Journal of New Theory

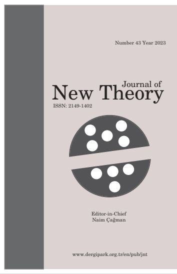
ISSN: 2149-1402

43 (2023) 63-72

Journal of New Theory

https://dergipark.org.tr/en/pub/jnt

Open Access



Exact Solutions of Some Basic Cardiovascular Models by Kashuri Fundo Transform

Haldun Alpaslan Peker[1] , **Fatma Aybike Çuha**[2]

Article Info
Received: 18 Mar 2023
Accepted: 23 Jun 2023
Published: 30 Jun 2023
doi:10.53570/jnt.1267202
Research Article

Abstract — Differential equations refer to the mathematical modeling of phenomena in various applied fields, such as engineering, physics, chemistry, astronomy, biology, psychology, finance, and economics. The solutions of these models can be more complicated than those of algebraic equations. Therefore, it is convenient to use integral transformations to attain the solutions of these models. In this study, we find exact solutions to two cardiovascular models through an integral transformation, namely the Kashuri Fundo transform. It can be observed that the considered transform is a practical, reliable, and easy-to-use method for obtaining solutions to differential equations.

Keywords *Kashuri Fundo transform, inverse Kashuri Fundo transform, cardiovascular models*

Mathematics Subject Classification (2020) 34A30, 44A15

1. Introduction

Ordinary differential equations are essential in describing the rates of change of quantities in diverse scientific disciplines, including physics, chemistry, biology, engineering, and economics. These equations provide a concise mathematical framework for modeling dynamic systems, where variables depend on a single independent variable, such as time. By formulating ordinary differential equations, scientists can represent complex real-world problems as mathematical equations, facilitating their analysis and prediction. Ordinary differential equations enable researchers to investigate the behavior of systems over time, making them invaluable in studying dynamic processes and phenomena. For this reason, differential equations are used to analyze many problems in many fields of applied sciences [1, 2].

Ordinary differential equations play a pivotal role in biology, providing a powerful mathematical tool for understanding and analyzing complex biological systems [3]. These equations are of paramount importance in biology due to the dynamic nature of biological processes, where variables such as concentrations, populations, and reaction rates change over time. Ordinary differential equations allow researchers to investigate the dynamics of biological systems, predict their behavior under different conditions, and gain insights into fundamental biological principles. They are instrumental in studying population dynamics, the spread of diseases, gene regulation, cellular signaling, and many other biological phenomena [4]. Ordinary differential equations provide a powerful mathematical framework for unraveling the intricacies of biological systems, allowing scientists to deepen their understanding of life processes and contribute to advancements in biological research and healthcare.

[1]pekera@gmail.com(Corresponding Author); [2]fatmaaybikecuha@gmail.com
[1,2]Department of Mathematics, Faculty of Science, Selçuk University, Konya, Türkiye

Finding a field of application in many fields has made it important to reach the solutions of this type of equations. The solution of differential equations can be more complicated than that of algebraic equations. Therefore, researchers have sought ways to convert differential equations into algebraic equations. One of the solution methods that emerged as a result of this search is integral transforms that convert differential equations into algebraic equations. These transforms give very effective results in solving a wide variety of problems in many different fields. Its application to various problems has led to the diversification of integral transforms [2]. In this study, we consider a type of integral transform, namely Kashuri Fundo transform [5].

