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INTRODUCTION TO MECHANODYNAMICS

Ph. M. Kanarev. kanphil@mail.ru

Announcement. Newton's dynamics has operated for 322 years with the vivid feature of a violation of the cause and effect relationships originating from its first law. A transition of dynamics into the framework of cause and effect relationships has proved to be possible only when new scientific notions have been introduced and its laws have been systematized.

THE FIRST LECTURE

1. General Date concerning mechanodynamics

A notion of "Dynamics" was introduced long ago and acquired various prefixes, which limit a sense laid down in this notion, and give more concise reflection of a gist of the phenomena and process being described. The notions of "Electrodynamics", "Hydrodynamics" and "Aerodynamics" have been used long ago. A notion of "Electrodynamics of microworld" has appeared. As a result, it has become necessary to distinguish dynamics, which describes mechanics of rigid bodies only. Taking it into account, we introduce a notion of "Mechanodynamics", which lays down a sense of dynamics of mechanical motions of rigid bodies, which have been described by the notion "Dynamics" prior to it.

"Mechanodynamics" is a part of theoretical mechanics, in which a relationship of a motion of the material points and bodies and the forces exerting influence on them is established and studied.

A material point and a perfect rigid body are the main models of the actual objects in mechanodynamics. Such actual objects, which variations in a motion of the separate points can be neglected, are considered as the material points. If it is impossible to do it, a motion of such object can be considered as a motion of a rigid body. A perfect rigid body is a complex of the material points, the distances between which are not changed in length of time. It appears from this that a material point is a particular case of a rigid body.

A complex of the material bodies, in which they cannot move independently from each other due to the relationships between them, is called a mechanical system.

The laws of mechanodynamics are based on the fundamental axioms of natural science: space and time are absolute; space, matter and time are inseparable. An authenticity of the axioms originates from obviousness of their statements. An authenticity of the laws of mechanodynamics, which are based on the axioms, is non-obvious and is proved experimentally; that's why of the laws of mechanodynamics cannot be considered the axioms, they are postulates.

For the first time, the laws of dynamics were systematized **by Isaac Newton in his book "Mathematical Principles of Natural Philosophy" (1687).** He formulated **the first law of dynamics in the following way: "Every body continues in its state of rest, or of uniform motion in a straight line, unless it is compelled to change this state by forces impressed upon it".** In this statement, we see at once a violation of the principle of the cause and effect relationships. Any motion is a cause of an action of a force, but it is missing in Newton's first law; there is no mathematical model of this law, which describes its constant movement in space, but a body ignores it and moves with constant velocity $\overline{V} = const$ (Fig. 1, position A). The discrepancies being described are a cause of a violation of the principle of sequence of an analysis of the phenomenon or the process being described. This principle requires a description of the process or the phenomenon from its very beginning, not from the middle. An accelerated motion is the beginning of any motion, and a uniform motion is its cause. Thus, in order to return the principle of the cause and effect relationships into the former Newtonian dynamics, it is necessary to put the law of the accelerated motion of a body to the first place. As a result, we'll get a new dynamics. In order to differentiate it from the old dynamics, let us call it "Mechanodynamics". It will describe only mechanical motions of the bodies. The centuries-old experience of the use of Newton's second law has proved its irreproachable authenticity; that's why we have every reason to put it in the first place and to call it the main law of mechanodynamics.

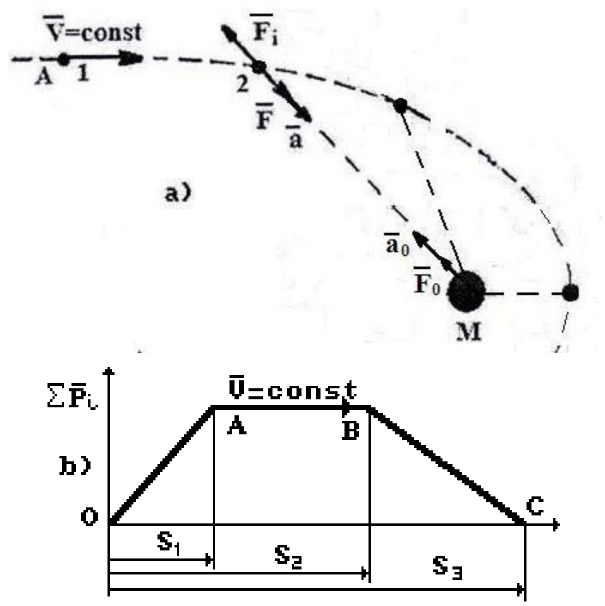

Fig. 1. On analysis of the law of mechanodynamics

a) diagram of appearance of the forces acting on asteroid A, which approaches planet M;

b) diagram of a change of resistance forces $\sum_{i=1}^{n} \overline{P}i$ acting on a body having the accelerated motion (OA), a body having the uniform motion (AB) and a body having the decelerated motion (BC)

2. Main Law of Mechanodynamics

Force $\overline{F}$ acting on a material body, which moves with acceleration $\overline{a}$, is always equal to mass m of the body multiplied by acceleration and coincides with an acceleration direction (Fig. 1, a, position 2).

$$\overline{F} = m \cdot \overline{a} \tag{1}$$

In order to discriminate force $\overline{F}$, which forms acceleration, from other forces, let us call it Newtonian force. It always coincides with the direction of acceleration $\overline{a}$, which it forms. All other forces are the motion resistance forces.

