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MAPLE- MODELS OF MOTION OF A PARTICLE IN A PLANE THAT PERFORMS RECIPROCATING OSCILLATIONS

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Abstract. *The purpose of the study is the development of Maple-model of motion of a particle on a sloping plane, which performs reciprocating oscillations.*

A computational experiment was conducted to study the trajectory-kinematic properties of the motion of a particle on a sloping plane, which performs reciprocating oscillations.

It is shown that for a horizontal rough plane, which performs reciprocating oscillation displacements, the absolute and relative trajectories of the particle are most rapidly stabilized by the largest coefficient of friction. Particles with a lower coefficient of friction have a smaller amplitude of absolute trajectory. The initial velocity and direction of throwing influence the time and place of the stabilization of the movement.

Key words: ***accompanying triedrone, material point, inclined plane, trajectory of motion***

Topicality. In many technological processes of agricultural production there is a movement of material particles on an inclined plane that performs reciprocating oscillations. Knowledge of the patterns of motion of a particle (as a material point) by a rough plane in three-dimensional space allows us to calculate the structural and kinematic parameters of the working bodies.

Analysis of recent research and publications. An analytical derivation of the motion of a particle on a sloping plane that performs reciprocating oscillations is reduced to the compilation of a system of differential equations of the second order, the dependence of which is the trajectory of the particle, its velocity, acceleration, the length of the traversed path, the force of the normal reaction, the time of movement to it stops and other trajectory-kinematic characteristics. The sequence of analytic transformations and methods for solving the derivation of a system of differential equations is quite labor-intensive.

Computer modeling of motion of a particle on a sloping plane, which performs reciprocating oscillations, allows to discard bulky analytical transformations carried out by a scientist and provide him with a convenient dialogue mode for performing necessary computational experiments on particle motion analysis under different initial conditions of its throwing [1].

The purpose of the study is the development of Mapple-a model of motion of a particle on a sloping plane, which performs reciprocating oscillations.

Materials and methods of research. Listing the maple model $PlaneOxaMove\_t$ of studing of the motion of a particle on a rough slope plane $\boldsymbol{R}[u\ cos(\xi), v\ sin(\xi), 0]$, which carries out different translational displacements in space, is presented on the site geometry.com.ua..

Let us dwell only on its vibrational displacement along the axis Ox:

$$\boldsymbol{M} = \boldsymbol{M}[l\ sin(vt), 0, 0], \tag{1}$$

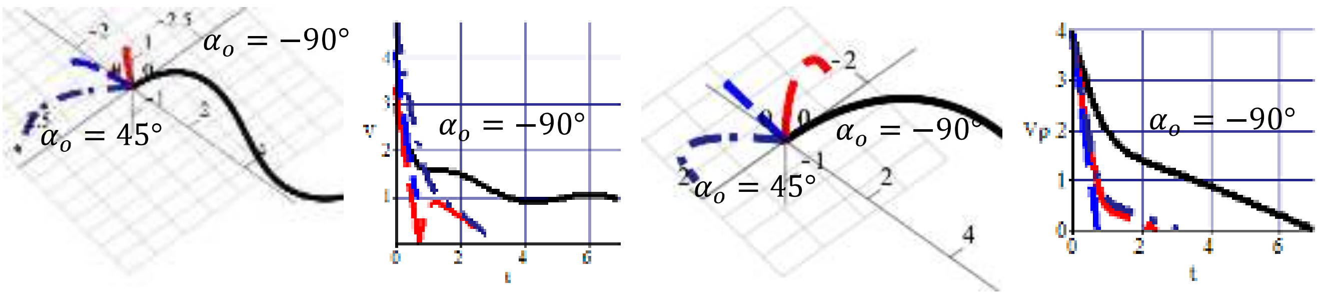
where: v, l - velocity and amplitude of oscillations.

In the projections on the orts $\boldsymbol{u}$ and $\boldsymbol{v}$ of triedrone $\boldsymbol{OuvN}$ [2, 3] we obtain the following system of differential equations of the particle motion law in an inclined plane:

$$\begin{cases} Ou := m\left(-l\ sin(vt)v^2 + \frac{d^2}{dt^2}u(t)\right) = -\dfrac{f\ mg\ \frac{d}{dt}u(t) sin(\xi)}{\sqrt{\left(\frac{d}{dt}u(t)\right)^2 + \left(\frac{d}{dt}v(t)\right)^2}} \\ Ov := m\frac{d^2}{dt^2}v(t) = -\dfrac{mg\left(f\ \frac{d}{dt}v(t)\ sin(\xi) + cos(\xi)\sqrt{\left(\frac{d}{dt}u(t)\right)^2 + \left(\frac{d}{dt}v(t)\right)^2}\right)}{\sqrt{\left(\frac{d}{dt}u(t)\right)^2 + \left(\frac{d}{dt}v(t)\right)^2}}. \end{cases} \tag{2}$$

