

Solving PDEs using Laplace Transforms, Chapter 15

Given a function $u(x, t)$ defined for all $t > 0$ and assumed to be bounded we can apply the Laplace transform in t considering x as a parameter.

$$L(u(x, t)) = \int_0^{\infty} e^{-st} u(x, t) dt \equiv U(x, s)$$

In applications to PDEs we need the following:

$$L(u_t(x, t)) = \int_0^{\infty} e^{-st} u_t(x, t) dt = e^{-st} u(x, t) \Big|_0^{\infty} + s \int_0^{\infty} e^{-st} u(x, t) dt = sU(x, s) - u(x, 0)$$

so we have

$$L(u_t(x, t)) = sU(x, s) - u(x, 0)$$

In exactly the same way we obtain

$$L(u_{tt}(x, t)) = s^2 U(x, s) - su(x, 0) - u_t(x, 0).$$

We also need the corresponding transforms of the x derivatives:

$$L(u_x(x, t)) = \int_0^{\infty} e^{-st} u_x(x, t) dt = U_x(x, s)$$

$$L(u_{xx}(x, t)) = \int_0^{\infty} e^{-st} u_{xx}(x, t) dt = U_{xx}(x, s)$$

Consider the following examples.

Example 1.

$$\frac{\partial u}{\partial x} + \frac{\partial u}{\partial t} = x, \quad x > 0, \quad t > 0,$$

with boundary and initial condition

$$u(0, t) = 0 \quad t > 0, \quad \text{and} \quad u(x, 0) = 0, \quad x > 0.$$

As above we use the notation $U(x, s) = L(u(x, t))(s)$ for the Laplace transform of u . Then applying the Laplace transform to this equation we have

$$\frac{dU}{dx}(x, s) + sU(x, s) - u(x, 0) = \frac{x}{s} \quad \Rightarrow \quad \frac{dU}{dx}(x, s) + sU(x, s) = \frac{x}{s}.$$

This is a constant coefficient first order ODE. We solve it by finding the integrating factor

$$\mu = e^{\int s dx} = e^{sx}$$

Thus we have

$$\frac{d}{dx} [e^{sx} U(x, s)] = e^{sx} \frac{x}{s}.$$

We integrate both sides to get

$$U(x, s) = \frac{e^{-sx}}{s} \left(\int e^{sx} x dx \right) + C e^{-sx}.$$

Solving Pdes Using Laplace Transforms Chapter 15

Neil Thomson



Solving Pdes Using Laplace Transforms Chapter 15:

Advanced Numerical and Semi-Analytical Methods for Differential Equations Snehashish Chakraverty, Nisha Mahato, Perumandla Karunakar, Tharasi Dilleswar Rao, 2019-04-10 Examines numerical and semi analytical methods for differential equations that can be used for solving practical ODEs and PDEs This student friendly book deals with various approaches for solving differential equations numerically or semi analytically depending on the type of equations and offers simple example problems to help readers along Featuring both traditional and recent methods Advanced Numerical and Semi Analytical Methods for Differential Equations begins with a review of basic numerical methods It then looks at Laplace Fourier and weighted residual methods for solving differential equations A new challenging method of Boundary Characteristics Orthogonal Polynomials BCOPs is introduced next The book then discusses Finite Difference Method FDM Finite Element Method FEM Finite Volume Method FVM and Boundary Element Method BEM Following that analytical semi analytic methods like Akbari Ganji s Method AGM and Exp function are used to solve nonlinear differential equations Nonlinear differential equations using semi analytical methods are also addressed namely Adomian Decomposition Method ADM Homotopy Perturbation Method HPM Variational Iteration Method VIM and Homotopy Analysis Method HAM Other topics covered include emerging areas of research related to the solution of differential equations based on differential quadrature and wavelet approach combined and hybrid methods for solving differential equations as well as an overview of fractal differential equations Further uncertainty in term of intervals and fuzzy numbers have also been included along with the interval finite element method This book Discusses various methods for solving linear and nonlinear ODEs and PDEs Covers basic numerical techniques for solving differential equations along with various discretization methods Investigates nonlinear differential equations using semi analytical methods Examines differential equations in an uncertain environment Includes a new scenario in which uncertainty in term of intervals and fuzzy numbers has been included in differential equations Contains solved example problems as well as some unsolved problems for self validation of the topics covered Advanced Numerical and Semi Analytical Methods for Differential Equations is an excellent text for graduate as well as post graduate students and researchers studying various methods for solving differential equations numerically and semi analytically

Advanced Engineering Mathematics with MATLAB Dean G. Duffy, 2010-10-26 Taking a practical approach to the subject Advanced Engineering Mathematics with MATLAB Third Edition continues to integrate technology into the conventional topics of engineering mathematics The author employs MATLAB to reinforce concepts and solve problems that require heavy computation MATLAB scripts are available for download at www.crcpres.com

