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INITIATION OF MOTION OF THE TRUCK WITH THE HELP OF VIBRATIONS OF A 2D-SPRING PENDULUM

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It is observed the way of the initiation of the trolley in the horizontal direction by means of variations in vertical loadof a 2d - spring pendulum, for which the non-chaotic trajectory of the movement was determined.

Keywords:** **2d - spring pendulum, the Lagrange equation of the second kind,** inertial propulsion engine **of V.N.Tolchin, phase trajectory.

Formulation of the problem. In the 30's of last century engineer V. Tolchyn created inertsioyid [1], which consists of two eccentric loads on levers mounted on a moving platform (fig. 1). Cams simultaneously rotate and move toward each other with continuous variable angular velocity. Thus in some sectors of the circle described eccentric, angular speed of rotation of the lever loads increase, while others - is reduced. Fig. 2 shows the movement of one cargo mode lever to [2]. To promote and demonstrate the features inertsioyida movement held its "competition" on the slippery surface of the cart to drive the wheels. Wheel drive truck with predictable buksuvav and VM cart Tolchyna moved across the surface. For comprehensive analysis of the problem inertsioyidiv wish to consider one of their kind, based at 2d-spring pendulum [4-7].

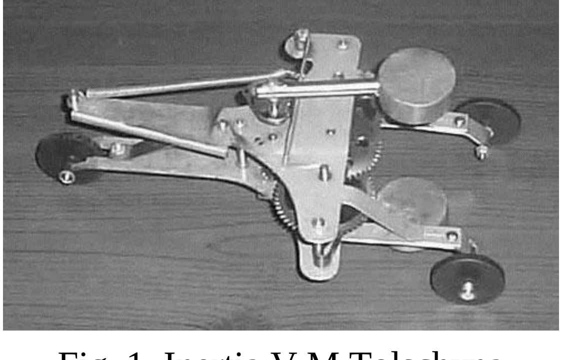

Fig. 1. Inertia V.M.Tolschyna

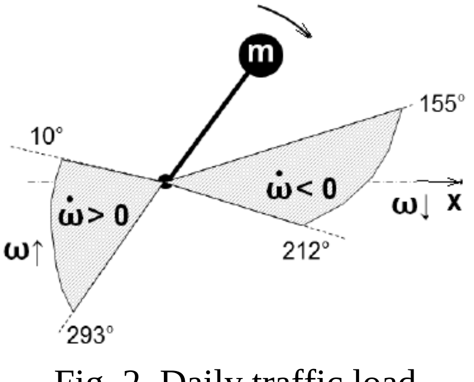

Fig. 2. Daily traffic load

Analysis of recent research and publications. Numerous experiments demonstrating inertsioyida movement and its variants have caused debate in the scientific community. Most scientists believe that the movement inertsioyida due to the presence in the system under consideration friction forces. While followers VM Tolchyna believe that inertsioyida movement associated with occurrence of forces of inertia due to the rapid rotation of the lever loads [2, 3]. However, this interpretation leads to the need for treatment inertsioyida assume that violated the laws of Newtonian mechanics. Indeed, given the possibility of creating an engine against the law of conservation of momentum. Therefore inertsioyidiv supporters argue that it uses some "new" properties of inertial mass and gravitational fields [3].

To explain the movement inertsioyida appropriate to consider its modification based on 2d-spring pendulum [4-7]. This would explain (and visualized) causes movement of the trolley that relate to compression or stretching springs in some convenient time position of cargo on its path of movement.

The wording of Article purposes. Explore mode initiate movement of the trolley in the horizontal direction with fluctuations in the vertical plane 2d-load spring pendulum for which it was determined nehaotychnu path of movement.

Main part. Mechanical springs or analogs of elastic materials are part of many machines and mechanisms, which are in the mode of extension or compression. But there are devices in which a spring body should carry out "two-dimensional" variations in the vertical plane around permanently fixed at one end and loaded with the other end (similar fluctuations mathematical pendulum). It is assumed that structurally provided nezhynannya spring axis in the transverse direction. This oscillating structure called 2d-spring pendulum [7].

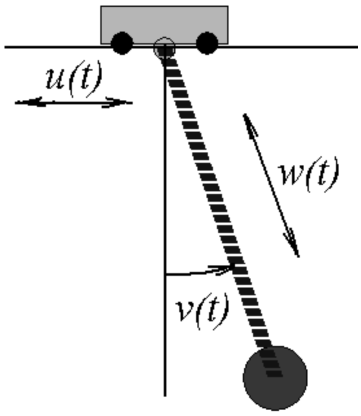

Fig. 3. Scheme spring pendulum cart

Feasibility studies 2d-oscillations of spring pendulums will demonstrate an example of initiating movement of the trolley in the horizontal direction (fig. 3).