The Kashuri Fundo transform is a powerful mathematical tool that has gained significant attention in the field of differential equations. The Kashuri Fundo integral transform offers a systematic approach to transform differential equations into algebraic equations, making it easier to solve them and obtain analytical or numerical solutions [5]. By employing this transform, researchers can simplify the mathematical representation of differential equations, which often leads to more tractable equations and allows for the application of established techniques for solving algebraic equations. The importance of the Kashuri Fundo transform lies in its potential to overcome the challenges associated with solving differential equations analytically or numerically, offering a promising alternative approach for obtaining solutions to a wide range of differential equations encountered in various scientific and engineering fields. Its utilization can enhance the efficiency and accuracy of solving differential equations, ultimately advancing our understanding and prediction of dynamic systems in applied science and engineering disciplines. Kashuri Fundo transform was introduced to the literature by Kashuri and Fundo with the statement that various properties can be found easily due to its deep connection with Laplace transform [2]. In later processes, many researchers, including Kashuri and Fundo, worked on different applications [6–16] of this transform. Helmi et al. [17], Singh [18], Dhange [19], and Güngör [20] investigated various applications of Kashuri Fundo transformation. Later, Peker et al. [21–26] applied this transform to the models, namely steady heat transfer, decay, some chemical reaction, one-dimensional Bratu's problem, Michaelis-Menten's biochemical reaction model, population growth and mixing problem to demonstrate the competence of the Kashuri Fundo transform in reaching solutions of ordinary differential equations.

Extracting analytic or approximate solutions for differential equations by using new mathematical methods always attract the attention of the researchers due to the academic curiosity and practical applications. Motivation for having a technique more effective, more applicable, and easier to use induces the possibility of analyzing the utility of other non-conventional solution techniques or methods.

In this study, we aim to present that the Kashuri Fundo transform is a technique that facilitates the solution of differential equations through two different cardiovascular models, one of which is glucose concentration in the blood during continuous intravenous glucose injection. The other is pressure in the aorta.

2. Preliminaries

This section provides some of basic definitions and properties related to Kashuri Fundo transform.

Definition 2.1. [5] Let F be a function set defined by

$$F = \left\{ f(t) \mid \exists M, k_1, k_2 > 0 \ni |f(t)| \leqslant M e^{\frac{|t|}{k_i^2}}, \text{ if } t \in (-1)^i \times [0, \infty) \right\}$$

where M is a constant and k_1 and k_2 are finite constants or infinite.

Definition 2.2. [5] Kashuri Fundo transform, defined on the set F and denoted by the operator $\mathscr{K}(.)$, is defined by

$$\mathscr{K}[f(t)](v) = A(v) = \frac{1}{v}\int_0^\infty e^{\frac{-t}{v^2}} f(t)\ dt, \quad t \geqslant 0 \quad \text{and} \quad -k_1 < v < k_2$$

which can be stated as well by

$$\mathscr{K}[f(t)](v) = A(v) = v\int_0^\infty e^{-t} f(v^2 t)\ dt$$

Inverse Kashuri Fundo transform is denoted by $\mathscr{K}^{-1}[A(v)] = f(t)$, $t \geq 0$.

Definition 2.3. [5] A function $f(t)$ is said to be of exponential order $\frac{1}{k^2}$, if there are positive constants T and M such that $|f(t)| \leq Me^{\frac{-t}{k^2}}$, for all $t \geq T$.

Theorem 2.4. [5] [Sufficient Conditions for Existence] If $f(t)$ is piecewise continuous on $[0, \infty)$ and has exponential order $\frac{1}{k^2}$, then $\mathscr{K}[f(t)](v)$ exists, for $|v| < k$.

Theorem 2.5. [5] [Linearity Property] Let $f(t)$ and $g(t)$ be functions whose Kashuri Fundo transforms exist and c_1 and c_2 be constants. Then,

$$\mathscr{K}[(c_1 f + c_2 g)(t)](v) = c_1\mathscr{K}[f(t)](v) + c_2\mathscr{K}[g(t)](v)$$

Theorem 2.6. [5] [Derivatives of a Function $f(t)$] Let $A(v)$ be a Kashuri Fundo transform of $f(t)$. Then,

$$\mathscr{K}[f^{(n)}(t)](v) = \frac{A(v)}{v^{2n}} - \sum_{k=0}^{n-1} \frac{f^{(k)}(0)}{v^{2(n-k)-1}} \tag{1}$$

Table 1 presents transformations of some special functions.

