   **An Introduction To Differential Equations With Applications** Harold Cohen,Daniel Gallup,2020-07-28 This book is for students in a first course in ordinary differential equations The material is organized so that the presentations begin at a reasonably introductory level Subsequent material is developed from this beginning As such readers with little experience can start at a lower level while those with some experience can use the beginning material as a review or skip this part to proceed to the next level The book contains methods of approximation to solutions of various types of differential equations with practical applications which will serve as a guide to programming so that such differential equations can be solved numerically with the use of a computer Students who intend to pursue a major in engineering physical sciences or mathematics will find this book useful   *An Introduction to Ordinary Differential Equations* Earl A. Coddington,1961 This book is meant to be a text which can be used for a first course in ordinary differential equations The student is assumed to have a knowledge of calculus but not what is usually called advanced calculus The aim is to give an elementary thorough systematic introduction to the subject All significant results are stated as theorems and careful proofs are given The exercises in the book serve two purposes to develop the student s technique in solving equations or to help sharpen the student s understanding of the mathematical structure of the subject The exercises also introduce the student to a variety of topics not treated in the text stability equations with periodic coefficients and boundary value problems   *Introduction to Differential Equations* William E. Boyce,Richard C. DiPrima,2012   *Differential Equations* Clay C. Ross,2013-03-09 Goals and Emphasis of the Book Mathematicians have begun to find productive ways to incorporate computing power into the mathematics curriculum There is no attempt here to use computing to avoid doing differential equations and linear algebra The goal is to make some first ex plorations in the

subject accessible to students who have had one year of calculus Some of the sciences are now using the symbol manipulative power of Mathemat ica to make more of their subject accessible This book is one way of doing so for differential equations and linear algebra I believe that if a student s first exposure to a subject is pleasant and exciting then that student will seek out ways to continue the study of the subject The theory of differential equations and of linear algebra permeates the discussion Every topic is supported by a statement of the theory But the primary thrust here is obtaining solutions and information about solutions rather than proving theorems There are other courses where proving theorems is central The goals of this text are to establish a solid understanding of the notion of solution and an appreciation for the confidence that the theory gives during a search for solutions Later the student can have the same confidence while personally developing the theory   *Differential Equations and Linear Algebra* Stephen W. Goode,2000 This very accessible guide offers a thorough introduction to the basics of differential equations and linear algebra Expertly integrating the two topics it explains concepts clearly and logically without sacrificing level or rigor and supports material with a vast array of problems of varying levels for readers to choose from Promotes in depth understanding vs rote memorization enabling readers to fully comprehend abstract concepts and finish with a solid and working knowledge of linear mathematics Offers one of the most lucid and clearly written narratives on the subject with material that is accessible to the average reader yet challenging to all Presents a greater emphasis on geometry to help users better visualize the abstract concepts and illustrates all concepts with an ample amount of worked examples Second Edition highlights include new discussions direction fields and Euler s method for first order differential equations row space and column space of a matrix and the rank nullity theorem non linear systems of differential equations including phase plane analysis and change of variables for differential equations Now features a chapter on second order linear differential equations that isnot based on vector space methods to gives users a firmer grasp of the differential equation concept early on and also on the solution techniques for this important class of differential equations   Introduction To Differential Equations, An: Deterministic Modeling, Methods And Analysis (Volume 1) Anilchandra G Ladde,Gangaram S Ladde,2012-05-31 Volume 2 Stochastic Modeling Methods and Analysis This is a twenty first century book designed to meet the challenges of understanding and solving interdisciplinary problems The book creatively incorporates cutting edge research ideas and techniques at the undergraduate level The book also is a unique research resource for undergraduate graduate students and interdisciplinary researchers It emphasizes and exhibits the importance of conceptual understandings and its symbiotic relationship in the problem solving process The book is proactive in preparing for the modeling of dynamic processes in various disciplines It introduces a break down the problem type of approach in a way that creates fun and excitement The book presents many learning tools like step by step procedures critical thinking the concept of math being a language applied examples from diverse fields frequent recaps flowcharts and exercises Uniquely this book introduces an innovative and unified method of solving nonlinear scalar differential equations

