

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

Léo Pomar



Solving Pdes Using Laplace Transforms Chapter 15:

Decoding **Solving Pdes Using Laplace Transforms Chapter 15**: Revealing the Captivating Potential of Verbal Expression

In a time characterized by interconnectedness and an insatiable thirst for knowledge, the captivating potential of verbal expression has emerged as a formidable force. Its capability to evoke sentiments, stimulate introspection, and incite profound transformations is genuinely awe-inspiring. Within the pages of "**Solving Pdes Using Laplace Transforms Chapter 15**," a mesmerizing literary creation penned by way of a celebrated wordsmith, readers embark on an enlightening odyssey, unraveling the intricate significance of language and its enduring impact on our lives. In this appraisal, we shall explore the book's central themes, evaluate its distinctive writing style, and gauge its pervasive influence on the hearts and minds of its readership.

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