Table 1. Kashuri Fundo and Laplace transforms of some special functions [2, 5, 13]

$f(t)$	$\mathscr{K}[f(t)] = A(v)$	$\mathscr{L}[f(t)] = F(s)$
1	v	$\frac{1}{s}$
t	v^3	$\frac{1}{s^2}$
t^n, $n \in \mathbb{Z}$	$n!v^{2n+1}$	$\frac{n!}{s^{n+1}}$
e^{at}	$\frac{v}{1-av^2}$	$\frac{1}{s-a}$
$\sin(at)$	$\frac{av^3}{1+a^2v^4}$	$\frac{a}{s^2+a^2}$
$\cos(at)$	$\frac{v}{1+a^2v^4}$	$\frac{s}{s^2+a^2}$
$\sinh(at)$	$\frac{av^3}{1-a^2v^4}$	$\frac{a}{s^2-a^2}$
$\cosh(at)$	$\frac{v}{1-a^2v^4}$	$\frac{s}{s^2-a^2}$
t^α, $\alpha \in \mathbb{R}^+$	$\Gamma(1+\alpha)v^{2\alpha+1}$	$\frac{\Gamma(\alpha+1)}{s^{\alpha+1}}$
$\sum_{k=0}^{n} a_k t^k$	$\sum_{k=0}^{n} k!a_k v^{2k+1}$	$\sum_{k=0}^{n} a_k \frac{k!}{s^{k+1}}$

Table 2 presents inverse transformations of some special functions.

Table 2. Inverse Kashuri Fundo transform of some special functions [5, 13]

$A(v)$	$\mathscr{K}^{-1}[A(v)] = f(t)$
v	1
v^3	t
$n!v^{2n+1}$	t^n, $n \in \mathbb{Z}$
$\frac{v}{1-av^2}$	e^{at}
$\frac{av^3}{1+a^2v^4}$	$\sin(at)$
$\frac{v}{1+a^2v^4}$	$\cos(at)$
$\frac{av^3}{1-a^2v^4}$	$\sinh(at)$
$\frac{v}{1-a^2v^4}$	$\cosh(at)$
$\Gamma(1+\alpha)v^{2\alpha+1}$	t^α, $\alpha \in \mathbb{R}^+$
$\sum\limits_{k=0}^{n} k!a_k v^{2k+1}$	$\sum\limits_{k=0}^{n} a_k t^k$

In order to better understand the application of Kashuri Fundo transform to ordinary differential equations, two simple numerical examples are provided below.

Example 2.7. [27] Consider differential equation

$$\frac{dy}{dt} - 16y = 2 \tag{2}$$

with the initial condition

$$y(0) = -4$$

Applying the Kashuri Fundo transform bilaterally to both sides of Equation 2,

$$\mathscr{K}\left[\frac{dy}{dt}\right] - \mathscr{K}[16y] = \mathscr{K}[2]$$

If we write the equivalent in Equation 1 instead of the expression $\mathscr{K}\left[\frac{dy}{dt}\right]$ and arrange the expression $\mathscr{K}[2]$ according to Table 1 using the linearity property of the transform,

$$\frac{A(v)}{v^2} - \frac{y(0)}{v} - 16A(v) = 2v \tag{3}$$

where $A(v) = \mathscr{K}[y(t)]$. Substituting the initial condition in Equation 3 and rearranging the equation,

$$A(v) = \frac{2v^3 - 4v}{1 - 16v^2} \tag{4}$$

We use Table 2 to apply the inverse Kashuri Fundo transform to Equation 4. For this, if we rearrange Equation 4,

$$A(v) = -\frac{1}{8}v - \frac{31}{8}\frac{v}{1 - 16v^2} \tag{5}$$

If we apply the inverse Kashuri Fundo transform to both sides of Equation 5 using Table 2, we find the solution of the given differential equation as

$$y(t) = -\frac{1}{8} - \frac{31}{8}e^{16t}$$

The 3D graph of this solution is in Figure 1. The graphics in this study is drawn using Python.