In 1743, Jean d'Alembert supplemented this Newton's law having mentioned that the inertia force $\overline{F}i$, which is directed conversely to the acceleration direction $\overline{a}$ and is equal to

$$\overline{F}_i = -m \cdot \overline{a} \quad (2)$$

It appears from this that two forces, which are equal in their values and opposite in their direction, act on the body, which moves with acceleration, in each given instant of time: Newtonian force $\overline{F}$ and d'Alembertean inertia force $\overline{F}i$. Newtonian force $\overline{F}$ acting on asteroid A, which approaches planet M, and the inertia force $\overline{F}i$ directed oppositely to Newtonian force are shown in Fig. 1, a, position 2. As there are no mechanical resistances in space, equality of these forces should bring the body in a quiescent state or in a steady motion state, but it moves with acceleration proving a discrepancy of such notions and demanding their elimination.

3. The First Law of Mechanodynamics

For more than 300 years, it was supposed that Newtonian force $m\overline{a}$ moves a body, and a sum of resistance forces $\sum_{i=1}^{n} \overline{P}i$ hinders this motion without a participation of the inertia force $\overline{F}i$, which is also directed oppositely to the motion (Fig. 2, b). In order to make certain of erroneousness of such an approach to the solution of the problems of mechanodynamics, let us consider the accelerated motion of a car in detail (Fig. 2, b).

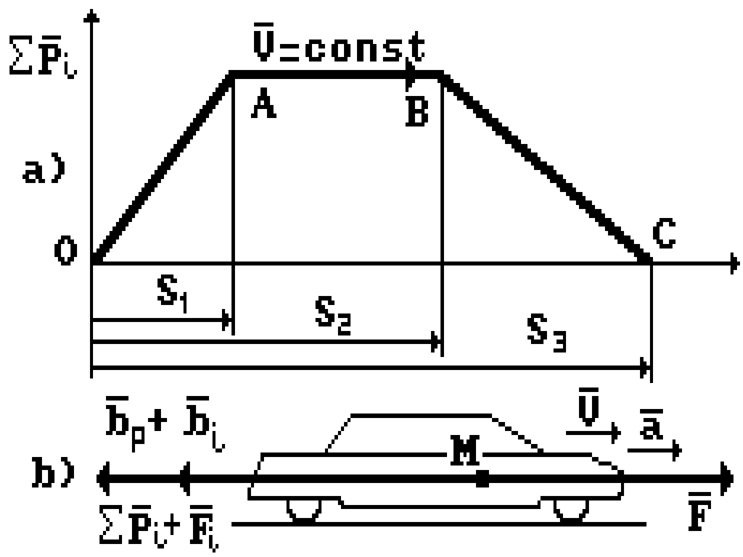

Fig. 2. Diagram of the forces acting on a car, which moves with acceleration (OA)

Each of us goes by car and knows that when it moves with acceleration, the inertia force presses us to a squab. If other car hits our car from behind, the acceleration can be such that strength of the muscles of our body and resistance power of the neck vertebra will be less than the inertia force, which carries our head back. A head-rest helps to save us from the inertia force, which is capable to tear off our head. If our car runs into an obstacle, which suddenly appears before the car, the acceleration of its motion will be changed for ат opposite one and will turn into a slow-up being directed against the motion of the car, and the inertia force will act in the direction of the car drive. In order to prevent this force from throwing us through a wind shield, we fasten the belts.

Thus, the authenticity of the described process of an appearance and a change of the inertia was proved by millions of lives of the passengers who perished in the road accidents when the cars were driven, but the physicists and fitters-theoreticians go on ignoring it thinking that the inertia force $\overline{F}i$ is not among the forces $\sum_{i=1}^{n}\overline{P}i$ acting on the body during its accelerated or decelerated motion. Let us correct their mistake.

When a car moves with acceleration (Fig. 2. b), the following forces act on it: Newtonian force $\overline{F}$ being generated by its engine, the inertia force $\overline{F}i$ directed oppositely to the acceleration $\overline{a}$ of the car and arresting its motion, an aggregate force of all external resistances $\sum_{i=1}^{n}\overline{P}i$, which is also directed conversely to the direction of the car. As a result, we have a conclusive equation of the forces exerting influence on the car, which moves with acceleration (Fig. 2, b).

$$\overline{F} = \overline{F}i + \sum_{i=1}^{n}\overline{P}i \, . \tag{3}$$

This is **the first law of mechanodynamics**. It reads: **the accelerated motion of a body takes place under the influence of Newton's active force $\overline{F}$ and the motion resistance forces in the form of the inertia force $\overline{F}i$ and the mechanical resistance forces $\sum_{i=1}^{n}\overline{P}i$.**

