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Application of somham transform in mechanics

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Abstract
Integral transform plays important role in handling diverse problems and have been utilized to convert complicated problems to simple one and obtain exact solution of the problem easily. In this paper we use recently developed Soham integral transform in mechanics.

Key Words: Integral transforms; Soham transform; Mechanics; Simple Harmonic Motion

1. Introduction: Recently, integral transforms are one of the most useful and simple mathematical technique for obtaining the solutions of advance problems occurred in many fields like science, Engineering, technology, commerce and economics. To provide exact solution of problem without lengthy calculations is the important feature of integral transforms. Due to this important feature of the integral transforms many researchers are attracted to this field and are engaged in introducing various integral transforms. Recently, Kushare and Patil [1] introduced new integral transform called as Kushare transform for solving differential equations in time domain. Further, Savita Khakale and Dinkar Patil [2] introduced Soham transform in November 2021. As researchers are interested in introducing the new integral transforms at the same time they are also interested in applying the transforms to various fields, various equations in different domain. In January 2022, Newton's law of Cooling is solved by using Kushare transform [3], Emad- Falih transform [22], Soham transform [23], HY integral transform[25] In April 2022 D. P. Patil, et al [4] used Kushare transform, HY integral transform[24], Emad Sara transform [28], Alenzi transform [29], Emad Falih transform[30], Kharrat Toma transform [39], KKAT transform[43], ARA transform[47], Ranging integral transform[48] and KKA transform [51] for solving the problems on population growth and decay. D.P. Patil [5] also used Sawi transform in Bessel functions. Further, Patil [6] evaluate improper integrals by using Sawi transform of error functions. Laplace transforms and Shehu transforms are used in chemical sciences by Patil [7]. Dinkar Patil [8] used Sawi transform and its convolution theorem for solving wave equation. Using Mahgoub transform, parabolic boundary value problems are solved by D .P. Patil [9]. D .P. Patil [10] used double Laplace and double Sumudu transforms to obtain the solution of wave equation. Further Dr. Patil [11] also obtained dualities between double integral transforms. Kandalkar, Gatkal and Patil [12] solved the system of differential equations using Kushare transform. D. P. Patil [13] used Aboodh and Mahgoub transforms to solve boundary value problems of the system of ordinary differential equations. Double Mahgoub transformed is used by Patil [14] to solve parabolic boundary value problems. Laplace, Sumudu , Aboodh , Elazki and Mahagoub transforms are compared and used it for solving boundary value problems by Dinkar Patil [15]. D. P. Patil et al obtained solution of Volterra Integral equations of first kind by using, Anuj transform [17], Kushare transform [34]. Rathi sisters and D. P. Patil [18] solved system of differential equations by using Soham transform. [18] Emad Sara transform[19] and Emad-Falih transform [26] are used for solving telegraph equation. Kandalkar, Zankar and Patil [20] evaluate the improper integrals by using general integral transform of error function. Dinkar Patil, Prerana Thakare and Prajakta Patil [21] obtained the solution of parabolic boundary value problems by using double general integral transform. Dinkar Patil et al [27] introduced double kushare transform. Nikam, Patil et al [31] used, Kushare transform of error functions in evaluating improper integrals. Wagh sisters and Patil used Kushare [32] and Soham [33] transform in chemical Sciences. Raundal and Patil [35] used double general integral transform for solving boundary value problems in partial differential equations. Rahane, et al [36] developed generalized double ranging integral transform. Shinde, et al [37] used Kushare transform is used for solving Volterra Integro-Differential equations of first kind. Patil et al [38] used new general integral transform [49] and Kushare transform [52] to solve Abel's integral equations. Patil et al [40] used Kushare transform for evaluating integrals containing Bessel's functions. Thakare and Patil [41] used general integral transform for solving mathematical models from health sciences. Rathi sisters used Soham transform for analysis of impulsive response of Mechanical and Electrical oscillators with Patil [42]. Models in health sciences and biotechnology are solved by using Soham transform [44] and Kushare transform [50] Kushare transform and NE transform is used in mechanics [45], [46]. Dighe et al [54] studies recent developments in integral transforms. Pawar and Patil [55] used NE transform to solve Volterra Integral equations of second kind. In this paper we use Sorm for solving the problems from mechanics. We solve the simple harmonic motion problem. We organize this paper as follows. Introduction is included in section one. Second section is devoted for preliminary concepts. Soham transform is applied to mechanics in third section. Applications are in fourth section. Section five is for conclusion.