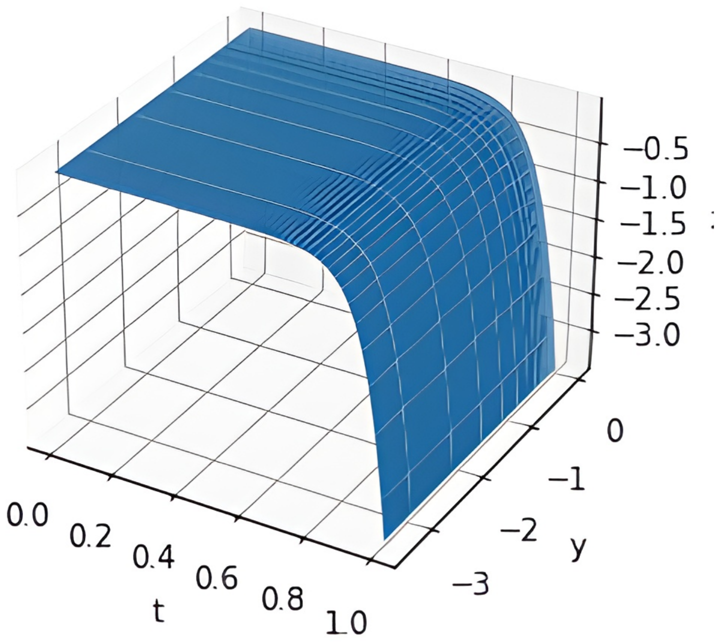


Figure 1. Graph of $y(t) = -\frac{1}{8} - \frac{31}{8}e^{16t}$

Example 2.8. [28] Consider differential equation

$$\frac{dy}{dt} - y = e^{3t} \tag{6}$$

with the initial condition

$$y(0) = 2$$

Applying the Kashuri Fundo transform bilaterally to both sides of Equation 6,

$$\mathscr{K}\left[\frac{dy}{dt}\right] - \mathscr{K}[y] = \mathscr{K}[e^{3t}]$$

If we write the equivalent in Equation 1 instead of the expression $\mathscr{K}\left[\frac{dy}{dt}\right]$ and arrange the expression $\mathscr{K}[e^{3t}]$ according to Table 1 using the linearity property of the transform,

$$\frac{A(v)}{v^2} - \frac{y(0)}{v} - A(v) = \frac{v}{1-3v^2} \tag{7}$$

where $A(v) = \mathscr{K}[y(t)]$. Substituting the initial condition in Equation 7 and rearranging the equation,

$$A(v) = \frac{2v - 5v^3}{(1-v^2)(1-3v^2)} \tag{8}$$

We use Table 2 to apply the inverse Kashuri Fundo transform to Equation 8. For this, if we rearrange the right-hand side of Equation 8,

$$\frac{2v - 5v^3}{(1-v^2)(1-3v^2)} = \frac{Av}{1-v^2} + \frac{Bv}{1-3v^2} \tag{9}$$

If this equation is solved, then

$$A = \frac{3}{2} \quad \text{and} \quad B = \frac{1}{2}$$

If we write these values in their places in Equation 9 and use the equation here in Equation 8,

$$A(v) = \frac{3}{2}\frac{v}{1-v^2} + \frac{1}{2}\frac{v}{1-3v^2} \tag{10}$$

If we apply the inverse Kashuri Fundo transform to both sides of Equation 10 using Table 2, we find the solution of the given differential equation as

$$y(t) = \frac{1}{2}(3e^t + e^{3t})$$

The 3D graph of this solution is in Figure 2.