If we agree with d'Alembert who thought that the inertia force value и $\overline{F}i$ is equal to the body mass m multiplied by the same acceleration $\overline{a}$, which takes place under the influence of Newtonian force $\overline{F} = m \cdot \overline{a}$, the resistance force $\sum_{i=1}^{n}\overline{P}i$ being a part of the equation (3), equals zero. There is only one way from this contradiction: it is necessary to introduce the notions of a force, which generates acceleration $\overline{a}$, and a force, which generates deceleration $\overline{b}$. Thus, Newtonian force $\overline{F}$ will always generate acceleration $\overline{a}$, and all other forces will generate deceleration. We have every reason to think that that Newtonian force $\overline{F}$ coincides with the acceleration $\overline{a}$ direction, and the forces, which hinder the motion and, consequently, generate deceleration, coincide with the direction of decelerations $\overline{b}$ being formed by them (Fig. 2, b). If we designate the deceleration, which belongs to the inertia force, via $\overline{b}_i$ and the deceleration, which is generated by the forces of mechanical resistances $\sum_{i=1}^{n}\overline{P}i$, via $\overline{b}_p$, we can rewrite the equation (3) in the following way

$$m \cdot \overline{a} = m \cdot \overline{b}_i + \sum_{i=1}^{n}\overline{P}i \cdot \tag{4}$$

It is easy to see that in case of a complete absence of the forces of mechanical resistances $\sum_{i=1}^{n}\overline{P}i = 0$ (for example, in space), the inertia force $\overline{F}_i = m \cdot \overline{b}_i$ equals Newtonian force $\overline{F} = m \cdot \overline{a}$, but the body is moving. It is possible only in case when Newtonian force exceeds the inertia force; that's why a mathematical model, which describes a motion of the body in space, should be presented in the form of an inequality

$$\overline{F} \geq \overline{F}_i \Rightarrow m\overline{a} \geq m\overline{b}_i \, , \tag{5}$$

or

$$\overline{a} \geq \overline{b}_i \cdot \tag{6}$$

This is a condition of the body motion in space in case of resistance absence. It appears from this that an actual inertial deceleration $\overline{b}_i$ of the body can be determined under the conditions when there are no external resistances. It is natural that the specialists in space engineering are in possession of the methods of such determinations and have experimental information concerning it. Thus, a value of complete acceleration $\overline{a}$ of the body, which moves with acceleration, equals a sum of the decelerations being generated by the motion resistance forces.

$$\bar{a} = \bar{b}_i + \bar{b}_p \quad (7)$$

In old dynamics, an inertial component of deceleration $\bar{b}_i$ was a part of a deceleration $\bar{b}_p$ being generated by the forces of mechanical resistances to motion; it hindered an analysis of the forces acting on all types of motions: accelerated motion, uniform motion and decelerated one. It was considered that the inertia force $\bar{F}i$, which also hindered the accelerated motion of the body, was not a part of the sum of all forces of mechanical resistances $\sum_{i=1}^{n} \bar{P}i$. It is the main fundamental error of Newtonian dynamics, which has remained unnoticed during 322 years. Automatically, the inertia force was a part of the aggregate force of mechanical resistances $\sum_{i=1}^{n} \bar{P}i$, but everybody thought that it was not there. As a result, all experimental coefficients of mechanical resistances to body motion prove to be erroneous.

It appears from the equation (4) that the inertia force $\bar{F}i$, which acts on the car when it moves with acceleration, equals

$$\bar{F}_i = m\bar{b}_i = m\bar{a} - \sum_{i=1}^{n} \bar{P}_i \, , \quad (8)$$

and a scalar value of inertial deceleration $\bar{b}_i$ is determined according to the formula

$$b_i = a - \frac{\sum_{i=1}^{n} \bar{P}_i}{m} . \quad (9)$$

A value of complete Newtonian acceleration is determined from the kinematical equation of the accelerated motion of the body

$$V = V_0 + at . \quad (10)$$

If the initial velocity of the car $V_0 = 0$ is, complete acceleration a equals velocity of the car V at the moment of its transition from the accelerated motion to the uniform motion divided by time of the accelerated motion.

$$a = V / t . \quad (11)$$

In principle, when the problems are being solved, it is possible to assume that a value of velocity V equals a value of constant velocity ($V = const$) of the body during its uniform motion, which takes place after the accelerated motion. A sum of the resistance forces $\sum_{i=1}^{n} \bar{P}i$ is **an experimental value**, which should be determined only in case of uniform motion in order to exclude the inertia force from it.

Thus, all the data, which are necessary for a determination of inertial deceleration $\bar{b}_i$ and a calculation of the inertia force $\bar{F}i$ according to the formula (8), are available. It appears from this formula that a fraction of inertial deceleration $\bar{b}_i$ depends on the medium resistance $\sum_{i=1}^{n} \bar{P}i$ (9).

If it is necessary to determine the body motion resistance forces, it should be done only during its uniform motion. If a sum of the body motion resistance forces $\sum_{i=1}^{i=n} \bar{P}i$ is determined during its accelerated motion, the inertia force $\bar{F}i$, in accordance with the formula (3), is automatically included in the sum of the motion resistance forces $\sum_{i=1}^{i=n} \overline{Pi}$, and a result of the determination of resistance forces will be completely erroneous.