Research results and their discussion. In fig. 1 an absolute$\boldsymbol{r}(t)$, relative $\boldsymbol{\rho}(t)$ of the trajectory of the particle, the graphs of its absolute $V(t)$ and the relative velocity

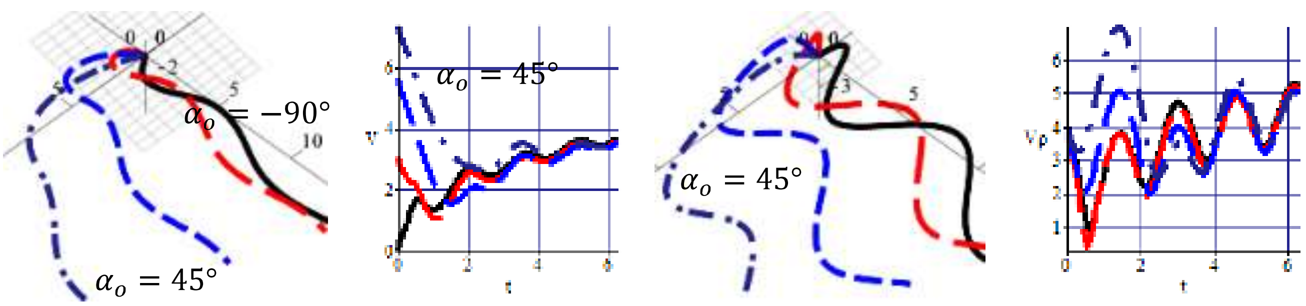
$V_\rho(t)$ are constructed, depending on the angle of the casting of the particle $\alpha_o = -90°, -45°, 0°, 45°$ under conditions : the slope of the plane at an angle $\xi = 75°$ from the vertical position; fluctuation velocity $\upsilon = 0.5c^{-1}$; amplitude of oscillation $l = 2$; coefficient of friction $f = 0.3$; initial velocity $V_o = 4$. Direction of graphs of relative velocities to zero (Fig. 1, d) suggests that all particles, regardless of the direction of the throw α_o stop in a sloping plane at different intervals of time - cease to slip in it. This will happen if $fg > l\upsilon^2$.



a) b) c) d)

Fig. 1. The trajectories $r(t)$, $\rho(t)$ and graphs of velocities $V(t)$, $V_\rho(t)$ of the particle depending on the angle of throwing α_o

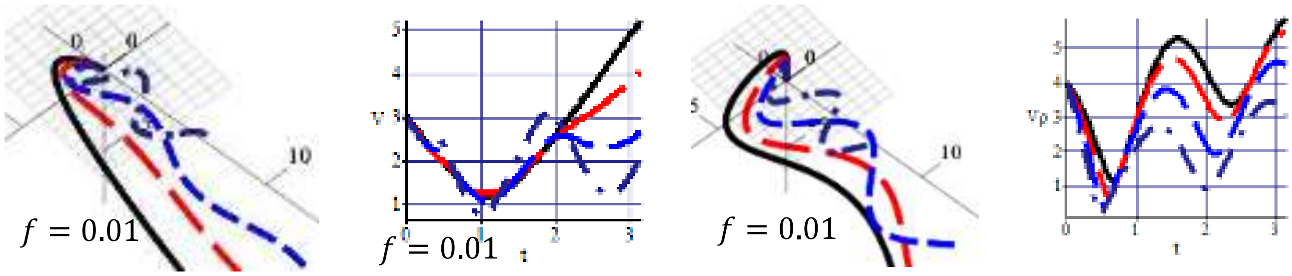
Let the oscillation velocity be equal to $\upsilon = 2c^{-1}$. In this case, the particles do not stop zigzag sliding down the sloping plane. Note that the motion of the particle has almost stabilized in the interval $t \approx 4$ the graphs of absolute $V(t)$ and relative $V_\rho(t)$ velocities coincide (Fig. 2).



a) b) c) d)

Fig. 2. Trajectories $r(t)$, $\rho(t)$ and graphs of velocities $V(t)$, $V_\rho(t)$ of the particle depending on the angle of throwing α_o

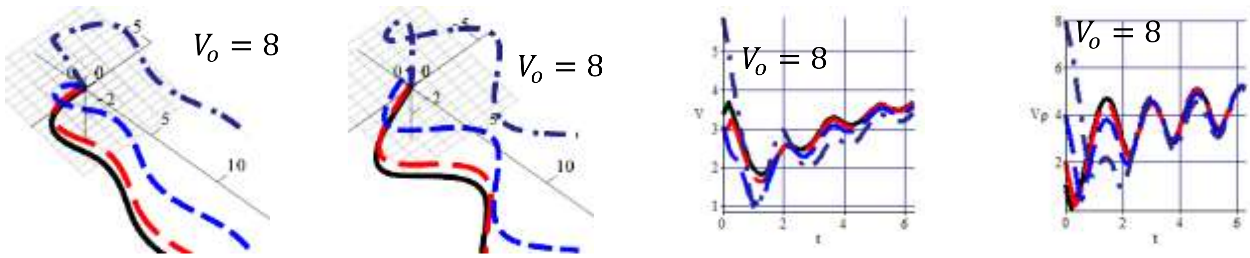
If the particles are throwing in the same direction $\alpha_o = -45°$ with the same initial velocity $V_o = 8$, but with different friction coefficient $f = 0.01, 0.15, 03, 0.45$, then particles with a lower coefficient of friction *f* slide down the plane faster and have a less zigzag trajectory (Fig. 3).



