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SOLUTION OF PROBLEMS RELATED TO THE MOTION OF A MATERIAL POINT IN A NON-INERTIAL FRAME

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Abstract:

In the article, the method of transferring the mechanical movement of a material point from inertial reference systems to non-inertial reference systems, introducing the concepts of Coriolis acceleration and centripetal acceleration was used. The equation of mechanical motion in relation to non-inertial systems and the method of solving problems on this basis were based, examples of problem solving were shown. In the article, the methods of comparison, scientific analysis and conclusion of the laws of motion of mechanical bodies in non-inertial and inertial reference systems were used.

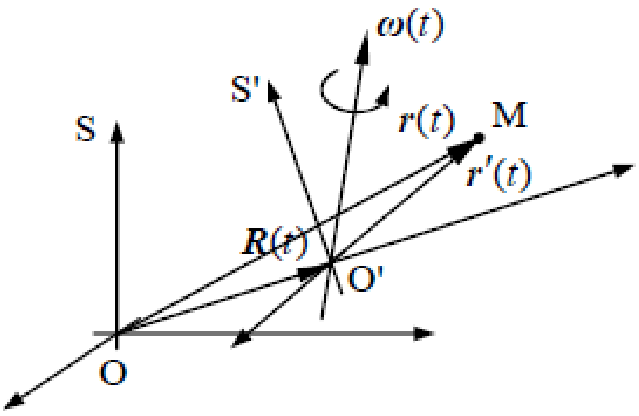
Keywords: Inertial frame of reference, non-inertial frame of reference, radius vector, angular velocity, velocity of material point, acceleration of material point, moving velocity, relative velocity, centripetal acceleration, Coriolis acceleration, relative acceleration, Coriolis force, centrifugal force, inertia forces, centrifugal force strength.

In the field of undergraduate education in physics, the problems related to the mechanical movement of a material point in relation to the inertial reference system are mainly solved in practical exercises from the mechanics section of the general physics course [1-3]

In such a number system, the main equation representing the movement of a material point is Newton's second law.

Now we put the problem of determining the equation of motion of a material point in non-inertial reference systems moving with acceleration compared to inertial reference systems, and use the modified laws and corresponding formulas of force and acceleration in the transition from the inertial reference system to the non-inertial reference system.

Let's look at the number systems S and S', which move arbitrarily relative to each other. The initial points of the reference systems S and S' are O and O', the radius vector R(t). we denote the angular velocity E(t).



Picture 1. Interposition of reference systems S and S' moving at an arbitrary speed relative to each other.

S' is a physically infinitely small deflection of the system and the measuring body $d\vec{\alpha}$ is given by a vector, the modulus of this vector is equal to the angle of rotation. The angular velocity of rotation is $\omega = \frac{d\alpha}{dt}$. M- the radius vector of the material point in relation to the system, - the radius vector in relation to the number system, the radius vector of the M- material point in relation to S is denoted by $\vec{r}\,'(t)$.[2,5]

$$\vec{r}(t)=\vec{R}(t)+\vec{r}\,'(t) \quad (1)$$

Taking both sides of the equation (4.1) and the backs of the system S as time-invariant, we determine the speed and acceleration of the material point by differentiating (1) and the angular speed of rotation of the reference system.
The speed of a material point relative to the S'-number system.

$$\vec{\upsilon}=\vec{V}+\vec{\upsilon}\,'+[\vec{\omega}r\,\vec{r}\,'] \quad (2)$$

(2) is called the moving speed of the $\vec{\upsilon}=\vec{V}+[\vec{\omega}\,\vec{r}\,']$th material point and $\vec{\upsilon}\,'-$ is the relative speed. Acceleration of a material point relative to the S'-counting system.

$$\vec{a}=\vec{A}+\vec{a}\,'+[2\vec{\omega}\vec{\upsilon}\,']+[\dot{\vec{\omega}}\,\vec{r}\,']+[\vec{\omega}[\vec{\omega}\,\vec{r}\,']] \quad (3)$$

In (3), the displacement acceleration is $\vec{a}=\vec{A}+[\dot{\vec{\omega}}\,\vec{r}\,']+[\vec{\omega}[\vec{\omega}\,\vec{r}\,']]$, the Coriolis acceleration is - $\vec{a}_{кор}=2[\vec{\omega}\vec{\upsilon}\,']$, centripetal acceleration - $\vec{a}_{ми}=[\vec{\omega}[\vec{\omega}\,\vec{r}\,']]$, is called the relative acceleration of $\vec{a}\,'-$ material points [4-6].

We were able to obtain the addition formulas expressing the interconnections of the radius vectors, velocities and accelerations of the material point relative to the reference systems S and S' moving with arbitrary speed relative to each other.

Let us assume that the S-system is an inertial reference system. We write the equation of motion of M-material point. Taking into account that F_i- forces act on the mechanical system, we write Newton's second law in relation to the S-counting system.

$$m\vec{a}=\sum\vec{F}_i \quad (4)$$

$$m\vec{A}+m\vec{a}\,'+m[2\vec{\omega}\vec{\upsilon}\,']+m[\dot{\vec{\omega}}\,\vec{r}\,']+m[\vec{\omega}[\vec{\omega}\,\vec{r}\,']]=\sum\vec{F}_i \quad (5)$$

We write (5) as follows.

$$m\vec{a}\,'=\sum\vec{F}_i-\quad m\vec{A}-[2\vec{\omega}\vec{\upsilon}\,']-m[\dot{\vec{\omega}}\,\vec{r}\,']-m[\vec{\omega}[\vec{\omega}\,\vec{r}\,']] \quad (6)$$

$$m\vec{a}\,'=\sum\vec{F}_i+\vec{F}_{кўў}+\quad\vec{F}_{кор} \quad (7)$$

Now we will study the main types of problems and methods of solving them. Most of the problems related to the movement of bodies in the non-inertial reference system can be conditionally included in the following types of problems or their combinations: [1-2,7-8]
1. Issues related to the movement of bodies in forward moving noninertial reference systems.
2. Issues related to the movement of bodies in rotating noninertial reference systems.

We will look at general schemes for solving mechanical problems using Newton's laws in non-inertial reference systems.

I. Determination of models of material objects and events.
1. Draw drawings depicting the objects in question.
2. Choosing a non-inertial reference system and choosing its coordinate system in the drawing.
3. Express all forces, including inertial forces, as well as necessary kinematic characteristics of the system in the drawing.
4. Choose a model of bodies and express their movement

II. Write a complete system of equations for the required quantities.
1. Write the equation of motion for all bodies in the system in projections relative to the coordinate axes of the selected non-inertial reference system.
2. Using Newton's third law for all material forces.
3. Use of laws describing individual (specific) properties of forces.
4. Write the equation of kinematic links
5. Using the special conditions of the problem and the results of previously solved problems.

III. Get the results you are looking for in analytical and quantitative views.
1. Solving the resulting system of equations.

2. Analysis of the solution. (check dimensionality and excess roots. consider characteristic cases, determine the field of application)
3. Calculate the numerical result.

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