4. The Second Law of Mechanodynamics

When the car begins uniform motion (Fig. 3, b), the inertia force $\overline{Fi}$ changes its direction for the opposite one automatically, and the equation of the sum of the forces (3), which act on the car, becomes as follows:

$$\overline{F_K} + \overline{Fi} = \sum_{i=1}^{n} \overline{P_i}\,. \qquad (12)$$

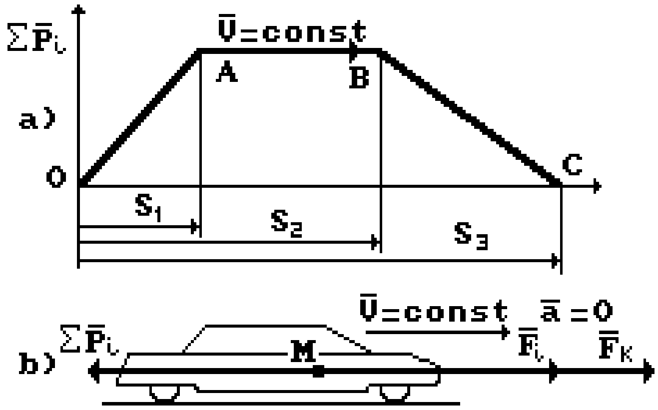

Fig. 3. Diagram of the forces acting on the car, which motion is a uniform one

This is **the second law of mechanodynamics** - the law of uniform motion of the body (the former first law of Newtonian dynamics). It reads: **if there are no resistances, uniform motion of the body (Fig. 1, a, position 1) takes place under the influence of the inertia force $\overline{Fi}$. If there are resistances, uniform motion of the body takes place under the influence of the inertia force $\overline{Fi}$ as well, and the constant active force $\overline{F_K}$ overcomes the motion resistance forces $\sum_{i=1}^{n} \overline{Pi}$ (Fig. 3, b).**

Thus, the essence of the second law of mechanodynamics is in the fact that uniform motion of the car (body) is provided by the inertia force $\overline{Fi}$, and the constant force $\overline{F_K}$ being generated by the car engine overcomes all external resistances $\sum_{i=1}^{n} \overline{Pi}$. The force $\overline{F_K}$ is constant, because the car has uniform motion, and its acceleration equals zero $\overline{a} = 0$.

In space, where there are no mechanical resistances to motion, constant force for their overcoming is not required. That’s why when the body changes its accelerated motion for uniform motion, the inertia force changes its direction for the opposite one and hereby provides its uniform motion with constant velocity $V = const$ (Fig. 1, position 1).

Again, let us pay attention to the main centuries-old error of the mechanicians. For this purpose, let us rewrite the equation (12) in the following way:

$$\overline{F_K} = \sum_{i=1}^{n} \overline{P_i} - \overline{Fi}\,, \qquad (13)$$

This is a mathematical model of the second law of mechanodynamics (the former first law of dynamics). There was no mathematical model for a description of uniform motion of the body for more than 300 years. Now it exists (12), (13).

Now we can set pilots' mind at rest. Uniform flight of their plane is described by the second law of mechanodynamics (12). According to this law, a sum of the forces, which act on the plane having uniform motion, does not equal zero (13). A force, which provides uniform motion of the plane, is the inertia force, which was directed oppositely to its motion when it moved with acceleration (took off). When the plane begins uniform motion, the inertia force changes its direction for the opposite direction and coincides with a force being created by the engines of the plane. As a result, the inertia force begins to provide a uniform flight of the plane, and the forces of the engines of the plane begin to overcome the resistance forces to its flight. Thus, the uniform flight of the plane is governed by the second law of mechanodynamics (12), according to which a sum of the forces acting on it does not equal zero.

5. The Third Law of Mechanodynamics

It is necessary to have a clear idea concerning a change of the direction of the inertia force when a transition from uniform motion to decelerated motion of the body (car) takes place. When the car changes its uniform motion for decelerated motion, the primary inertia force $\overline{F}i$ (Fig. 4, b) does not change its direction, and the deceleration $\overline{b}_p$, which has occurred and is generated by the resistance forces, is directed opposite to this force.

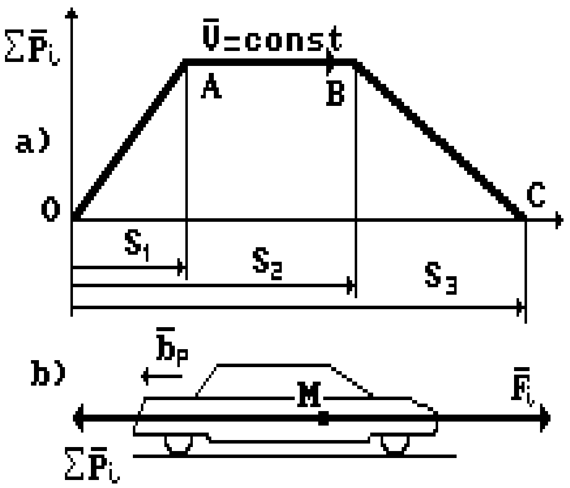

Fig. 4. Diagram of forces acting on the car, which has decelerated motion

Thus, if the car changes its uniform motion for decelerated motion, the former inertia force $\overline{F}i$ and the motion resistance forces $\sum_{i=1}^{n}\overline{P}i$ do not change their directions. The inertia force does not generate acceleration, and irregularity of the resistance forces results to a gradual reduction of the inertia force $\overline{F}i$, and the body stops.

