Heading: mathematical physics.
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Cochetkov Victor Nikolayevich
chief specialist FGUP “The operation center of the objects of ground-based space infrastructure” (FGUP “TSENKI”)
vnkochetkov@gmail.com

SPECIAL THEORY OF RELATIVITY.
BRIEF NOTES

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Abstract

In this article the attempt to establish is made, are in the special theory of relativity the conversions of Lorenz the only possible connection between the coordinates and the time in the inertial reference systems, and also the conclusions of the special theory of relativity do correspond to the requirements, superimposed by the condition of the symmetry of space and time.

1. Introduction

In spite of that, the theories of relativity are more than 100 years, it is universally recognized and is studied from the school desk, me it seems it would be not-without-interest to examine the special theory of relativity for the conditions less rigid, than they were accepted with its creation.

1.1. Brief history of the creation of the special theory of relativity

At the turn XIX-XX of the century the efforts of the most important physicists of peace created the special theory of relativity.

In the end XIX of the century between two most important branches of physics - mechanics and electrodynamics - serious contradictions arose.

In the mechanics the law of relativity of Galileo was affirmed - the complete equality of rights of the systems of references, which move relative to each other is rectilinearly and evenly.

In the electrodynamics the basic place occupied the idea of ether - the medium, which fills outer space, and in which occur all physical processes, in such cases electromagnetic vibrations. In this case the particle motion and field it was to be described in the coordinates, rigidly connected with ether - absolute system of reference.

In 1881, 1886-1887 years in the course the Michelson-Morley experiments could not be registered “ether drift”. As a result the ether theory of light, it would seem reliably confirmed by experiences, it was not coordinated with the classical mechanics.

In 1889 Irish physicist D. Fitzgerald proposed to consider that during the motion of body with a speed **v** relative to ether his longitudinal size $\boldsymbol{l'}$ experiences reduction according to the law:

$$l' = l \cdot \sqrt{1 - \frac{v^2}{c^2}} \tag{1}$$

where: **c -** speed of light,

$\boldsymbol{l}$ - the length of fixed in the relation ether of body.

In 1892 Netherlands physicist H. Lorenz supplemented the D. Fitzgerald hypothesis by the idea “local” time $\boldsymbol{t'}$, connected with “true” universal time $\boldsymbol{t}$ преобразованием:

$$t' = t - \left(\frac{x \cdot v}{c^2}\right) \tag{2}$$

where: **v** - speed of the motion of body with the passage of the point of space with the coordinate **x**.

Also H. Lorenz modified the conversions of Galileo in the case of the high speeds:

$$x_1 = \beta \cdot [x_2 + (V \cdot t_2)] \qquad (3)$$

$$y_1 = y_2 \qquad (4)$$

$$z_1 = z_2 \qquad (5)$$

$$t_1 = \beta \cdot \left[t_2 + \left(\frac{x_2 \cdot V}{c^2}\right)\right] \qquad (6)$$

by the introduction “relativistic” coefficient β:

$$\beta = \frac{1}{\sqrt{1 - \frac{V^2}{c^2}}} \qquad (7)$$

Formulas (3) - (6) of the passage between the inertial reference systems obtained the designation “the conversion of Lorenz”.

Still in 1881 English physicist D. Thomson assumed that the mass **M** of the body, which moves with a speed **v**, will be more than mass $\mathbf{M_o}$ in the state of rest; moreover value **M** is equal:

$$M = \frac{M_0}{\sqrt{1 - \frac{v^2}{c^2}}} \qquad (8)$$

1.2. Special theory of relativity

In 1905, A. Einstein were looked at as the basis the fundamental principles, in the compressed form which transmit the essence of two classical physical theories: from the mechanics - principle of the equality of rights of all inertial reference systems (law of relativity), from the electrodynamics - principle of the constancy of the speed of light.

Law of relativity: **in any inertial reference systems all physical phenomena with one and the same conditions flow equally**, i.e., physical laws are independent (they are invariant) with respect to the selection of inertial reference system - the equations, which express these laws, have identical form in all inertial reference systems.

Principle of the invariance of the speed of light: **the speed of light in the vacuum does not depend on the motion of luminous source**, i.e., the speed of light is identical in all directions and in all inertial reference systems.

Using the law of relativity and principle of the constancy of the speed of light, A. Einstein were derived the conversions of Lorenz; however, another physical sense gave to them:

$$\mathrm{x}_1 = \frac{\mathrm{x}_2 + (\mathrm{V}\cdot t_2)}{\sqrt{1-\frac{\mathrm{V}^2}{c^2}}} \qquad (9)$$

$$\mathrm{x}_2 = \frac{\mathrm{x}_1 - (\mathrm{V}\cdot t_1)}{\sqrt{1-\frac{\mathrm{V}^2}{c^2}}} \qquad (10)$$

$$\mathrm{y}_1 = \mathrm{y}_2 \qquad (11)$$

$$\mathrm{z}_1 = \mathrm{z}_2 \qquad (12)$$

where: $\mathbf{x_1}$, $\mathbf{y_1}$, $\mathbf{z_1}$ – coordinate of point **A** at the moment of time t_1 in the fixed inertial reference system $\mathbf{O_1x_1y_1z_1}$;

$\mathbf{x_2}$, $\mathbf{y_2}$, $\mathbf{z_2}$ – coordinate of point **A** at the moment of time t_2 in the mobile inertial reference system $\mathbf{O_2x_2y_2z_2}$, corresponding to moment of time t_1 in the fixed inertial reference system $\mathbf{O_1x_1y_1z_1}$ (as shown in Fig. 1).

$$t_1 = \frac{t_2 + \left(\frac{\mathrm{x}_2\cdot \mathrm{V}}{c^2}\right)}{\sqrt{1-\frac{\mathrm{V}^2}{c^2}}} \qquad (13)$$

$$t_2 = \frac{t_1 - \left(\frac{\mathrm{x}_1\cdot \mathrm{V}}{c^2}\right)}{\sqrt{1-\frac{\mathrm{V}^2}{c^2}}} \qquad (14)$$

On the basis of formulas (9)-(14), the connection between the projections $\mathbf{v_{x1}}$, $\mathbf{v_{y1}}$ and $\mathbf{v_{z1}}$ on the axis of Cartesian coordinates of the speed of the motion of point at the moment of time t_1 in the fixed inertial reference system $\mathbf{O_1x_1y_1z_1}$ and the analogous projections $\mathbf{v_{x2}}$, $\mathbf{v_{y2}}$ and $\mathbf{v_{z2}}$ of the speed of the same point in the mobile inertial reference system $\mathbf{O_2x_2y_2z_2}$ at the moment of time t_2, corresponding to moment of time t_1 in the fixed inertial reference system $\mathbf{O_1x_1y_1z_1}$, is determined in the form (Einstein's equations for the relativistic addition of velocities):

$$v_{x1} = \frac{v_{x2} + V}{1 + \frac{V \cdot v_{x2}}{c^2}} \qquad (15)$$

$$v_{x2} = \frac{v_{x1} - V}{1 - \frac{V \cdot v_{x1}}{c^2}} \qquad (16)$$

$$v_{y1} = \frac{v_{y2} \cdot \sqrt{1 - \frac{V^2}{c^2}}}{1 + \frac{V \cdot v_{x2}}{c^2}} \qquad (17)$$

$$v_{y2} = \frac{v_{y1} \cdot \sqrt{1 - \frac{V^2}{c^2}}}{1 - \frac{V \cdot v_{x1}}{c^2}} \qquad (18)$$

$$v_{z1} = \frac{v_{z2} \cdot \sqrt{1 - \frac{V^2}{c^2}}}{1 + \frac{V \cdot v_{x2}}{c^2}} \qquad (19)$$

$$v_{z2} = \frac{v_{z1} \cdot \sqrt{1 - \frac{V^2}{c^2}}}{1 - \frac{V \cdot v_{x1}}{c^2}} \qquad (20)$$

In the special theory of relativity the dependences of mass **M(v)** , momentum **P(v)** and kinetic energy $\mathbf{E_к(v)}$ of the material point, which moves with a speed **v**, are expressed by the formulas:

$$M = \frac{M_0}{\sqrt{1 - \frac{v^2}{c^2}}} \qquad (21)$$

$$P(V) = \frac{M_0 \cdot v}{\sqrt{1 - \frac{v^2}{c^2}}} \qquad (22)$$

$$E_k(V) = M_0 \cdot c^2 \cdot \left(\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1 \right) \qquad (23)$$

where: $\mathbf{M_o}$ - mass of this material point in the state of rest.

2. Equations of relation between the coordinates and the time in the inertial reference systems

2.1. Equations of relation between the coordinates and the time in the inertial reference systems in general form

Task: to write down the equations of relation between the coordinates and the time in the inertial reference systems, trying without the need not to use the principle of the constancy of the speed of light.

Let us assume that space is uniform and it is isotropic, and time is uniform (i.e. there is a symmetry of space and time).

With the examination we will use the law of relativity only: **in any inertial reference systems all physical phenomena with one and the same conditions flow equally**.

Let us assume that there are two inertial reference systems: fixed $\mathbf{O_1x_1y_1z_1}$ and mobile $\mathbf{O_2x_2y_2z_2}$, depicted in Fig. 1 and in which:

- the similar axes of the Cartesian coordinates of the systems $\mathbf{O_1x_1y_1z_1}$ and $\mathbf{O_2x_2y_2z_2}$ are in pairs parallel and it is equally directed;

- the system $\mathbf{O_2x_2y_2z_2}$ moves relative to the system $\mathbf{O_1x_1y_1z_1}$ with a constant speed $\mathbf{V_2}$ relative to the axis $\mathbf{Ox_1}$;

- the system $\mathbf{O_1x_1y_1z_1}$ moves relative to the system $\mathbf{O_2x_2y_2z_2}$ with a constant speed $\mathbf{V_1}$ relative to the axis $\mathbf{Ox_2}$;

- as the zero time reference (t_1=0 and t_2=0) in both systems is selected that moment, when the origins of the coordinates $\mathbf{O_1}$ and $\mathbf{O_2}$ of these systems coincide.

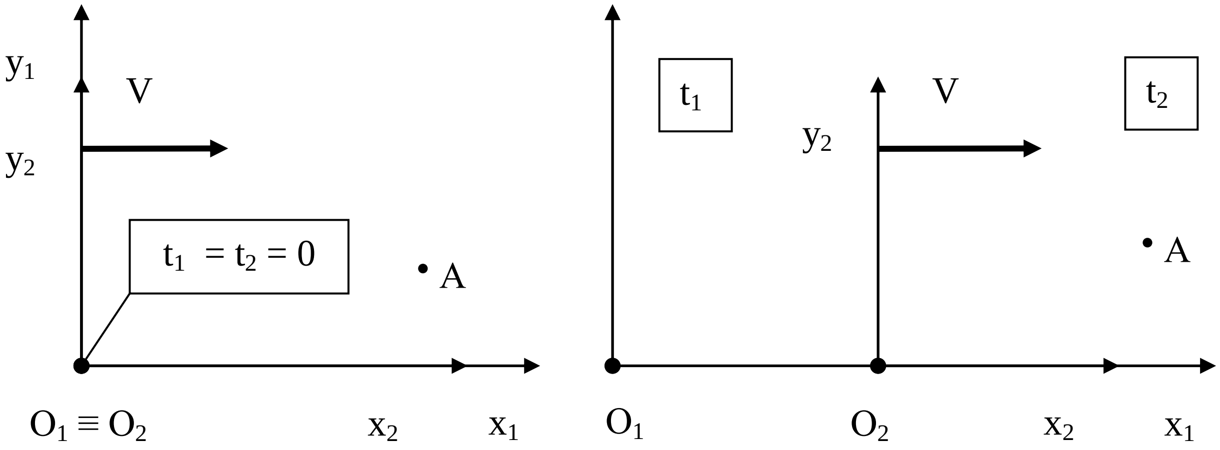

Fig. 1

On the basis of the symmetry of spaces and time, relationship between the coordinates and the time of one and the same event in two inertial reference systems the fixed $\mathbf{O_1x_1y_1z_1}$ and the mobile $\mathbf{O_2x_2y_2z_2}$ they can be recorded as follows:

$$x_1 = \beta_1 \cdot [x_2 + (V_1 \cdot t_2)] \qquad (24)$$

$$x_2 = \beta_2 \cdot [x_1 + (V_2 \cdot t_1)] \qquad (25)$$

$$y_1 = \beta_3 \cdot y_2 \qquad (26)$$

$$y_2 = \beta_4 \cdot y_1 \qquad (27)$$

$$z_1 = \beta_5 \cdot z_2 \qquad (28)$$

$$z_2 = \beta_6 \cdot z_1 \qquad (29)$$

where: $\mathbf{x_1}$, $\mathbf{y_1}$, $\mathbf{z_1}$ and $\mathbf{x_2}$, $\mathbf{y_2}$, $\mathbf{z_2}$ – coordinate of point **A** in the reference systems $\mathbf{O_1x_1y_1z_1}$ and $\mathbf{O_2x_2y_2z_2}$, respectively;

t_1 and t_2 - value of time in the reference systems $\mathbf{O_1x_1y_1z_1}$ and $\mathbf{O_2x_2y_2z_2}$, respectively;

β_1, β_2, β_3, β_4, β_5 and β_6 - conversion coefficients;

$\mathbf{V_1}$ - speed of the motion of the system $\mathbf{O_1x_1y_1z_1}$ relative to the system $\mathbf{O_2x_2y_2z_2}$.

The use of the law of relativity and symmetry of space and time makes it possible to obtain:

$$V_1 = -V_2 = V \qquad (30)$$

$$\beta_1 = \beta_2 = \beta \qquad (31)$$

$$\beta_3 = \beta_4 = 1 \qquad (32)$$

$$\beta_5 = \beta_6 = 1 \qquad (33)$$

In this case the system of equations (24) - (29) will become simpler and signs the form:

$$x_1 = \beta \cdot [x_2 + (V \cdot t_2)] \qquad (34)$$

$$x_2 = \beta \cdot [x_1 - (V \cdot t_1)] \qquad (35)$$

$$y_1 = y_2 \qquad (36)$$

$$z_1 = z_2 \qquad (37)$$

The value of conversion coefficient **β** does not depend on the values of coordinates $\mathbf{x_1}$, $\mathbf{y_1}$, $\mathbf{z_1}$, $\mathbf{x_2}$, $\mathbf{y_2}$, $\mathbf{z_2}$ and time $\boldsymbol{t_1}$ and $\boldsymbol{t_2}$, but supposedly it can be the function of speed **V** displacement of the reference systems $\mathbf{O_1x_1y_1z_1}$ and $\mathbf{O_2x_2y_2z_2}$ relative to each other.

Moreover, taking into account one the directivity of the axes $\mathbf{O_1x_1}$ and $\mathbf{O_2x_2}$, accepted, it is possible to note that the value of conversion coefficient **β** always must be more than zero.

From formulas (34) and (35) it is possible to write down dependence for the values of times $\boldsymbol{t_1}$ and $\boldsymbol{t_2}$:

$$t_1 = \frac{(\beta^2 - 1) \cdot x_2}{\beta \cdot V} + (\beta \cdot t_2) \qquad (38)$$

$$t_2 = \frac{(1 - \beta^2) \cdot x_1}{\beta \cdot V} + (\beta \cdot t_1) \qquad (39)$$

Using formulas (24) - (39), it is possible to obtain the single-valued connection between the projections $\mathbf{v_{x1}}$, $\mathbf{v_{y1}}$ and $\mathbf{v_{z1}}$ on the axis of Cartesian coordinates of the speed of the motion of point at the moment of time $\boldsymbol{t_1}$ in the fixed inertial reference system $\mathbf{O_1x_1y_1z_1}$ and the analogous projections $\mathbf{v_{x2}}$, $\mathbf{v_{y2}}$ and $\mathbf{v_{z2}}$ of the speed of the same point in the mobile inertial reference system $\mathbf{O_2x_2y_2z_2}$ at the moment of time $\boldsymbol{t_2}$, corresponding to moment of time $\boldsymbol{t_1}$ in the fixed inertial reference system $\mathbf{O_1x_1y_1z_1}$:

$$v_{x1} = \frac{v_{x2} + V}{\dfrac{(\beta^2 - 1) \cdot v_{x2}}{\beta^2 \cdot V} + 1} \qquad (40)$$

$$v_{x2} = \frac{v_{x1} - V}{\frac{(1 - \beta^2) \cdot v_{x1}}{\beta^2 \cdot V} + 1} \quad (41)$$

$$v_{y1} = \frac{v_{y2}}{\frac{(\beta^2 - 1) \cdot v_{x2}}{\beta \cdot V} + \beta} \quad (42)$$

$$v_{y2} = \frac{v_{y1}}{\frac{(1 - \beta^2) \cdot v_{x1}}{\beta \cdot V} + \beta} \quad (43)$$

$$v_{z1} = \frac{v_{z2}}{\frac{(\beta^2 - 1) \cdot v_{x2}}{\beta \cdot V} + \beta} \quad (44)$$

$$v_{z2} = \frac{v_{z1}}{\frac{(1 - \beta^2) \cdot v_{x1}}{\beta \cdot V} + \beta} \quad (45)$$

From formulas (38) - (45) can be obtained the single-valued connection between the projections $\boldsymbol{a}_{x1}$, $\boldsymbol{a}_{y1}$ and $\boldsymbol{a}_{z1}$ on the axis of Cartesian coordinates of the acceleration of the motion of point at the moment of time $\boldsymbol{t_1}$ in the fixed inertial reference system $\mathbf{O_1x_1y_1z_1}$ and the analogous projections $\boldsymbol{a}_{x2}$, $\boldsymbol{a}_{y2}$ and $\boldsymbol{a}_{z2}$ of the acceleration of the same point in the mobile inertial reference system $\mathbf{O_2x_2y_2z_2}$ at the moment of time $\boldsymbol{t_2}$, corresponding to moment of time $\boldsymbol{t_1}$ in the fixed inertial reference system $\mathbf{O_1x_1y_1z_1}$:

$$a_{x1} = \frac{a_{x2}}{\beta^3 \cdot \left[\frac{(\beta^2 - 1) \cdot v_{x2}}{\beta^2 \cdot V} + 1\right]^3} \quad (46)$$

$$a_{x2} = \frac{a_{x1}}{\beta^3 \cdot \left[\frac{(1 - \beta^2) \cdot v_{x1}}{\beta^2 \cdot V} + 1\right]^3} \quad (47)$$

$$a_{y1} = \frac{\left\{a_{y2} \cdot \left[\frac{(\beta^2 - 1) \cdot v_{x2}}{\beta \cdot V} + \beta\right]\right\} - \frac{(\beta^2 - 1) \cdot a_{x2} \cdot v_{y2}}{\beta \cdot V}}{\left[\frac{(\beta^2 - 1) \cdot v_{x2}}{\beta \cdot V} + \beta\right]^3} \quad (48)$$

$$a_{y2} = \frac{\left\{a_{y1} \cdot \left[\frac{(1 - \beta^2) \cdot v_{x1}}{\beta \cdot V} + \beta\right]\right\} - \frac{(1 - \beta^2) \cdot a_{x1} \cdot v_{y1}}{\beta \cdot V}}{\left[\frac{(1 - \beta^2) \cdot v_{x1}}{\beta \cdot V} + \beta\right]^3} \quad (49)$$

$$a_{z1} = \frac{\left\{a_{z2}\cdot\left[\frac{(\beta^2 - 1)\cdot v_{x2}}{\beta\cdot V} + \beta\right]\right\} - \frac{(\beta^2 - 1)\cdot a_{x2}\cdot v_{z2}}{\beta\cdot V}}{\left[\frac{(\beta^2 - 1)\cdot v_{x2}}{\beta\cdot V} + \beta\right]^3} \qquad (50)$$

$$a_{z2} = \frac{\left\{a_{z1}\cdot\left[\frac{(1 - \beta^2)\cdot v_{x1}}{\beta\cdot V} + \beta\right]\right\} - \frac{(1 - \beta^2)\cdot a_{x1}\cdot v_{z1}}{\beta\cdot V}}{\left[\frac{(1 - \beta^2)\cdot v_{x1}}{\beta\cdot V} + \beta\right]^3} \qquad (51)$$

2.2. Equation of relation for the conversion coefficients

Task: to determine the connection between the conversion coefficients for the inertial reference systems.

