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*Obosnovano Using aggregate-nodes method of repair of automobile transport selskohozyaystvennыh enterprises and Basic Principles of organization kooperatyvnoy forms tehnycheskoho Maintenance of cars on the basis of known method.*

***Automobiles, Tehnicheskoe Maintenance, Repair potochnыy, nekompleksnыy garage transportnыe costs.***

*In paper is modular-nodal method of repair of motor transport of the agricultural factories and main principles of architecture of the co-operative shape of engineering service of cars on basis of given method is justified.*

***Car, engineering service, continuous repair, not complex garage, cost of transportation.***

UDC. 631,816, 631.03

## Movement of material particle on the rough disks

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*The equations of motion of a particle on the surface of a flat and conical disks that rotate around a vertical axis in a rectangular Cartesian and curvilinear (polar and cylindrical)*



*coordinate systems. These equations pass one another and in the equations of motion of a particle on the surface of the cylinder which rotates confirming their authenticity.*

***The movement material particle drive.***

**Problem.** Disks without blades, centrifugal sprayer used in pesticide, the devices for the circular distribution of grain vibrovidtsentrovyh and air separators, etc. [1, 2, 5].

**Analysis of recent research.** The general equation of motion of a particle in kryvoliniynyh coordinates given in [3, 6, 7]. The equations of motion of such particles on rough flat disc that rotates around a vertical axis, displayed in polar coordinates in [3]. The equations of motion of a particle in conical disc in absolute parameters of its motion filed without their output in [1, 5]. However, in [1, 5] serves various systems of equations. This, and the lack of the simplest output of these equations in rectangular Cartesian coordinate system for both types of drives, encourages further research in this direction.

**The purpose of research.** Print the following equation based on the most general laws of mechanics.

**Results.** Consider a rough flat disc that rotates around a vertical axis with angular velocity $\omega(1/c)$ Is shown in Fig. 1. In a piece that moves the disk in the coordinates XOY with absolute speed $V$ (M / s), will act only on the friction disk particle. In this case the solution of the problem lies in determining the direction of the force of friction and distribution of components along the axes OX and OY. It is clear that the total friction $F$ (H) to drive the particle with a coefficient of friction of its $f \neq 0$ is equal to $F = fmg$ Where: $m -$ particle mass, kg; $g = 9{,}81 м/c^2$ - Acceleration of gravity. It is known that the frictional force acting on the support piece opposite the relative velocity of the particles on this support. Then speed $V_B(м/c)$ of a particle about the point of contact with the disk that rotates clockwise with angular velocity $\omega(1/c)$ In the case of particles stay on the radius $R(м)$ (Fig. 1) will be equal to:

$$V_B = \sqrt{(-\omega R \sin\varphi - V_X)^2 + (\omega R \cos\varphi - V_Y)^2}\ , \qquad (1)$$

where $\varphi -$ angle between the axis and the radius OX $R$ (Fig. 1), radians; $V_X, V_Y$ - Velocity of the particles according to the axis OX and OY axis, m / s.

Signs in (1) are taken with the understanding that when taken (Fig. 1) initial values $0 \le \varphi \le \pi/2$ value $V_X \le 0$ And values $\omega R$ always taken positive.

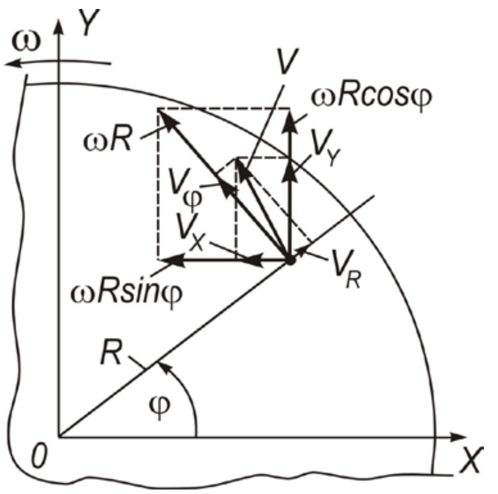



Fig. 1. Location of vectors $\omega R$ and $V$ and their components in Cartesian and polar coordinate systems for flat disc.