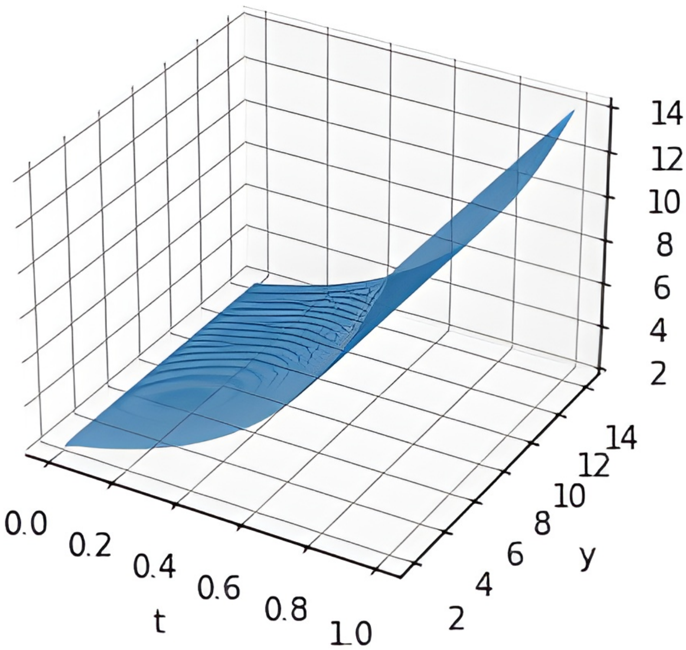


Figure 2. Graph of $y(t) = \frac{1}{2}(3e^t + e^{3t})$

3. Applications of Kashuri Fundo Transform to Cardiovascular Models

This section presents two applications of Kashuri Fundo transform to two cardiovascular models.

Application 3.1. (Glucose concentration in the blood) During continuous intravenous glucose injection, the concentration of glucose in the blood is $C(t)$ exceeding the baseline value at the start of the infusion. The function $C(t)$ satisfies the initial value problem [2]

$$\frac{dC(t)}{dt} + kC(t) = \frac{\alpha}{V}, \quad t > 0 \tag{11}$$

and

$$C(0) = 0$$

where k is the constant velocity of elimination, α is the rate of infusion, and V is the volume in which glucose is distributed. We will find the concentration of glucose in the blood by using the Kashuri Fundo transform method.

Applying the transform bilaterally to the given Equation 11,

$$\mathscr{K}\left[\frac{dC(t)}{dt}\right] + k\,\mathscr{K}[C(t)] = \mathscr{K}\left[\frac{\alpha}{V}\right] \tag{12}$$

Let $\mathscr{K}[C(t)] = A(v)$. If we rearrange the Equation 12 by using the Equation 1 with the initial condition and the transforms in Table 1,

$$\frac{A(v)}{v^2} - \frac{C(0)}{v} + kA(v) = \frac{\alpha}{V}v$$

and thus

$$A(v) = \frac{\alpha}{V}\left(\frac{v^3}{1+kv^2}\right) \tag{13}$$

Having rearranged the Equation 13,

$$A(v) = \frac{\alpha}{V}\left(v - \frac{v}{1+kv^2}\right) \tag{14}$$

Applying the inverse Kashuri Fundo transform to Equation 14,

$$\mathscr{K}^{-1}[A(v)] = \mathscr{K}^{-1}\left[\frac{\alpha}{V}\left(v - \frac{v}{1+kv^2}\right)\right] \tag{15}$$

If we rearrange Equation 15 using the linearity property of the inverse Kashuri Fundo transform,

$$\mathscr{K}^{-1}[A(v)] = \frac{\alpha}{V}\left(\mathscr{K}^{-1}[v] - \mathscr{K}^{-1}\left[\frac{v}{1+kv^2}\right]\right) \tag{16}$$

According to Table 2, the equivalents of the expressions in Equation 16 are

$$\mathscr{K}^{-1}[A(v)] = C(t), \quad \mathscr{K}^{-1}[v] = 1, \quad \text{and} \quad \mathscr{K}^{-1}\left[\frac{v}{1+kv^2}\right] = e^{-kt}$$

