Applications of Dinesh Verma Transformation to An Electromagnetic Device

GOVIND RAJ NAUNYAL[1], UPDESH KUMAR[2], DINESH VERMA[3]
[1, 2] *Associate Professor, Department of Mathematics, KGK (PG) College Moradabad*

Abstract- This paper, integral transform is known as Dinesh Verma transform is produced to the study of a moving-coil galvanometer. A moving-coil galvanometer is an electromagnetic device it means that it is utilization to calculate little values of electric currents. When a quantity of current is passed at some stage in the moving-coil galvanometer, its coil may suffer a few back-and-forth oscillations about its final mean position before coming to rest. The moving-coil galvanometer and its mathematical study is ordinarily done by an ordinary calculus approach. This paper extents the useful of Dinesh Verma transform for study of a moving-coil galvanometer and hence, for getting its response. The response get gives the deflection of the coil of the moving-coil galvanometer from its mean situation. In this paper, the response of a moving-coil galvanometer is get as a demonstration of the application of the new integral transform called Dinesh Verma transform.

Indexed Terms- Dinesh Verma Transform; Response; moving-coil galvanometer.

I. INTRODUCTION

In different areas of science, engineering and technology has been applied The Dinesh Verma Transform (DVT). [1], [2], [3] [4], [5], [6], [7]. The Dinesh Verma Transform (DVT) is applicable in different fields and successfully solving L.D.E, O.D.E with constant coefficient and variable coefficient can be simply explaind by the Dinesh Verma Transform (DVT) without finding their complementary solutions. It also comes out to be extremely useful tool to analyze differential equations, Simultaneous differential equations, Integral equations etc. [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18] [19], [20]. A moving-coil galvanometer is an electromagnetic device that is used to measure small values of electric currents. It consists of a coil wrapped over a non-metallic frame which has a soft iron core, permanent horse-shoe magnets, pivoted spring, scale, and pointer. When some current is passed through the moving-coil galvanometer, its coil may suffer a few back and forth oscillations about its final mean position before coming to rest. As the coil suffers deflection, it moves in a permanent magnetic field and therefore, an e.m.f. is induced in it, which opposes the motion of the coil. The electromagnetic damping, responsible for the damping of coil, can be increased by winding the coil on a metallic frame. When the coil rotates, eddy currents are produced in the frame moving along with the coil, which tends to damp its motion and hence the coil soon comes to rest [1-5] [21]. The Dinesh Verma transform is a new integral transform which has been recently put forward by the author Dinesh Verma. It has been applied in science and engineering to solve most of the initial value problems [6],[24],[25],[26]. The analysis of a moving-coil galvanometer is usually done by ordinary calculus approach [1-5] [22],[23]. This paper proves the applicability of Dinesh Verma Transform for obtaining the response of the moving-coil galvanometer and concludes that ; Dinesh Verma transform like other methods or approaches is an effective and simple tool for obtaining the response of the moving-coil galvanometer.

II. DEFINITIONS

DEFINITION OF DINESH VERMA TRANSFORM (DVT)

Dr. Dinesh Verma recently introduced a novel transform and named it as Dinesh Verma Transform (DVT). Let f(t) is a well-defined function of real numbers $t \geq 0$. 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 OF ELEMENTARY FUNCTIONS

According to the definition of Dinesh Verma transform (DVT),

$$D\{t^n\} = p^5 \int_0^\infty e^{-pt}\, t^n dt$$

$$= p^5 \int_0^\infty e^{-z} \left(\frac{z}{p}\right)^n \frac{dz}{p} \quad , z = pt$$

$$= \frac{p^5}{p^{n+1}} \int_0^\infty e^{-z}\, (z)^n dz$$

Applying the definition of gamma function,

$$D\,\{y^n\} = \frac{p^5}{p^{n+1}} \lceil(n+1)$$

$$= \frac{1}{p^{n-4}} n!$$

$$= \frac{n!}{p^{n-4}}$$

Hence, $D\{t^n\} = \frac{n!}{p^{n-4}}$

Dinesh Verma Transform (DVT) of some elementary Functions

- $D\{t^n\} = \frac{n!}{p^{n-4}}$, $where\ n = 0,1,2,..$
- $D\{e^{at}\} = \frac{p^5}{p-a}$,
- $D\{sinat\} = \frac{ap^5}{p^2+a^2}$,
- $D\{cosat\} = \frac{p^6}{p^2+a^2}$,
- $D\{sinhat\} = \frac{ap^5}{p^2-a^2}$,
- $D\{coshat\} = \frac{p^6}{p^2-a^2}$.
- $D\{\delta(t)\} = p^5$