Three inertial reference systems will examine: fixed $\mathbf{O_1x_1y_1z_1}$ and mobile $\mathbf{O_2x_2y_2z_2}$ and $\mathbf{O_3x_3y_3z_3}$, shown in Fig. 2 and in which:

- the similar axes of the Cartesian coordinates of the systems $\mathbf{O_1x_1y_1z_1}$, $\mathbf{O_2x_2y_2z_2}$ and $\mathbf{O_3x_3y_3z_3}$ are in pairs parallel and it is equally directed;

- the system $\mathbf{O_2x_2y_2z_2}$ moves relative to the system $\mathbf{O_1x_1y_1z_1}$ with a constant speed $\mathbf{V_2}$ relative to the axis $\mathbf{Ox_1}$;

- the system $\mathbf{O_3x_3y_3z_3}$ moves relative to the system $\mathbf{O_1x_1y_1z_1}$ with a constant speed $\mathbf{V_3}$ relative to the axis $\mathbf{Ox_1}$;

- as the zero time reference ($\mathbf{t_1}$=0 , $\mathbf{t_2}$=0 and $\mathbf{t_3}$=0) in these three systems is selected that moment, when their origins of coordinates $\mathbf{O_1}$, $\mathbf{O_2}$ and $\mathbf{O_3}$ coincide.

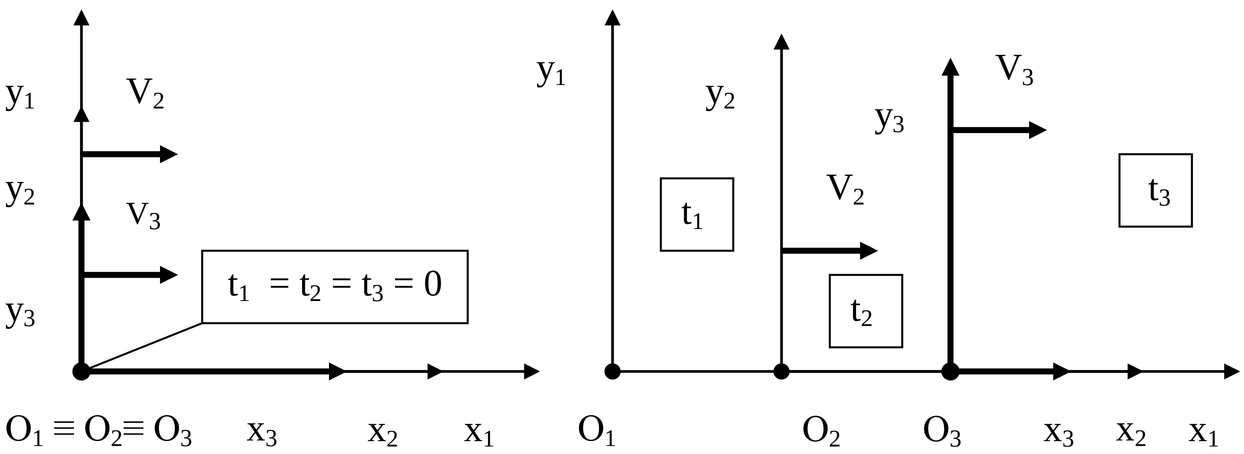

Fig. 2

Relying on formula (41), it is possible to determine the value of the speed $\mathbf{V_{23}}$ of the motion of point $\mathbf{O_3}$ relative to point $\mathbf{O_2}$:

$$V_{23} = \frac{V_3 - V_2}{\frac{(1 - \beta_2^2) \cdot V_3}{\beta_2^2 \cdot V_2} + 1} \tag{52}$$

and the value of the speed $\mathbf{V_{32}}$ of the motion of point $\mathbf{O_2}$ relative to point $\mathbf{O_3}$:

$$V_{32} = \frac{V_2 - V_3}{\frac{(1 - \beta_3^2) \cdot V_2}{\beta_3^2 \cdot V_3} + 1} \tag{53}$$

where: $\boldsymbol{\beta_2}$ and $\boldsymbol{\beta_3}$ - conversion coefficients for the inertial reference systems, which move relative to fixed reference system of reference with a speed $\mathbf{V_2}$ and $\mathbf{V_3}$, respectively.

Using the law of relativity, according to which the point $\mathbf{O_3}$ will be moved away relative to point $\mathbf{O_2}$ with speed, equal in the absolute value it is opposite to the directed speed, with which the point $\mathbf{O_2}$ is moved away relative to point $\mathbf{O_3}$, i.e.:

$$V_{32} = - V_{23} \tag{54}$$

After substituting equation (54) into formulas (52) and (53), we will obtain:

$$\frac{(1 - \beta_2^2) \cdot V_3}{\beta_2^2 \cdot V_2} + 1 = \frac{(1 - \beta_3^2) \cdot V_2}{\beta_3^2 \cdot V_3} + 1 \tag{55}$$

Hence equation for the conversion coefficients $\boldsymbol{\beta_2}$ and $\boldsymbol{\beta_3}$ will be written down as follows:

$$\beta_3^2 = \frac{\beta_2^2 \cdot V_2^2}{V_3^2 - (\beta_2^2 \cdot V_3^2) + (\beta_2^2 \cdot V_2^2)} \tag{56}$$

2.3. Obtaining dependence for the conversion coefficient β

Task: to obtain the dependence of conversion coefficient **β** from the speed **V**.

From equation (55) it is possible to obtain the formula:

$$\frac{\beta_2^2 - 1}{\beta_2^2 \cdot V_2^2} = \frac{\beta_3^2 - 1}{\beta_3^2 \cdot V_3^2} \qquad (57)$$

Since the values of the conversion coefficients of $\boldsymbol{\beta_2}$ and $\boldsymbol{\beta_3}$ do not depend on each other, but they depend only on speeds $\mathbf{V_2}$ and $\mathbf{V_3}$, correspondingly, and speeds $\mathbf{V_2}$ and $\mathbf{V_3}$ were assigned arbitrarily (also they do not depend on each other), then it is possible to say that:

$$\frac{\beta_2^2 - 1}{\beta_2^2 \cdot V_2^2} = \frac{\beta_3^2 - 1}{\beta_3^2 \cdot V_3^2} = K = Const \qquad (58)$$

i.e. it is obtained in general form, that:

$$\frac{\beta^2 - 1}{\beta^2 \cdot V^2} = K = Const \qquad (59)$$

where: **К** - the constant, which is independent of the speed **V** and value of conversion coefficient **β**.

After squaring both parts of the equation we will obtain:

$$\left(\frac{\beta^2 - 1}{\beta^2 \cdot V^2}\right)^2 = K^2 \qquad (60)$$

that with any values of conversion coefficient **β** the constant, equal $\mathbf{K^2}$, can have only positive value.

As can be seen from formula (59), depending on the value of conversion coefficient **β** the constant **К** can have the following values:

- with $\boldsymbol{\beta = 1}$ constant **К** will be equal to 0;

- if conversion coefficient $\boldsymbol{\beta > 1}$, then constant **К** will have positive value, i.e., $\mathbf{K} > 0$;

- if conversion coefficient $\mathbf{0} < \boldsymbol{\beta} < \mathbf{1}$, then constant **К** will have negative value, i.e., $\mathbf{K} < \mathbf{0}$.

From equation (59) it is possible to obtain formula for the conversion coefficient **β**:

$$\beta^2 = \frac{1}{1 - (K \cdot V^2)} \qquad (61)$$

For the larger clarity with the examination let us assume that:

- with the values of conversion coefficient $\boldsymbol{\beta > 1}$ the constant **K** are equal:

$$K = \frac{1}{C_1^2} \tag{62}$$

- with the values of conversion coefficient $\boldsymbol{0 < \beta < 1}$ constant **K** are equal:

$$K = -\frac{1}{C_2^2} \tag{63}$$

where: $\mathbf{C_1}$ and $\mathbf{C_2}$ - real constants.

2.4. Determination of the special speed

Task: to determine possibly existence of the equality of the projections $\mathbf{v_{x1}}$ and $\mathbf{v_{x2}}$ of the speeds of the motion of one and the same point; if this equality is possible, then with what values of conversion coefficient $\boldsymbol{\beta}$.

Let us assume that there is this value $\mathbf{V_{хкр}}$ of the projection $\mathbf{v_{x1}}$ of the speed of the motion of point **A** in the fixed reference system $\mathbf{O_1x_1y_1z_1}$, to which would correspond the value of the projection $\mathbf{v_{x2}}$ of the speed of the motion of point **A** in the mobile inertial reference system $\mathbf{O_2x_2y_2z_2}$, equal $\mathbf{V_{хкр}}$, i.e., when:

$$v_{x1} = v_{x2} = V_{хкр} \tag{64}$$

After substituting value (64) into formula (40) or (41), we will obtain:

$$V_{хкр}^2 = \frac{\beta^2 \cdot V^2}{\beta^2 - 1} \tag{65}$$

From formula (65) follows the dependence of the special speed $\mathbf{V_{хкр}}$ on the speed **V** and conversion coefficient $\boldsymbol{\beta}$:

$$V_{хкр} = \pm \frac{\beta \cdot V}{\sqrt{\beta^2 - 1}} \tag{66}$$

As can be seen from formula (66):

- with the values of conversion coefficient $\boldsymbol{\beta}$, which are been located in the range $\boldsymbol{\beta > 1}$ equality of the projections $\mathbf{v_{x1}}$ and $\mathbf{v_{x2}}$ of speeds is possible, since with $\boldsymbol{\beta > 1}$ the special speed $\mathbf{V_{хкр}}$ will have actual value;

- with the values of conversion coefficient $\boldsymbol{\beta}$, which are been located in the range $\boldsymbol{0 < \beta < 1}$ equality of the projections $\mathbf{v_{x1}}$ and $\mathbf{v_{x2}}$ of speeds not possibly, i.e., the value $\mathbf{v_{x1}}$ never can be equal to the value $\mathbf{v_{x2}}$, since with $\mathbf{0 < \beta < 1}$ special speed $\mathbf{V_{xкр}}$ will have imaginary value.

From formula (65) it is possible to obtain the dependence of conversion coefficient **β** from the speed **V**:

$$\beta^2 = \frac{1}{1 - \frac{V^2}{V_{xкр}^2}} \qquad (67)$$

If we return ourselves to formula (61):

$$\beta^2 = \frac{1}{1 - (K \cdot V^2)} \qquad (61)$$

and to compare it with formula (67), then it is possible to note that:

$$K = \frac{1}{V_{xкр}^2} \qquad (68)$$

i.e., since. constant **К** – is constant, then $\mathbf{V_{xкр}}^{\mathbf{2}}$ will be the constant, which does not depend on the values of the speed **V** and conversion coefficient **β**.

2.5. Fundamental kinematic equations for the case, when $\boldsymbol{\beta > 1}$

Using formula (61) taking into account equation (62) for the conversion coefficient **β**, which has values $\boldsymbol{\beta} > 1$ and which let us designate as $\boldsymbol{\beta}_>$, it is possible to write down:

$$\beta_>^2 = \frac{1}{1 - \frac{V^2}{C_1^2}} \qquad (69)$$

After substituting formula (69) into equations (34), (35), (38) - (39), (40) - (45) and (46) - (51), we will obtain the following system of equations with the conversion coefficient $\boldsymbol{\beta = \beta_>}$:

$$x_{1>} = \frac{x_{2>} + (V \cdot t_{2>})}{\sqrt{1 - \frac{V^2}{C_1^2}}} \qquad (70)$$

$$x_{2>} = \frac{x_{1>} - (V \cdot t_{1>})}{\sqrt{1 - \frac{V^2}{C_1^2}}} \qquad (71)$$

$$t_{1>} = \frac{t_{2>} + \frac{V \cdot x_{2>}}{C_1^2}}{\sqrt{1 - \frac{V^2}{C_1^2}}} \qquad (72)$$

$$t_{2>} = \frac{t_{1>} - \frac{V \cdot x_{1>}}{C_1^2}}{\sqrt{1 - \frac{V^2}{C_1^2}}} \qquad (73)$$

$$v_{x1>} = \frac{v_{x2>} + V}{1 + \frac{V \cdot v_{x2>}}{C_1^2}} \qquad (74)$$

$$v_{x2>} = \frac{v_{x1>} - V}{1 - \frac{V \cdot v_{x1>}}{C_1^2}} \qquad (75)$$

$$v_{y1>} = \frac{v_{y2>} \cdot \sqrt{1 - \frac{V^2}{C_1^2}}}{1 + \frac{V \cdot v_{x2>}}{C_1^2}} \qquad (76)$$

$$v_{y2>} = \frac{v_{y1>} \cdot \sqrt{1 - \frac{V^2}{C_1^2}}}{1 - \frac{V \cdot v_{x1>}}{C_1^2}} \qquad (77)$$

$$\mathrm{v}_{z1>} = \frac{\mathrm{v}_{z2>} \cdot \sqrt{1 - \frac{V^2}{C_1^2}}}{1 + \frac{V \cdot \mathrm{v}_{x2>}}{C_1^2}} \qquad (78)$$

$$\mathrm{v}_{z2>} = \frac{\mathrm{v}_{z1>} \cdot \sqrt{1 - \frac{V^2}{C_1^2}}}{1 - \frac{V \cdot \mathrm{v}_{x1>}}{C_1^2}} \qquad (79)$$

$$a_{x1>} = \frac{a_{x2>} \cdot \left(\sqrt{1 - \frac{V^2}{C_1^2}}\right)^3}{\left(1 + \frac{V \cdot \mathrm{v}_{x2>}}{C_1^2}\right)^3} \qquad (80)$$

$$a_{x2>} = \frac{a_{x1>} \cdot \left(\sqrt{1 - \frac{V^2}{C_1^2}}\right)^3}{\left(1 - \frac{V \cdot \mathrm{v}_{x1>}}{C_1^2}\right)^3} \qquad (81)$$

$$a_{y1>} = \frac{\left\{\left[a_{y2>} \cdot \left(1 + \frac{V \cdot \mathrm{v}_{x2>}}{C_1^2}\right)\right] - \frac{V \cdot a_{x2>} \cdot \mathrm{v}_{y2>}}{C_1^2}\right\} \cdot \left(1 - \frac{V^2}{C_1^2}\right)}{\left(1 + \frac{V \cdot \mathrm{v}_{x2>}}{C_1^2}\right)^3} \qquad (82)$$

$$a_{y2>} = \frac{\left\{\left[a_{y1>} \cdot \left(1 - \frac{V \cdot \mathrm{v}_{x1>}}{C_1^2}\right)\right] + \frac{V \cdot a_{x1>} \cdot \mathrm{v}_{y1>}}{C_1^2}\right\} \cdot \left(1 - \frac{V^2}{C_1^2}\right)}{\left(1 - \frac{V \cdot \mathrm{v}_{x1>}}{C_1^2}\right)^3} \qquad (83)$$

$$a_{z1>} = \frac{\left\{\left[a_{z2>} \cdot \left(1 + \frac{V \cdot \mathrm{v}_{x2>}}{C_1^2}\right)\right] - \frac{V \cdot a_{x2>} \cdot \mathrm{v}_{z2>}}{C_1^2}\right\} \cdot \left(1 - \frac{V^2}{C_1^2}\right)}{\left(1 + \frac{V \cdot \mathrm{v}_{x2>}}{C_1^2}\right)^3} \qquad (84)$$

$$a_{z2>} = \frac{\left\{\left[a_{z1>} \cdot \left(1 - \frac{V \cdot v_{x1>}}{C_1^2}\right)\right] + \frac{V \cdot a_{x1>} \cdot v_{z1>}}{C_1^2}\right\} \cdot \left(1 - \frac{V^2}{C_1^2}\right)}{\left(1 - \frac{V \cdot v_{x1>}}{C_1^2}\right)^3} \quad (85)$$