Finally, substitute these expressions in Equation 16, we find the concentration of glucose in the blood as

$$C(t) = \frac{\alpha}{kV}(1 - e^{-kt})$$

Application 3.2. (Pressure in the aorta) The blood is pumped into the aorta by the contraction of the heart. The pressure $p(t)$ in the aorta satisfies the initial value problem [2]

$$\frac{dp(t)}{dt} + \frac{c}{k}p(t) = cA\sin\omega t \tag{17}$$

and

$$p(0) = p_0$$

where c, k, A, and p_0 are constants. We will obtain the pressure in the aorta by using the Kashuri Fundo transform method.

Applying the transform bilaterally to the given Equation 17,

$$\mathscr{K}\left[\frac{dp(t)}{dt}\right] + \frac{c}{k}\mathscr{K}[p(t)] = cA\mathscr{K}[\sin\omega t] \tag{18}$$

Let $\mathscr{K}[p(t)] = A(v)$. If we rearrange the Equation 18 by using the Equation 1 with the initial condition and the transforms in Table 1,

$$\frac{A(v)}{v^2} - \frac{p_0}{v} + \frac{c}{k}A(v) = cA\frac{\omega v^3}{1+\omega^2 v^4}$$

and thus

$$A(v) = p_0\frac{v}{1+\frac{c}{k}v^2} + cA\left(\frac{k\omega v^5}{(k+cv^2)(1+\omega^2 v^4)}\right) \tag{19}$$

Regrouping the Equation 19,

$$A(v) = p_0\frac{v}{1+\frac{c}{k}v^2} + cA\left(\frac{kc}{\omega^2k^2+c^2}\frac{v^3}{1+\omega^2v^4} - \frac{\omega k^2}{\omega^2k^2+c^2}\frac{v}{1+\omega^2v^4} + \frac{\omega k^2}{\omega^2k^2+c^2}\frac{v}{1+\frac{c}{k}v^2}\right) \tag{20}$$

Applying the inverse Kashuri Fundo transform to Equation 20,

$$\mathscr{K}^{-1}[A(v)] = \mathscr{K}^{-1}\left[p_0\frac{v}{1+\frac{c}{k}v^2} + cA\left(\frac{kc}{\omega^2k^2+c^2}\frac{v^3}{1+\omega^2v^4} - \frac{\omega k^2}{\omega^2k^2+c^2}\frac{v}{1+\omega^2v^4} + \frac{\omega k^2}{\omega^2k^2+c^2}\frac{v}{1+\frac{c}{k}v^2}\right)\right] \tag{21}$$

If we rearrange Equation 21 using the linearity property of the inverse Kashuri Fundo transform,

$$\begin{aligned}\mathscr{K}^{-1}[A(v)] = cA\left(\tfrac{kc}{\omega^2k^2+c^2}\mathscr{K}^{-1}\left[\tfrac{v^3}{1+\omega^2v^4}\right] - \tfrac{\omega k^2}{\omega^2k^2+c^2}\mathscr{K}^{-1}\left[\tfrac{v}{1+\omega^2v^4}\right] + \tfrac{\omega k^2}{\omega^2k^2+c^2}\mathscr{K}^{-1}\left[\tfrac{v}{1+\frac{c}{k}v^2}\right]\right) \\ +p_0\mathscr{K}^{-1}\left[\tfrac{v}{1+\frac{c}{k}v^2}\right]\end{aligned} \tag{22}$$

According to Table 2, the equivalents of the expressions in Equation 22 are

$$\mathscr{K}^{-1}[A(v)] = p(t), \quad \mathscr{K}^{-1}\left[\frac{v}{1+\frac{c}{k}v^2}\right] = e^{-\frac{c}{k}t},$$

$$\mathscr{K}^{-1}\left[\frac{v^3}{1+\omega^2v^4}\right] = \sin\omega t, \quad \text{and} \quad \mathscr{K}^{-1}\left[\frac{v}{1+\omega^2v^4}\right] = \cos\omega t.$$