It should be noted that during rotation of the disc clockwise signs before $\omega$ change in (1) to the opposite.

Given that the friction particles axes will be distributed in proportion to the ratio of the components of the relative velocity of the particles in these axes until this velocity, Fig. 1 we obtain:

$$\dot{V}_X = fg\frac{-\omega R\sin\varphi - V_X}{\sqrt{(-\omega R\sin\varphi - V_X)^2 + (\omega R\cos\varphi - V_Y)^2}};$$

$$\dot{V}_Y = fg\frac{\omega R\cos\varphi - V_Y}{\sqrt{(-\omega R\sin\varphi - V_X)^2 + (\omega R\cos\varphi - V_Y)^2}}. \quad (2)$$

The system (2) is solved using standard software at: $\sin\varphi = \frac{Y}{R}$; $\cos\varphi = \frac{X}{R}$; $R = \sqrt{X^2 + Y^2}$; $\dot{V}_X = \ddot{X}$; $\dot{V}_Y = \ddot{Y}$; $V_X = \dot{X}$; $V_Y = \dot{Y}$.

From (2) shows that the feed particles to a point on the axis OX values $V_X = V_Y = 0$, Acceleration of particles along the axis OX will initially zero and then increase in its magnitude and directed sideways axis OY, ie the opposite direction OX. The acceleration of particles along the axis OY first will be the maximum, and then with increasing $\varphi$ will gradually fall. This vyhynatyme its trajectory in the direction of rotation of the disc. When $f = 0$, Meaning $\dot{V}_X = 0, \dot{V}_Y = 0$ And a piece of (2) and will stand or move to drive in a straight line at a rate equal to the original. When $f \to \infty$, Friction, equaling in (2) of the centrifugal force will not continue to grow, and particle maintaining equality friction force and centrifugal force will move in a circle, that is true. Derivation of equations in curvilinear coordinates is best done using Lagrange equations of the second kind [3, 4, 6] type:

$$\frac{d}{dt}\frac{\partial E}{\partial \dot{R}} - \frac{\partial E}{\partial R} = Q_R; \frac{d}{dt}\frac{\partial E}{\partial \dot{\varphi}} - \frac{\partial E}{\partial \varphi} = Q_\varphi; \frac{d}{dt}\frac{\partial E}{\partial \dot{h}} - \frac{\partial E}{\partial h} = Q_H. \quad (3)$$

where $E$ - Kinetic energy (J) particles, which is equal to:

$$E = \frac{m}{2}[(\dot{R})^2 + R^2(\dot{\varphi})^2 + (\dot{h})^2], \qquad (4)$$

where $h-$ height of the particle above the earth's surface, m;

$Q_R$,- So-called living force acting on the particle radius $R$, N;

$Q_\varphi -$ living force acting on it tangent to the circle radius $R$, N m;

$Q_H -$ the so-called living force acting vertically, N.

Taking the derivative in (3) for both versions of the disc gives:

$$\frac{\partial E}{\partial \dot{R}} = m\dot{R} \quad \frac{\partial E}{\partial R} = mR(\dot{\varphi})^2; \frac{\partial E}{\partial \dot{\varphi}} = mR^2\dot{\varphi}; \frac{\partial E}{\partial \varphi} = 0; \frac{\partial E}{\partial \dot{h}} = m\dot{h}; \quad \frac{\partial E}{\partial h} = 0;$$

$$\frac{d}{dt}\frac{\partial E}{\partial \dot{R}} = m\ddot{R}; \frac{d}{dt}\frac{\partial E}{\partial \dot{\varphi}} = 2mR(\dot{R})(\dot{\varphi}) + mR^2\ddot{\varphi}; \frac{d}{dt}\frac{\partial E}{\partial \dot{h}} = m\ddot{h}.$$