2.6. Fundamental kinematic equations for the case, when $\mathbf{0 < \beta < 1}$

Using formula (61) taking into account equation (63) for the conversion coefficient **β**, which has values of $\mathbf{0 < \beta <} 1$ and which let us designate as $\boldsymbol{\beta}_<$**,** it is possible to write down:

$$\beta_<^2 = \frac{1}{1 + \frac{V^2}{C_2^2}} \quad (86)$$

After substituting formula (86) into equations (34), (35), (38) - (39), (40) - (45) and (46) - (51), we will obtain the following system of equations with the conversion coefficient $\boldsymbol{\beta} = \boldsymbol{\beta}_<$:

$$x_{1<} = \frac{x_{2<} + (V \cdot t_{2<})}{\sqrt{1 + \frac{V^2}{C_2^2}}} \quad (87)$$

$$x_{2<} = \frac{x_{1<} - (V \cdot t_{1<})}{\sqrt{1 + \frac{V^2}{C_2^2}}} \quad (88)$$

$$t_{1<} = \frac{t_{2<} - \frac{V \cdot x_{2<}}{C_2^2}}{\sqrt{1 + \frac{V^2}{C_2^2}}} \quad (89)$$

$$t_{2<} = \frac{t_{1<} + \frac{V \cdot x_{1<}}{C_2^2}}{\sqrt{1 + \frac{V^2}{C_2^2}}} \quad (90)$$

$$v_{x1<} = \frac{v_{x2<} + V}{1 - \frac{V \cdot v_{x2<}}{C_2^2}} \quad (91)$$

$$v_{x2<} = \frac{v_{x1<} - V}{1 + \frac{V \cdot v_{x1<}}{C_2^2}} \qquad (92)$$

$$v_{y1<} = \frac{v_{y2<} \cdot \sqrt{1 + \frac{V^2}{C_2^2}}}{1 - \frac{V \cdot v_{x2<}}{C_2^2}} \qquad (93)$$

$$v_{y2<} = \frac{v_{y1<} \cdot \sqrt{1 + \frac{V^2}{C_2^2}}}{1 + \frac{V \cdot v_{x1<}}{C_2^2}} \qquad (94)$$

$$v_{z1<} = \frac{v_{z2<} \cdot \sqrt{1 + \frac{V^2}{C_2^2}}}{1 - \frac{V \cdot v_{x2<}}{C_2^2}} \qquad (95)$$

$$v_{z2<} = \frac{v_{z1<} \cdot \sqrt{1 + \frac{V^2}{C_2^2}}}{1 + \frac{V \cdot v_{x1<}}{C_2^2}} \qquad (96)$$

$$a_{x1<} = \frac{a_{x2<} \cdot \left(\sqrt{1 + \frac{V^2}{C_2^2}}\right)^3}{\left(1 - \frac{V \cdot v_{x2<}}{C_2^2}\right)^3} \qquad (97)$$

$$a_{x2<} = \frac{a_{x1<} \cdot \left(\sqrt{1 + \frac{V^2}{C_2^2}}\right)^3}{\left(1 + \frac{V \cdot v_{x1\leq}}{C_2^2}\right)^3} \quad (98)$$

$$a_{y1<} = \frac{\left\{\left[a_{y2<} \cdot \left(1 - \frac{V \cdot v_{x2\leq}}{C_2^2}\right)\right] + \frac{V \cdot a_{x2<} \cdot v_{y2<}}{C_2^2}\right\} \cdot \left(1 + \frac{V^2}{C_2^2}\right)}{\left(1 - \frac{V \cdot v_{x2\leq}}{C_2^2}\right)^3} \quad (99)$$

$$a_{y2<} = \frac{\left\{\left[a_{y1<} \cdot \left(1 + \frac{V \cdot v_{x1\leq}}{C_2^2}\right)\right] - \frac{V \cdot a_{x1<} \cdot v_{y1<}}{C_2^2}\right\} \cdot \left(1 + \frac{V^2}{C_2^2}\right)}{\left(1 + \frac{V \cdot v_{x1\leq}}{C_2^2}\right)^3} \quad (100)$$

$$a_{z1<} = \frac{\left\{\left[a_{z2<} \cdot \left(1 - \frac{V \cdot v_{x2\leq}}{C_2^2}\right)\right] + \frac{V \cdot a_{x2<} \cdot v_{z2<}}{C_2^2}\right\} \cdot \left(1 + \frac{V^2}{C_2^2}\right)}{\left(1 - \frac{V \cdot v_{x2\leq}}{C_2^2}\right)^3} \quad (101)$$

$$a_{z2<} = \frac{\left\{\left[a_{z1<} \cdot \left(1 + \frac{V \cdot v_{x1\leq}}{C_2^2}\right)\right] - \frac{V \cdot a_{x1<} \cdot v_{z1<}}{C_2^2}\right\} \cdot \left(1 + \frac{V^2}{C_2^2}\right)}{\left(1 + \frac{V \cdot v_{x1\leq}}{C_2^2}\right)^3} \quad (102)$$

2.7. Comparative graphic representation of the basic kinematic of equation for the cases, when $\boldsymbol{\beta} > 1$ and $\mathbf{0} < \boldsymbol{\beta} < 1$

The graph of the dependence of the length of the section $\boldsymbol{\Delta x_1}$ in the fixed reference system $\mathbf{O_1x_1y_1z_1}$, to which in the mobile inertial reference system $\mathbf{O_2x_2y_2z_2}$ corresponds the section $\boldsymbol{\Delta x_2}$, whose ends are fixed, from the speed **V**:

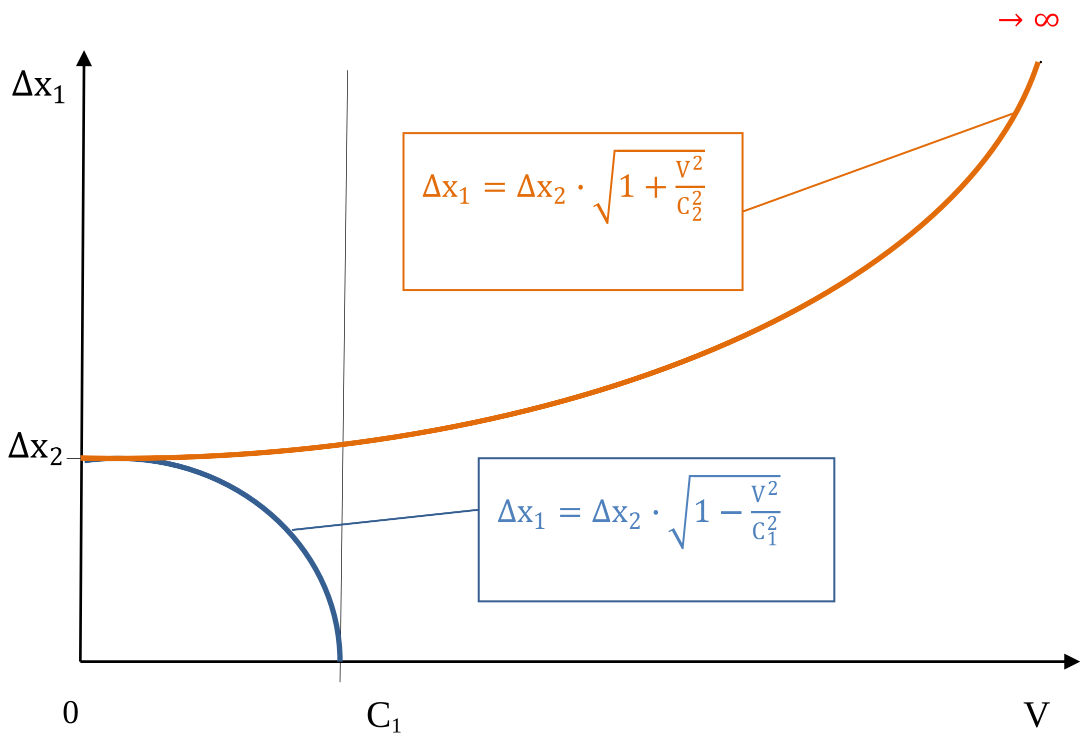

Fig.3

The graph of the dependence of the time interval $\boldsymbol{\Delta t_1}$ between two events in the fixed reference system $\mathbf{O_1x_1y_1z_1}$, which in the mobile inertial reference system $\mathbf{O_2x_2y_2z_2}$ occurred into the time interval $\boldsymbol{\Delta t_2}$ at one and the same point, from the speed **V**:

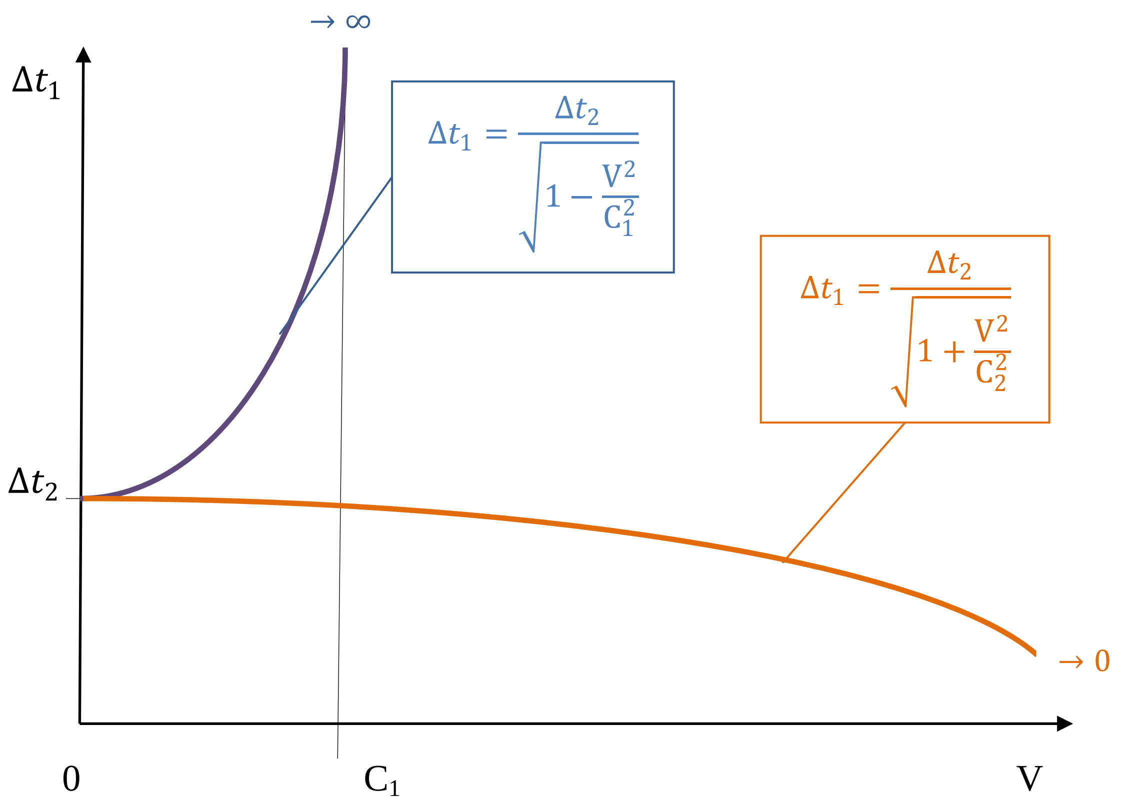

Fig.4

Graph of dependence between the projection $\mathbf{v_{x2}}$ of the speed of the motion of point in the mobile system $\mathbf{O_2x_2y_2z_2}$ and the projection $\mathbf{v_{x1}}$ of the speed of this point in the fixed system $\mathbf{O_1x_1y_1z_1}$ (with a constant speed $\mathbf{V}$):

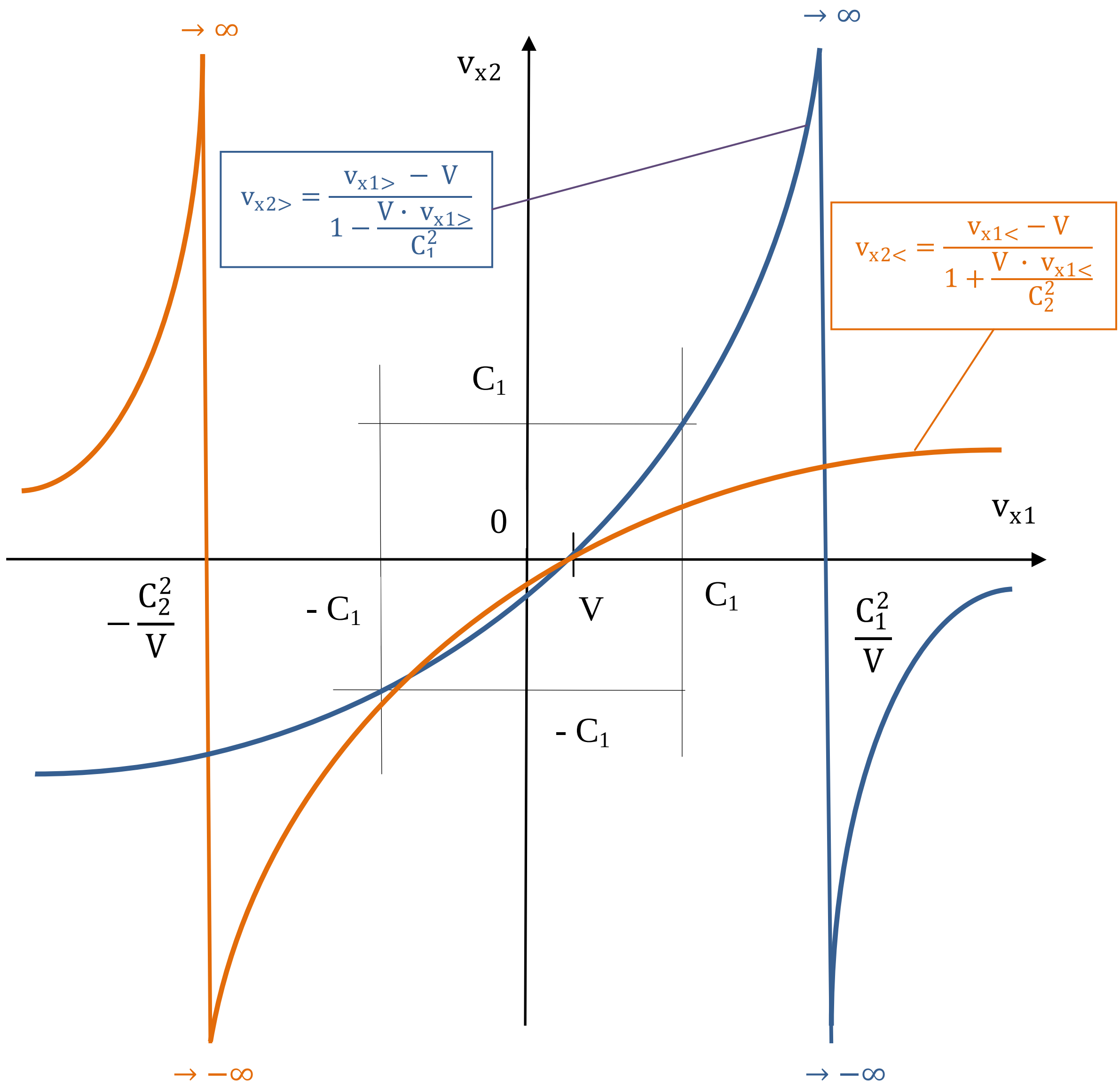

Fig.5

Graph of dependence between the projection $\mathbf{v_{x1}}$ of the speed of the motion of point in the mobile system $\mathbf{O_1x_1y_1z_1}$ and the projection $\mathbf{v_{x2}}$ of the speed of this point in the fixed system $\mathbf{O_2x_2y_2z_2}$ (with a constant speed $\mathbf{V}$):

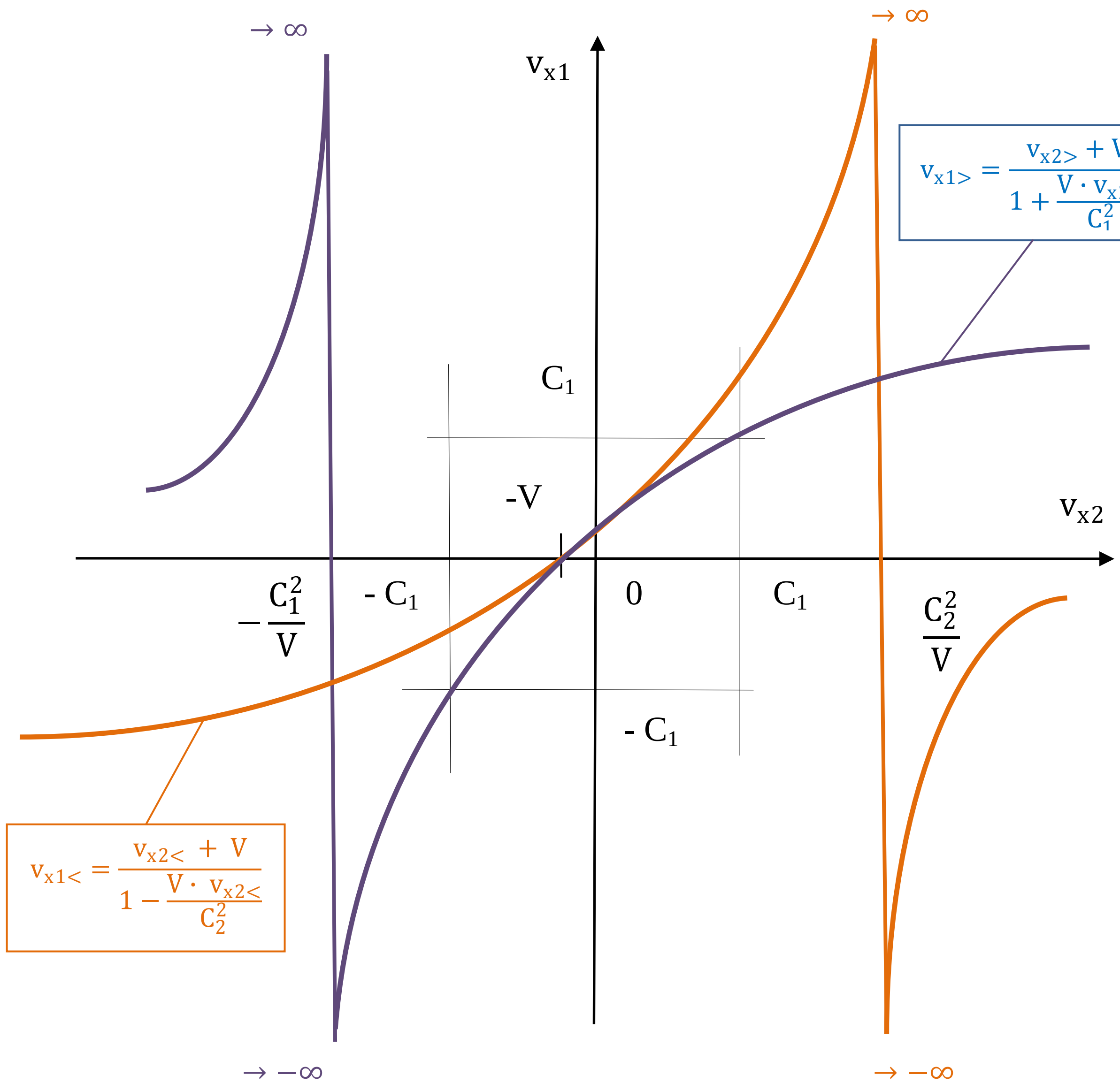

Fig.6

Graph of dependence between the projection $\boldsymbol{a}_{x2}$ of the acceleration of the motion of point in the mobile system $\mathbf{O_2x_2y_2z_2}$ and the projection $\mathbf{v}_{x1}$ of the speed of this point in the fixed system $\mathbf{O_1x_1y_1z_1}$ (with a constant speed $\mathbf{V}$ and constant quantity of the projection $\boldsymbol{a}_{x1}$ of acceleration):