As generalized coordinates, select [6] the following options: *u (t)* - a horizontal displacement of the trolley; *v (t)* - angle from vertical springs; *w (t)* - elastic extension springs. The preparation systems Lagrange equations of the second kind use *Lagrangian L = K - P* with formulas for kinetic and potential energies:

$$
\begin{aligned}
K = {} & (m_1+m_2)\left(\frac{d}{dt}u(t)\right)^2 + \\
& +\frac{1}{2}m_2\left(\left(\frac{d}{dt}w(t)\right)^2 + w^2(t)\left(\frac{d}{dt}v(t)\right)^2 + 2\left(\frac{d}{dt}u(t)\right)^2 \times \right. \\
& \left.\left(\left(\frac{d}{dt}w(t)\right)\sin(v(t)) + w(t)\left(\frac{d}{dt}v(t)\right)\cos(v(t))\right)\right)
\end{aligned} \qquad (1)
$$

$$
P = -m_2 w(t) g\cos(v(t)) + \frac{1}{2}k\,(w(t)-d)^2 .
$$

In formulas (1) approved the designation: m1 - mass of the trolley; m2 - bulk cargo; d - the length of the pendulum springs in unloaded condition; k - stiffness spring.

The system of Lagrange equations of the second kind is:

$$
\begin{aligned}
& (m1+m2)\left(\frac{d^2}{dt^2}u(t)\right) + \frac{1}{2}m2\left(2\left(\frac{d^2}{dt^2}w(t)\right)\sin(v(t))\right. \\
& + 4\left(\frac{d}{dt}w(t)\right)\cos(v(t))\left(\frac{d}{dt}v(t)\right) + 2\,w(t)\left(\frac{d^2}{dt^2}v(t)\right)\cos(v(t)) \\
& \left. - 2\,w(t)\left(\frac{d}{dt}v(t)\right)^2\sin(v(t))\right) = 0
\end{aligned}
$$

. (2)

$$
\begin{aligned}
& \frac{1}{2}m2\left(4\,w(t)\left(\frac{d}{dt}v(t)\right)\left(\frac{d}{dt}w(t)\right) + 2\,w(t)^2\left(\frac{d^2}{dt^2}v(t)\right) + 2\left(\frac{d^2}{dt^2}u(t)\right)w(t)\cos(v(t))\right. \\
& \left. + 2\left(\frac{d}{dt}u(t)\right)\left(\frac{d}{dt}w(t)\right)\cos(v(t)) - 2\left(\frac{d}{dt}u(t)\right)w(t)\sin(v(t))\left(\frac{d}{dt}v(t)\right)\right) \\
& - m2\left(\frac{d}{dt}u(t)\right)\left(\left(\frac{d}{dt}w(t)\right)\cos(v(t)) - w(t)\left(\frac{d}{dt}v(t)\right)\sin(v(t))\right) + m2\,g\,w(t)\sin(v(t)) = 0
\end{aligned}
$$

$$
\begin{aligned}
& \frac{1}{2}m2\left(2\left(\frac{d^2}{dt^2}w(t)\right) + 2\left(\frac{d^2}{dt^2}u(t)\right)\sin(v(t)) + 2\left(\frac{d}{dt}u(t)\right)\cos(v(t))\left(\frac{d}{dt}v(t)\right)\right) \\
& - \frac{1}{2}m2\left(2\,w(t)\left(\frac{d}{dt}v(t)\right)^2 + 2\left(\frac{d}{dt}u(t)\right)\cos(v(t))\left(\frac{d}{dt}v(t)\right)\right) - m2\,g\cos(v(t)) + k\,(w(t)-d) = 0
\end{aligned}
$$

Untie the system of equations (2) will be numerically using Runge-Kutta method with initial conditions u0 = 0; u′0 = 1; v0 = π/2; v′0 = 0; w0 = 1 i w′0 = 0 (where g = 9,81).

Calculation fluctuations 2d-spring pendulum cart fulfill the conditions for determining the unknown values of mass m2 depending on other known circuit parameters m1; k and d. That is in the process of calculations necessary to determine the value of a load mass m2, which provide nehaotychnu trajectory of movement of goods and the movement by which to realize the initiation of movement of the trolley. As a result, image building close integral curve in the phase space of functions of generalized coordinates that depend on a particular value m2. To calculate the critical value m2 used method of projection focusing [7].

Using the obtained approximate solutions *u (t), v (t)* and *w (t)* the system of Lagrange equations of the second kind, we can construct the trajectory of movement of goods 2d-spring pendulum in Cartesian xOy by the formulas:

$$\begin{aligned} x(t) &= u(t) + (d + w(t))\sin(v(t)); \\ y(t) &= -(d + w(t))\cos(v(t)). \end{aligned} \tag{3}$$

Example. Let m1 = 150; k = 250 and d = 5 (hereinafter all values in arbitrary units). As a result, the focus of projection received two meanings m2 = 40 and m2 = 56.8. Fig. 4 shows the integral line and phase trajectories for approximate solutions w (t) as the generalized coordinates. Fig. 5 shows footage created animated film 2d-oscillations of a spring pendulum on a cart nehaotychniy calculated trajectory. From the animated film can clearly see that the cart will move right through organized movements of cargo on a computed trajectory.