- **T**he Inverse Dinesh Verma Transform (DVT) of some of the functions are given by
- $D^{-1}\left\{\frac{1}{p^{n-4}}\right\} = \frac{t^n}{n!}$, $where\ n = 0,1,2,..$
- $D^{-1}\left\{\frac{p^5}{p-a}\right\} = e^{at}$,
- $D^{-1}\left\{\frac{p^5}{p^2+a^2}\right\} = \frac{sinat}{a}$,
- $D^{-1}\left\{\frac{p^6}{p^2+a^2}\right\} = cosat$,
- $D^{-1}\left\{\frac{p^5}{p^2-a^2}\right\} = \frac{sinhat}{a}$,
- $D^{-1}\left\{\frac{p^6}{p^2-a^2}\right\} = coshat$,
- $D^{-1}\{p^5\} = \delta(t)$

DINESH VERMA TRANSFORM (DVT) OF DERIVATIVES

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

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

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

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

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

$D\{tf''(t)\} = \frac{5}{p}\left[p^2\bar{x}(p) - p^6 x(0) - p^5 x'(0)\right] - \frac{d}{dp}\left[p^2\bar{x}(p) - p^6 x(0) - p^5 x'(0)\right]$ and so on….

METHODOLOGY

When current is flow flowing coil of moving-coil galvanometer, it is turned by the deflecting couple perfirming on it, and if φ is the deflection of the coil from the equilibrium position at any instant t, then the motion of the coil is opposed by the following couples [1-5]:

(a) If ғ is damping constant and the negative sign shows that the motion of the coil is opposed by the damping couple. Then Damping couple will be (τ_d) i.e. $\tau_d = -ғ\,\dot{\varphi}(t)$.

(b) If C is torsional rigidity of suspension fibre, and the minus sign indicates that the motion is also opposed by the restoring couple. then Restoring couple (τ_r) i.e. $\tau_s = -C\,\varphi(t)$.

(c) A couple $\tau_e = -\frac{K}{R}\dot{\varphi}(t)$ arises due to electromagnetic damping i.e. due to induced eddy currents in the coil and depends directly upon the angular velocity of the coil and inversely upon its resistance R and also depends upon the magnetic field strength. All these factors are included in the constant Ҡ.

The application of Newton's second law of motion gives the equation of motion of the coil as follows

$I\ddot{\varphi}(t) = -ғ\,\dot{\varphi}(t) - C\,\varphi(t) - \frac{K}{R}\dot{\varphi}(t)$, where I is the moment of inertia of the coil about its axis of rotation and $\ddot{\varphi}(t)$ is its angular acceleration.

This equation can be rewritten as

$\ddot{\varphi}(t) = -\frac{ғ}{I}\dot{\varphi}(t) - \frac{C}{I}\varphi(t) - \frac{K}{IR}\dot{\varphi}(t)$

Or

$\ddot{\varphi}(t) + \left(\frac{ғ}{I} + \frac{K}{IR}\right)\dot{\varphi}(t) + \frac{C}{I}\varphi(t) = 0$…. (I)

For convenience let us put $\left(\frac{ɼ}{I}+\frac{K}{IR}\right)=2\epsilon$ and $\frac{C}{I}=\mu^2$, then equation (I) can be rewritten as

$\ddot{\Theta}(t)+2\epsilon\,\dot{\Theta}(t)+\mu^2\Theta(t)=0$…. (II)

The equation (8) is known as a differential equation of the PMMC instrument.

To solve equation (8), the initial boundary conditions are as follows [1-5]:

(a) If the maximum deflection of the coil from the equilibrium position is assumed to be φ_o and we measure the time from the instant when the coil is at the position of its maximum deflection, then at t = 0, $\varphi(0)=\varphi_o$.

(b) At the instant t = 0, the angular velocity $\dot{\varphi}(0)=0$as the coil is at rest at the instant t = 0.