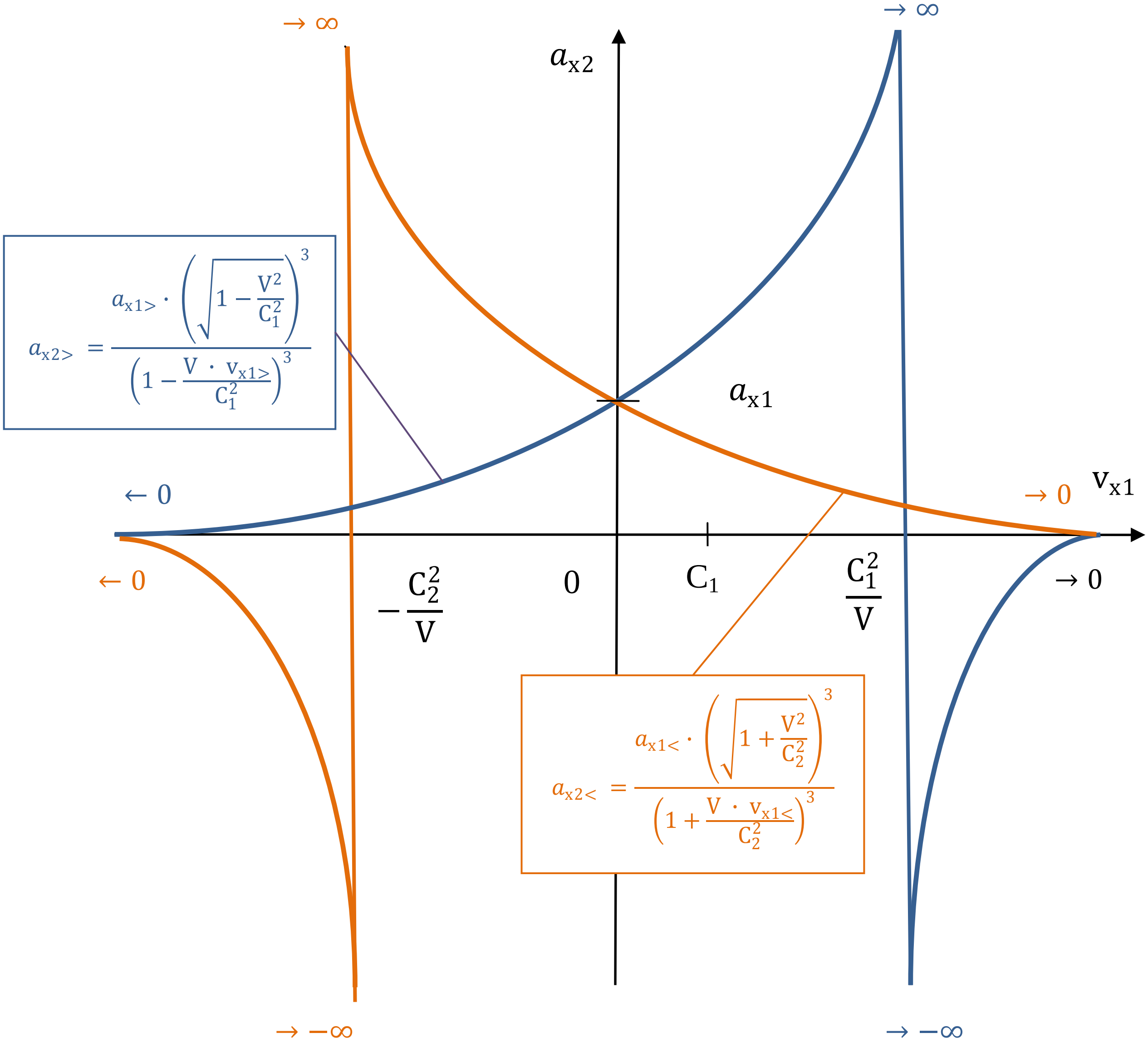

Fig.7

Graph of dependence between the projection $\boldsymbol{a}_{x1}$ of the acceleration of the motion of point in the mobile system $\mathbf{O_2x_2y_2z_2}$ and the projection $\mathbf{v}_{x2}$ of the speed of this point in the fixed system $\mathbf{O_1x_1y_1z_1}$ (with a constant speed $\mathbf{V}$ and constant quantity of the projection $\boldsymbol{a}_{x2}$ of acceleration):

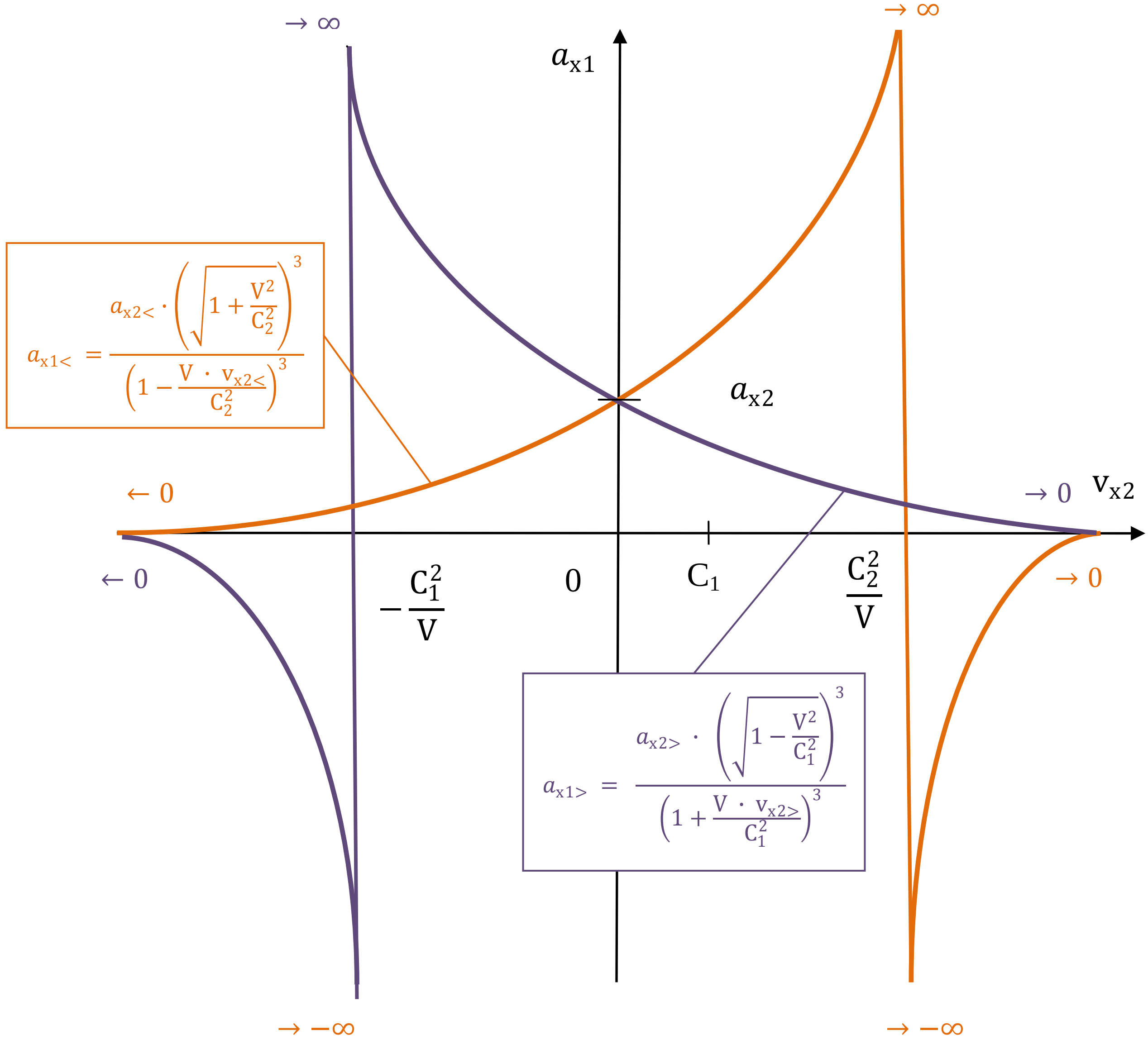

Fig.8

3. Dependence of mass, momentum and kinetic energy of the moving body on the speed

3.1. Formulas of the dependence of mass, momentum and kinetic energy of the moving body on the speed with the conversion coefficient $\boldsymbol{\beta} > 1$

For the case, when the value of conversion coefficient **β** is located in the range $\boldsymbol{\beta} > 1$, dependences for the mass $\mathbf{M(v)}_{>}$, the momentum $\mathbf{P(v)}_{>}$, the kinetic energy $\mathbf{E_к(v)}_{>}$ of the moving body with a speed **v** they take the form:

$$M(v)_{>} = \frac{M_0}{\sqrt{1 - \frac{v^2}{C_1^2}}} \qquad (103)$$

$$P(v)_{>} = \frac{M_0 \cdot v}{\sqrt{1 - \frac{v^2}{C_1^2}}} \qquad (104)$$

$$E_к(v)_{>} = M_0 \cdot C_1^2 \cdot \left(\frac{1}{\sqrt{1 - \frac{v^2}{C_1^2}}} - 1 \right) \qquad (105)$$

3.2. Formulas of the dependence of mass, momentum and kinetic energy of the moving body on the speed with the conversion coefficient $0 < \boldsymbol{\beta} < 1$

For the case, when the value of conversion coefficient **β** is located in the range $0 < \boldsymbol{\beta} < 1$, dependences for the mass $\mathbf{M(v)}_{<}$, the momentum $\mathbf{P(v)}_{<}$, the kinetic energy $\mathbf{E_к(v)}_{<}$ of the moving body with a speed **v** they take the form:

$$M(v)_{<} = \frac{M_0}{\sqrt{1 + \frac{v^2}{C_2^2}}} \qquad (106)$$

$$P(v)_{<} = \frac{M_0 \cdot v}{\sqrt{1 + \frac{v^2}{C_2^2}}} \qquad (107)$$

$$E_{к}(v)_{<} \;=\; M_0 \cdot C_2^2 \cdot \left(1 - \frac{1}{\sqrt{1 + \frac{v^2}{C_2^2}}}\right) \qquad (108)$$

Is in detail obtaining dependences (103) - (105) and (106) - (108) it is stated in article “Special theory of relativity without the postulate about the constancy of the speed of light”.

3.3. Confirmation of the correctness of the selection of dependences (103) - (105) and (106) - (108) mass, momentum and kinetic energy of the moving body

Task: to verify the correctness of the selection of formulas (103) - (105) and (106) - (108) using laws of the momentum conservation and energy of the closed mechanical system of the bodies, interactions between which bear short-term nature.

Let us assume that there are two inertial reference systems, to the similar reference systems, depicted in Fig. 1, fixed $\mathbf{O_1x_1y_1z_1}$ and mobile $\mathbf{O_2x_2y_2z_2}$, which moves with a speed **V** in parallel to the axis $\mathbf{O_1x_1}$ relative to the system $\mathbf{O_1x_1y_1z_1}$.

Let us assume that there is a closed mechanical system of bodies, which consists of body 1 and body 2 (as shown in Fig. 9), that have the masses in the state of rest, equal $\mathbf{M_{o1}}$ and $\mathbf{M_{o2}}$ respectively.

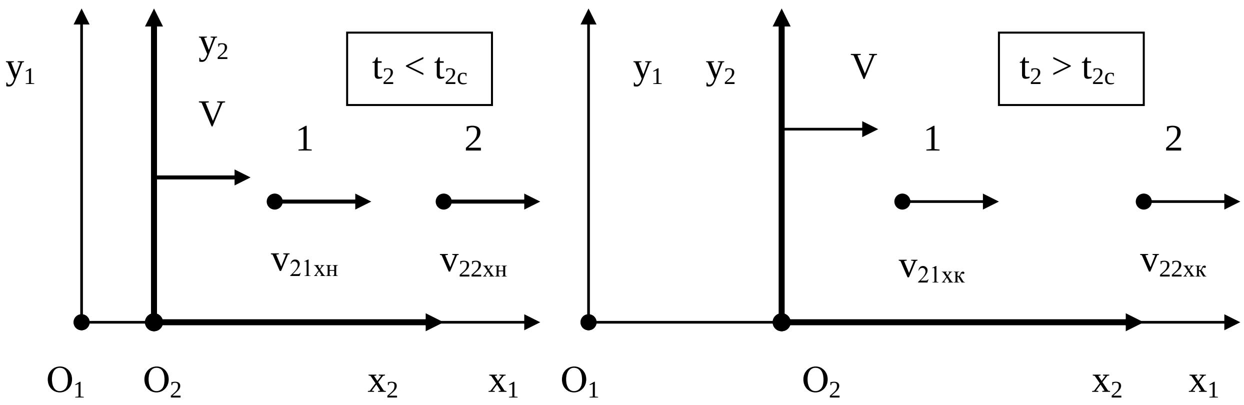

Fig. 9

In the mobile reference system $\mathbf{O_2x_2y_2z_2}$ body 1 and body 2 to certain moment of the time t_{2c} moved in parallel to the axis $\mathbf{O_2x_2}$ along one line with constant in the speeds $\mathbf{v_{21xн}}$ and $\mathbf{v_{22xн}}$ respectively, i.e., to moment of time larger $\mathbf{t_{2c}}$ body 1 had momentum $\mathbf{P_{21xн}}$ and kinetic energy $\mathbf{E_{к21xн}}$, and body 2 had momentum $\mathbf{P_{22xн}}$ and kinetic energy $\mathbf{E_{к22xн}}$.

At some moment of the time t_{2c} between bodies 1 and 2 occurred absolutely elastic straight central collision.

Further after collision at the moment of time larger t_{2c} body 1 and 2 began to move in parallel to the axis $\mathbf{O_2x_2}$ along one line with constant in the speeds $\mathbf{v_{21xк}}$ and $\mathbf{v_{22xк}}$ respectively, i.e., at the moment of time larger t_{2c} body 1 had momentum $\mathbf{P_{21xк}}$ and kinetic energy $\mathbf{E_{к21xк}}$, and body 2 had momentum $\mathbf{P_{22xк}}$ and kinetic energy $\mathbf{E_{к22xк}}$.

In the fixed reference system $\mathbf{O_1x_1y_1z_1}$ the collision between bodies 1 and 2 occurred at the moment of the time t_{1c} , which corresponds to moment of the time t_{2c} in the mobile reference system $\mathbf{O_2x_2y_2z_2}$.

In the fixed reference system $\mathbf{O_1x_1y_1z_1}$ body 1 and body 2 to certain moment of the time t_{1c} moved in parallel to the axis $\mathbf{O_2x_2}$ along one line with constant in the speeds $\mathbf{v_{11xн}}$ and $\mathbf{v_{12xн}}$ respectively, i.e., to moment of time larger $\mathbf{t_{1c}}$ body 1 had momentum $\mathbf{P_{11xн}}$ and kinetic energy $\mathbf{E_{к11xн}}$, and body 2 had momentum $\mathbf{P_{12xн}}$ and kinetic energy $\mathbf{E_{к12xн}}$.

Further after collision at the moment of time larger t_{1c} body 1 and 2 began to move in parallel to the axis $\mathbf{O_1x_1}$ along one line with constant in the speeds $\mathbf{v_{11xк}}$ and $\mathbf{v_{12xк}}$ respectively, i.e., at the moment of time larger t_{1c} body 1 had momentum $\mathbf{P_{11xк}}$ and kinetic energy $\mathbf{E_{к11xк}}$, and body 2 had momentum $\mathbf{P_{12xк}}$ and kinetic energy $\mathbf{E_{к12xк}}$.

Taking into account that:

- is a symmetry of space and time,
- body 1 and body 2 compose the closed mechanical system,
- between bodies 1 and 2 occurred straight central collision,
- the collision between bodies 1 and 2 bore the elastic nature

it is possible to write down the laws of the momentum conservation and mechanical energy for the closed mechanical system, which consists of bodies 1 and 2, examining moments of the time before and after of the collision:

in the fixed reference system $\mathbf{O_1x_1y_1z_1}$:

$$P_{11хн} + P_{12хн} = P_{11хк} + P_{12хк} \quad (109)$$

$$E_{к11хн} + E_{к12хн} = E_{к11хк} + E_{к12хк} \quad (110)$$

in the mobile reference system $\mathbf{O_2x_2y_2z_2}$:

$$P_{21хн} + P_{22хн} = P_{21хк} + P_{22хк} \quad (111)$$

$$E_{к21хн} + E_{к22хн} = E_{к21хк} + E_{к22хк} \quad (112)$$

3.3.1. Calculated checking of the selection of dependences (103) - (105) of mass, momentum, kinetic energy of the moving body with the conversion coefficient $\boldsymbol{\beta} > 1$

For the case, when the value of conversion coefficient $\boldsymbol{\beta}$ is located in the range $\boldsymbol{\beta} > 1$, formulas (109) - (112) taking into account dependences (103) - (105) will be written down in the form:

$$\frac{M_{01} \cdot v_{21хн}}{\sqrt{1 - \frac{v_{21хн}^2}{C_1^2}}} + \frac{M_{02} \cdot v_{22хн}}{\sqrt{1 - \frac{v_{22хн}^2}{C_1^2}}} = \frac{M_{01} \cdot v_{21хк}}{\sqrt{1 - \frac{v_{21хк}^2}{C_1^2}}} + \frac{M_{02} \cdot v_{22хк}}{\sqrt{1 - \frac{v_{22хк}^2}{C_1^2}}} \quad (113)$$

$$\frac{M_{01}}{\sqrt{1 - \frac{v_{21хн}^2}{C_1^2}}} + \frac{M_{02}}{\sqrt{1 - \frac{v_{22хн}^2}{C_1^2}}} = \frac{M_{01}}{\sqrt{1 - \frac{v_{21хк}^2}{C_1^2}}} + \frac{M_{02}}{\sqrt{1 - \frac{v_{22хк}^2}{C_1^2}}} \quad (114)$$

$$\frac{M_{01} \cdot v_{11хн}}{\sqrt{1 - \frac{v_{11хн}^2}{C_1^2}}} + \frac{M_{02} \cdot v_{12хн}}{\sqrt{1 - \frac{v_{12хн}^2}{C_1^2}}} = \frac{M_{01} \cdot v_{11хк}}{\sqrt{1 - \frac{v_{11хк}^2}{C_1^2}}} + \frac{M_{02} \cdot v_{12хк}}{\sqrt{1 - \frac{v_{12хк}^2}{C_1^2}}} \quad (115)$$

$$\frac{M_{01}}{\sqrt{1 - \frac{v_{11хн}^2}{C_1^2}}} + \frac{M_{02}}{\sqrt{1 - \frac{v_{12хн}^2}{C_1^2}}} = \frac{M_{01}}{\sqrt{1 - \frac{v_{11хк}^2}{C_1^2}}} + \frac{M_{02}}{\sqrt{1 - \frac{v_{12хк}^2}{C_1^2}}} \quad (116)$$

Where, on the basis of formulas (74) and (75) the connection between the speeds $\mathbf{v_{11xн}}$, $\mathbf{v_{21xн}}$, $\mathbf{v_{12xн}}$, $\mathbf{v_{22xн}}$, $\mathbf{v_{11xк}}$, $\mathbf{v_{21xк}}$, $\mathbf{v_{12xк}}$ and $\mathbf{v_{22xк}}$ signs the form:

$$v_{11xн} = \frac{v_{21xн} + V}{1 + \frac{V \cdot v_{21xн}}{C_1^2}} \qquad (117)$$

$$v_{12xн} = \frac{v_{22xн} + V}{1 + \frac{V \cdot v_{22xн}}{C_1^2}} \qquad (118)$$

$$v_{11xк} = \frac{v_{21xк} + V}{1 + \frac{V \cdot v_{21xк}}{C_1^2}} \qquad (119)$$

$$v_{12xк} = \frac{v_{22xк} + V}{1 + \frac{V \cdot v_{22xк}}{C_1^2}} \qquad (120)$$

Let us assume that $\mathbf{M_{o1}} = 1$, $\mathbf{M_{o2}} = 0,5$, $\mathbf{V / C_1} = 0,5$, $\mathbf{v_{21xн} / C_1} = 0,9$, $\mathbf{v_{22xн} / C_1} = 0,6$.