a) b) c) d)

Fig. 3. The trajectories $r(t)$, $\rho(t)$ and the graphs $V(t)$, $V_\rho(t)$ of the particle of the dependence f

From particles abandoned in one direction $\alpha_o = -45°$ with a coefficient of friction $f = 0.3$, but with different initial velocities $V_o = 1, 2, 4, 8$, the particles with the smallest initial velocity will come forward the fastest way to stabilize the movement: $t \approx 2$ when $V_o = 2$ and $t \approx 6$ when $V_o = 8$ (Fig. 4).



a) b) c) d)

Fig. 4. The trajectories $r(t)$, $\rho(t)$ and the graphs $V(t)$, $V_\rho(t)$ of the particle in the dependence V_o

Conclusions and perspectives.

1. The possibilities of the developed method of computer simulation of the motion of a particle on the investigation of the trajectory-kinematic properties of the motion of a particle on an inclined plane, which performs reciprocating oscillations, are confirmed.

2. The peculiarities of analytical calculations in the formation of the laws of motion of a particle in projections on the otters of the accompanying triedrone ***OuvN*** and ***OTPN*** are given, with the choice of an independent time parameter *t*, position *u*, and direction *a*.

3. A complex of computational experiments was conducted to study the trajectory-kinematic properties of the motion of a particle from the study of trajectory-kinematic properties of the motion of a particle on an inclined plane, which performs reciprocating oscillations under initial conditions: position of a plane, place $[u_o, v_o]$ and direction α_o of the particle, its initial velocity V_o and friction coefficient f.

4. It is shown that for a horizontal rough plane, which performs reciprocation oscillations, the absolute and relative trajectories of the particle are most rapidly stabilized at the highest friction coefficient. Particles with a lower coefficient of friction have a smaller amplitude of absolute trajectory. The initial velocity and direction of throwing influence the time and place of the stabilization of the movement.

5. The angle of inclination of the rough vibrational plane greatly affects the form of the absolute and relative particle trajectory after stabilizing their displacement-they are zigzag-shaped, whose amplitude depends on the oscillation parameters.

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MAPLE-МОДЕЛІ РУХУ ЧАСТИНКИ ПО ПОХИЛІЙ ПЛОЩИНІ, ЯКА ЗДІЙСНЮЄ ЗВОРОТНО-ПОСТУПАЛЬНІ КОЛИВАННЯ

А. В. Несвідомін

Анотація. *Мета дослідження – розробка Mapple-моделі руху частинки* по похилій площині, яка здійснює зворотно-поступальні коливання.

Проведений обчислювальний експеримент з дослідження траєкторно-кінематичних властивостей руху частинки по похилій площині, яка здійснює зворотно-поступальні коливання.

Показано, що для горизонтальної шорсткої площини, яка здійснює зворотно-коливальні переміщення, найшвидше стабілізують абсолютну та відносну траєкторії частинки за найбільшим коефіцієнтом тертя. Частинки з меншим коефіцієнтом тертя мають меншу амплітуду абсолютної траєкторії. Початкова швидкість та напрям кидання впливає на час та місце стабілізація руху.

Ключові слова: ***супровідний тригранник, матеріальна точка, похила площина, траєкторія руху***

MAPLE-МОДЕЛИ ДВИЖЕНИЯ ЧАСТИЦЫ ПО НАКЛОННОЙ ПЛОСКОСТИ, СОВЕРШАЮЩЕЙ ВОЗВРАТНО-ПОСТУПАТЕЛЬНЫЕ КОЛЕБАНИЯ

А. В. Несвидомин

Аннотация. *Цель исследования - разработка Mapple-модели движения частицы по наклонной плоскости, совершающей возвратно-поступательные колебания.*

Проведен вычислительный эксперимент по исследованию траекторно-кинематических свойств движения частицы по наклонной плоскости, которая совершает возвратно-поступательные колебания.

Показано, что для горизонтальной шероховатой плоскости, совершающей возвратно-колебательные перемещения, наиболее быстро стабилизируют абсолютную и относительную траектории частицы по наибольшему коэффициенту трения. Частицы с меньшим коэффициентом трения имеют меньшую амплитуду абсолютной траектории. Начальная скорость и направление бросание влияет на время и место стабилизация движения.

Ключевые слова: ***сопроводительный трехгранник, материальная точка, наклонная плоскость, траектория движения***