The Dinesh Verma transform [8, 9] of equation (II) provides

$s^2\bar{\varphi}(s)-s^6\varphi(0)-s^5\dot{\varphi}(0)+2\epsilon\{s\bar{\varphi}(s)-s^5\varphi(0)\}+\mu^2\bar{\varphi}(s)=0$....... (III)

Here $\bar{\varphi}$(r) denotes the Dinesh Verma Transform of $\varphi(t)$.

Applying initial conditions [5] $\varphi(0)=\varphi_o$ and $\dot{\varphi}(0)=0$, equation (III) becomes,

$s^2\bar{\varphi}(s)-s^6\varphi_o+2\epsilon\{s\bar{\varphi}(s)-s^5\varphi_o\}+\mu^2\bar{\varphi}(s)=0$

Or

$$[s^2+2\delta s+\mu^2]\,\bar{\varphi}(s)=[s^6+2\epsilon s^5]\,\varphi_o$$

Or

$$\bar{\varphi}(s)=\frac{[s^6+2\epsilon s^5]\,\Theta_o}{s^2+2\delta s+\mu^2}$$

Or

$$\bar{\varphi}(s)=\frac{[s^6+2\epsilon s^5]\,\varphi_o}{(s+\epsilon)^2-\sqrt{\epsilon^2-\mu^2}}$$

Or

$$\bar{\varphi}(s)=\frac{[s^6+2\epsilon s^5]\,\Theta_o}{(s+\epsilon+\sqrt{\epsilon^2-\mu^2})\,(s+\epsilon-\sqrt{\epsilon^2-\mu^2})}\ \text{……. (IV)}$$

For convenience let us substitute $\delta+\sqrt{\epsilon^2-\mu^2}=\alpha_1$ and $\delta-\sqrt{\epsilon^2-\mu^2}=\alpha_2$ such that $\alpha_1-\alpha_2=2\sqrt{\epsilon^2-\mu^2}$, then equation (IV) can be re written as

$$\bar{\varphi}(s)=\frac{[s^6+2\epsilon s^5]\,\varphi_o}{(s+\alpha_1)\,(s+\alpha_2)}$$

Or

$$\bar{\varphi}(s)=\frac{[-\alpha_1+2\epsilon]\,s^5\varphi_o}{(-\alpha_1+\alpha_2)\,(s+\alpha_1)}+\frac{[-\alpha_2+2\epsilon]\,s^5\varphi_o}{(-\alpha_2+\alpha_1)\,(s+\alpha_2)}$$

Or

$$\bar{\varphi}(s)=\frac{[-\epsilon-\sqrt{\epsilon^2-\mu^2}+2\epsilon]\,s^5\varphi_o}{-2\sqrt{\epsilon^2-\mu^2}(s+\alpha_1)}+\frac{[-\epsilon+\sqrt{\epsilon^2-\mu^2}+2\epsilon]\,s^5\varphi_o}{2\sqrt{\epsilon^2-\mu^2}(s+\alpha_2)}$$

Or

$$\bar{\varphi}(s)=-\frac{[\epsilon-\sqrt{\epsilon^2-\mu^2}]\,s^5\varphi_o}{2\sqrt{\epsilon^2-\mu^2}(s+\alpha_1)}+\frac{[\epsilon+\sqrt{\epsilon^2-\mu^2}]\,s^5\varphi_o}{2\sqrt{\epsilon^2-\mu^2}(s+\alpha_2)}\ \text{…… (V)}$$

The application of inverse Dinesh Verma Transform [6, 12, 13,] provides

$$\varphi(t)=-\frac{[\epsilon-\sqrt{\epsilon^2-\mu^2}]\,\varphi_o e^{-\alpha_1 t}}{2\sqrt{\epsilon^2-\mu^2}}+\frac{[\epsilon+\sqrt{\epsilon^2-\mu^2}]\,\varphi_o e^{-\alpha_2 t}}{2\sqrt{\epsilon^2-\mu^2}}$$

Or

$$\varphi(t)=-\frac{[\epsilon-\sqrt{\epsilon^2-\mu^2}]\,\varphi_o e^{-\epsilon t}e^{-\sqrt{\epsilon^2-\mu^2}\,t}}{2\sqrt{\epsilon^2-\mu^2}}+\frac{[\epsilon+\sqrt{\epsilon^2-\mu^2}\,\varphi_o e^{-\epsilon t}e^{\sqrt{\epsilon^2-\mu^2}t}}{2\sqrt{\epsilon^2-\mu^2}}$$