Then numerical computations give the following results for the example in question:

I. In the mobile reference system $\mathbf{O_2x_2y_2z_2}$:

1) a body 1 had:

Object	Period of the time	Value	Value of the quantity
Body 1	To the collision	the speed $\mathbf{v_{21xн} / C_1}$	0,9
		the mass $\mathbf{M_{21н}}$	2,294157338706
		the momentum $\mathbf{P_{21н} / C_1}$	2,064741604835
		the kinetic energy $\mathbf{E_{к21н} / C_1^2}$	1,294157338706
	After the collision	the speed $\mathbf{v_{21xк} / C_1}$	0,7360143377
		the mass $\mathbf{M_{21к}}$	1,477179174242
		the momentum $\mathbf{P_{21к} / C_1}$	1,087225051595
		the kinetic energy $\mathbf{E_{к21к} / C_1^2}$	0,477179174242

2) a body 2 had:

Object	Period of the time	Value	Value of the quantity
Body 2	To the collision	the speed $\mathbf{v_{22xн} / C_1}$	0,6
		the mass $\mathbf{M_{22н}}$	0,625
		the momentum $\mathbf{P_{22н} / C_1}$	0,375
		the kinetic energy $\mathbf{E_{к22н} / C_1^2}$	0,125
	After the collision	the speed $\mathbf{v_{22xк} / C_1}$	0,937959108239
		the mass $\mathbf{M_{22к}}$	1,441978164463
		the momentum $\mathbf{P_{22к} / C_1}$	1,35251655324
		the kinetic energy $\mathbf{E_{к22к} / C_1^2}$	0,941978164463

3) the system of bodies 1 and 2 had:

Object	Period of the time	Value	Value of the quantity
System of bodies 1 and 2	To the collision	the mass $\mathbf{(M_{21н} + M_{22н})}$	2,919157338706
		the momentum $\mathbf{(P_{21н} + P_{22н}) / C_1}$	2,439741604835
		the kinetic energy $\mathbf{E_{к22н} / C_1^2}$	1,419157338706
	After the collision	the mass $\mathbf{(M_{21к} + M_{22к})}$	2,919157338706
		the momentum $\mathbf{(P_{21к} + P_{22к}) / C_1}$	2,439741604835
		the kinetic energy $\mathbf{(E_{к21к} + E_{к22к}) / C_1^2}$	1,419157338706

II. In the fixed reference system $\mathbf{O_1x_1y_1z_1}$:

1) a body 1 had:

Object	Period of the time	Value	Value of the quantity
Body 1	To the collision	the speed $\mathbf{v_{11хн} / C_1}$	0,965517241379
		the mass $\mathbf{M_{11н}}$	3,841143835489
		the momentum $\mathbf{P_{11н} / C_1}$	3,708690599782
		the kinetic energy $\mathbf{E_{к11н} / C_1^2}$	2,841143835489
	After the collision	the speed $\mathbf{v_{11хк} / C_1}$	0,903514517939
		the mass $\mathbf{M_{11к}}$	2,333409263988
		the momentum $\mathbf{P_{11к} / C_1}$	2,108269146306
		the kinetic energy $\mathbf{E_{к11к} / C_1^2}$	1,333409263988

2) a body 2 had:

Object	Period of the time	Value	Value of the quantity
Body 2	To the collision	the speed $\mathbf{v_{12хн} / C_1}$	0,846153846154
		the mass $\mathbf{M_{12н}}$	0,938194187433
		the momentum $\mathbf{P_{12н} / C_1}$	0,793856620136
		the kinetic energy $\mathbf{E_{к12н} / C_1^2}$	0,438194187433
	After the collision	the speed $\mathbf{v_{12хк} / C_1}$	0,978882996844
		the mass $\mathbf{M_{12к}}$	2,445928758933
		the momentum $\mathbf{P_{12к} / C_1}$	2,394278073612
		the kinetic energy $\mathbf{E_{к12к} / C_1^2}$	1,945928758933

3) the system of bodies 1 and 2 had:

Object	Period of the time	Value	Value of the quantity
System of bodies 1 and 2	To the collision	the mass $(\mathbf{M_{11н}} + \mathbf{M_{12н}})$	4,779338022922
		the momentum $(\mathbf{P_{11н}} + \mathbf{P_{12н}}) / \mathbf{C_1}$	4,502547219918
		the kinetic energy $(\mathbf{E_{к11н}} + \mathbf{E_{к12н}}) / \mathbf{C_1^2}$	3,279338022922
	After the collision	the mass $(\mathbf{M_{11к}} + \mathbf{M_{12к}})$	4,779338022922
		the momentum $(\mathbf{P_{11к}} + \mathbf{P_{12к}}) / \mathbf{C_1}$	4,502547219918
		the kinetic energy $(\mathbf{E_{к11к}} + \mathbf{E_{к12к}}) / \mathbf{C_1^2}$	3,279338022922

According to the results of calculation it is possible to make the following conclusion: in the mobile $\mathbf{O_2x_2y_2z_2}$ and fixed $\mathbf{O_1x_1y_1z_1}$ reference systems before and after of collision the mass, momentum and kinetic energy of the mechanical system of bodies 1 and 2 remain constant with the conversion coefficient $\boldsymbol{\beta} > 1$.

3.3.2. Calculated checking of the selection of dependences (106) - (108) of mass, momentum, kinetic energy of the moving body with the conversion coefficient $\mathbf{0} < \boldsymbol{\beta} < \mathbf{1}$

For the case, when the value of conversion coefficient $\boldsymbol{\beta}$ is located in the range by $\mathbf{0} < \boldsymbol{\beta} < 1$, formulas (109) - (112) taking into account dependences (106) - (108) will be written down in the form:

$$\frac{\mathrm{M}_{01}\cdot \mathrm{v}_{21хн}}{\sqrt{1+\frac{\mathrm{v}_{21хн}^2}{\mathrm{C}_2^2}}} + \frac{\mathrm{M}_{02}\cdot \mathrm{v}_{22хн}}{\sqrt{1+\frac{\mathrm{v}_{22хн}^2}{\mathrm{C}_2^2}}} = \frac{\mathrm{M}_{01}\cdot \mathrm{v}_{21хк}}{\sqrt{1+\frac{\mathrm{v}_{21хк}^2}{\mathrm{C}_2^2}}} + \frac{\mathrm{M}_{02}\cdot \mathrm{v}_{22хк}}{\sqrt{1+\frac{\mathrm{v}_{22хк}^2}{\mathrm{C}_2^2}}} \qquad (121)$$

$$\frac{\mathrm{M}_{01}}{\sqrt{1+\frac{\mathrm{v}_{21хн}^2}{\mathrm{C}_2^2}}} + \frac{\mathrm{M}_{02}}{\sqrt{1+\frac{\mathrm{v}_{22хн}^2}{\mathrm{C}_2^2}}} = \frac{\mathrm{M}_{01}}{\sqrt{1+\frac{\mathrm{v}_{21хк}^2}{\mathrm{C}_2^2}}} + \frac{\mathrm{M}_{02}}{\sqrt{1+\frac{\mathrm{v}_{22хк}^2}{\mathrm{C}_2^2}}} \qquad (122)$$

$$\frac{M_{01}\cdot v_{11xн}}{\sqrt{1+\frac{v_{11xн}^2}{C_2^2}}}+\frac{M_{02}\cdot v_{12xн}}{\sqrt{1+\frac{v_{12xн}^2}{C_2^2}}}=\frac{M_{01}\cdot v_{11xк}}{\sqrt{1+\frac{v_{11xк}^2}{C_2^2}}}+\frac{M_{02}\cdot v_{12xк}}{\sqrt{1+\frac{v_{12xк}^2}{C_2^2}}} \qquad (123)$$

$$\frac{M_{01}}{\sqrt{1+\frac{v_{11xн}^2}{C_2^2}}}+\frac{M_{02}}{\sqrt{1+\frac{v_{12xн}^2}{C_2^2}}}=\frac{M_{01}}{\sqrt{1+\frac{v_{11xк}^2}{C_2^2}}}+\frac{M_{02}}{\sqrt{1+\frac{v_{12xк}^2}{C_2^2}}} \qquad (124)$$

Where, on the basis of formulas (91) and (92) the connection between the speeds $\mathbf{v_{11xн}}$, $\mathbf{v_{21xн}}$, $\mathbf{v_{12xн}}$, $\mathbf{v_{22xн}}$, $\mathbf{v_{11xк}}$, $\mathbf{v_{21xк}}$, $\mathbf{v_{12xк}}$ and $\mathbf{v_{22xк}}$ signs the form:

$$v_{11xн} = \frac{v_{21xн} + V}{1-\frac{V\cdot v_{21xн}}{C_2^2}} \qquad (125)$$

$$v_{12xн} = \frac{v_{22xн} + V}{1-\frac{V\cdot v_{22xн}}{C_2^2}} \qquad (126)$$

$$v_{11xк} = \frac{v_{21xк} + V}{1-\frac{V\cdot v_{21xк}}{C_2^2}} \qquad (127)$$

$$v_{12xк} = \frac{v_{22xк} + V}{1-\frac{V\cdot v_{22xк}}{C_2^2}} \qquad (128)$$

Let us assume that $\mathbf{M_{o1}}$ = 1 , $\mathbf{M_{o2}}$ = 0,5 , $\mathbf{V}$ / $\mathbf{C_2}$ = 0,5 , $\mathbf{v_{21xн}}$ / $\mathbf{C_2}$ = 0,9 , $\mathbf{v_{22xн}}$ / $\mathbf{C_2}$ = 0,6 .

Then numerical computations give the following results for the example in question:

I. In the mobile reference system $\mathbf{O_2x_2y_2z_2}$:

1) a body 1 had:

Object	Period of the time	Value	Value of the quantity
Body 1	To the collision	the speed $\mathbf{v_{21xн} / C_2}$	0,9
		the mass $\mathbf{M_{21н}}$	0,743294146247
		the momentum $\mathbf{P_{21н} / C_2}$	0,668964731622
		the kinetic energy $\mathbf{E_{к21н} / C_2^2}$	0,256705853753
	After the collision	the speed $\mathbf{v_{21xк} / C_2}$	0,691099932748
		the mass $\mathbf{M_{21к}}$	0,822656908881
		the momentum $\mathbf{P_{21к} / C_2}$	0,568538134403
		the kinetic energy $\mathbf{E_{к21к} / C_2^2}$	0,177343091119

2) a body 2 had:

Object	Period of the time	Value	Value of the quantity
Body 2	To the collision	the speed $\mathbf{v_{22xн} / C_2}$	0,6
		the mass $\mathbf{M_{22н}}$	0,428746462856
		the momentum $\mathbf{P_{22н} / C_2}$	0,257247877714
		the kinetic energy $\mathbf{E_{к22н} / C_2^2}$	0,071253537144
	After the collision	the speed $\mathbf{v_{22xк} / C_2}$	1,023729712365
		the mass $\mathbf{M_{22к}}$	0,349383700222
		the momentum $\mathbf{P_{22к} / C_2}$	0,357674474934
		the kinetic energy $\mathbf{E_{к22к} / C_2^2}$	0,150616299778

3) the system of bodies 1 and 2 had:

Object	Period of the time	Value	Value of the quantity
System of bodies 1 and 2	To the collision	the mass $(\mathbf{M_{21н}} + \mathbf{M_{22н}})$	1,172040609103
		the momentum $(\mathbf{P_{21н}} + \mathbf{P_{22н}}) / \mathbf{C_2}$	0,926212609336
		the kinetic energy $\mathbf{E_{к22н}} / \mathbf{C_2}^2$	0,327959390897
	After the collision	the mass $(\mathbf{M_{21к}} + \mathbf{M_{22к}})$	1,172040609103
		the momentum $(\mathbf{P_{21к}} + \mathbf{P_{22к}}) / \mathbf{C_2}$	0,926212609336
		the kinetic energy $(\mathbf{E_{к21к}} + \mathbf{E_{к22к}}) / \mathbf{C_2}^2$	0,327959390897

II. In the fixed reference system $\mathbf{O_1x_1y_1z_1}$:

1) a body 1 had:

Object	Period of the time	Value	Value of the quantity
Body 1	To the collision	the speed $\mathbf{v_{11xн}} / \mathbf{C_2}$	2,545454545455
		the mass $\mathbf{M_{11н}}$	0,365652372423
		the momentum $\mathbf{P_{11н}} / \mathbf{C_2}$	0,93075149344
		the kinetic energy $\mathbf{E_{к11н}} / \mathbf{C_2}^2$	0,634347627577
	After the collision	the speed $\mathbf{v_{11xк}} / \mathbf{C_2}$	1,820001331727
		the mass $\mathbf{M_{11к}}$	0,481548724902
		the momentum $\mathbf{P_{11к}} / \mathbf{C_2}$	0,876419320614
		the kinetic energy $\mathbf{E_{к11к}} / \mathbf{C_2}^2$	0,518451275098

2) a body 2 had:

Object	Period of the time	Value	Value of the quantity
Body 2	To the collision	the speed $\mathbf{v_{12xн} / C_2}$	1,571428571429
		the mass $\mathbf{M_{12н}}$	0,268437746097
		the momentum $\mathbf{P_{12н} / C_2}$	0,421830743866
		the kinetic energy $\mathbf{E_{к12н} / C_2^2}$	0,231562253903
	After the collision	the speed $\mathbf{v_{12xк} / C_2}$	3,121532492927
		the mass $\mathbf{M_{12к}}$	0,152541393617
		the momentum $\mathbf{P_{12к} / C_2}$	0,476162916693
		the kinetic energy $\mathbf{E_{к12к} / C_2^2}$	0,347458606383

3) the system of bodies 1 and 2 had:

Object	Period of the time	Value	Value of the quantity
System of bodies 1 and 2	To the collision	the mass $\mathbf{(M_{11н} + M_{12н})}$	0,63409011852
		the momentum $\mathbf{(P_{11н} + P_{12н}) / C_2}$	1,352582237306
		the kinetic energy $\mathbf{(E_{к11н} + E_{к12н}) / C_2^2}$	0,86590988148
	After the collision	the mass $\mathbf{(M_{11к} + M_{12к})}$	0,63409011852
		the momentum $\mathbf{(P_{11к} + P_{12к}) / C_2}$	1,352582237306
		the kinetic energy $\mathbf{(E_{к11к} + E_{к12к}) / C_2^2}$	0,86590988148

According to the results of calculation it is possible to make the following conclusion: in the mobile $\mathbf{O_2x_2y_2z_2}$ and fixed $\mathbf{O_1x_1y_1z_1}$ reference systems before and after of collision the mass, momentum and kinetic energy of the mechanical system of bodies 1 and 2 remain constant with the conversion coefficient $\mathbf{0<\beta <1}$.

3.3.3. Comparison of formulas (103) - (105) with formulas (106) - (108)

On dependences (103) - (105):

$$M(v)_{>} = \frac{M_0}{\sqrt{1 - \frac{v^2}{C_1^2}}} \quad (103)$$

$$P(v)_{>} = \frac{M_0 \cdot v}{\sqrt{1 - \frac{v^2}{C_1^2}}} \quad (104)$$

$$E_к(v)_{>} = M_0 \cdot C_1^2 \cdot \left(\frac{1}{\sqrt{1 - \frac{v^2}{C_1^2}}} - 1 \right) \quad (105)$$

for the mass **M(v)**$_>$, the momentum **P(v)**$_>$ and kinetic energy **E$_к$(v)**$_>$ the moving body with a speed **v** in the case, when conversion coefficient **β > 1**, it is possible to say the following:

The speed **v**	The mass **M(v)**$_>$	The momentum **P(v)**$_>$	The kinetic energy **E$_к$(v)**$_>$
$v \ll C_1$	M_0	$M_0 \cdot v$	$\frac{M_0 \cdot v^2}{2}$
$v < C_1$	has the actual value	has the actual value	has the actual value
$v = C_1$	∞	∞	∞
$v > C_1$	it does not have the actual value	it does not have the actual value	it does not have the actual value

It is analogous about dependences (106) - (108):

$$M(v)_< = \frac{M_0}{\sqrt{1+\frac{v^2}{C_2^2}}} \qquad (106)$$

$$P(v)_< = \frac{M_0 \cdot v}{\sqrt{1+\frac{v^2}{C_2^2}}} \qquad (107)$$

$$E_\kappa(v)_< = M_0 \cdot C_2^2 \cdot \left(1 - \frac{1}{\sqrt{1+\frac{v^2}{C_2^2}}}\right) \qquad (108)$$

for the mass **M(v)**$_<$, the momentum **P(v)**$_<$ and kinetic energy **E$_\kappa$(v)**$_<$ the moving body with a speed **v** in the case, when conversion coefficient **0 < β < 1**, it is possible to say the following:

The speed **v**	The mass **M(v)**$_<$	The momentum **P(v)**$_<$	The kinetic energy **E$_\kappa$(v)**$_<$
$v \ll C_2$	M_0	$M_0 \cdot v$	$\frac{M_0 \cdot v^2}{2}$
$v < C_2$	has the actual value	has the actual value	has the actual value
$v = C_2$	$\frac{M_0}{\sqrt{2}}$	$\frac{M_0 \cdot C_2}{\sqrt{2}}$	$M_0 \cdot C_2^2 \cdot \left(1 - \frac{1}{\sqrt{2}}\right)$
$v > C_2$	has the actual value	has the actual value	has the actual value
$v = \infty$	it approaches zero	$M_0 \cdot C_2$	$M_0 \cdot C_2^2$

As can be seen from comparison, both ranges of the possible value of conversion coefficient **β** > **1** and **0** < **β** < **1** are equivalent to (both they satisfy boundary condition).