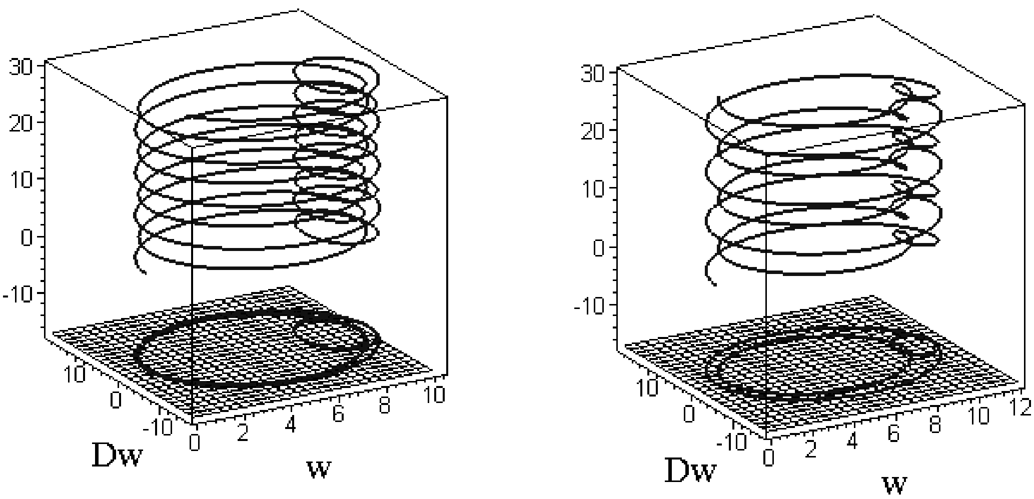

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Fig. 4. Integrated line and phase trajectories
in phase space {w, Dw, t} for: a) $m_2 = 40$ i b) $m_2 = 56,8$

Moving trolley explained agreed with the direction of its movement straightening processes (Fig. 5 a) and compression springs (Fig. 5 b). That is, in the first case, the distance between the masses artificially increases, and the second - decreases, which affects the position of the cart. The same is true for oscillations shown in fig. 6. The direction and speed of movement of the trolley is determined by the initial condition u′0=1.

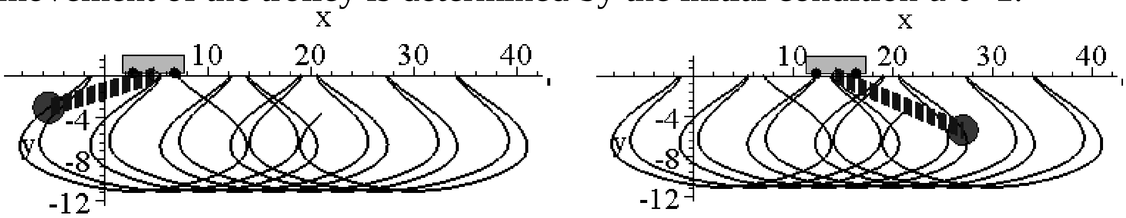

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Fig. 5. Fluctuations 2d-spring pendulum cart
with values m_1 = 150; m_2 = 40; k = 250 and d = 5

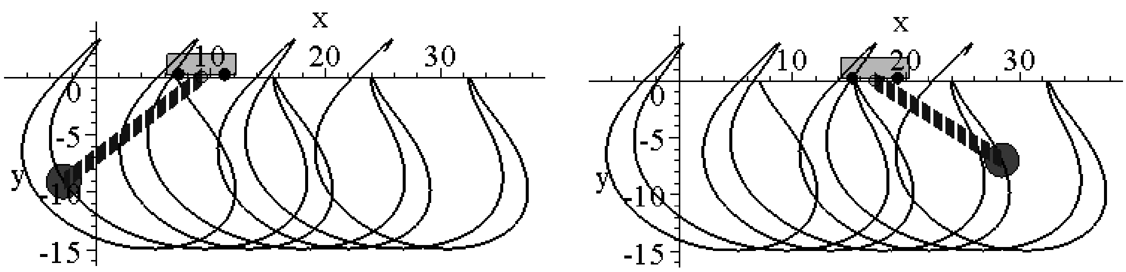

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Fig. 6. Fluctuations 2d-spring pendulum cart
with values m_1 = 150; m_2 = 56,8; k = 250 and d = 5

Assertion. As a result of computer experiments it was found identity trajectories during truck transportation 2d-spring pendulum with a combination of parameters:

1) m_1 = 150; m_2 = 40; k = 250 i d = 5;
2) m_1 = 300; m_2 = 52,4; k = 450 i d = 5;
3) m_1 = 500; m_2 = 86,8; k = 750 i d = 5;

They have the form shown in fig. 5.

Conclusions. The developed method allows to determine parameters nehaotychnyh fluctuations in the vertical plane 2d-load spring pendulum moving truck. It is shown that these fluctuations are able to initiate movement of the trolley in the horizontal direction. The reason for moving the trolley can be explained by the compression or stretching springs found in certain moments of the position load on its path of movement. Due to the distance between the spring pendulum masses periodically increases or decreases affecting the position of the cart. The investigations will be useful to analyze the causes movement inertsioyidiv varieties.

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