Or

$$\varphi(t)=\frac{\varphi_o e^{-\epsilon t}}{2}\{(1+\frac{\epsilon}{\sqrt{\epsilon^2-\mu^2}})e^{\sqrt{\epsilon^2-\mu^2}\,t}+(1-\frac{\epsilon}{\sqrt{\epsilon^2-\mu^2}})e^{-\sqrt{\epsilon^2-\mu^2}\,t}\}\text{………… (VI)}$$

This equation (12) provides the deflection of the coil of the When current is flow flowing coil of moving-coil galvanometer, it is turned by the deflecting couple performing on it, and if φ is the deflection of the coil from the equilibrium position at any instant t, then the motion of the coil is opposed by the following couples [1-5]:

i)

ii) If ɼ is damping constant and the negative sign shows that the motion of the coil is opposed by the damping couple. Then Damping couple will be (τ_d) i.e. $\tau_d=-ɼ\,\dot{\varphi}(t)$.

iii)

iv) If C is torsional rigidity of suspension fibre, and the minus sign indicates that the motion is also opposed by the restoring couple. Then Restoring couple (τ_r) i.e. $\tau_s=-C\,\varphi(t)$.

v) A couple $\tau_e=-\frac{K}{R}\dot{\varphi}(t)$ arises due to electromagnetic damping i.e. due to induced eddy current in the coil and depends directly upon the angular velocity of the coil and inversely upon its resistance R and also depends upon the magnetic field strength. All these factors are included in the constant Ⱪ.

The application of Newton's second law of motion gives the equation of motion of the coil as follows and reveals that the nature of its deflection depends on the nature of the quantity$\sqrt{\epsilon^2-\mu^2}$ which may be real, zero or imaginary depending upon the values of ϵ and μ . We have the following three cases:

Case I: $When\ \epsilon > \mu$, thenthe quantity $\sqrt{\epsilon^2-\mu^2}$ is real and therefore, the equation (VI) can be rewritten as

$$\varphi\ (\mathrm{t}) = \varphi_o e^{-\epsilon t}\left[\frac{\delta}{\sqrt{\epsilon^2-\mu^2}}\sin\mathrm{h}\sqrt{\epsilon^2-\mu^2}\ t + \cos\mathrm{h}\sqrt{\epsilon^2-\mu^2}\ t\right] \ldots\ldots \text{(VII)}$$

It is clear from the equation (VII) that the motion of the coil of the moving-coil galvanometer is non-oscillatory and the coil approaches equilibrium quite slowly without any oscillation when a steady current is passed through it.The galvanometer in such a case is said to be over-damped or dead beat [5, 15].

Case II: $When\ \epsilon = \mu$, then the quantity $\sqrt{\epsilon^2-\mu^2}$is zero. In this case, equation (VI) reveals that the motion of the coil of the moving-coil galvanometer indeterminate, which is not possible. If the quantity $\sqrt{\epsilon^2-\mu^2}$ is so small that it approaches zero, then on expanding the exponential terms containing the quantity $\sqrt{\epsilon^2-\mu^2}$ and neglecting higher order terms, we can rewrite equation (VI) as

$$\varphi\ (\mathrm{t}) = \varphi_o e^{-\epsilon t}\left\{\frac{\epsilon}{\sqrt{\epsilon^2-\mu^2}}\frac{1+\left(\sqrt{\epsilon^2-\mu^2}\right)\mathrm{t}-[\,1-\left(\sqrt{\epsilon^2-\mu^2}\right)\mathrm{t}\,]}{2} + \frac{1+\left(\sqrt{\epsilon^2-\mu^2}\right)\mathrm{t}+[\,1-\left(\sqrt{\epsilon^2-\mu^2}\right)\mathrm{t}\,]}{2}\right\}$$

Or $\varphi\ (\mathrm{t}) = \varphi_o(\,1+\ \epsilon t)e^{-\epsilon t} \ldots\ldots$ (VIII)

It is clear from the equation (VIII) that the motion of the coil of the moving-coil galvanometer is non – oscillatory and the coil approaches equilibrium as fast as possible without any oscillation when a steady current is passed through it. The galvanometer in such a case is said to be critically damped [5, 16]. This type of damping is very desirable feature in the PMMC instrument.