$$\sum_{i=1}^{n}\overline{P}i > \overline{F}i. \quad (14)$$

This is a mathematical model of **the third law of mechanodynamics.** It reads: **decelerated motion of a rigid body is governed by exceeding the motion resistance forces over the inertia force.**

If a speed-box of the car is cut off, active force disappears $\overline{F}_K$ (Fig. 3, b), and two oppositely directed forces remain: the inertia force $\overline{F}i$ and a sum of forces of mechanical resistances to motion $\sum_{i=1}^{n} \overline{P}i$ (Fig. 4, b). As the inertia force has no source, which keeps it in a constant state, it proves to be less than the motion resistance forces ($\overline{F}i < \sum_{i=1}^{n} \overline{P}i$), and the car, which begins decelerated motion (Fig. 4, b), stops (Fig. 4, a, point C). Taking it into account, we have every reason to call the inertia force a passive force, which cannot generate acceleration, because it is a consequence of its emerging.

Let us pay attention to the fact that a distance S_1 of the car motion with acceleration is less than a distance of motion with deceleration $S_3 - S_2$ (Fig. 4, a). It is stipulated by the fact that a value of the resistance forces $\sum_{i=1}^{n} \overline{P}i$ in case of acceleration from stop on the part S_1 exceeds the resistance forces in case of decelerated motion due to the fact that in case of decelerated motion the engine and the speed-box are cut off. This is the main reason of fuel conservancy when the car moves with a periodic speed-box cutoff.

6. The Fourth Law of Mechanodynamics

The fourth law of mechanodynamics (There is always an equal and opposite reaction to every action): **the forces, with which two bodies act on each other (Fig. 1, a, pos. 2), are always equal according to the modulus and are directed in a straight line, which connects the centres of masses of these bodies, to the opposite directions.**

In the second position of Fig. 1, a, it is clear that force $\overline{F}$ of action of planet M equals $\overline{F} = m \cdot \overline{a}$, and force $\overline{F}_0$ of action of asteroid A on planet equals $\overline{F}_0 = M \cdot \overline{a}_0$ (a, a_0 - accelerations of the asteroid and the planet, respectively). As $\overline{F} = -\overline{F}_0$, it means that $m \cdot \overline{a} = -M \cdot \overline{a}_0$ or

$$\frac{a}{a_0} = \frac{M}{m}. \qquad (15).$$

It means that the accelerations, which two bodies give each other, are inversely proportional to their masses. The accelerations are directed along one and the same line to the opposite directions. It should be noted that the fourth law of mechanodynamics reflects an interaction of the bodies both at a distance (Fig. 1, a, position 2) and in case of a direct contact (Fig. 5). It is shown in Fig. 5 that when the bodies A and B contact each other, the forces of their interaction $\overline{F}_A$ and $\overline{F}_B$ are equal in their value and are opposite in the direction. Both forces $\overline{F}_A$ and $\overline{F}_B$ are the forces of external impact, and they emerge simultaneously.

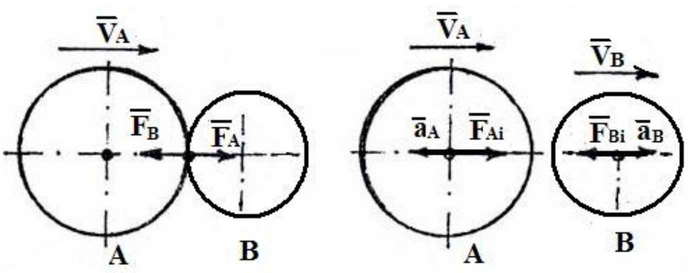

Fig. 5. Diagram of contact interaction of two bodies

The inertia forces $\overline{F}_{Ai}$ and $\overline{F}_{Bi}$ are equal in their value and opposite in the direction.

7. The Fifth Law of Mechanodynamics

The fifth law of mechanodynamics (independence of action of the forces). If several motion resistance forces $\sum_{i=1}^{n} \overline{P}i = \overline{P}_1, \overline{P}_2, \overline{P}_3, ..., \overline{P}_n$ act simultaneously on a body or a point, Newtonian acceleration $\overline{a}$ of the material point or a body is equal to a geometrical sum of decelerations befalling to each motion resistance force $\sum_{i=1}^{n} \overline{P}i = \overline{P}_1, \overline{P}_2, \overline{P}_3, ..., \overline{P}_n$. Taking into account that in the equation (7) $\overline{b}_p$ the geometrical sum of decelerations befalling to all resistance forces is $\sum_{i=1}^{n} \overline{P}i = \overline{P}_1, \overline{P}_2, \overline{P}_3, ..., \overline{P}_n$, except the inertia force $\overline{F}_i$, i.e. $\overline{b}_p = \overline{b}_1 + \overline{b}_2 + \overline{b}_3 + ... + \overline{b}_n$. The equation (7) can be written in such a way:

$$\overline{a} = \overline{b}_i + \overline{b}_1 + \overline{b}_2 + \overline{b}_3 + ... + \overline{b}_n \quad (16)$$

This is a mathematical model of **the fifth law of mechanodynamics.** It reads: **when a rigid body moves with acceleration, Newtonian acceleration being forms by Newtonian force equal a sum of decelerations being formed by all motion resistance forces.**

Let us recollect Galileo's experiment, in which he placed the bodies having different masses and densities in a tube. He pumped air out of it, and it turned out that if the tube was placed vertically, all bodies fall down at the same rate. As in accordance with the main law of mechanodynamics the force acting on the body equals a product of mass by acceleration, it seems that the bodies having different masses should move with different rates, but it is not observed. Why?