Finally, substitute these expressions in Equation 22, we obtain the pressure in the aorta as

$$p(t) = p_0e^{-\frac{c}{k}t} + cA\frac{\omega k^2}{\omega^2k^2+c^2}\left(\frac{c}{\omega k}\sin\omega t - \cos\omega t + e^{-\frac{c}{k}t}\right)$$

4. Conclusion

Differential equations appear in the modeling of many phenomena in applied sciences. Using these equations in modeling makes understanding and interpreting the phenomenon underlying these events more accessible. The fact that it is used in modeling many important events makes it essential to solving these equations. On the other hand, differential equations are more difficult to solve than algebraic equations. Thus, using integral transformations is very helpful in solving these equations. In this study, we applied the Kashuri Fundo transform, one of the integral transforms closely related to the Laplace transform, with a few cardiovascular models. As seen from these applications, the considered transform is suitable for applicability, reliability, effectiveness, and ease of use.

In future studies, researchers can study by considering systems of differential equations as well as fractional differential equations emerging in applied fields.

Author Contributions

All authors contributed equally to this work. They all read and approved the final version of the paper.

Conflicts of Interest

All authors declare no conflict of interest.

References

[1] Y. A. Çengel, W. J. Palm, Differential Equations for Engineers and Scientists, McGraw Hill, New York, 2012.

[2] L. Debnath, D. Bhatta, Integral Transforms and Their Applications, 2nd Edition, Chapman and Hall/CRC, Boca Raton, 2007.

[3] P. Städter, Y. Schälte, L. Schmiester, J. Hasenauer, P. L. Stapor, *Benchmarking of Numerical Integration Methods for ODE Models of Biological Systems*, Scientific Reports 11 (2020) Article Number 2696 11 pages.

[4] D. Hasdemir, H. C. J. Hoefsloot, A. K. Smilde, *Validation and Selection of ODE Based Systems Biology Models: How to Arrive at More Reliable Decisions*, BMC Systems Biology 9 (2015) Article Number 32 19 pages.

[5] A. Kashuri, A. Fundo, *A New Integral Transform*, Advances in Theoretical and Applied Mathematics 8 (1) (2013) 27–43.

[6] A. Kashuri, A. Fundo, M. Kreku, *Mixture of A New Integral Transform and Homotopy Perturbation Method for Solving Nonlinear Partial Differential Equations*, Advances in Pure Mathematics 3 (3) (2013) 317–323.

[7] A. Kashuri, A. Fundo, R. Liko, *On Double New Integral Transform and Double Laplace Transform*, European Scientific Journal 9 (33) (2013) 1857–7881.

[8] A. Kashuri, A. Fundo, R. Liko, *New Integral Transform for Solving Some Fractional Differential Equations*, International Journal of Pure and Applied Mathematics 103 (4) (2015) 675–682.

[9] A. Fundo, A. Kashuri, R. Liko, *New Integral Transform in Caputo Type Fractional Difference Operator*, Universal Journal of Applied Science 4 (1) (2016) 7–10.

[10] K. Shah, T. Singh, *A Solution of the Burger's Equation Arising in the Longitudinal Dispersion Phenomenon in Fluid Flow through Porous Media by Mixture of New Integral Transform and Homotopy Perturbation Method*, Journal of Geoscience and Environment Protection 3 (4) (2015) 24–30.

[11] K. Shah, T. Singh, *The Mixture of New Integral Transform and Homotopy Perturbation Method for Solving Discontinued Problems Arising in Nanotechnology*, Open Journal of Applied Sciences 5 (11) (2015) 688–695.

[12] K. Shah, T. Singh, B. Kılıçman, *Combination of Integral and Projected Differential Transform Methods for Time-Fractional Gas Dynamics Equations*, Ain Shams Engineering Journal 9 (4) (2018) 1683–1688.

