

## 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

**Tobias Bleicker**



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

## Unveiling the Magic of Words: A Review of "**Solving Pdes Using Laplace Transforms Chapter 15**"

In a world defined by information and interconnectivity, the enchanting power of words has acquired unparalleled significance. Their power to kindle emotions, provoke contemplation, and ignite transformative change is actually awe-inspiring. Enter the realm of "**Solving Pdes Using Laplace Transforms Chapter 15**," a mesmerizing literary masterpiece penned by a distinguished author, guiding readers on a profound journey to unravel the secrets and potential hidden within every word. In this critique, we shall delve in to the book is central themes, examine its distinctive writing style, and assess its profound effect on the souls of its readers.

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