After substituting the values of partial derivatives in (3) we obtain:

$$m\ddot{R} - mR(\dot{\varphi})^2 = Q_R; 2mR(\dot{R})(\dot{\varphi}) + mR^2\ddot{\varphi} = Q_\varphi; m\ddot{h} = Q_H. \qquad (5)$$

Living forces manifest themselves here in the form of normal reaction force $N$ drive; gravity - $mg$; friction forces and friction torque. For a flat disk, where $\ddot{h} = 0$, The third equation (5) we obtain: $Q_H = N - mg = 0; N = mg$. The speed of the particle relative to the point of contact with the disk, will be equal to $R$ value of radial velocity $V_R$ And in the circumferential direction (Fig. 1) value $(\omega R - V_\varphi)$ Where $V_\varphi$ - The angular velocity of the particle, taken positive m / s. Absolute Relative particle velocity relative to the specified point is equal to a flat disk: $V_B = \sqrt{(\omega R - V_\varphi)^2 + V_R^2}$ And living forces:

$$Q_R = -fmg\frac{V_R}{\sqrt{(\omega R - V_\varphi)^2 + V_R^2}}; Q_\varphi = Rfmg\frac{(\omega R - V_\varphi)}{\sqrt{(\omega R - V_\varphi)^2 + V_R^2}}.$$

Whereas: $V_R = \dot{R}; V_\varphi = R\dot{\varphi}; \ddot{R} = \frac{d\dot{R}}{dt}$; $\ddot{\varphi} = \frac{d\dot{\varphi}}{dt}$', Equation (5) will be closed with unknown $R$ and $\varphi$:

$$\frac{d\dot{R}}{dt} = R(\dot{\varphi})^2 - \frac{fgV_R}{\sqrt{(\omega R - V_\varphi)^2 + (V_R)^2}}; \quad \frac{d\dot{\varphi}}{dt} = \frac{fg(\omega R - V_\varphi)}{R\sqrt{(\omega R - V_\varphi)^2 + V_R^2}} - \frac{2(\dot{R})(\dot{\varphi})}{R}; \quad \frac{d\dot{h}}{dt} = 0. \qquad (6)$$

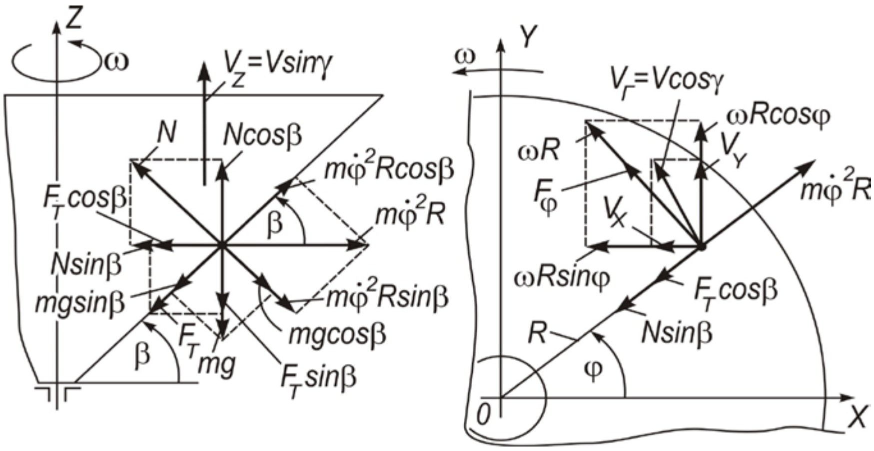
Or in a more convenient form for integration:

$$\frac{d\dot{R}}{dt} = R(\dot{\varphi})^2 - \frac{fg\dot{R}}{\sqrt{[\omega R - R(\dot{\varphi})]^2 + (\dot{R})^2}}; \quad \frac{d\dot{\varphi}}{dt} = \frac{fg(\omega - \dot{\varphi})}{\sqrt{[\omega R - R(\dot{\varphi})]^2 + (\dot{R})^2}} - \frac{2(\dot{R})(\dot{\varphi})}{R}; \frac{d\dot{h}}{dt} = 0$$