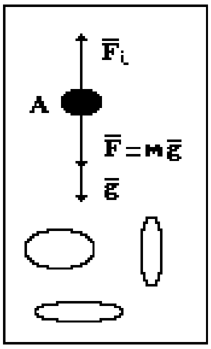

Fig. 6. Diagram of action of the forces on the bodies, which move in the evacuated tube

If only one force of gravity $\overline{F} = m\overline{g}$ acted on the bodies in the evacuated tube (Fig. 6), each body would move at a different rate; but as all of them move at the same rate and with one and the same acceleration, two forces act on each of them: force of gravity $\overline{F} = m\overline{g}$ and inertia force $\overline{F}i = -m\overline{g}_i$. Accelerated motion of each of them points out to the fact that force of gravity exceeds inertia force $\overline{F} > \overline{F}i$. Thus, we have:

$$g = g_i \Rightarrow g > g_i \ . \quad (17)$$

As

$$\overline{F} = m \cdot \overline{g} \Rightarrow m = F / g \ , \quad (18)$$

mass of a material body equals to its weight F divided by free fall acceleration in a given place of the surface of the earth.

As a force measurement unit in SI system, a Newton is accepted (N). One Newton force is that force which produces an acceleration of 1 m/s^2.

In technical unit system, 1 kg is accepted as a force measurement unit, and 1 kg·m/s^2 is accepted as a mass measurement unit. As $F = mg$, it means that 1 kg=1·9.81 N or 1 N=0.102 kg.

New knowledge in the field of mechanodynamics makes it possible to determine exactly the resistance forces to motion of any body. A determination method of these forces results from the formulas (3-11). If the car motion resistance forces are determined, it is necessary to choose a uniform horizontal part of the road, to drive a specified distance along it with a specified constant velocity and to measure fuel consumption. Energy of this fuel will be equal to work of a force $\overline{F}_K$, which counteracts all motion resistance forces $\sum_{i=1}^{n} \overline{P}i$, at the registered part of the road. It appears from this that the force $\overline{F}_K$ is equal to a sum of forces $\sum_{i=1}^{n} \overline{P}i$.

If a similar experiment is carried out at an accelerated motion of the car, the inertia force $\overline{F}i$, according to the formula (3), which hinders an accelerated motion of the car, will be automatically included in the sum of resistance forces $\sum_{i=1}^{n} \overline{P}i$, and a result of the resistance force determination will be completely erroneous.

Newtonian or motive force will be determined in accordance with Newton's second law

$$F = m \cdot \frac{dV}{dt} = m \cdot a\ . \tag{19}$$

In this case it is more convenient to determine Newtonian acceleration a according to the formula (11) and an inertial component b_i according to the formula (9). The inertia force will be determined according to the formula (8).

THE SECOND LECTURE

MECHANODYNAMICS OF CURVILINEAR ACCELERATED MOTION, UNIFORM MOTION AND DECELERATED ONE OF A MATERIAL POINT

1. Mechanodynamics of Accelerated Curvilinear Motion of a Point

A curvilinear motion of a point is usually described in a natural system of coordinates, which has a normal axis on, a tangential axis $o\tau$ and a binormal ob (Fig. 7). A plane $on\tau$ is called an osculating plane. The axis ob is perpendicular to the osculating plane. Velocity $\overline{V}$ of the point is directed along the motion.

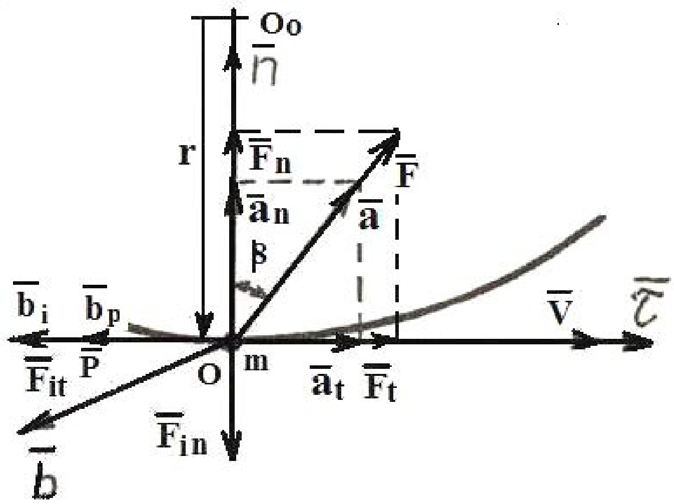

Fig. 7. Diagram of accelerations and forces acting on the material point, which moves curvilinearly and with acceleration

As the motion is a curvilinear one, a normal component $\bar{a}_n$ of complete acceleration $\bar{a}$ is always directed to a concavity of the curve (Fig. 7). A direction of the tangential component $\bar{a}_t$ of complete acceleration $\bar{a}$ depends on a nature of the curvilinear motion. If it is accelerated, the directions of the tangential acceleration $\bar{a}_t$ and a velocity vector $\bar{V}$ coincide (Fig. 7).

