ISSN: 2455-3794

Contents lists available at http://www.albertscience.com

ASIO Journal of Engineering & Technological Perspective Research (ASIO-JETPR)

Volume 5, Issue 1, 2020, 04-07

EMPIRICAL STUDY OF HIGHER ORDER DIFFERENTIAL EQUATIONS WITH VARIABLE CO-EFFICIENT BY DINESH VERMA TRANSFORM (DVT)

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ARTICLE INFO

Received: 15 May, 2020
Accepted: 01 June, 2020

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ABSTRACT

In this paper, the solutions of higher order differential equations with constant co-efficient are obtained by applying Dinesh Verma Transform (DVT). The boundary value problems described by higher order linear ordinary differential equations in science and engineering are analyzed by Dinesh Verma Transform (DVT). It is revealed that the higher order linear ordinary differential equations in science and engineering are easily analyzed by Dinesh Verma Transform (DVT).

Index Terms: Dinesh Verma transform (DVT), Higher Order Linear Ordinary Differential equations.

INTRODUCTION

The integral transforms such as Laplace Transform [1], [2], [3], [4], Elzaki Transform [5], Sadik Transform [6], Kamal Transform [7], Aboodh Transform [8], [9], [10], [11], [12], [13], [14], [15], Mohand Transform [16], [17], [18], Sumudu Transform [19], Shehu Transform [20], Mahgoub Transform [21], [22], [23], [24], [25], Yang Transform [26], [27], [28], [29], [30], [31], [32], [33] are widely used for analyzing the boundary value problems described by ordinary differential equations in Science and Engineering [34], [35], [36], [37], [38], [39], [40].This paper proposed a novel integral transform named as Dinesh Verma transform (DVT) and applied it for analyzing boundary value problems described by higher order linear ordinary differential equations with constant coefficients in Science and Engineering.

DEFINITION OF DINESH VERMA TRANSFORM (DVT)

Dr. Dinesh Verma Introduced a novel Transform and named it as **Dinesh Verma transform (DVT).** Let f(t) is a well-defined function of real numbers t ≥ 0. The **Dinesh Verma transform (DVT)** of f(t), denoted by $D\{f(t)\}$, is defined as

$$D\{f(t)\} = p^5 \int_0^\infty e^{-pt} f(t)\,dt = \bar{f}(p)$$

Provided that the integral is convergent, where p may be a real or complex parameter and D is the **Dinesh Verma transform (DVT)** operator.

Dinesh Verma transform (DVT) of derivatives

Let f(t) is continuous function and is piecewise continuous on any interval, then the Dinesh Transform of first derivative of g(y) i.e. $D\{f'(t)\}$ is given by

$$D\{f'(t)\} = p^5 \int_0^\infty e^{-pt} f'(t)\,dt$$

Integrating by parts and applying limits, we get

$D\{f'(t)\}$

$$= p^5\{-f(0) - \textstyle\int_0^\infty -pe^{-pt} f(t)\,dt\}$$

$$= p^5\{-f(0) + p\textstyle\int_0^\infty e^{-pt} f(t)\,dt\}$$

$$= p^5\{-f(0) + pD\{f(t)\}$$

$$= p\bar{f}(p) - p^5 f(0)$$

Hence

$$D\{f'(t)\} = p\bar{f}(p) - p^5 f(0)$$

Since

$D\{f'(t)\} = pD\{f(t)\} - p^5 f(0)$, Therefore, on replacing g(y) by $f'(t)$ by $g''(y)$, we have

$$D\{f''(y)\} = pD\{f'(t)\} - p^5 f'(0)$$

doi no.: 10.2016-56941953/; DOI Link :: http://doi-ds.org/doilink/06.2020-33288887/

$= p\{pD\{f(t)\} - p^5 f(0)\} - p^5 f'(0)$

$= p^2 D\{f(t)\} - p^6 f(0) - p^5 f'(0)$

$= p^2 \bar{f}(p) - p^6 f(0) - p^5 f'(0)$

Hence

$D\{f''(t)\} = p^2 \bar{f}(p) - p^6 f(0) - p^5 f'(0)$

Similarly,

$D\{g'''(y)\} = p^3 \bar{f}(p) - p^7 f(0) - p^6 f'(0) - p^5 f''(0)$ And so on.

And,

$D\{tf(t)\} = \frac{5}{p}\bar{f}(p) - \frac{d\bar{f}(p)}{dp}$,

$D\{tf'(t)\} = \frac{5}{p}[p\bar{f}(p) - p^5 f(0)] - \frac{d}{dp}[p\bar{f}(p) - p^5 f(0)]$ and

$D\{tx''(t)\} = \frac{5}{p}[p^2\bar{x}(p) - p^6 x(0) - p^5 x'(0)] - \frac{d}{dp}[p^2\bar{x}(p) - p^6 x(0) - p^5 x'(0)]$

And so on

APPLICATIONS OF DINESH VERMA TRANSFORM (DVT)

APPLICATION 1:

Solve the differential equation

$\ddot{x} + t\dot{x} - x = 0$

with the initial conditions

$x(0) = 0, x'(0) = 0$

Solution:

The given equation can be written as

$x'' + tx' - x = 0 \quad \ldots\ldots\ldots\ldots(1)$

Taking **Dinesh Verma Transform (DVT)** on both sides,

$D\{x''\} + D\{tx'\} - D\{x\} = 0$

Or

$$[p^2\bar{x}(p) - p^6 x(0) - p^5 x'(0)] + \frac{5}{p}[p\bar{x}(p) - p^5 x(0)] - \frac{d}{dp}[p\bar{x}(p) - p^5 x(0)] - \bar{x}(p) = 0$$

Applying initial condition

$$[p^2 + 3]\bar{x}(p) = p\frac{d}{dp}\bar{x}(p)$$

Or

$$\frac{p^2+3}{p}dp = \frac{d\bar{x}}{\bar{x}}$$

$$\log\frac{\bar{x}\,c}{p^3} = \frac{p^2}{2}$$

$$\bar{x} = \frac{p^3 e^{p^2/2}}{c}$$

By using the inverse **Dinesh Verma Transform (DVT)** we obtain the solution

$x = t$

APPLICATION 2:

Solve the differential equation

$\ddot{x} + t\dot{x} - 4x = 6$

with the initial conditions

$x(0) = 0, x'(0) = 0$

Solution:

The given equation can be written as

$x'' + tx' - 4x = 6 \quad \ldots\ldots\ldots\ldots(1)$

Taking **Dinesh Verma Transform (DVT)** on both sides,

$D\{x''\} + D\{tx'\} - 4D\{x\} = 6D\{1\}$

Or

$$[p^2\bar{x}(p) - p^6 x(0) - p^5 x'(0)] + \frac{5}{p}[p\bar{x}(p) - p^5 x(0)] - \frac{d}{dp}[p\bar{x}(p) - p^5 x(0)] - \overline{4x}(p) = 6p^4$$

Applying initial condition

$$\frac{d\bar{x}(p)}{dp} - p\bar{x}(p) = 6p^3$$

This is linear in $\bar{x}(p)$

The solution is

$$\bar{x}(p) = 6p^2 + 12 + ce^{p^2/2}$$

By using the inverse **Dinesh Verma Transform (DVT)** we obtain the solution

$x(t) = 3t^2$

APPLICATION 3:

Solve the differential equation

$t\ddot{x} - \dot{x} = -1$

with the initial conditions

$x(0) = 0, x'(0) = 0$

Solution:

doi no.: 10.2016-56941953/; DOI Link :: http://doi-ds.org/doilink/06.2020-33288887/

The given equation can be written as

$$tx'' - x' = -1 \quad \dots\dots\dots\dots (1)$$

Taking **Dinesh Verma Transform (DVT)** on both sides,

$$D\{tx''\} - D\{x'\} = -D\{1\}$$

Or

$$\frac{5}{p}[p^2\bar{x}(p) - p^6x(0) - p^5x'(0)] - \frac{d}{dp}[p^2\bar{x}(p) - p^6x(0) - p^5x'(0)] - [p\bar{x}(p) - p^5x(0)] = -p^4$$

Applying initial condition

$$\frac{d\bar{x}(p)}{dp} - \frac{2}{p}\bar{x}(p) = p^2$$

This is linear in $\bar{x}(p)$

The solution is

$$\bar{x}(p) = p^3 + cp^2$$

By using the inverse **Dinesh Verma Transform (DVT)** we obtain the solution

$$x(t) = t + \frac{ct^2}{2}$$

Where, c is constant. Obviously, the solution satisfies.

CONCLUSION

In this paper a novel integral transform named as Dinesh Verma transform (DVT) has successfully applied for analyzing boundary value problems described by higher order linear ordinary differential equations with variable coefficients in Science and Engineering.

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Table for Dinesh Verma Transforms (DVT)

S. No.	$D\{f(t)\}$	$\bar{f}(p)$
1.	$DL\{1\}$	p^4
2.	$DL\{t\}$	p^3
3.	$D\{t^n\}$	$\frac{n!}{p^{n-4}}$
4.	$D\{e^{at}\}$	$\frac{p^5}{(p-a)}$
5.	$D\{sinat\}$	$\frac{ap^5}{(p^2+a^2)}$
6.	$D\{cosat\}$	$\frac{p^6}{(p^2+a^2)}$
7.	$D\{sinhat\}$	$\frac{ap^5}{(p^2-a^2)}$
8.	$D\{coshat\}$	$\frac{p^6}{(p^2-a^2)}$
9.	$D\{te^{at}\}$	$\frac{p^5}{(p-a)^2}$
10.	$D\{e^{at}sinbt\}$	$\frac{bp^5}{(p-a)^2+b^2}$
11.	$D\{e^{at}cosbt\}$	$\frac{p^5(p-a)}{(p-a)^2+b^2}$
12.	$\{e^{at}sinhbt\}$	$\frac{bp^5}{(p-a)^2-b^2}$
12.	$D\{tsinat\}$	$\frac{2ap^6}{(p^2+a^2)^2}$
13.	$D\{tcosat\}$	$\frac{p^5(p^2-a^2)}{(p^2+a^2)^2}$
14.	$D\{t^n e^{at}\}$	$\frac{n!}{p^{n-4}}$

doi no.: 10.2016-56941953/; DOI Link :: http://doi-ds.org/doilink/06.2020-33288887/