They solved using standard programs and the transition to the relative motion of a particle consistent with [3]. Analysis (6) shows that

when applying a particle with zero initial velocity at a point on the axis' with a certain radius $R$, Radial acceleration of the particle and its radial velocity at the initial time will be zero, and the acceleration $\ddot{\varphi}$ angular velocity of the particles is greatest. With increasing time angle, and with this and the angular velocity of rotation of a particle around its axis, the radial acceleration of particles will increase and accelerate the angular velocity of the particles will fall, which will bend the trajectory of the particle in the direction of rotation of the disk. The equations [4] type: $X = R\cos\varphi$; $Y = R\sin\varphi$; $V_X = \dot{R}\cos\varphi - R\sin\varphi\dot{\varphi}$; $V_Y = \dot{R}\sin\varphi + R\cos\varphi\dot{\varphi}$;
$\dot{V}_X = [\ddot{R} - R(\dot{\varphi})^2]\cos\varphi - (2\dot{R}\dot{\varphi} + R\ddot{\varphi})\sin\varphi$; $\dot{V}_Y = [\ddot{R} - R(\dot{\varphi})^2]\sin\varphi + (2\dot{R}\dot{\varphi} + R\ddot{\varphi})\cos\varphi$ Of

which $\dot{V}_X\cos\varphi + \dot{V}_Y\sin\varphi = \ddot{R} + R(\dot{\varphi})^2$; $\dot{V}_Y\cos\varphi - \dot{V}_X\sin\varphi = R\ddot{\varphi} + 2\dot{R}\dot{\varphi}$ (2) becomes (6). The expression on the left of the first equation (6) is the acceleration of particles along the radius $R$. The first term on the right - centrifugal acceleration particles, the second thing is the acceleration of the radial component of the friction disk. In the second equation (6) the expression on the left is the acceleration of the particle angular velocity about an axis; the first term on the right - acceleration angular velocity of rotation of the tangential component of the friction disc on particle; the second term on the right - the acceleration of the Coriolis force of inertia. It is clear that the active component of the Coriolis force entered into force on particle friction disc in circumferential direction, and their difference divided by the mass of the particle acceleration and angular velocity was $\ddot{\varphi}$ particle rotation around this axis, that is a member of the left. Unlike the motion of a particle along a plane perpendicular to the disk blades [8] established to drive at an angle to the radius where the similar case of movement of the disc is also at an angle to the radius, in this case the effect of centrifugal force and Coriolis forces of inertia always appears so if a particle moving along the radial blade that rotates with the drive variable (equal $\dot{\varphi}$ But not constant) circular speed of the particle. Just because changes $\dot{\varphi}$ Coriolis inertial force in this case is less than the tangential force that propels the piece in the circumferential direction. As blades installed perpendicular to the horizontal plane radial disk in case $\omega = const$ Its normal reaction equal to the active power Coriolis force is always equal to the Coriolis inertia [8]. This is the key to removing the equations of motion of a particle on cone drive. For this we consider in Fig. 2 conical disc generatrix which is inclined to the horizontal plane at an angle $\beta$. As shown in Fig. 2a, the particle that is on the side surface of the conical disc are: centrifugal force particles, which is equal to $m(\dot{\varphi})^2 R$; gravity particles is equal to $mg$; normal reaction force of the lateral surface of the disk, which is equal to $N = m(\dot{\varphi})^2 R\sin\beta + mg\cos\beta$.




a) b)

Fig. 2. The forces acting on the particle, and its motion parameters in cone disk: a) in the plane of the axis of rotation of the disk and the radius $R$: B) top view.

