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# EXPERIMENTAL SCHEME OF TRAILER SUSPENSION FOR TRANSPORTATION OF DANGEROUS GOODS

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***The experimental scheme of suspension with three springs and two compensating weights to be used in a trailer for transportation of explosive cargo in off-road conditions is reviewed.***

***Keywords: suspension of the trailer truck, lagrangian, Lagrange equation of the second kind, compensation weights.***

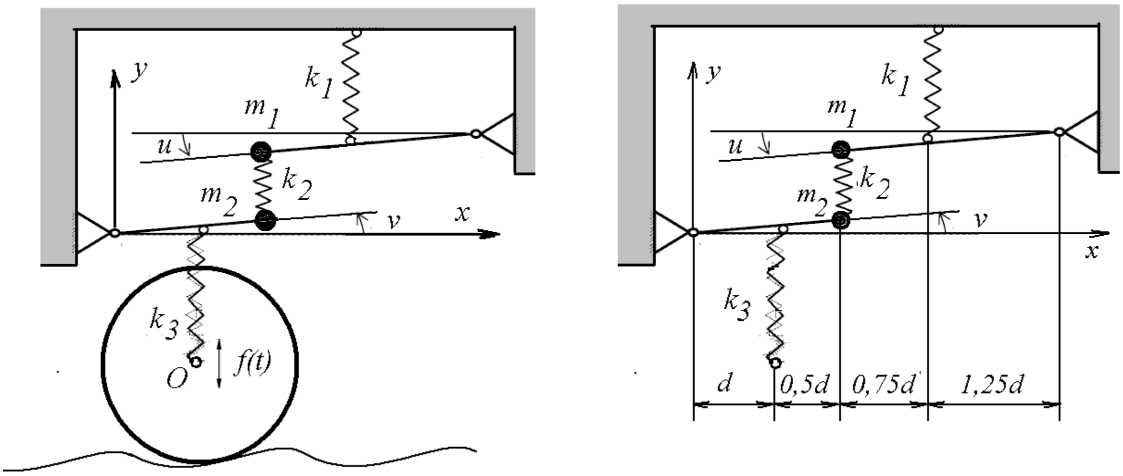
***Formulation of the problem.*** Dynamic quality transport systems are limited spring suspension characteristics [1], which is insufficient for the transport of dangerous goods. Lack of small tools difficult off-road transportation from the place of detection to the point of disposal of hazardous cargo, including old ammunition. So important is the development schemes special automobile trailers from "soft" spring (or spring) suspension, which will safely transport dangerous goods in the field.

***Analysis of recent research and publications.*** Payments single-spring suspensions focused mainly on the automotive industry [1,2]. For hazardous cargo trailer suspension upgrade from Alabuzhev device with variable stiffness [2], the addition of the second stage [3] and other schemes of structures, dynamic characteristics which ensure safe transportation. Lack of engine and transmission, projected low weight and speed of movement cause the appearance of simple construction trailer. This enables new experimental schemes automobile trailers focus primarily on the characteristics of "softness" of his suspension.

***Formulation of the article purposes.*** Develop a pilot scheme trypruzhynnoyi suspension trolley with two compensatory goods for use in automotive trailer capable of transporting explosive cargo off-road.

***Main part***. In small vertical oscillations speeds significantly affect the dynamic properties of the vehicle. Therefore, appropriate to their calculation on the plane model. In the above diagram (Fig. 1, a) suspension (one wheel trailer) used three springs with stiffness *k1*, *k2* and *k3*, and two auxiliary loads masses m1 and m2, which act as compensators fluctuations. Compensation goods intended for pre-damping and reduce their impact on the body of the trailer. For successful implementation of the scheme should ensure that the necessary interconnected springs and movements of goods.

It is believed that the oscillating system through the wheel force described the function *f (t) = Acos (wt)*. Fig. 1b shows a circuit size of the suspension, expressed in terms of module d.




а б

Fig. 1. Scheme for the transport trailer suspension hazardous cargo

To study the dynamic characteristics of the suspension of the trailer was compiled and solved a system of Lagrange equations of the second kind. For this purpose uses Lagrangian L = K - P, where the formula for kinetic and potential energies are of the form:

$$K = \frac{1}{2}(a_{11}\dot{u}^2 + a_{22}\dot{v}^2); \qquad (1)$$

$$P = \frac{1}{2}(c_{11}u^2 + 2c_{12}uv + c_{22}v^2 + k_3(f\sin wt)^2 - 2dk_3 fv\sin wt). \qquad (2)$$

These expressions $a_{11} = \frac{4m_1 d^2}{3}$ і $a_{22} = \frac{(1,5)^2 m_2 d^2}{3}$ – inertia ratios,

$c_{11} = (k_1(1,25)^2 + 4k_2)d^2$; $c_{12} = c_{21} = 3k_2 d^2$; $c_{22} = (k_2(1,5)^2 + k_3)d^2$ – коефіцієнти жорсткості.

With Maple-defined analytical application form expression systems Lagrange equations of the second kind:

$$a11\left(\frac{d^2}{dt^2}\mathrm{u}(t)\right) + c11\,\mathrm{u}(t) + c12\,\mathrm{v}(t) = 0\ ; \qquad (3)$$

$$a22\left(\frac{d^2}{dt^2}\mathrm{v}(t)\right) + c12\,\mathrm{u}(t) + c22\,\mathrm{v}(t) - k3\,\mathrm{f}(t)\,d\sin(w\,t) = 0\ . \qquad (4)$$

Untie this system will equations numerically using Runge-Kutta method with initial conditions u(0) = u0, u′(0) = Du0, v(0) = v0, v′(0) = Dv0}.