As a motion is an accelerated curvilinear one, the following forces act on the material point: Newtonian (active force) $\bar{F}$, a sum of resistance forces $\sum_{i=1}^{i=n} \bar{P}i$ directed oppositely to the motion, the tangential component $\bar{F}it$ and the normal component $\bar{F}in$ of complete inertia forces $\bar{F}i$. A vector of Newtonian force $\bar{F}$ is directed along a vector of complete acceleration $\bar{a}$ to the concavity of the curve. It is decomposed into two components: the normal component $\bar{F}n$ and the tangential one $\bar{F}t$.

As the tangential inertia force $\bar{F}it$ is directed oppositely to the acceleration $\bar{a}_t$, the normal component $\bar{F}in$ of the inertia force is always directed from the from the trajectory curvature centre along a curvature radius, and the tangential component $\bar{F}it$ of the inertia force is directed oppositely to the tangential component $\bar{a}t$ of the complete Newtonian acceleration $\bar{a}$ and coincides with a direction of the tangential deceleration $\bar{b}_i$.

Thus, an equation of the forces, which act to the material point along a tangent to the curvilinear trajectory, will be written in the following way

$$\bar{F}t = \bar{F}it + \sum_{i=1}^{i=n} \bar{P}i \tag{20}$$

or

$$m \cdot \bar{a}t = m \cdot \bar{b}i + \sum_{i=1}^{i=n} \bar{P}i \ . \tag{21}$$

As it is clear, the equations (20) and (21) are similar to the equations of the forces (3) and (4) acting on a body, which moves with acceleration in case of a straight-line motion. In order to solve this equation, it is necessary to know acceleration $\bar{a}t$ and deceleration $\bar{b}_i$. In order to determine them, it is necessary to know primarily a point motion equation. In the case being considered, it is preset in a true form

$$S = S(t) . \tag{22}$$

When we know the point motion equation (22), we find its velocity

$$V = \frac{dS}{dt} \tag{23}$$

and the tangential acceleration

$$\bar{a}t = \frac{dV}{dt} . \tag{24}$$

A normal acceleration modulus $\bar{a}n$ is determined according to the formula

$$a_n = \frac{V^2}{r} , \tag{25}$$

where r is a trajectory curvature radius.

A deceleration modulus $\bar{b}_i$ can be determined only in the case when a sum of the resistance forces $\sum_{i=1}^{i=n} \bar{P}i$, which act on the point, is known. The value $\sum_{i=1}^{i=n} \bar{P}i$ is determined experimentally. If we know it, we find a deceleration $\bar{b}_i$, which is formed by the tangential component $\bar{F}_{it}$ of the inertia system (Fig. 7).

$$b_i = a_t - \frac{\sum_{i=1}^{i=n} P_i}{m} . \quad (26)$$

It appears from this equation that the deceleration $\bar{b}_p$, which falls to the share of the resistance forces $\sum_{i=1}^{i=n} \bar{P}i$, is equal to

$$b_p = \frac{\sum_{i=1}^{i=n} P_i}{m} \quad (27)$$

or

$$b_p = a_t - b_i . \quad (28)$$

Thus, new laws of mechanodynamics make it possible to describe a process of the accelerated curvilinear motion of the material point correctly. Let us describe a uniform curvilinear motion of the point.

2. Mechanodynamics of Uniform Curvilinear Motion of a Point

In case of the uniform curvilinear motion of the point, the tangential acceleration $\bar{a}_t$ equals zero, but a tangential force of inertia $\bar{F}_{it}$, which acted on the point when it moved with acceleration prior to a transition to a uniform motion, does not disappear anywhere. It changes its direction to the opposite one (Fig. 8). As a result, a sum of the tangential forces, which act on the material point, will be written in the following way

$$\bar{F}_{tk} + \bar{F}_{it} = \sum_{i=1}^{i=n} \bar{P}i . \quad (29)$$

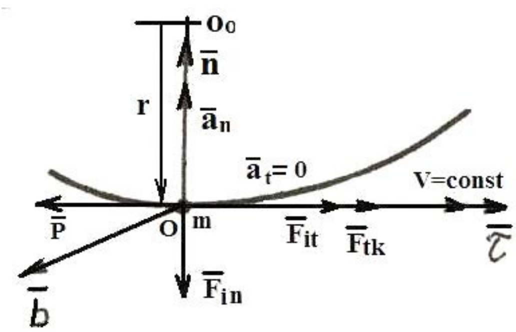

Fig. 8. Diagram of the forces acting on the material point in case of the uniform curvilinear motion

Let us remind that the sum of the point motion resistance forces $\sum_{i=1}^{i=n} \bar{P}i$ is an experimental value. As velocity of the curvilinear motion of the point is a constant value $V = const$ in this case, the tangential component of its complete acceleration $\bar{a}$ equals zero $\bar{a}_t = 0$, and there remains only the normal acceleration $\bar{a}_n$, which corresponds to the normal component of the inertia force $\bar{F}_{in}$ directed oppositely to the normal acceleration (Fig. 8).