[13] I. Sumiati, Sukono, A. T. Bon, *Adomian Decomposition Method and the New Integral Transform*, in: C. Mbohwa (Ed.), Proceedings of the 2nd African International Conference on Industrial Engineering and Operations Management, Harare, 2020, pp. 7–10.

[14] M. D. Johansyah, A. K. Supriatna, E. Rusyaman, J. Saputra, *Solving the Economic Growth Acceleration Model with Memory Effects: An Application of Combined Theorem of Adomian Decomposition Methods and Kashuri–Fundo Transformation Methods*, Symmetry 14 (2) (2022) 192 18 pages.

[15] H. A. Peker, F. A. Cuha, *Application of Kashuri Fundo Transform and Homotopy Perturbation Methods to Fractional Heat Transfer and Porous Media Equations*, Thermal Science 26 (4A) (2022) 2877–2884.

[16] F. A. Cuha, H. A. Peker, *Solution of Abel's Integral Equation by Kashuri Fundo Transform*, Thermal Science 26 (4A) (2022) 3003–3010.

[17] N. Helmi, M. Kiftiah, B. Prihandono, *Penyelesaian Persamaan Diferensial Parsial Linear Dengan Menggunakan Metode Transformasi Artion-Fundo*, Buletin Ilmiah Matematika Statistika dan Terapannya 5 (3) (2016) 195–204.

[18] K. B. Singh, *Homotopy Perturbation New Integral Transform Method for Numeric Study of Space- and Time Fractional (N+1)-Dimensional Heat-and Wave-like Equations*, Waves Wavelets and Fractals 4 (1) (2018) 19–36.

[19] N. Dhange, *A New Integral Transform for Solution of Convolution Type Volterra Integral Equation of First Kind*, International Journal of Mathematics Trends and Technology 66 (10) (2020) 52–57.

[20] N. Güngör, *Solving Convolution Type Linear Volterra Integral Equations with Kashuri Fundo Transform*, Journal of Abstract and Computational Mathematics 6 (2) (2021) 1–7.

[21] H. A. Peker, F. A. Cuha, B. Peker, *Solving Steady Heat Transfer Problems via Kashuri Fundo Transform*, Thermal Science 26 (4A) (2022) 3011–3017.

[22] H. A. Peker, F. A. Çuha, *Application of Kashuri Fundo Transform to Decay Problem*, SDU Journal of Natural and Applied Sciences 26 (3) (2022) 546–551.

[23] H. A. Peker, F. A. Çuha, B. Peker, *Kashuri Fundo Transform for Solving Chemical Reaction Models*, in: T. Acar (Ed.), Proceedings of International E-Conference on Mathematical and Statistical Sciences: A Selçuk Meeting, Konya, 2022, pp. 145–150.

[24] H. A. Peker, F. A. Çuha, *Solving One-Dimensional Bratu's Problem via Kashuri Fundo Decomposition Method*, Romanian Journal of Physics 68 (5-6) (2023) (in press).

[25] H. A. Peker, F. A. Çuha, B. Peker, *Kashuri Fundo Decomposition Method for Solving Michaelis-Menten Nonlinear Biochemical Reaction Model*, MATCH Communications in Mathematical and in Computer Chemistry 90 (2) (2023) 315–332.

[26] H. A. Peker, F. A. Çuha, *Application of Kashuri Fundo Transform to Population Growth and Mixing Problem*, in: D. J. Hemanth, T. Yigit, U. Kose, U. Guvenc (Eds.), 4th International Conference on Artificial Intelligence and Applied Mathematics in Engineering, Vol. 7 of *Engineering Cyber-Physical Systems and Critical Infrastructures*, Springer, Cham, 2023, pp. 407–414.

[27] Y. Pala, Modern Applied Differential Equations (in Turkish), Nobel Akademik Publishing, Ankara, 2013.

[28] S. L. Ross, Differential Equations, 3rd Edition, John Wiley & Sons, New York, 1984.