Friction $F$ lateral surface of the disk on particle that can be decomposed into components. As a flat disk, particle velocity relative to the point tapered drive under particle is equal to the axes OX and OY (Fig. 2b), respectively $(-\omega R\sin\varphi - V_X)$ and $(\omega R\cos\varphi - V_Y)$ And along the axis OZ - equal $V_Z$ Ie the actual value of a particle velocity component along this axis. Thus, the absolute relative velocity of the particle relative to the disk will be equal to: $V_B = \sqrt{(-\omega R\sin\varphi - V_X)^2 + (\omega R\cos\varphi - V_Y)^2 + V_Z^2}$ And components of the friction force to drive the particle along the coordinate axes X, Y, Z are equal:

$$F_X = \frac{-Nf(\omega R\sin\varphi + V_X)}{V_B};\ F_Y = \frac{Nf(\omega R\cos\varphi - V_Y)}{V_B};\ F_Z = \frac{-NfV_Z}{V_B}. \quad (7)$$

These expressions can be obtained through the power $F_T$ by generating friction cone (Fig. 2b). The second active force acting on the particle radius $R$ Is power $F_A$ Which is equal constituent $-N\sin\beta$ (Fig. 2a), ie: $F_A = -m(\dot{\varphi})^2 R\sin^2\beta - mg\cos\beta\sin\beta$. Sign (-) indicates that this power is directed to the axis of rotation of the disk. After the expansion of the axes OX and OY with (7), we obtain:

$$\dot{V}_X = -[(\dot{\varphi})^2 R\sin^2\beta + g\cos\beta\sin\beta]\cos\varphi - f\,\frac{[(\dot{\varphi})^2 R\sin\beta + g\cos\beta](\omega R\sin\varphi + V_X)}{\sqrt{(-\omega R\sin\varphi - V_X)^2 + (\omega R\cos\varphi - V_Y)^2 + V_Z^2}};$$

$$\dot{V}_Y = -[(\dot{\varphi})^2 R\sin^2\beta - g\cos\beta\sin\beta]\sin\varphi + f\,\frac{[(\dot{\varphi})^2 R\sin\beta + g\cos\beta](\omega R\cos\varphi - V_Y)}{\sqrt{(-\omega R\sin\varphi - V_X)^2 + (\omega R\cos\varphi - V_Y)^2 + V_Z^2}};$$

$$\dot{V}_Z = [(\dot{\varphi})^2 R\sin\beta cos\beta - g\sin^2\beta] - f\frac{[(\dot{\varphi})^2 R\sin\beta + g\cos\beta]V_Z}{\sqrt{(-\omega R\sin\varphi - V_X)^2 + (\omega R\cos\varphi - V_Y)^2 + V_Z^2}}. \quad (8)$$

The last equation is obtained considering that the axis OZ the particle has two active forces, namely the vertical component $N\cos\beta$ and gravity particles $(-mg)$ (Fig. 2a) and passive force $F_Z$ friction with (7). From Fig. 2 values $\dot{\varphi} = (V_Y\cos\varphi - V_X\sin\varphi)/R$ That, after taking into account: $R = \sqrt{X^2 + Y^2}$; $\sin\varphi = X/R$; $\cos\varphi = Y/R$; $dX/dt = V_X$; $dY/dt = V_Y$ Makes the system closed last equations, which is solved by standard software. The question is where are gone centrifugal force particles? The analysis shows that it has entered part of the normal reaction of the side wall of the conical disk and an increased wall friction force on the particle, the increased obstacles in the radial motion of the particle. As for the centrifugal force, it is a force of inertia and manifests itself only as a reaction force on the curved trajectory of the particles that form the active force here. It should be said that in $\beta = 0$, The latest move in the equation of equation (2) for a flat disc, while $\beta = 90^O$ in the equations of motion of a vertical cylinder that spins.