For the clarity of comparison let us give the following graphs:

- the graph of the dependence of mass **M(v)** the moving body from the speed **v**:

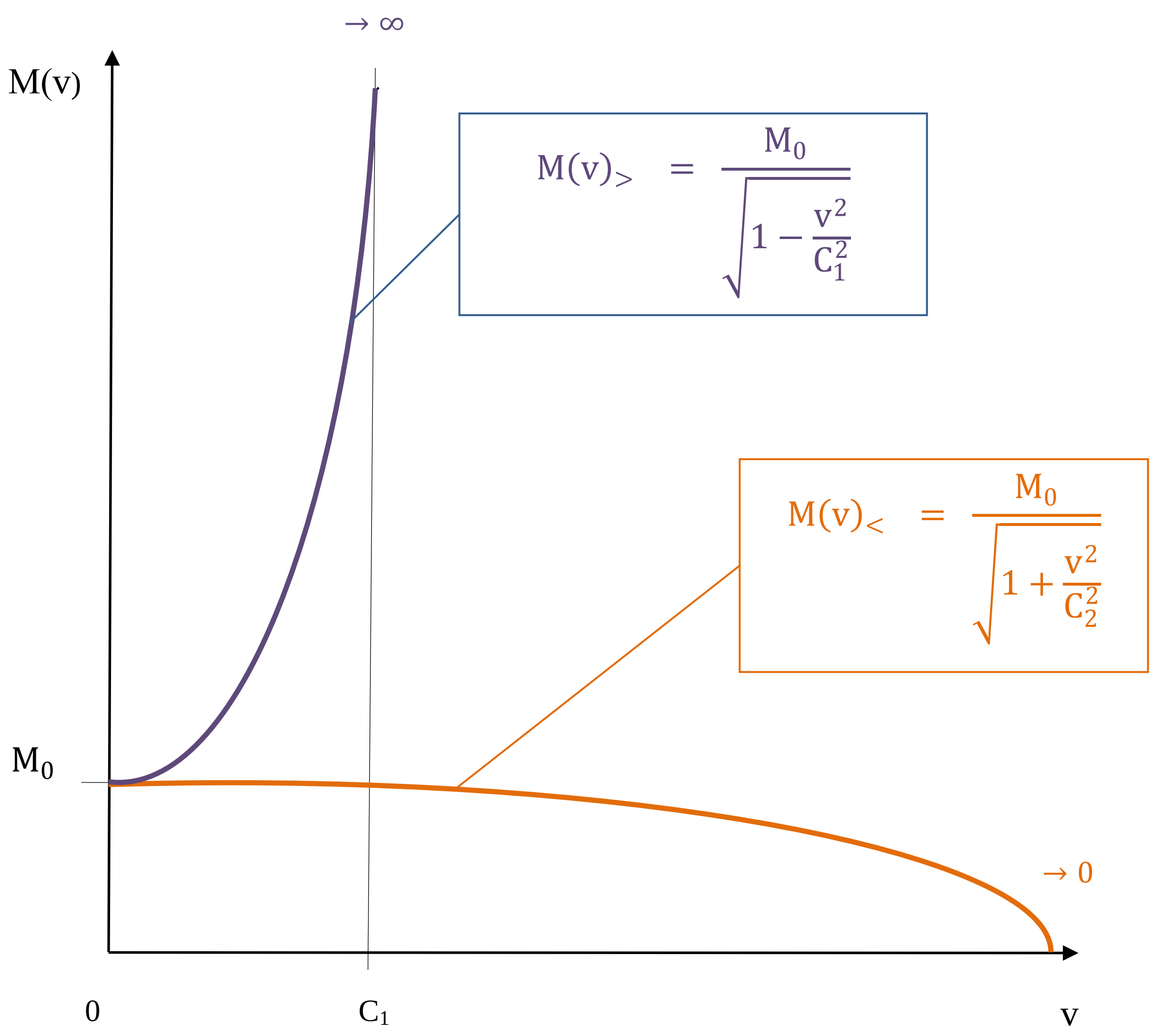

Fig.10

- the graph of the dependence of the momentum **P(v)** of the moving body on the speed **v**:

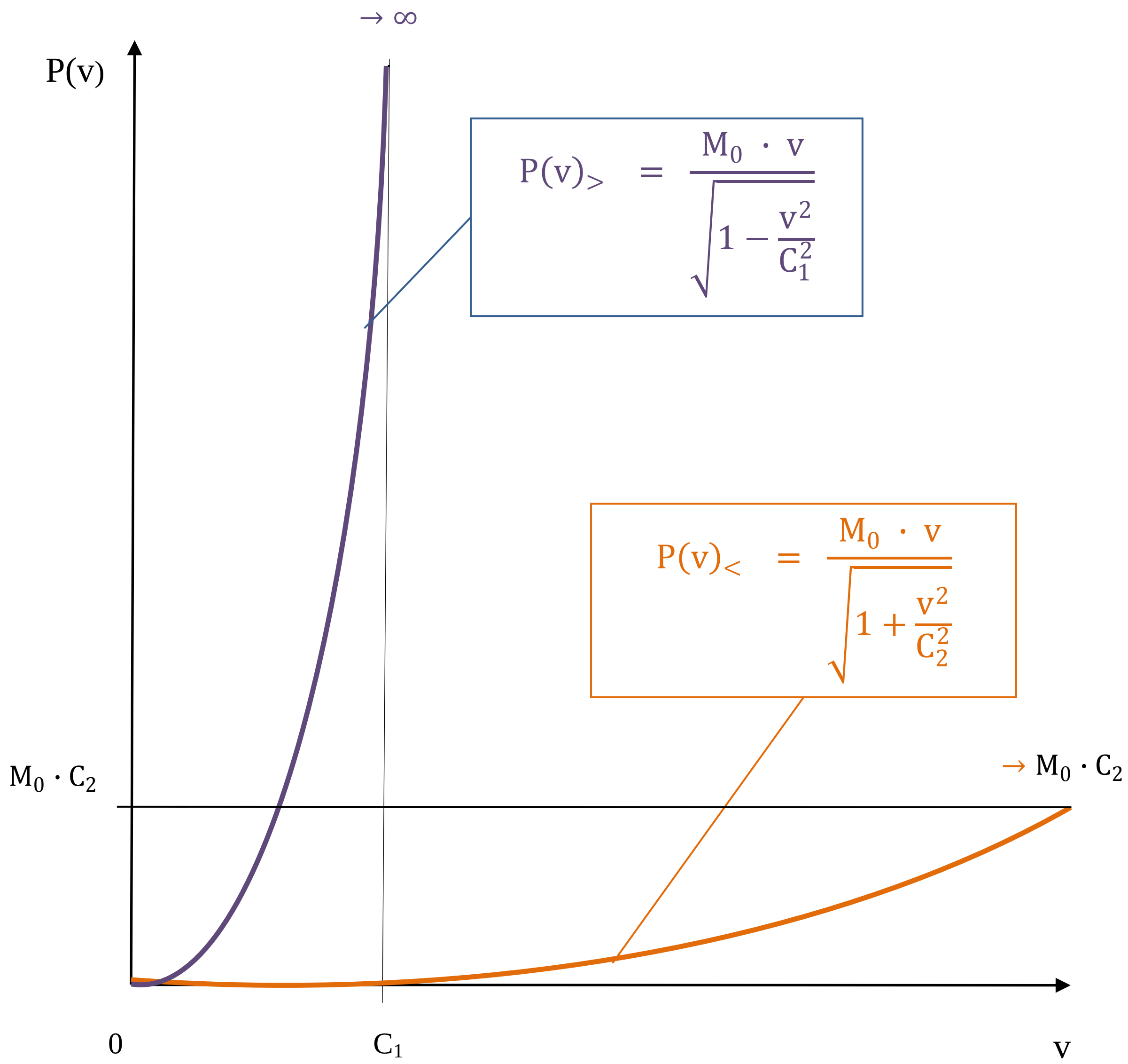

Fig.11

- the graph of the dependence of kinetic energy **$E_к(v)$** of the moving body on the speed **v**:

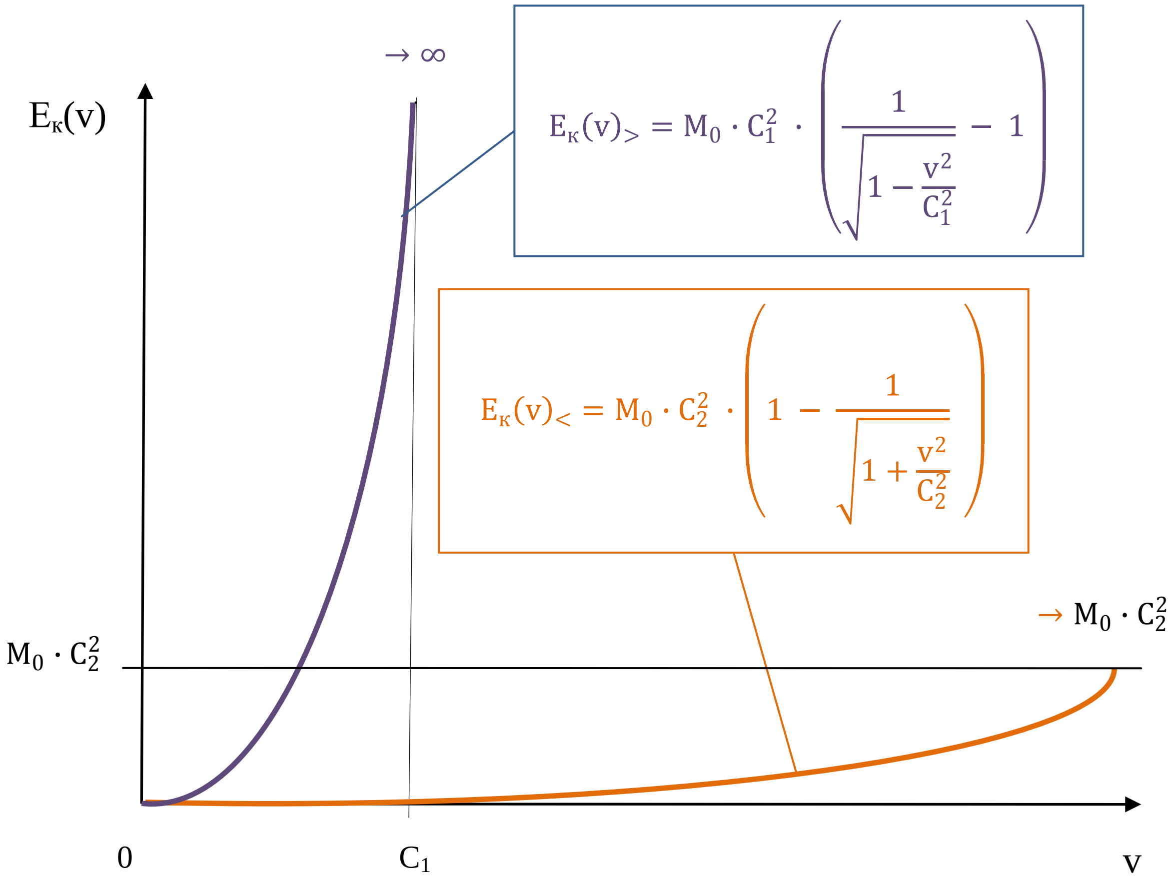

Fig.12

4. Determination of the values of the constant quantities C_1 and C_2

Task: using a law of momentum conservation for the closed mechanical system of the bodies, which have continuous cooperation, to determine the value of conversion coefficient **β** .

With the examination let us try to lean on the law of the momentum conservation of the closed mechanical system, which is connected with the property of the symmetry of space - by uniformity of space.

The law of momentum conservation asserts that the momentum of the closed mechanical system of bodies (on which they do not act external forces) it is constant value, i.e., in any inertial reference system for any moment of time the value of the momentum of the closed mechanical system of bodies is constant value (since there is no external interaction).

In example given below in the inertial reference system with the aid of the special theory of relativity the momentums of the bodies, which compose the closed mechanical system, will be determined for two moments of time, and then using the law of the momentum conservation of the closed mechanical system they will be determined the value of constant quantities $\mathbf{C_1}$ and $\mathbf{C_2}$.

4.1. Example of № 1 for the determination of the values of the constant quantities $\mathbf{C_1}$ and $\mathbf{C_2}$

Let us assume that there are two inertial reference systems, to the similar systems of counting, depicted in Fig. 1 - fixed $\mathbf{O_1x_1y_1z_1}$ and mobile $\mathbf{O_2x_2y_2z_2}$, which moves with a speed **V** in parallel to the axis $\mathbf{O_1x_1}$ relative to the system $\mathbf{O_1x_1y_1z_1}$.

Let us assume that there is a closed mechanical system of bodies, shown in Fig. 13 and consisting of point bodies 1 and 2, having equal masses $\mathbf{M_o}$ in the state of rest, and thread 3.

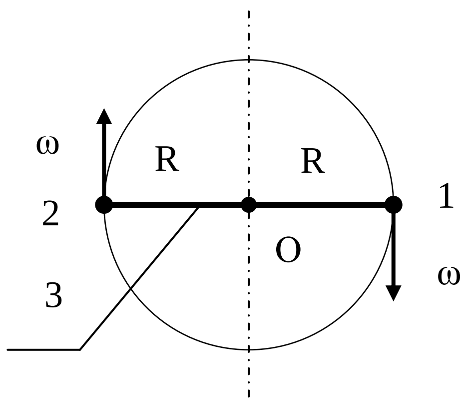

Fig. 13

Bodies 1 and 2 are connected by absolutely rigid (not having the deformation) thread 3, which does not have mass.

Bodies 1 and 2 revolve with a angular velocity **ω** around the overall center of masses - point **O**.

Distance from point body 1 (body 2) to the point **O** is equal to **R**.

Let us place the considered closed mechanical system of bodies 1 and 2 with thread 3 into the mobile reference system $\mathbf{O_2x_2y_2z_2}$ in such a way that the point **O** would be fixed in this reference system and would coincide since the origin of the coordinates $\mathbf{O_2}$, and the rotation of bodies 1 and 2 around it would occur clockwise in the plane $\mathbf{O_2x_2y_2}$, as shown in Fig. 14.

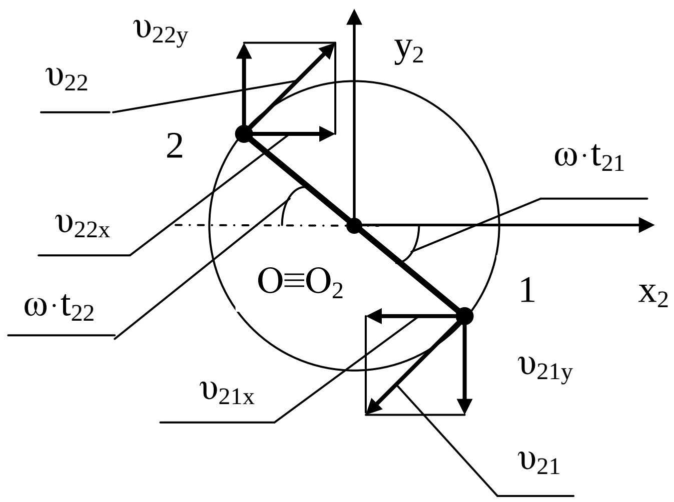

Fig. 14

Also let us assume that at the moment the zero time references ($\boldsymbol{t_2}$=0) in the reference system $\mathbf{O_2x_2y_2z_2}$ the body 1 and 2 were located on the axis $\mathbf{O_2x_2}$, and, body 1 it had positive coordinate, and body 2 it was negative.

Relying on state aboved, it is possible to note that in the mobile reference system $\mathbf{O_2x_2y_2z_2}$ at any moment of the time $\boldsymbol{t_2}$ body 1 and 2 they will have speeds $\boldsymbol{\upsilon_{21}}$ and $\boldsymbol{\upsilon_{22}}$, respectively equal:

$$v_{21} = v_{22} = v = \omega \cdot \mathrm{R} \qquad (129)$$

In this case the projections $\boldsymbol{\upsilon_{21x}}$ and $\boldsymbol{\upsilon_{21y}}$ of the speed of body 1 and the projections of projection $\boldsymbol{\upsilon_{22x}}$ and $\boldsymbol{\upsilon_{22y}}$ of the speed of body 2 on the axis $\mathbf{O_2x_2}$ and $\mathbf{O_2y_2}$, respectively for moments of the time $\boldsymbol{t_{21}}$ and $\boldsymbol{t_{22}}$, will be equal:

$$v_{21\mathrm{x}} = -\,[v \cdot \sin(\omega \cdot t_{21})] \qquad (130)$$

$$v_{21\mathrm{y}} = -\,[v \cdot \cos(\omega \cdot t_{21})] \qquad (131)$$

$$v_{22\mathrm{x}} = v \cdot \sin(\omega \cdot t_{22}) \qquad (132)$$

$$v_{22\mathrm{y}} = v \cdot \cos(\omega \cdot t_{22}) \qquad (133)$$

The connection between the coordinates $\mathbf{x_{21}}$ and $\mathbf{y_{21}}$ of body 1 depending on the time $\boldsymbol{t_{21}}$ and connection between the coordinates $\mathbf{x_{22}}$ and $\mathbf{y_{22}}$ of body 2 depending on the time $\boldsymbol{t_{22}}$ in the mobile reference system $\mathbf{O_2x_2y_2z_2}$ can be written down in the form:

$$x_{21} = R \cdot \cos(\omega \cdot t_{21}) \qquad (134)$$

$$y_{21} = -[R \cdot \sin(\omega \cdot t_{21})] \qquad (135)$$

$$x_{22} = -[R \cdot \cos(\omega \cdot t_{22})] \qquad (136)$$

$$y_{22} = R \cdot \sin(\omega \cdot t_{22}) \qquad (137)$$

Relying on equation (34) and (36), it is possible to write the connection between the coordinates $\mathbf{x_{11}}$ and $\mathbf{y_{11}}$ of body 1 at the moment of the time $\mathbf{t_{11}}$ in the fixed reference system $\mathbf{O_1x_1y_1z_1}$ and the coordinates $\mathbf{x_{21}}$ and $\mathbf{y_{21}}$ of body 1 at the moment of the time $\boldsymbol{t_{21}}$, which corresponds to moment of the time $\mathbf{t_{11}}$ in the fixed reference system $\mathbf{O_1x_1y_1z_1}$, in the mobile reference system $\mathbf{O_2x_2y_2z_2}$:

$$x_{11} = \beta \cdot [x_{21} + (V \cdot t_{21})] \qquad (138)$$

$$y_{11} = y_{21} \qquad (139)$$

It is analogous, using equations (34) and (36), it is possible to write down the connection between the coordinates $\mathbf{x_{12}}$ and $\mathbf{y_{12}}$ of body 2 at the moment of the time $\boldsymbol{t_{12}}$ in the fixed reference system $\mathbf{O_1x_1y_1z_1}$ and the coordinates $\mathbf{x_{22}}$ and $\mathbf{y_{22}}$ of body 2 at the moment of the time $\boldsymbol{t_{22}}$, which corresponds to moment of the time $\mathbf{t_{12}}$ in the fixed reference system $\mathbf{O_1x_1y_1z_1}$, in the mobile reference system $\mathbf{O_2x_2y_2z_2}$:

$$x_{12} = \beta \cdot [x_{22} + (V \cdot t_{22})] \qquad (140)$$

$$y_{12} = y_{22} \qquad (141)$$

With the aid of formula (38) it is possible to write the connection between the values of the times $\boldsymbol{t_{11}}$, $\boldsymbol{t_{21}}$ and $\boldsymbol{t_{12}}$, $\boldsymbol{t_{22}}$:

$$t_{11} = \frac{(\beta^2 - 1) \cdot x_{21}}{\beta \cdot V} + (\beta \cdot t_{21}) \qquad (142)$$

$$t_{12} = \frac{(\beta^2 - 1) \cdot x_{22}}{\beta \cdot V} + (\beta \cdot t_{22}) \qquad (143)$$

In the example in question us it will interest the position of bodies 1 and 2 in the fixed reference system $\mathbf{O_1x_1y_1z_1}$ at one and the same moment of time, i.e., when:

$$t_{11} \;=\; t_{12} \qquad (144)$$

Then equation (144) taking into account formulas (134), (136), (138), (140), (142) and (143) signs the form:

$$\frac{(\beta^2-1)\cdot \mathrm{R}\cdot \cos(\omega\cdot t_{21})}{\beta\,\cdot\,\mathrm{V}} + (\beta\cdot t_{21}) \;=$$

$$= \frac{(1-\beta^2)\cdot \mathrm{R}\,\cdot \cos(\omega\cdot t_{22})}{\beta\,\cdot\,\mathrm{V}} + (\beta\cdot t_{22}) \qquad (145)$$

In the mobile reference system $\mathbf{O_2x_2y_2z_2}$ with the fulfillment of conditions (144) is of interest the position of bodies 1 and 2, when:

$$t_{21} = t_{22} = t_{2\mathrm{p}} \qquad (146)$$

After substituting condition (146) into equation (145) for the case, when $\boldsymbol{(\omega\cdot t_{2p}) < \pi}$, we will obtain:

$$\omega\cdot t_{2\mathrm{p}} = \frac{\pi}{2} \qquad (147)$$

I.e. for the fulfillment of conditions (144) and (146) body 1 and 2 at the moments of time in question they must be located on the line, parallel to the axis $\mathbf{O_2y_2}$ $(\mathbf{O_1y_1})$.