Case III: In the case of light damping [5] $, \epsilon < \mu$. In such a case, the quantity $\sqrt{\epsilon^2-\mu^2}$ is imaginary. We can rewrite the quantity $\sqrt{\epsilon^2-\mu^2}$ as $\sqrt{\epsilon^2-\mu^2} = \mathrm{i}\sqrt{\epsilon^2-\mu^2}$ ………….. (IX)

Using equation (15), we can rewrite equation (12) as

$$\varphi\ (\mathrm{t}) = \varphi_o e^{-\epsilon t}\left[\frac{\epsilon}{\sqrt{\mu^2-\epsilon^2}}\sin\sqrt{\mu^2-\epsilon^2}\ t + \cos\sqrt{\mu^2-\epsilon^2}\ t\right] \ldots\ldots\ldots\ldots \text{(X)}$$

Let us substitute$\frac{\varphi_o\epsilon}{\sqrt{\mu^2-\epsilon^2}} = \mathcal{A}\cos\ \Theta$ and $\varphi_o = \mathcal{A}\sin\Theta$ such that $\mathcal{A} = \frac{\varphi_o\omega}{\sqrt{\mu^2-\epsilon^2}}$ and $\Theta = \tan^{-1}\frac{\sqrt{\mu^2-\epsilon^2}}{\epsilon}$, then equation (X) becomes

$$\varphi\ (\mathrm{t}) = \mathcal{A}e^{-\epsilon t}sin\left[\left(\sqrt{\mu^2-\epsilon^2}\right)\mathrm{t}+\Theta\right] \ldots\ldots\ldots \text{(XI)}$$

It is clear from the equation (XI) that the motion of the coil of the moving-coil galvanometer is oscillatory with amplitude $\mathcal{A}e^{-\epsilon t}$ which is decreasing exponentially with time over many oscillations, and the oscillating angular frequency is$\sqrt{\mu^2-\epsilon^2}$. The galvanometer in such a case is said to be under-damped [5, 17, 18, 19] or ballistic galvanometer.

CONCLUSION

In this paper, an effort made to exemplify the Dinesh Verma transform for talk about the theory of a moving-coil galvanometer. This paper brought up the Dinesh Verma transform as a powerful mathematical tool for determining the response of a moving-coil galvanometer. The response obtained is the same as obtained with other the methods or approaches [1-5, 14].

REFERENCES

[1] Basic Electrical Engineering, C. L. Wadhwa. Publisher: New Age International Pvt. Ltd. 2nd edition, 2011.

[2] Electrical Measurements and Measuring Device by U. A. Bakshi and A.V. Bakshi. Publisher: Technical Publications, 2008.

[3] A Text Book of Engineering Physics by M.N. Avadhanulu and P.G. Kshirsagar.*Publisher*: S. Chand *Publishing*, 11th edition, 2018.

[4] The Physics of Wave and Oscillations by N.K. Bajaj. Publisher: Tata Mc-Graw Hill *Publishing* Co. Ltd., 1988.

[5] Gupta Rohit , Gupta Rahul, Residue approach to mathematical analysis of the moving coil galvanometer, International Journal of Advanced Trends in Engineering and Technology, 4(1), 2019, pp. 06-10.

[6] Gupta Rohit, On Novel Integral Transform: Rohit Transform and Its Application to Boundary Value Problems, "ASIO Journal of Chemistry, Physics, Mathematics and Applied Sciences", 4(1), 2020: 08-13.

[7] Gupta Rohit, Gupta Rahul, Verma Dinesh, Solving Schrodinger equation for a quantum mechanical particle by a new integral transform: Rohit Transform, "ASIO Journal of Chemistry, Physics, Mathematics and Applied Sciences", 4(1), 2020: 32-36.

[8] Gupta Rohit, Gupta Rahul, Analysis of RLC circuits with exponential excitation sources by a new integral transform: Rohit Transform, "ASIO Journal of Engineering and Technological Perspective Research", 5(1), 2020, pp.22-24.

[9] Gupta Rohit, Singh Yuvraj, Verma Dinesh, Response of a basic series inverter by the application of convolution theorem, "ASIO Journal of Engineering and Technological Perspective Research", 5(1), 2020, pp. 14-17.

