Applications of Double Laplace Transform to Boundary Value Problems

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Abstract: In this paper, we applied the method of Double Laplace Transform for solving the one dimensional Boundary Value Problems. Through this method the boundary value problem is solved without converting it into Ordinary Differential equation, therefore no need to find complete solution of Ordinary Differential equation. This is the biggest advantage of this method. The scheme is tested through some examples & the results demonstrate reliability.

Mathematics Subject Classifications 44Axx

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I. Introduction

Integral transforms [1, 2] are extensively used in solving boundary value problems & integral equations. The problem related to partial differential equation commonly can be solved by using a special integral transform thus many authors solved the boundary value problem by using single Laplace Transform [6]. The Wave equation, Heat equation & Laplace,s equations as three fundamental equations in mathematical Physics & occur in many branches of Physics, in Applied mathematics as well as in Engineering. Elzayeb and Kilicman [3] has worked on the non-homogeneous wave equation with variable coefficients is solved by applying the Double Laplace Transform.

In 1990 [4], R. S. Dahiya & Vinayagomoorthy established several new theorems & corollaries for calculating Laplace Transforms pairs of n-dimensions. They also considered two boundary value problems. The first was related to heat transfer for cooling off a very thin semi-infinite homogeneous plate into the surrounding medium solved by using double Laplace Transform, the second, was heat equation for the semi-infinite slab where the sides of the slab are maintained at prescribed temperature.

Recently in 2013 [5], Aghili & Motahhari have applied the Double Laplace Transform to solve second order Linear Differential equation with constant coefficients.

In this study, we use Double Laplace Transform to solve one dimensional boundary value problem, that is, Wave & Heat equation. Henceforth the different problems of boundary value is solved without converting it into Ordinary Differential Equation, & no need to find complete solution. So this method is very reliable & convenient for solving boundary value problem.

The scheme is tested through three different examples which are being referred from [7, 8].

Definition of double Laplace transform:

First of all, we recall the following definitions given by Estrin & Higgins [2].

Let $f(x, t)$ be a function of two variables x and t, where $x, t > 0$. The double Laplace transform of $f(x, t)$ is defined as

$$L_t L_x \{f(x, t)\} = \overline{f}(p, s) = \int_0^\infty e^{-st} \int_0^\infty e^{-px} f(x, t) \, dx \, dt \qquad (1)$$

whenever the improper integral converges. Here p, s are complex numbers.

Existence of double Laplace transforms:

Let $f(x, t)$ be a continuous function on the interval $[0, \infty)$ which is of exponential order, that is, for some $a, b \in R$.

Consider $\sup_{x > 0, t > 0} \dfrac{|f(x, t)|}{e^{ax + bt}} < \infty$

In this case, the double Laplace transform of $f(x,t)$ that is

$$L_t L_x \{f(x, t)\} = \overline{f}(p, s) = \int_0^\infty e^{-st} \int_0^\infty e^{-px} f(x, t) \, dx \, dt$$

exists for all $p > a$ & $s > b$ & is infact infinitely differentiable with respect to $p > a$ & $s > b$.

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Ivar Stakgold

Applications Of Double Laplace Transform To Boundary Value:

Solution of Boundary-value Problems in Arbitrary Sectors by Use of the Double Laplace Transform John Murray Perry,1960 **Double Laplace Transformation in Mixed Boundary-initial Value Problems and Its Application to Multi-component Plasmas** Kenneth Edward Evans (Jr),ILLINOIS UNIV URBANA COORDINATED SCIENCE LAB.,1969 The application of the double Laplace transform Laplace transformation in both space and time to the solution of systems of linear homogenous hyperbolic partial differential equations with real constant coefficients is treated The purpose of this treatment is to discuss comprehensively a method whereby the mixed boundary initial value problem for these equations can be solved The treatment is limited to one dimensional systems Certain features of the double Laplace transform method which appear in the solution of equations of the type described are examined in detail Two of these features are the important role played by the characteristics of the partial differential equations and the restrictions among the boundary and initial conditions which are necessary for a well defined solution The method is applied to the moment equations for a multi component plasma and the connection between the general solution and the usual normal mode solution is discussed The case of a monoenergetic beam injected into a cold semi infinite plasma is treated in detail The effect of the collisions of the plasma particles with the background is included A solution for the growth of an initial thermal disturbance in the plasma is obtained This treatment yields the first picture of the relationship between the temporal and spatial growth in a finite unstable plasma Author *Integral Transforms and Their Applications* Lokenath Debnath,Dambaru Bhatta,2014-11-07 Integral Transforms and Their Applications Third Edition covers advanced mathematical methods for many applications in science and engineering The book is suitable as a textbook for senior undergraduate and first year graduate students and as a reference for professionals in mathematics engineering and applied sciences It presents a systematic *Wave Propagation in Drilling, Well Logging and Reservoir Applications* Wilson C. Chin,2014-09-19 Wave propagation is central to all areas of petroleum engineering e g drilling vibrations MWD mud pulse telemetry swab surge geophysical ray tracing ocean and current interactions electromagnetic wave and sonic applications in the borehole but rarely treated rigorously or described in truly scientific terms even for a single discipline Wilson Chin an MIT and Caltech educated scientist who has consulted internationally provides an integrated comprehensive yet readable exposition covering all of the cited topics offering insights algorithms and validated methods never before published A must on every petroleum engineering bookshelf In particular the book Delivers drillstring vibrations models coupling axial torsional and lateral motions that predict rate of penetration bit bounce and stick slip as they depend on rock bit interaction and bottomhole assembly properties Explains why catastrophic lateral vibrations at the neutral point cannot be observed from the surface even in vertical wells but providing a proven method to avoid them Demonstrates why Fermat s principle of least time used in geophysics applies to non dissipative media only but using the kinematic wave theory developed at MIT derives powerful methods applicable to general attenuative

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