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Dennis G. Zill,2020-12-01 This package includes the printed hardcover book and access to the Navigate 2 Companion Website The seventh edition of Advanced Engineering Mathematics provides learners with a modern and comprehensive compendium of topics that are most often covered in courses in engineering mathematics and is extremely flexible to meet the unique needs of courses ranging from ordinary differential equations to vector calculus to partial differential equations Acclaimed author Dennis G Zill s accessible writing style and strong pedagogical aids guide students through difficult concepts with thoughtful explanations clear examples interesting applications and contributed project problems **Modern Mathematical Methods For Scientists And Engineers: A Street-smart Introduction** Athanassios Fokas,Efthimios Kaxiras,2022-12-12 Modern Mathematical Methods for Scientists and Engineers is a modern introduction to basic topics in mathematics at the undergraduate level with emphasis on explanations and applications to real life problems There is also an Application section at the end of each chapter with topics drawn from a variety of areas including neural networks fluid dynamics and the behavior of put and call options in financial markets The book presents several modern important and computationally efficient topics including feedforward neural networks wavelets generalized functions stochastic optimization methods and numerical methods A unique and novel feature of the book is the introduction of a recently developed method for solving partial differential equations PDEs called the unified transform PDEs are the mathematical cornerstone for describing an astonishingly wide range of phenomena from quantum mechanics to ocean waves to the diffusion of heat in matter and the behavior of financial markets Despite the efforts of many famous mathematicians physicists and engineers the solution of partial differential equations remains a challenge The unified transform greatly facilitates this task For example two and a half centuries after Jean d Alembert formulated the wave equation and presented a solution for solving a simple problem for this equation the unified transform derives in a simple manner a generalization of the d Alembert solution valid for general boundary value problems Moreover two centuries after Joseph Fourier introduced the classical tool of the Fourier series for solving the heat equation the unified transform constructs a new solution to this ubiquitous PDE with important analytical and numerical advantages in comparison to the classical solutions The authors present the unified transform pedagogically building all the necessary background including functions of real and of complex variables and the Fourier transform illustrating the method with numerous examples Broad in scope but pedagogical in style and content the book is an introduction to powerful mathematical concepts and modern tools for students in science and engineering *U.S.S.R. Computational Mathematics and Mathematical Physics* ,1969 [Memoirs of the Scientific Sections of the Academy of the Socialist Republic of Romania](#) ,2007 **Mathematics Catalog 2005** Neil Thomson,2004-10 [Elementary Partial Differential Equations with Boundary Value Problems](#) Larry C. Andrews,1986 [Elementary Differential Equations](#) William E. Boyce,Richard C. DiPrima,Douglas B. Meade,2021-12-21 Elementary Differential Equations 12th Edition is written from the viewpoint of the applied mathematician whose interest in differential equations may

sometimes be quite theoretical sometimes intensely practical and often somewhere in between In this revision new author Douglas Meade focuses on developing students conceptual understanding with new concept check questions and worksheets for each chapter Meade builds upon Boyce and DiPrima s work to combine a sound and accurate but not abstract exposition of the elementary theory of differential equations with considerable material on methods of solution analysis and approximation that have proved useful in a wide variety of applications The main prerequisite for engaging with the program is a working knowledge of calculus gained from a normal two or three semester course sequence or its equivalent Some familiarity with matrices will also be helpful in the chapters on systems of differential equations Elementary Differential Equations and Boundary Value Problems William E. Boyce, Richard C. DiPrima, Douglas B. Meade, 2021-12-21 Elementary Differential Equations and Boundary Value Problems 12th Edition is written from the viewpoint of the applied mathematician whose interest in differential equations may sometimes be quite theoretical sometimes intensely practical and often somewhere in between In this revision new author Douglas Meade focuses on developing students conceptual understanding with new concept questions and worksheets for each chapter Meade builds upon Boyce and DiPrima s work to combine a sound and accurate but not abstract exposition of the elementary theory of differential equations with considerable material on methods of solution analysis and approximation that have proved useful in a wide variety of applications The main prerequisite for engaging with the program is a working knowledge of calculus gained from a normal two or three semester course sequence or its equivalent Some familiarity with matrices will also be helpful in the chapters on systems of differential equations *Advances in Computer Methods for Partial Differential Equations*, 1979 *Mathematical Reviews*, 2008

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Stepleman, 1979 One Thursday Imogene wakes up with a pair of antlers growing out of her head and causes a sensation

Journal of Applied Mechanics, 1954 *Partial Differential Equations with Fourier Series and Boundary Value*

Problems Nakhlé H. Asmar, 2005 This example rich reference fosters a smooth transition from elementary ordinary differential equations to more advanced concepts Asmar s relaxed style and emphasis on applications make the material accessible even to readers with limited exposure to topics beyond calculus Encourages computer for illustrating results and applications but is also suitable for use without computer access Contains more engineering and physics applications and more mathematical proofs and theory of partial differential equations than the first edition Offers a large number of exercises per section Provides marginal comments and remarks throughout with insightful remarks keys to following the material and formulas recalled for the reader s convenience Offers Mathematica files available for download from the author s website A useful reference for engineers or anyone who needs to brush up on partial differential equations **Electrical Engineering Reference Manual for the Electrical and Computer PE Exam** John A. Camara, 2007 Electrical Engineering Reference Manual is the most comprehensive reference available for the electrical and computer engineering PE exam Partial

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