[10] Gupta Rohit, Anamika, Analysis Of Basic Series Inverter Via The Application Of Rohit Transform, "International Journal of Advance Research and Innovative Ideas in Education",6(6), 2020, pp. 868-873.

[11] Dinesh Verma , Elzaki –Laplace Transform of some significant Functions, Academia Arena, Volume-12, Issue-4, April 2020..

[12] Dinesh Verma, Aftab Alam, Analysis of Simultaneous Differential Equations By Elzaki Transform Approach, Science, Technology And Development Volume Ix Issue I January 2020.

[13] Dinesh Verma Analytical Solutuion of Differential Equations by Dinesh Verma Tranforms (DVT), ASIO Journal of Chemistry, Physics, Mathematics & Applied Sciences (ASIO-JCPMAS), Volume -4, Issue-1, 2020, PP:24-27.

[14] A Study of Electromagnet Moving Coil Galvanometers for Use in Alternating-current Measurements by Ernest Edward Weibel. Publisher: U.S. Government Printing Office, 1918.

[15] Dinesh Verma, Empirical Study of Higher Order Diffeential Equations with Variable Coefficient by Dinesh Verma Transformation (DVT), ASIO Journal of Engineering & Technological Perspective Research (ASIO-JETPR), Volume - 5, Issue-1, 2020, pp:04-07.

[16] Gupta Rahul, Gupta Rohit, Verma Dinesh, Application of Convolution Method to the Impulsive Response of A Lightly Damped Harmonic Oscillator, International Journal of Scientific Research in Physics and Applied Sciences ,Vol.7, Issue.3, pp.173-175, June (2019).

[17] Rohit Gupta, Rahul Gupta, Sonica Rajput, Analysis of Damped Harmonic Oscillator by Matrix Method, International Journal of Research and Analytical Reviews (IJRAR), Volume 5, Issue 4, October 2018, pp. 479-484.

[18] Gupta Rahul, Gupta Rohit, Verma Dinesh, Application of Novel Integral Transform: Gupta Transform to Mechanical and Electrical Oscillators, "ASIO Journal of Chemistry, Physics, Mathematics and Applied Sciences", 4(1), 2020: 04-07.

[19] Engineering Physics by R.K. Gaur and S.L. Gupta. Publisher: Dhanpat Rai publications, 8th edition, 2008.

[20] Arun Prakash Singh, and Dinesh Verma , An Empirical analysis of a particle in an infinite square well potential by elzaki transform with eigen energy valus and eigen function, IOSR Journal of applied physics (IOSR-JAP)" Volume-14, Issue-2, SERIAL –II, March- April-2022, eISSN 2478-4861; PP: 18-22.

[21] Updesh Kumar and Dinesh Verma, Anayzation of physical sciences problems, EPRA International Journal of Multidisciplinary Research (IJMR), Volume-8, Issue-4, April-2022, eISSN 2455-3662; PP: 174-178.

[22] Updesh Kumar, Govinfd Raj Naunyal, and Dinesh Verma , A Study of the Beam Fixed at Ends Loaded in the Middle and Cantilever,IOSR Journal of Mathematics, Volume-18, Issue-2, Series -3, March-April- 2022, eISSN 2278-5728; PP: 01-04.

[23] Govinfd Raj Naunyal, Updesh Kumar and Dinesh Verma, Mathematical analysis of infinite power series, International Journal of Mathematics Trends and Technology, Volume-

68, Issue-3, March 2022, ISSN 2231-5373; PP: 01-10.

[24] Govinfd Raj Naunyal, Updesh Kumar and Dinesh Verma, Analysis of uniform infinite fin by Elzaki Transform,Compliance Engineering Journal, Volume-13, Issue-3, February 2022, ISSN 0898-3577; PP: 119-121.

[25] Updesh Kumar, Govind Raj Naunyal and Dinesh Verma,Elzaki Transform to Differential Equations with Delta Function, New York Science Journal, Volume-15, Issue-2, February 2022, ISSN 1554-0200 (print); ISSN 2375-723X (online).PP: 45-48.

[26] Arun Prakash Singh and Dinesh Verma, An approach of damped electrica land mechanical resonators, SSRG International Journal of Applied Physics), Volume 9, Issue-1, January-April-2022, ISSN 2350-o301; PP: 21-24.