

## 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

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

# Solving Pdes Using Laplace Transforms Chapter 15

**John A. Camara**



## **Solving Pdes Using Laplace Transforms Chapter 15:**

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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

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Journal of Applied Mechanics ,1954      Elementary Differential Equations Earl D. Rainville, 1964

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Mathematics Manual Frederick S. Merritt,1962

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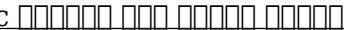
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