Here is an example calculation circuit spring suspension provided determine the values of stiffness k1 of the first spring constants depending on other circuit parameters. For definiteness choose the setting (all in arbitrary units):

$m_1$ = 82.5 – first cargo weight;

$m_2$ = 20 – second cargo weight;

$k_2$ = 600 – stiffness of the second spring;

$k_3$ = 700 – third spring stiffness;

d = 0.5 – module design;

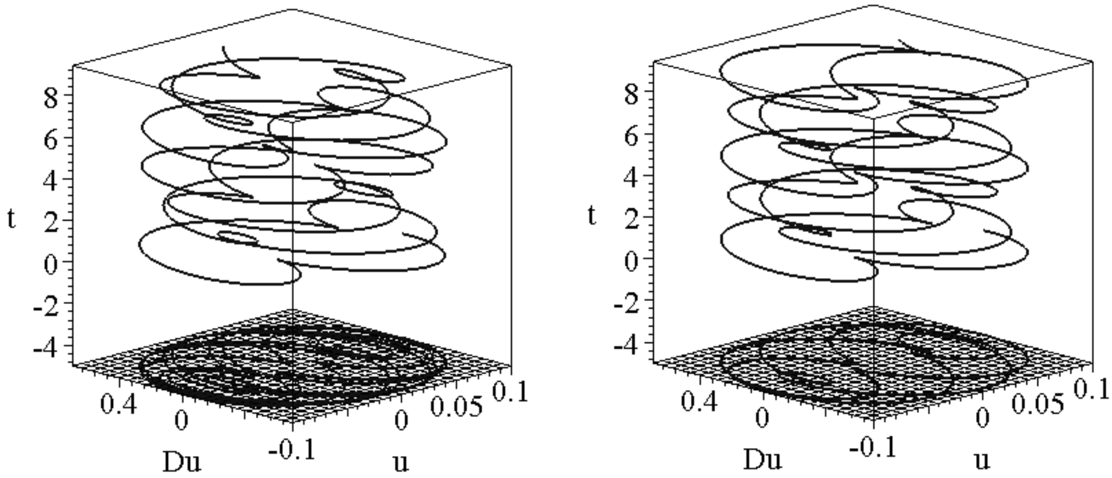
*w* = 16 – frequency power forced action;

A = 0.1 – amplitude forced action forces;

f = A*cos(*w**t) – law forced action forces.

During the calculations necessary to determine the stiffness *k1* of the first spring whose value is linked movements provide circuit elements of the suspension. Will untie the system of equations numerical method of Runge-Kutta conditions: u0 = 0,1; u′0 = 0; v0 = 0,1; v′0 = 0. As a result, image building close integral curve in phase space {v, *Dv*, *t*}. It is composed of a plurality of segments connecting the successive points obtained from the approximate solution of systems of equations. This image will depend on the particular importance of "managing" parameter k1. At random values k1 phase space {v, Dv, t} formed "confused" integral curve, the projection of which on the phase plane {v, Dv} will also be "confusing" phase trajectories (Fig. 2a), resulting in " unnatural "movements suspension circuit elements.

If you change the values of "Management" option has changed and the nature of the phase trajectory. At a certain critical value, it will change to qualitative level - turn into "a natural" curve (Fig. 2b). In the phase plane {v, Dv} if observed optical effect "pointing to sharpen" the confusion phase trajectories (ie projection focus [4.5]).

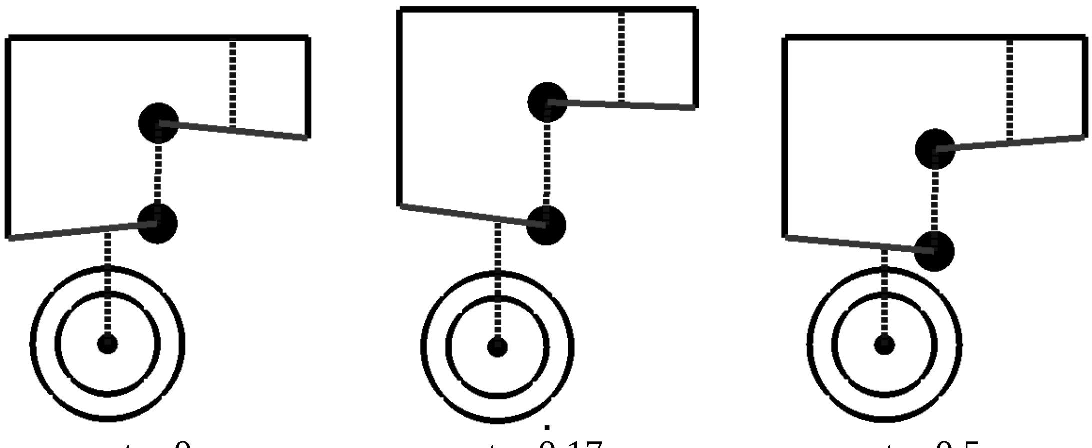



a b

Fig. 2. Integral curves and phase trajectories for:

a) random value k1; b) the calculated value $k_1 = 1188$

Thus, in this example, with k2 = 600, 700 = k3 critical factor stiffness of the first spring advisable to choose k1 = 1188. Considering the value of k1 = 1,188 in solving the system of equations allows to calculate approximate angles u (t) and v (t), which provide interrelated movements of circuit elements at the time of suspension. Ensure that you can use the created animated film, some footage of which are shown in Fig. 3.



t = 0 t = 0,17 t = 0.5

Fig. 3. Personnel animated film position
suspension elements at a time t

***Conclusions.*** This scheme allows you to calculate the projection focus pilot scheme trypruzhynnoyi suspension wheel cart with two compensatory goods.

Further studies will be associated with determining the limits of parameters necessary to ensure the scheme interrelated movements of the suspension.

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