Also in the mobile reference system $\mathbf{O_2x_2y_2z_2}$ with the fulfillment of conditions (144) is of interest the position of bodies 1 and 2, when:

$$t_{21} = 0 \qquad (148)$$

The value of the time $\boldsymbol{t_{22}}$ with the fulfillment of conditions (144) and (148) let us designate $\boldsymbol{t_{22\text{т}}}$, for which equation (145) of signs the form:

$$t_{22\text{т}} = \left(1-\frac{1}{\beta^2}\right)\cdot\,[1+\,\cos(\omega\cdot t_{22\text{т}})]\,\cdot\,\frac{\mathrm{R}}{\mathrm{V}} \qquad (149)$$

or:

$$\omega\cdot t_{22\text{т}} = \left(1-\frac{1}{\beta^2}\right)\cdot\,[1+\,\cos(\omega\cdot t_{22\text{т}})]\,\cdot\,\frac{v}{\mathrm{V}} \qquad (150)$$

As can be seen from equations (150), value of the time $\boldsymbol{t_{22т}}$ depending on the value of conversion coefficient **β** can be:

- $\boldsymbol{t_{22т}} > 0$ with $\boldsymbol{\beta > 1}$; (151)
- $\boldsymbol{t_{22т}} < 0$ with $\boldsymbol{0 < \beta < 1}$; (152)
- $\boldsymbol{t_{22т}} = 0$ with $\boldsymbol{\beta = 1}$. (153)

Now we can approach checking of fulfilling of the law of momentum conservation.

Let us examine two moments of time in the fixed reference system $\mathbf{O_1x_1y_1z_1}$.

4.2. Moment of the time $\boldsymbol{t_{1p}}$

According to conditions (144) and (146) for bodies 1 and 2, to moment of the time $\boldsymbol{t_{1p}}$ (when bodies 1 and 2 are found on the line of parallel axis $\mathbf{O_1y_1}$) in the fixed reference system $\mathbf{O_1x_1y_1z_1}$ will correspond moment of the time $\boldsymbol{t_{2p}}$ in the mobile reference system $\mathbf{O_2x_2y_2z_2}$.

As shown in Fig. 15, according to equations (147), (130) - (133) in the mobile reference system $\mathbf{O_2x_2y_2z_2}$ at the moment of the time $\boldsymbol{t_{2p}}$ bodies 1 and 2 respectively have the following values of the projections $\boldsymbol{\upsilon_{21xp}}$, $\boldsymbol{\upsilon_{21yp}}$ and $\boldsymbol{\upsilon_{22xp}}$, $\boldsymbol{\upsilon_{22yp}}$ of the speeds of their motion on the axis $\mathbf{O_2x_2}$ and $\mathbf{O_2y_2}$:

$$v_{21\text{xp}} = -\,v \qquad (154)$$

$$v_{21\text{yp}} = 0 \qquad (155)$$

$$v_{22\text{xp}} = v \qquad (156)$$

$$v_{22\text{yp}} = 0 \qquad (157)$$

Then, on the basis of formulas (40), (42) and equalities (154) - (157), in the fixed reference system $\mathbf{O_1x_1y_1z_1}$ at the moment of the time $\boldsymbol{t_{1p}}$ body 1 and body 2 will respectively have the following values of the projections $\boldsymbol{\upsilon_{11xp}}$, $\boldsymbol{\upsilon_{11yp}}$ and $\boldsymbol{\upsilon_{12xp}}$, $\boldsymbol{\upsilon_{12yp}}$ of the speeds of their motion on the axis $\mathbf{O_1x_1}$ and $\mathbf{O_1y_1}$:

$$v_{11\text{xp}} = \frac{\text{V} - v}{1 - \dfrac{(\beta^2 - 1)\cdot v}{\beta^2 \cdot \text{V}}} \qquad (158)$$

$$v_{11\text{yp}} = 0 \qquad (159)$$

$$v_{12xp} = \frac{V + v}{\frac{(\beta^2 - 1) \cdot v}{\beta^2 \cdot V} + 1} \qquad (160)$$

$$v_{12yp} = 0 \qquad (161)$$

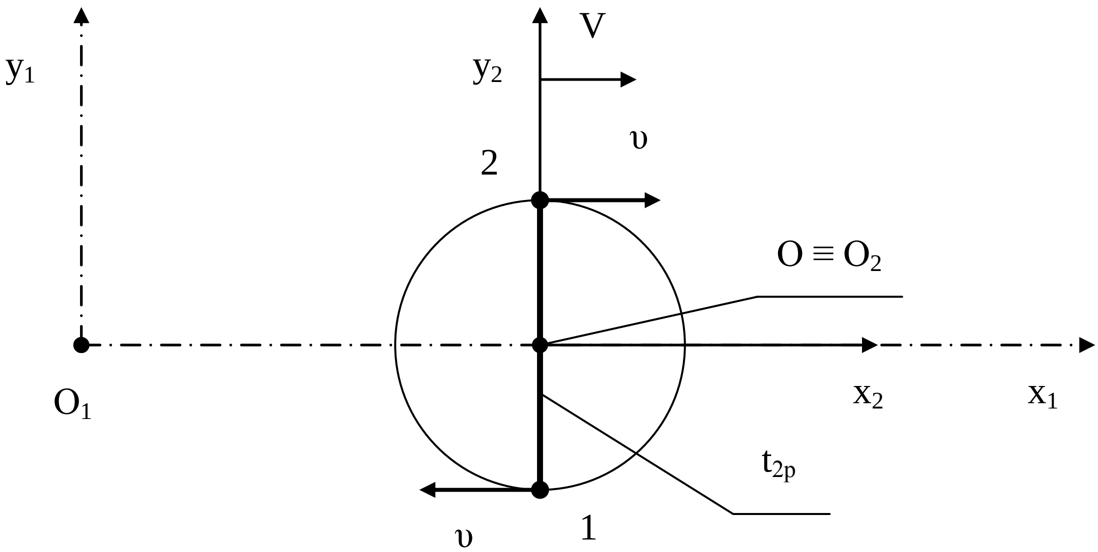

Fig. 15

4.3. Moment of the time $t_{1т}$

According to conditions (144) and (148) to moment of the time $t_{1т}$ in the fixed reference system $\mathbf{O_1x_1y_1z_1}$ will correspond in the mobile reference system $\mathbf{O_2x_2y_2z_2}$ moment of the time $t_{21} = 0$ for body 1 (when body 1 will be found to axis $\mathbf{O_2x_2}$) and at moment of the time $t_{22т}$ for body 2 (according to conditions (151) and (152) with the value of the conversion coefficient $\boldsymbol{\beta \neq 1}$ body 2 it cannot be located on the axis $\mathbf{O_2x_2}$).

As shown in Fig. 16, in the mobile reference system $\mathbf{O_2x_2y_2z_2}$ at the moment of the time $t_{21} = 0$ body 1 and at the moment of the time $t_{22т}$ body 2 respectively have the following values of the projections $\upsilon_{21xт}$, $\upsilon_{21yт}$ and $\upsilon_{22xт}$, $\upsilon_{22yт}$ of the speeds of their motion on the axis $\mathbf{O_2x_2}$ and $\mathbf{O_2y_2}$, moreover:

$$v_{21xт} = 0 \qquad (162)$$

$$v_{21yт} = -v \qquad (163)$$

Then, on the basis of formulas (40), (42) and equalities (162), (163) in the fixed reference system $\mathbf{O_1x_1y_1z_1}$ at the moment of the time $t_{1т}$ body 1 and body 2 will respectively have values of projections $\boldsymbol{\upsilon_{11xт}}$, $\boldsymbol{\upsilon_{11yт}}$ and $\boldsymbol{\upsilon_{12xт}}$, $\boldsymbol{\upsilon_{12yт}}$ of the speeds of their motion on the axis $\mathbf{O_1x_1}$ and $\mathbf{O_1y_1}$, moreover :

$$v_{11xт} = V \qquad (164)$$

$$v_{11yт} = -\frac{v}{\beta} \qquad (165)$$

$$v_{12xт} = \frac{V + v_{22xт}}{\frac{(\beta^2 - 1)\cdot v_{22xт}}{\beta^2 \cdot V} + 1} \qquad (166)$$

$$v_{12yт} = \frac{v_{22yт}}{\frac{(\beta^2 - 1)\cdot v_{22xт}}{\beta \cdot V} + \beta} \qquad (167)$$

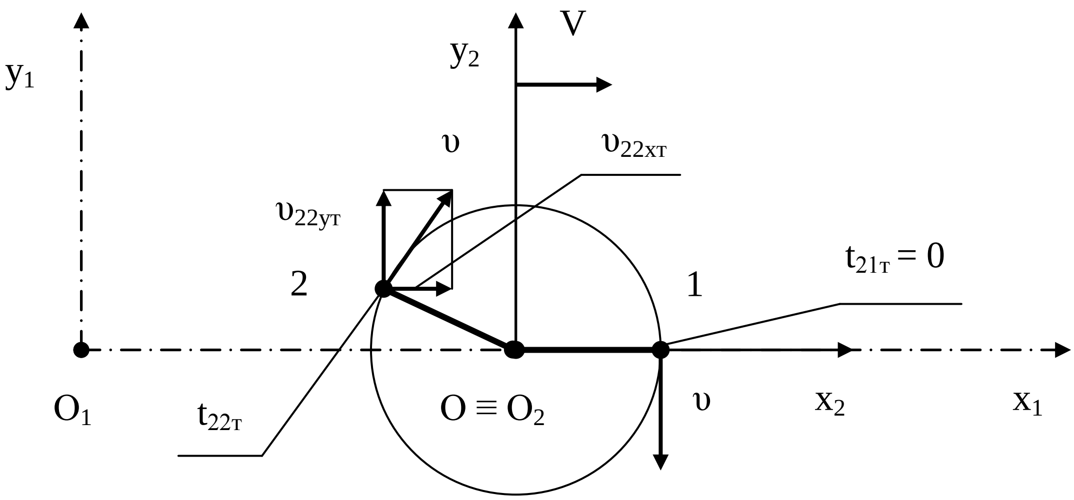

Fig. 16

Taking into account condition (151) that with the conversion coefficient $\boldsymbol{\beta > 1}$ time $t_{22т} > 0$, it is possible to note that with the conversion coefficient $\boldsymbol{\beta > 1}$ projection of the speed $\boldsymbol{\upsilon_{22yт}}$ will be directed along the direction of the axis $\mathbf{O_2y_2}$.

Also, on the basis of condition (152), which asserts that with the conversion coefficient $\mathbf{0 < \beta < 1}$ time $t_{22т} < 0$, it is possible to note that with the conversion coefficient $\mathbf{0 < \beta < 1}$ projection of the speed $\boldsymbol{\upsilon_{22yт}}$ will have a direction, opposite to the direction of the axis $\mathbf{O_2y_2}$.

And (133) it is possible to obtain from equations (132):

$$v_{22xт}{}^2 + v_{22xт}{}^2 = v^2 \qquad (168)$$

4.4. Equation of the law of momentum conservation for an example № 1

In the fixed reference system $\mathbf{O_1x_1y_1z_1}$ at the moment of the time t_{1p} body 1 and body 2 will respectively have the following values of the projections $\mathbf{P_{11xp}}$, $\mathbf{P_{11yp}}$ and $\mathbf{P_{12xp}}$, $\mathbf{P_{12yp}}$ of momentums on the axis $\mathbf{O_1x_1}$ and $\mathbf{O_1y_1}$:

$$P_{11xp} = M(v = v_{11xp}) \cdot v_{11xp} \qquad (169)$$

$$P_{12xp} = M(v = v_{12xp}) \cdot v_{12xp} \qquad (170)$$

$$P_{11yp} = 0 \qquad (171)$$

$$P_{12yp} = 0 \qquad (172)$$

But in the fixed reference system $\mathbf{O_1x_1y_1z_1}$ at the moment of the time $t_{1т}$ body 1 and body 2 will respectively have values of projections $\mathbf{P_{11xт}}$, $\mathbf{P_{11yт}}$ and $\mathbf{P_{12xт}}$, $\mathbf{P_{12yт}}$ of momentums on the axis и $\mathbf{O_1x_1}$ and $\mathbf{O_1y_1}$:

$$P_{11xт} = M\left(V = \sqrt{v_{11xт}^2 + v_{11yт}^2}\right) \cdot v_{11xт} \qquad (173)$$

$$P_{12xт} = M\left(V = \sqrt{v_{12xт}^2 + v_{12yт}^2}\right) \cdot v_{12xт} \qquad (174)$$

$$P_{11yт} = M\left(V = \sqrt{v_{11xт}^2 + v_{11yт}^2}\right) \cdot v_{11yт} \qquad (175)$$

$$P_{12yт} = M\left(V = \sqrt{v_{12xт}^2 + v_{12yт}^2}\right) \cdot v_{12yт} \qquad (176)$$

In connection with the fact that the mechanical system of bodies 1 and 2 (and thread 3) is locked, the law of momentum conservation makes it possible to write down for moments of the time $\mathbf{t_{1p}}$ and $\mathbf{t_{1т}}$ the following equations:

$$P_{11xp} + P_{12xp} = P_{11xт} + P_{12xт}$$

or:

$$\{M(V = v_{11xp}) \cdot v_{11xp}\} + \{M(V = v_{12xp}) \cdot v_{12xp}\} =$$

$$= \left\{M\left(V = \sqrt{v_{11xт}^2 + v_{11yт}^2}\right) \cdot v_{11xт}\right\} +$$

$$+ \left\{M\left(V = \sqrt{v_{12xт}^2 + v_{12yт}^2}\right) \cdot v_{12xт}\right\} \qquad (177)$$

$$P_{11yp} + P_{12yp} = P_{11yт} + P_{12yт}$$

or:

$$0 = \left\{ \mathrm{M}\left(\mathrm{V} = \sqrt{v_{11\text{хт}}^2 + v_{11\text{ут}}^2}\right) \cdot v_{11\text{ут}} \right\} +$$

$$+ \left\{ \mathrm{M}\left(\mathrm{V} = \sqrt{v_{12\text{хт}}^2 + v_{12\text{ут}}^2}\right) \cdot v_{12\text{ут}} \right\} \qquad (178)$$

4.4.1. Determination of the conditions of fulfilling the law of momentum conservation for an example № 1 with the conversion coefficient β ≥ 1

If the conversion coefficient **β ≥ 1** , then the values of the conversion coefficient **β** and of mass **M(v)** moving with speed **v** of body are determined:

$$\beta_{>}^2 = \frac{1}{1 - \frac{\mathrm{V}^2}{\mathrm{C}_1^2}} \qquad (69)$$

$$\mathrm{M(v)}_{>} = \frac{\mathrm{M}_0}{\sqrt{1 - \frac{\mathrm{v}^2}{\mathrm{C}_1^2}}} \qquad (103)$$

Then taking into account formula (103) of equation (177) and (178) is taken the form itself:

$$\frac{\mathrm{M}_0 \cdot v_{11\text{хр}}}{\sqrt{1 - \frac{v_{11\text{хр}}^2}{\mathrm{C}_1^2}}} + \frac{\mathrm{M}_0 \cdot v_{12\text{хр}}}{\sqrt{1 - \frac{v_{12\text{хр}}^2}{\mathrm{C}_1^2}}} = \frac{\mathrm{M}_0 \cdot v_{11\text{хт}}}{\sqrt{1 - \frac{v_{11\text{хт}}^2 + v_{11\text{ут}}^2}{\mathrm{C}_1^2}}} + \frac{\mathrm{M}_0 \cdot v_{12\text{хт}}}{\sqrt{1 - \frac{v_{12\text{хт}}^2 + v_{12\text{ут}}^2}{\mathrm{C}_1^2}}} \qquad (179)$$

$$0 = \frac{\mathrm{M}_0 \cdot v_{11\text{ут}}}{\sqrt{1 - \frac{v_{11\text{хт}}^2 + v_{11\text{ут}}^2}{\mathrm{C}_1^2}}} + \frac{\mathrm{M}_0 \cdot v_{12\text{ут}}}{\sqrt{1 - \frac{v_{12\text{хт}}^2 + v_{12\text{ут}}^2}{\mathrm{C}_1^2}}} \qquad (180)$$

Formulas (158) - (161) and (164) - (167) taking into account formula (69) can be written down:

$$v_{11\text{хр}} = \frac{\mathrm{V} - v}{1 - \frac{\mathrm{V} \cdot v}{\mathrm{C}_1^2}} \qquad (181)$$

$$v_{12\text{хр}} = \frac{\mathrm{V} + v}{1 + \frac{\mathrm{V} \cdot v}{\mathrm{C}_1^2}} \qquad (182)$$

$$v_{11\text{хт}} = \mathrm{V} \tag{164}$$

$$v_{11\text{ут}} = -\left(v \cdot \sqrt{1 - \frac{\mathrm{V}^2}{\mathrm{C}_1^2}}\right) \tag{183}$$

$$v_{12\text{хт}} = \frac{\mathrm{V} + v_{22\text{хт}}}{1 + \frac{\mathrm{V} \cdot v_{22\text{хт}}}{\mathrm{C}_1^2}} \tag{184}$$

$$v_{12\text{ут}} = \frac{v_{22\text{ут}} \cdot \sqrt{1 - \frac{\mathrm{V}^2}{\mathrm{C}_1^2}}}{1 + \frac{\mathrm{V} \cdot v_{22\text{хт}}}{\mathrm{C}_1^2}} \tag{185}$$

After putting the projections of the speeds $\boldsymbol{\upsilon_{11xp}}$, $\boldsymbol{\upsilon_{12xp}}$, $\boldsymbol{\upsilon_{11\text{хт}}}$, $\boldsymbol{\upsilon_{11\text{ут}}}$, $\boldsymbol{\upsilon_{12\text{хт}}}$ and $\boldsymbol{\upsilon_{12\text{ут}}}$ from formulas (164), (181) - (185) into equations (179) and (180) and by using formula (168), we will obtain:

$$\frac{\mathrm{M}_0 \cdot (\mathrm{V} - v)}{\sqrt{1 - \frac{v^2}{\mathrm{C}_1^2}} \cdot \sqrt{1 - \frac{\mathrm{V}^2}{\mathrm{C}_1^2}}} + \frac{\mathrm{M}_0 \cdot (\mathrm{V} + v)}{\sqrt{1 - \frac{v^2}{\mathrm{C}_1^2}} \cdot \sqrt{1 - \frac{\mathrm{V}^2}{\mathrm{C}_1^2}}} =$$

$$= \frac{\mathrm{M}_0 \cdot \mathrm{V}}{\sqrt{1 - \frac{v^2}{\mathrm{C}_1^2}} \cdot \sqrt{1 - \frac{\mathrm{V}^2}{\mathrm{C}_1^2}}} + \frac{\mathrm{M}_0 \cdot (\mathrm{V} + v_{22\text{хт}})}{\sqrt{1 - \frac{v^2}{\mathrm{C}_1^2}} \cdot \sqrt{1 - \frac{\mathrm{V}^2}{\mathrm{C}_1^2}}} \tag{186}$$

$$0 = -\frac{\mathrm{M}_0 \cdot v}{\sqrt{1 - \frac{v^2}{\mathrm{C}_1^2}}} + \frac{\mathrm{M}_0 \cdot v_{22\text{ут}}}{\sqrt{1 - \frac{v^2}{\mathrm{C}_1^2}}} \tag{187}$$

or:

$$\mathrm{V} - v + \mathrm{V} + v = \mathrm{V} + \mathrm{V} + v_{22\text{хт}}$$

$$0 = -v + v_{22yт}$$

From equations (186) and (187) we obtain the necessary conditions (value of the projections of the speeds $\boldsymbol{\upsilon_{22\text{хт}}}$ and $\boldsymbol{\upsilon_{22\text{ут}}}$), with which in an example № 1 with the conversion coefficient $\boldsymbol{\beta \geq 1}$ will be carried out the law of momentum conservation in the fixed inertial reference system $\mathbf{O_1x_1y_1z_1}$:

$$v_{22\text{xт}} = 0 \qquad (188)$$

$$v_{22y\text{т}} = v \qquad (189)$$

From equalities (188) and (189) it follows that the values of the projections of the speeds $\mathbf{v_{22x\text{т}}}$ and $\mathbf{v_{22y\text{т}}}$ do not depend on the speed **V** (and, therefore, they do not depend on the value of conversion coefficient **β**).