2.PRELIMINARY

In this section we state some preliminary concepts required ie defination , formulae and theorems from Soham Transform

A .Defination of Soham Integral Transform :

Soham transform for the function f(t) of exponential order in the set B defined by:

B={f(t):∃M,k1.k2>0.|f(t)|<$Me^{|t|kj}$, if t ϵ$(-1)^j$ ×{0,∞}

For a given function in the set B,the constant M must be finite Number, ,k_1,k_2 may be finite or infinite. Soham transform denoted by the operation δ(.) defined by the integral equations

$\propto$

$v\,t$ δ[f(t)] = $\frac{1}{v}\int_0^{\infty} f(t)\, e^{-}$ P(v)=dt , α is non zero real number t ≥0,k_1≤vk_2(2)

- **Inverse soham transform:** Inverse soham transform of f(t) is P(v) then inverse soham transform is **S^{-1}[P(v)]=F(t)**

B .Soham transformation of the elementary function:

S.N	F(t)	S{F(t)} = P(v)
1)	1	$\frac{1}{v^{\alpha+1}}$
2)	t	$\frac{1}{v^{2\alpha+1}}$
3)	t^2	$\frac{2!}{v^{2\alpha+\alpha+1}}$
4)	t^n, n∈N	$\frac{\Gamma(n+1)}{v^{\alpha n+\alpha+1}}$
5)	e^{at}	$\frac{1}{v(v^{\alpha}-a)}$
6)	e^{-at}	$\frac{1}{v(v^{\alpha}+a)}$
7)	$\sin at$	$\frac{a}{v(v^{2\alpha}+a^2)}$
8)	$\cos at$	$\frac{v^{\alpha}}{v(v^{2\alpha}+a^2)}$

C. Soham Transformation of derivative :

If $P(v)$ is Soham transform of function $f(t)$ then

1. $S[f'(t)] = v^{\alpha}P(v) - \frac{1}{v}f(0)$.
2. $S[f''(t)] = v^{2\alpha}P(v) - v^{\alpha-1}f(0) - \frac{1}{v}f'(0)$
3. $S[f^{(n)}(t)] = v^{n\alpha}P(v) - \frac{1}{v}\sum_{k=0}^{n-1} v^{\alpha(n-1-k)} f^{k}(0)$

3. Application of Soham Transform to Mechanics.

In this section we used Soham Transform to solve problems from mechanics.

- Simple Harmonic Motion

We consider a particle having mass m, which execute the simple harmonic motion . let x be the displacement of the particle from the mean position at any time t. The differential equation describing the motion of the particle at time t is given by

$x''(t) + w^2x = 0, w^2 = k/m$

Applying Soham transform to find the displacement of this particle at any time t.

Assume that at $t = 0$ and $x(0) = 0, x'(0) = 1$

$$S[x''(t)] + w^2S(x) = 0$$

$$v^{2\alpha}P(v) - v^{\alpha-1}x(0) - \frac{1}{v}x'(0) + w^2P(v) = 0$$

$$v^{2\alpha}P(v) + w^2P(v) = \frac{1}{v}$$

$$P(v) = \frac{1}{v(v^{2\alpha} + w^2)}$$

Taking inverse on both side

$$S^{-1}[P(v)] = S^{-1}\left[\frac{1}{v(v^{2\alpha} + w^2)}\right]$$

$$x(t) = \frac{\sin(wt)}{w}$$

That is $x(t) = \sqrt{\frac{m}{k}}\ \sin\sqrt{\frac{k}{m}}t$

It is required displacement of the particle .

4 Examples: In this section we solve some examples by using Soham transform

Example 1: Let a body A of mass 1 gram moves on -axis. It is attracted towards the origin 0 with a force equal to 4x . Also , assume that initially it is at rest when x=5 then; determine its position by considering no any other force acting on it.

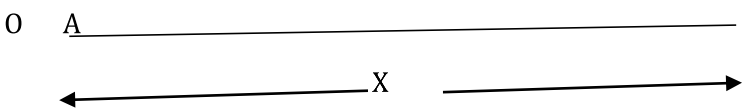


Figure 1: Motion of the body along x-axis

Solution: See above figure number :1

For $x > 0$ the net force towards left is given by -4x , while

For $x < 0$ the net force towards right is given by -4x.

Thus, for both cases, the net force is equal to -4x.