A physical essence of the equation (29) is as follows. The active tangential force $\bar{F}_{tk}$ overcomes all motion resistances $\sum_{i=1}^{i=n} \bar{P}_i$, and the inertia force $\bar{F}_{it}$ moves the point uniformly. Thus, we have all the information being necessary for a determination of the forces acting on the material point, which moves curvilinearly and uniformly.

3. Mechanodynamics of Decelerated Curvilinear Motion of a Point

When a material point changes its uniform motion for a decelerated curvilinear motion, a tangential component $\bar{F}_{tk}$ of the active force disappears. There remain a tangential component $\bar{F}_{it}$ of the inertia force and the sum of the motion resistance forces $\sum_{i=1}^{i=n} \bar{P}_i$, which generates a deceleration $\bar{b}_p$ (Fig. 9). As the sum of the motion resistance forces $\sum_{i=1}^{i=n} \bar{P}_i$ exceeds the inertia tangential force $\bar{F}_{it}$, which does not generate acceleration, the deceleration $\bar{b}_p$, which corresponds to force $\sum_{i=1}^{i=n} \bar{P}_i$ and coincides with its direction, forms together with the acceleration normal component $\bar{a}_n$ a complete acceleration $\bar{a}$ directed from the left side of the normal axis on (Fig. 9).

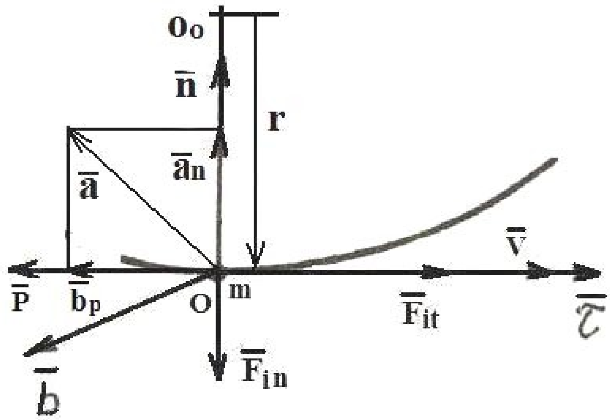

Fig. 9. Diagram of accelerations and forces acting on the point in case of its decelerated curvilinear motion

When the point passes to a decelerated motion, the sum of the motion resistance forces $\sum_{i=1}^{i=n} \bar{P}_{ci}$ exceeds the inertia force $\bar{F}_{it}$, and the motion of the point is decelerated gradually.

New knowledge in the field of mechanodynamics makes it possible to determine exactly the resistance forces to motion of any body. A determination method of these forces results from the formula (29). If the point motion resistance forces are determined, it is necessary to do it only when it moves uniformly. If the sum of the point motion resistance forces $\sum_{i=1}^{i=n} \bar{P}_i$ is determined in case of its accelerated motion, the inertia force $\bar{F}_{it}$, in accordance with the formula (29), which hinders the accelerated motion of the point, will become a part of the sum of the motion resistance forces $\sum_{i=1}^{i=n} \overline{Pi}$ automatically, and the result of the determination of the resistance forces will be erroneous completely.

In case of the curvilinear motion, Newtonian, or active, force is determined according to Newton's main law

$$F = m \cdot \frac{dV}{dt} = m \cdot a \,. \tag{30}$$

Complete Newtonian acceleration a is connected with its normal component $\overline{a}_n$ and the tangential one $\overline{a}_t$ by simple dependence

$$a = \sqrt{a_n^2 + a_t^2} \,, \tag{31}$$

That's why if $\overline{a}_n$ and $\overline{a}_t$ are known, it gives an opportunity to determine complete acceleration a .

Let us note that if the radius of the point motion trajectory curvature is constant, all the facts, which are described in this lecture, belong to a motion of the point in a circle as well.

CONCLUSION

These two introductory lectures in mechanodynamics have enough information for a review of all other parts of Newton's old dynamics. The specialists in theoretical mechanics will understand an essence of the first two lectures and will write all other ones without our participation. But if they fail to understand the essence of erroneousness of Newton's first law, erroneous dynamics will exist for a long time.

New laws of mechanodynamics have already allowed us to describe in details process of a shot of second power unit Sajano-Shushenskoj of HYDROELECTRIC POWER STATION. The sum of forces of resistance to power unit movement exceeded $F_0 = 2580 + 21764 = 24344 tonn$. Physical and chemical process in a water delivery zone on the turbine blade has generated the shock force equal to

Equation.3 $F_y = \frac{F}{t_y} = \frac{5{,}10 \cdot 10^8}{0{,}03} = 1{,}70 \cdot 10^{10} H / c = 1700000 тонн / c.$

EMBED Equation.3 $F_y = \frac{F}{t_y} = \frac{5.10 \cdot 10^8}{0.03} = 1.70 \cdot 10^{10} N / S = 1.700.000 tonn / s.$

Results of calculation of pulse force by means of laws mechanodynamics coincide on 93 % with calculations of this force by means of laws of physchemistry of processes which have generated by this force.

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