In deriving these equations in curvilinear coordinates, the so-called living force will be equal to Fig. 2:

$$Q_R = -N\sin\beta - F_T cos\beta;\ Q_\varphi = RF_\varphi;\ Q_H = N\cos\beta - mg - F_T\sin\beta, \quad (9)$$

where $F_T$ - Part of the friction force on the particle drive in the direction of its generatrix, N; $F_\varphi$ - Part of the friction force on the particle in the disk circumferential direction, N. The relative motion of a particle along the generatrix cone drive even the absolute velocity of the particles in this direction $\sqrt{V_R^2 + V_H^2}$ Similarly in the circumferential direction $(\omega R - V_\varphi)$. How we get:

$$Q_R = -m(\dot{\varphi})^2 R\sin^2\beta - mg\sin\beta\cos\beta - f\frac{[m(\dot{\varphi})^2 R\sin\beta + mg\cos\beta](V_R)}{\sqrt{(\omega R - V_\varphi)^2 + V_R^2 + V_H^2}};$$

$$Q_\varphi = Rf\frac{[m(\dot{\varphi})^2 R\sin\beta + mg\cos\beta](\omega R - V_\varphi)}{\sqrt{(\omega R - V_\varphi)^2 + V_R^2 + V_H^2}};$$

$$Q_H = m(\dot{\varphi})^2 R\sin\beta\cos\beta - mg\sin^2\beta - f\frac{[m(\dot{\varphi})^2 R\sin\beta + mg\cos\beta](V_H)}{\sqrt{(\omega R - V_\varphi)^2 + V_R^2 + V_H^2}}.$$

Substituting the value of the last living forces in equation (5) we have:

$$\frac{dV_R}{dt} = \frac{V_\varphi^2}{R}\cos^2\beta - g\cos\beta\sin\beta - f\,\frac{[(V_\varphi)^2\sin\beta + Rg\cos\beta](V_R)}{R\sqrt{(\omega R - V_\varphi)^2 + V_R^2 + V_H^2}};$$

$$\frac{dV_\varphi}{dt} = f\,\frac{[(V_\varphi)^2\sin\beta + Rg\cos\beta](\omega R - V_\varphi)}{R\sqrt{(\omega R - V_\varphi)^2 + V_R^2 + V_H^2}} - \frac{2V_R V_\varphi}{R}; \qquad (10)$$

$$\frac{dV_H}{dt} = \frac{(V_\varphi)^2}{R}\sin\beta\cos\beta - g\sin^2\beta - f\,\frac{[(V_\varphi)^2\sin\beta + Rg\cos\beta](V_H)}{R\sqrt{(\omega R - V_\varphi)^2 + V_R^2 + V_H^2}}.$$

Or to simplify integration:

$$\ddot{R} = (\dot{\varphi})^2 R\cos^2\beta - g\sin\beta\cos\beta - f\,\frac{[(\dot{\varphi})^2 R\sin\beta + g\cos\beta](\dot{R})}{\sqrt{[\omega R - (\dot{\varphi})R]^2 + (\dot{R})^2 + (\dot{h})^2}};$$

$$\ddot{\varphi} = f\,\frac{[(\dot{\varphi})^2 R\sin\beta + g\cos\beta](\omega R - \dot{\varphi}R)}{R\sqrt{[\omega R - (\dot{\varphi})R]^2 + (\dot{R})^2 + (\dot{h})^2}} - \frac{2(\dot{R})(\dot{\varphi})}{R}; \qquad (11)$$

$$\ddot{h} = (\dot{\varphi})^2 R\sin\beta\cos\beta - g\sin^2\beta - f\,\frac{[(\dot{\varphi})^2 R\sin\beta + g\cos\beta](\dot{h})}{\sqrt{[\omega R - (\dot{\varphi})R]^2 + (\dot{R})^2 + (\dot{h})^2}}.$$

In the transition from (10) (11) estimated, made: $dV_R/dt = (\ddot{R})$; $dV_\varphi/dt = R(\ddot{\varphi})$; $(\dot{R}) = V_R$; $V_\varphi = R(\dot{\varphi})$; $dV_H/dt = \dot{V}_Z = \ddot{h}$; $\dot{h} = dh/dt = V_H = V_Z = V\sin\gamma$ Where $\gamma$ - Angle absolute velocity vector particles $V$ to the horizontal plane radians.