After substituting conditions (188) and (189) into equations (132) and (133), we will obtain:

$$t_{22\text{т}} = t_{21\text{т}} = 0 \qquad (190)$$

But after substituting equation (190) into formula (150):

$$\omega \cdot 0 = \left(1 - \frac{1}{\beta^2}\right) \cdot [1 + 1] \cdot \frac{v}{\mathrm{V}} \qquad (191)$$

we will have one additional condition of fulfilling the law of momentum conservation in the fixed inertial reference system $\mathbf{O_1x_1y_1z_1}$ for an example № 1:

$$\beta = 1 \qquad (192)$$

Thus, it is possible to draw the conclusion that in the closed mechanical system of bodies, examined in an example № 1, for the values of the conversion coefficient **β > 1** law of momentum conservation it is not carried out.

Let us confirm that state aboved by numerical computations.

4.4.1.1. Digital calculation for an example № 1 with the conversion coefficient β > 1

Let us assume that:

$\mathbf{V / C_1} = 0{,}9$, $\mathbf{v / C_1} = 0{,}6$.

Equation (150) taking into account formula (69) can be written down in the form:

$$\omega \cdot t_{22\text{т}} = \frac{v \cdot \mathrm{V} \cdot [1 + \cos(\omega \cdot t_{22\text{т}})]}{\mathrm{C}_1^2} \qquad (193)$$

Then we obtain:

$\boldsymbol{\omega \cdot t_{22\text{т}}} = 0{,}8828669738$, the projections $\mathbf{v_{22x\text{т}} / C_1} = 0{,}4635374427$ and

$\upsilon_{22yт}$ / C_1 = 0,3809633042 speed of the motion of body 2 in the mobile inertial reference system $O_2x_2y_2z_2$.

In the fixed inertial reference system $O_1x_1y_1z_1$:

a) at the moment of the time t_{1p}:

Moment of the time	Object	Value	Value of the quantity
t_{1p}	Body 1	the projection of momentum on the axis O_1x_1 $К_{11xp}/(M_o\cdot C_1)$	0,860309002
	Body 2	the projection of momentum on the axis O_1x_1 $К_{12xp}/(M_o\cdot C_1)$	4,30154501
	System of bodies 1 and 2	the projection of momentum on the axis O_1x_1 $К_{12x\Sigma p}/(M_o\cdot C_1)$	5,161854012
		the projection of momentum on the axis O_1y_1 $К_{12y\Sigma p}/(M_o\cdot C_1)$	0

b) at the moment of the time $t_{1т}$:

Moment of the time	Object	Value	Value of the quantity
$t_{1т}$	Body 1	the projection of momentum on the axis O_1x_1 $К_{11xт}/(M_o\cdot C_1)$	2,580927006
		the projection of momentum on the axis O_1y_1 $К_{11yт}/(M_o\cdot C_1)$	– 0,75
	Body 2	the projection of momentum on the axis O_1x_1 $К_{12xт}/(M_o\cdot C_1)$	3,9102117884
		the projection of momentum on the axis O_1y_1 $К_{12yт}/(M_o\cdot C_1)$	0,4762041303
	System of bodies 1 and 2	the projection of momentum on the axis O_1x_1 $К_{12x\Sigma т}/(M_o\cdot C_1)$	6,491138794
		the projection of momentum on the axis $O_1 y_1$ $К_{12y\Sigma т}/(M_o\cdot C_1)$	– 0,2737958696

The law of momentum conservation is not carried out, since: 5,161854012 # 6,491138794 and - 0,2737958696 # 0.

4.4.2. Determination of the conditions of fulfilling the law of momentum conservation for an example № 1 with the conversion coefficient 0 < β ≤ 1

If conversion coefficient **0 < β ≤ 1**, then the values of the conversion coefficient **β** and of mass **M(v)** moving with speed **v** of body are determined:

$$\beta_{<}^{2} = \frac{1}{1 + \frac{V^2}{C_2^2}} \qquad (86)$$

$$M(v)_{<} = \frac{M_0}{\sqrt{1 + \frac{v^2}{C_2^2}}} \qquad (106)$$

Then, taking into account formula (106) of equation (177) and (178) is taken the form itself:

$$\frac{M_0 \cdot v_{11xp}}{\sqrt{1 + \frac{v_{11xp}^2}{C_2^2}}} + \frac{M_0 \cdot v_{12xp}}{\sqrt{1 + \frac{v_{12xp}^2}{C_2^2}}} = \frac{M_0 \cdot v_{11xт}}{\sqrt{1 + \frac{v_{11xт}^2 + v_{11yт}^2}{C_2^2}}} + \frac{M_0 \cdot v_{12xт}}{\sqrt{1 + \frac{v_{12xт}^2 + v_{12yт}^2}{C_2^2}}} \qquad (194)$$

$$0 = \frac{M_0 \cdot v_{11yт}}{\sqrt{1 + \frac{v_{11xт}^2 + v_{11yт}^2}{C_2^2}}} + \frac{M_0 \cdot v_{12yт}}{\sqrt{1 + \frac{v_{12xт}^2 + v_{12yт}^2}{C_2^2}}} \qquad (195)$$

Formulas (158) - (161) and (164) - (167) taking into account formula (86) can be written down:

$$v_{11xp} = \frac{V - v}{1 + \frac{V \cdot v}{C_2^2}} \qquad (196)$$

$$v_{12xp} = \frac{V + v}{1 - \frac{V \cdot v}{C_2^2}} \qquad (197)$$

$$v_{11xт} = V \qquad (164)$$

$$v_{11\text{ут}} = -\left(v \cdot \sqrt{1 + \frac{V^2}{C_2^2}}\right) \tag{198}$$

$$v_{12\text{хт}} = \frac{V + v_{22\text{хт}}}{1 - \frac{V \cdot v_{22\text{хт}}}{C_2^2}} \tag{199}$$

$$v_{12\text{ут}} = \frac{v_{22\text{ут}} \cdot \sqrt{1 + \frac{V^2}{C_2^2}}}{1 - \frac{V \cdot v_{22\text{хт}}}{C_2^2}} \tag{200}$$

After putting the projections of the speeds $\boldsymbol{\upsilon_{11xp}}$, $\boldsymbol{\upsilon_{12xp}}$, $\boldsymbol{\upsilon_{11x\text{т}}}$, $\boldsymbol{\upsilon_{11y\text{т}}}$, $\boldsymbol{\upsilon_{12x\text{т}}}$ and $\boldsymbol{\upsilon_{12y\text{т}}}$ from formulas (164), (196) - (200) into equations (194) and (195) and by using formula (168), we will obtain:

$$\frac{M_0 \cdot (V - v)}{\sqrt{1 + \frac{v^2}{C_2^2}} \cdot \sqrt{1 + \frac{V^2}{C_2^2}}} + \frac{M_0 \cdot (V + v)}{\sqrt{1 + \frac{v^2}{C_2^2}} \cdot \sqrt{1 + \frac{V^2}{C_2^2}}} =$$

$$= \frac{M_0 \cdot V}{\sqrt{1 + \frac{v^2}{C_2^2}} \cdot \sqrt{1 + \frac{V^2}{C_2^2}}} + \frac{M_0 \cdot (V + v_{22\text{хт}})}{\sqrt{1 + \frac{v^2}{C_2^2}} \cdot \sqrt{1 + \frac{V^2}{C_2^2}}} \tag{201}$$

$$0 = -\frac{M_0 \cdot v}{\sqrt{1 + \frac{v^2}{C_2^2}}} + \frac{M_0 \cdot v_{22y\text{т}}}{\sqrt{1 + \frac{v^2}{C_2^2}}} \tag{202}$$

or:

$$V - v + V + v = V + V + v_{22\text{хт}}$$

$$0 = -v + v_{22y\text{т}}$$

From equations (201) and (202) we obtain the necessary conditions (value $\boldsymbol{\upsilon_{22x\text{т}}}$ and $\boldsymbol{\upsilon_{22y\text{т}}}$), with which in an example № 1 with the conversion coefficient $\mathbf{0 < \beta \leq 1}$ will be carried out the law of momentum conservation in the fixed inertial reference system $\mathbf{O_1x_1y_1z_1}$:

$$v_{22\text{хт}} = 0 \tag{188}$$

$$v_{22y\text{т}} = v \qquad (189)$$

From equalities (188) and (189) it follows that the values of the projections of the speed $\mathbf{\upsilon_{22x\text{т}}}$ and $\mathbf{\upsilon_{22y\text{т}}}$ do not depend on the speed **V** (and, therefore, they do not depend on the value of conversion coefficient **β**).

After substituting conditions (188) and (189) into equations (132) and (133), we will obtain:

$$t_{22\text{т}} = t_{21\text{т}} = 0 \qquad (190)$$

But after substituting equation (190) into formula (150):

$$\omega \cdot 0 = \left(1 - \frac{1}{\beta^2}\right) \cdot [1 + 1] \cdot \frac{v}{V} \qquad (191)$$

we will have one additional condition of fulfilling the law of momentum conservation in the fixed inertial reference system $\mathbf{O_1x_1y_1z_1}$ for an example № 1:

$$\beta = 1 \qquad (192)$$

Thus, it is possible to draw the conclusion that in the closed mechanical system of bodies, examined in an example № 1, for the values of conversion coefficient **$0 < \beta < 1$** law of momentum conservation is not carried out.

Let us confirm that state aboved by numerical computations.

4.4.2.1. Digital calculation for an example of № 1 with the conversion coefficient 0 < β < 1

Let us assume that $\mathbf{V / C_2} = 0{,}9$, $\mathbf{\upsilon / C_2} = 0{,}6$.

Equation (150) taking into account formula (86) can be written down in the form:

$$\omega \cdot t_{22\text{т}} = -\frac{v \cdot V \cdot [1 + \cos(\omega \cdot t_{22\text{т}})]}{C_2^2} \qquad (203)$$

Then we obtain:

$\mathbf{\omega \cdot t_{22\text{т}}} = -\ 0{,}8828669738$, the projections $\mathbf{\upsilon_{22x\text{т}} / C_2} = -\ 0{,}4635374427$ and $\mathbf{\upsilon_{22y\text{т}} / C_2} = 0{,}3809633042$ speed of the motion of body 2 in the mobile inertial reference system $\mathbf{O_2x_2y_2z_2}$.

In the fixed inertial reference system $\mathbf{O_1x_1y_1z_1}$:

a) at the moment of the time $\boldsymbol{t_{1р}}$:

Moment of the time	Object	Value	Value of the quantity
$\boldsymbol{t_{1р}}$	Body 1	the projection of momentum on the axis $\mathbf{O_1x_1}$ $\mathbf{К_{11xр} / (M_o \cdot v_{xкр2})}$	0,1912108416
	Body 2	the projection of momentum on the axis $\mathbf{O_1x_1}$ $\mathbf{К_{12xр} / (M_o \cdot v_{xкр2})}$	0,9560542082
	System of bodies 1 and 2	the projection of momentum on the axis $\mathbf{O_1x_1}$ $\mathbf{К_{12x\Sigma р} / (M_o \cdot v_{xкр2})}$	1,1472650498
		the projection of momentum on the axis $\mathbf{O_1\ y_1}$ $\mathbf{К_{12y\Sigma р} / (M_o \cdot v_{xкр2})}$	0

b) at the moment of the time $\mathbf{t_{1т}}$:

Moment of the time	Object	Value	Value of the quantity
$\mathbf{t_{1т}}$	Body 1	the projection of momentum on the axis $\mathbf{O_1x_1}$ $\mathbf{К_{11xт} / (M_o \cdot v_{xкр2})}$	0,5736325249
		the projection of momentum on the axis $\mathbf{O_1\ y_1}$ $\mathbf{К_{11yт} / (M_o \cdot v_{xкр2})}$	– 0,5144957554
	Body 2	the projection of momentum on the axis $\mathbf{O_1x_1}$ $\mathbf{К_{12xт} / (M_o \cdot v_{xкр2})}$	0,2781879097
		the projection of momentum on the axis $\mathbf{O_1\ y_1}$ $\mathbf{К_{12yт} / (M_o \cdot v_{xкр2})}$	0,3266733383
	System of bodies 1 and 2	the projection of momentum on the axis $\mathbf{O_1x_1}$ $\mathbf{К_{12x\Sigma т} / (M_o \cdot v_{xкр2})}$	0,8518204346
		the projection of momentum on the axis $\mathbf{O_1\ y_1}$ $\mathbf{К_{12y\Sigma т} / (M_o \cdot v_{xкр2})}$	– 0,187822417

The law of momentum conservation is not carried out, since: 1,1472650498 # 0,8518204346 and – 0,187822417 # 0.

4.5. Conclusions

As a result the examination of an example № 1 it was obtained that with the values of conversion coefficient **β**, which are located in the ranges **β > 1** and **0 < β < 1**, in the fixed reference system $\mathbf{O_1x_1y_1z_1}$:

the momentum of the closed mechanical system of bodies 1 and 2 (and thread 3) at the moment of the time, when bodies 1 and 2 are found on the line, parallel to the axis $\mathbf{O_1y_1}$, is not equal to the momentum of this system of bodies 1 and 2 (and thread 3) at any other moment of the time, when bodies 1 and 2 are not found on the line, parallel to the axis $\mathbf{O_1y_1}$, i.e., **in the fixed (inertial) reference system $\mathbf{O_1x_1y_1z_1}$ the closed mechanical system of bodies 1 and 2 (and thread 3) will have the momentum changing in the time, what is the disturbance of the law of the momentum conservation of the closed mechanical system of bodies**.

Change in the time of the values of the momentum of the closed mechanical system of bodies 1 and 2 (and thread 3) in an example № 1 attests to the fact that with the values of conversion coefficient **β**, which are located in the ranges **β > 1** and **0 < β < 1**, occurs the nonfulfillment of the law of momentum conservation.

On the basis of the fact that the law of the momentum conservation of the closed mechanical system is connected with the symmetry of space and time (with the uniformity of space), it is possible to note that with the values of conversion coefficient **β**, which are located in the ranges **β > 1** and **0 < β < 1**, is disrupted the condition of the symmetry of space and time (the initial condition, accepted with the creation of the special theory of relativity).

I.e., if the law of the momentum conservation of the closed mechanical system is accurate, then in the case the symmetries of space and time the connection between the coordinates and the time in the inertial reference systems cannot be recorded with the aid of the special theory of relativity with the values of conversion coefficient **β**, which are located in the ranges **β > 1** and **0 < β < 1**.

As shown with the examination of an example № 1, the law of the momentum conservation of the closed mechanical system, and, therefore, also condition the symmetries of space and time are carried out only with the conversion coefficient **β = 1**, i.e., when conversion coefficient **β** is not the function of speed **V** of the motion of inertial reference system.

In the case **β = 1** the constants $\mathbf{C_1}$ and $\mathbf{C_2}$ will be equal:

$$C_1 = \pm\infty \qquad (204)$$

$$C_2 = \pm\infty \qquad (205)$$

5. Conclusion

In conclusion it is possible to generalize that above written:

1. With the use of the law of relativity and symmetry of space and time it was obtained that the connection between the inertial reference systems - fixed $\mathbf{O_1x_1y_1z_1}$ and mobile $\mathbf{O_2x_2y_2z_2}$ can look like:

$$x_{1>} = \frac{x_{2>} + (V \cdot t_{2>})}{\sqrt{1 - \frac{V^2}{C_1^2}}} \qquad (70)$$

$$x_{2>} = \frac{x_{1>} - (V \cdot t_{1>})}{\sqrt{1 - \frac{V^2}{C_1^2}}} \qquad (71)$$

$$y_1 = y_2 \qquad (36)$$

$$z_1 = z_2 \qquad (37)$$

so:

$$x_{1<} = \frac{x_{2<} + (V \cdot t_{2<})}{\sqrt{1 + \frac{V^2}{C_2^2}}} \qquad (87)$$

$$x_{2<} = \frac{x_{1<} - (V \cdot t_{1<})}{\sqrt{1 + \frac{V^2}{C_2^2}}} \qquad (88)$$

$$y_1 = y_2 \qquad (36)$$

$$z_1 = z_2 \qquad (37)$$

where: $\mathbf{C_1}$ and $\mathbf{C_2}$ – real constants.

2. The dependence of mass $\mathbf{M}(\mathbf{v})$, momentum $\mathbf{P}(\mathbf{v})$ and kinetic energy $\mathbf{E}_{\text{к}}(\mathbf{v})$ of body from the speed **v** of its motion can be as:

$$M(v)_{>} = \frac{M_0}{\sqrt{1 - \frac{v^2}{C_1^2}}} \qquad (103)$$

$$P(v)_{>} = \frac{M_0 \cdot v}{\sqrt{1 - \frac{v^2}{C_1^2}}} \qquad (104)$$

$$E_{\text{к}}(v)_{>} = M_0 \cdot C_1^2 \cdot \left(\frac{1}{\sqrt{1 - \frac{v^2}{C_1^2}}} - 1 \right) \qquad (105)$$

so:

$$M(v)_{<} = \frac{M_0}{\sqrt{1 + \frac{v^2}{C_2^2}}} \qquad (106)$$

$$P(v)_{<} = \frac{M_0 \cdot v}{\sqrt{1 + \frac{v^2}{C_2^2}}} \qquad (107)$$

$$E_{\kappa}(v)_{<} \;=\; M_0 \;\cdot\; C_2^2 \;\cdot\; \left(1 - \frac{1}{\sqrt{1 + \frac{v^2}{C_2^2}}} \right) \qquad (108)$$

3. Based on the separate example (example № 1), in which was examined the closed mechanical system of bodies, which are found in the continuous cooperation, it was shown that with the values of conversion coefficient **β**, which are located in the ranges **β > 1** and **0 < β < 1**, can occur the disturbance of the law of momentum conservation, i.e., with the use of the special theory of relativity in the inertial reference system the momentum of the closed mechanical system can be time-varying value.

It was obtained with the examination of an example № 1 that the law of the momentum conservation of the closed mechanical system, and, therefore, also the condition of the symmetry of space and time can be carried out only with the conversion coefficient **β = 1**.

It was noted based on the example № 1, that the special theory of relativity can come into conflict with the law of the momentum conservation of the closed mechanical system.

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Author V.N. Cochetkov