This is called the Energy Lyapunov Function Method This is accomplished by adequately covering the standard methods with creativity beyond the entry level differential equations course *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 *Introduction to Ordinary Differential Equations* Shepley L. Ross,1980 **Introduction to Differential Equations: Second Edition** Michael E. Taylor,2021-10-21 This text introduces students to the theory and practice of differential equations which are fundamental to the mathematical formulation of problems in physics chemistry biology economics and other sciences The book is ideally suited for undergraduate or beginning graduate students in mathematics and will also be useful for students in the physical sciences and engineering who have already taken a three course calculus sequence This second edition incorporates much new material including sections on the Laplace transform and the matrix Laplace transform a section devoted to Bessel s equation and sections on applications of variational methods to geodesics and to rigid body motion There is also a more complete treatment of the Runge Kutta scheme as well as numerous additions and improvements to the original text Students finishing this book will be well prepare **Ordinary Differential Equations** Kenneth B. Howell,2018-12-07 Ordinary Differential Equations An Introduction to the Fundamentals is a rigorous yet remarkably accessible textbook ideal for an introductory course in ordinary differential equations Providing a useful resource both in and out of the classroom the text Employs a unique expository style that explains the how and why of each topic covered Allows for a flexible presentation based on instructor preference and student ability Supports all claims with clear and solid proofs Includes material rarely found in introductory texts Ordinary Differential Equations An Introduction to the Fundamentals also

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Differential Equations ,2015-12-30 Differential Equations A Visual Introduction for Beginners was written to gently ease the shock of transitioning from beginning calculus to differential equations It was written by a retired high school math teacher in collaboration with his editor math tutor physics tutor illustrator MatLab consultant and reviewers It is not intended as a replacement of a traditional university text and curriculum but rather as a supplement **Introduction to Partial Differential Equations with Applications** E. C. Zachmanoglou,Dale W. Thoe,2012-04-20 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 Ordinary Differential Equations Albert L. Rabenstein,2014-05-12 Introduction to Ordinary Differential Equations is a 12 chapter text that describes useful elementary methods of finding solutions using ordinary differential equations This book starts with an introduction to the properties and complex variable of linear differential equations Considerable chapters covered topics that are of particular interest in applications including Laplace transforms eigenvalue

problems special functions Fourier series and boundary value problems of mathematical physics Other chapters are devoted to some topics that are not directly concerned with finding solutions and that should be of interest to the mathematics major such as the theorems about the existence and uniqueness of solutions The final chapters discuss the stability of critical points of plane autonomous systems and the results about the existence of periodic solutions of nonlinear equations This book is great use to mathematicians physicists and undergraduate students of engineering and the science who are interested in applications of differential equation   Introduction to Differential Equations Using Sage David Joyner,Marshall Hampton,2012-09-01 Differential equations can be taught using Sage as an inventive new approach David Joyner and Marshall Hampton s lucid textbook explains differential equations using the free and open source mathematical software Sage Since its release in 2005 Sage has acquired a substantial following among mathematicians but its first user was Joyner who is credited with helping famed mathematician William Stein turn the program into a usable and popular choice Introduction to Differential Equations Using Sage extends Stein s work by creating a classroom tool that allows both differential equations and Sage to be taught concurrently It s a creative and forward thinking approach to math instruction Topics include First Order Differential Equations Incorporation of Newtonian Mechanics Second Order Differential Equations The Annihilator Method Using Linear Algebra with Differential Equations Nonlinear Systems Partial Differential Equations Romeo and Juliet   *Introduction to Linear Algebra and Differential Equations* John W. Dettman,1986-01-01 Excellent introductory text for students with one year of calculus Topics include complex numbers determinants orthonormal bases symmetric and hermitian matrices first order non linear equations linear differential equations Laplace transforms Bessel functions and boundary value problems Includes 48 black and white illustrations Exercises with solutions Index   An Introduction to Ordinary Differential Equations Ravi P. Agarwal,Donal O'Regan,2008-12-10 Ordinary differential equations serve as mathematical models for many exciting real world problems Rapid growth in the theory and applications of differential equations has resulted in a continued interest in their study by students in many disciplines This textbook organizes material around theorems and proofs comprising of 42 class tested lectures that effectively convey the subject in easily manageable sections The presentation is driven by detailed examples that illustrate how the subject works Numerous exercise sets with an answers and hints section are included The book further provides a background and history of the subject

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