By Newton's second low of motion:

Mass* acceleration = net force
Therefore we can obtain second order differential equation P

$$\frac{d^2x}{dt^2} = -4x$$
$$\frac{d^2x}{dt^2} - 4x = 0$$

The initial condition are $x(0) = 5$ and $x^{'}(0) = 0$

$$x^{''}(t) + 4x = 0$$

Applying Soham integral transform

$$S[x^{''}(t)] + 4S(x) = 0$$
$$v^{2\alpha}P(v) - v^{\alpha-1}x(0) - \frac{1}{v}x^{'}(0) + 4P(v) = 0$$
$$v^{2\alpha}P(v) - 5v^{\alpha-1} + 4P(v) = 0$$
$$-0 + v^{2\alpha}P(v) - 5v^{\alpha-1} + 4P(v) = 0$$
$$(v^{2\alpha} + 4)P(v) = 5v^{\alpha-1}$$
$$P(v) = \frac{5v^{\alpha-1}}{v^{2\alpha} + 4}$$

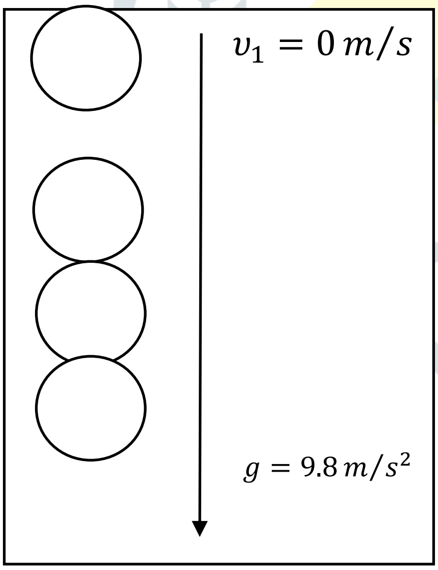
Taking inverse on both side

$$S^{-1}[P(v)] = S^{-1}\left[\frac{5v^{\alpha-1}}{v^{2\alpha} + 4}\right]$$
$$x(t) = 5\cos(2t)$$

It is required solution

Example 2 :The relationship between resistive force of air and the velocity of a freely following body is given by $\frac{dy}{dt} = g - \alpha v$, where $v(t)$ is the velocity at any time t. Initially the body is at rest.

Solution:



Solution: See above fig :

The equation for the motion of the body moving under constant gravitational acceleration is

$$\frac{dv}{dt} = g - \gamma v$$

ie $x^{'} = g - \gamma x$

Applying Soham Integral Transform on both side

$$S[x^{'}(t)] = gS(1) - \gamma S(x)$$

$$v^{\alpha}P(v) - \frac{1}{v}x(0) = g\left(\frac{1}{v^{\alpha+1}}\right) - \gamma P(v)$$

$$v^{\alpha}P(\alpha) + \gamma P(v) = g\left(\frac{1}{v^{\alpha+1}}\right)$$

$$(v^{\alpha} + \gamma)P(v) = g\left(\frac{1}{v^{\alpha+1}}\right)$$

$$P(v) = \frac{g}{v^{\alpha+1}}\left(\frac{1}{v^{\alpha} + \gamma}\right)$$

$$P(v) = \frac{g}{v^{\alpha+1}}\left(\frac{1}{\gamma} - \frac{v^{\alpha}/\gamma}{v^{\alpha} + \gamma}\right)$$

$$P(v) = \left(\frac{g}{v^{\alpha+1}}\right)\left(\frac{1}{\gamma} - \frac{v^{\alpha}}{\gamma(v^{\alpha} + \gamma)}\right)$$

$$P(v) = \left(\frac{g}{\gamma}\right)\left(\frac{1}{v^{\alpha+1}} - \frac{v^{\alpha}}{v^{\alpha+1}(v^{\alpha} + \gamma)}\right)$$

$$P(v) = \left(\frac{g}{\gamma}\right)\left(\frac{1}{v^{\alpha+1}} - \frac{1}{v(v^{\alpha} + \gamma)}\right)$$

Applying Inverse on both side

$$S^{-1}[P(v)] = \frac{g}{\gamma}S^{-1}\left(\frac{1}{v^{\alpha+1}} - \frac{1}{v(v^{\alpha} + \gamma)}\right)$$

$$S^{-1}[P(v)] = \frac{g}{\gamma}\left(S^{-1}\left(\frac{1}{v^{\alpha+1}}\right) - S^{-1}\left(\frac{1}{v(v^{\alpha} + \gamma)}\right)\right)$$

$x(t) = \frac{g}{\gamma}(1 - e^{-\gamma t})$ It is required solution.

5 . Conclusion: Soham Transform is applied successfully in mechanics.

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