From the first equation (10), (11) shows that the particle moves along the radius of the horizontal projection of the longitudinal component of the generatrix to centrifugal force, and inhibit particle - the horizontal projection of the longitudinal component of the generatrix to the weight of the particles and the radial component of the friction force on the particle drive. This corresponds to the scheme of Fig forces. 2 as well. From the second equation (10), (11) it follows that in the circumferential direction of the particle is driven circular disk component of friction force on the particle, and it inhibits the Coriolis force of inertia. From the third equation (10), (11) shows that the top piece moves designed to longitudinal axis OZ generating component of centrifugal force and brake - designed for longitudinal axis OZ generating component of gravity particles together with the vertical component of the force of friction. As one would expect, the third division of the equation (10), (11) in the first - gives $tg\beta$ Because they are part of a particle along the generatrix (Fig. 2a). When $\beta = 0$ Equation (10), (11) becomes (6), and the $\beta = 90^0$ in the equations of motion of a particle in a cylinder that rotates. Equation (8) becomes (10), (11) and vice versa, by moving to a coordinate system that rotates around the axis OZ, just switch (2) to (6), and vice versa. Denominator component of the friction disc on particle translated in both cases they substitution values $V_X$ and $V_Y$. Note that after elimination in [5] some errors and inaccuracies, given in [5] settlement system equations of motion of a particle on the surface of the grain spreader cone will coincide with the obtained system of equations (11).

## Conclusions

The simplest equation of motion of a particle on the rough flat disk rotating around a vertical axis, is an equation derived in a rectangular coordinate system.

When the motion of material particles on rough flat disk rotating around a vertical axis, the centrifugal force and the Coriolis force manifest themselves as if the particle moves along the radial blades on this drive that spins at a variable angular velocity $\dot{\varphi}$ Determined system of equations (6).

Obtained from the Lagrange equations of the second kind equation (11) of a particle on the surface of the conical rough disk rotating around a vertical axis, correctly modeled the physical phenomena that accompany this process and their transition to the equations obtained for rectangular Cartesian coordinate system, and to equations (2) and (6) of a particle on a flat disk and on the walls of the cylinder that rotates around a vertical axis, confirms the correctness of these equations.

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*Vыvedenы equation of motion materyalnoy particles on the surface of a flat disk and konycheskoho, kotorыe vraschayutsya Around vertykalnoy wasps in pryamouholnoy polyarnoy and Cartesian coordinate systems. Poluchnnыe equation pass into each other, as well as in the equation of motion for particle surface vraschayuschehosya cylinder, confirms something s accuracy.*

***Movement, materyalnaya particles, disc.***

*Equations of motion of material particles on surface flat and conical disks that rotate around vertical axis, in rectangular cartesian and polar coordinate systems. Findings equations transfer in each other, as well as in equation of particles on surface of rotating cylinder that confirms their authenticity.*

***Motion, Material particle, Disk.***

UDC 637.1

## DIAGNOSTIC SYSTEM physiological state COW BASED EVALUATION its mobility

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*Describes ways of solving the problem of diagnosing the physiological condition of the animal, such as diseases of the extremities, based on evaluation of its mobility. The application system videoanalizu based sensor camera «Kinect» with infrared light as a means of building maintenance diagnostic system.*

***Diagnosis, disease of the extremities, Kinect, mobility system.***

**Problem.** Diseases limbs often observed in cows and farms cause noticeable damage. Research [1] found an average herd structure in stages limb disease according to the proposed scoring (Table. 1), which is shown in Fig. 1.