# Impulse as a True Measure of Inertia

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**Funding:** No specific funding was received for this work.

**Potential competing interests:** No potential competing interests to declare.

## Abstract

It is shown that, according to Newtonian mechanics, the measure of the inertial properties of any substance is its momentum, and not its mass. The immediate consequences of this provision are revealed, consisting of the need to distinguish between ordered (translational and rotational) and disordered (oscillatory) motion and their quantitative measures, as well as taking into account the irreversibility of any real process. On this basis, a new interpretation of the forces of inertia is given and the erroneousness of relativistic mass transformations is revealed. The expediency of replacing entropy with a thermal impulse, which has lost its vector nature due to the chaotic motion, is substantiated. Thus, the theory of heat death of the Universe was refuted and the flagrant contradiction between thermodynamics and the theory of evolution was eliminated.

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**Keywords**: momentum and momentum, mass and acceleration, inertia and irreversibility, energy carriers and their inhomogeneity parameters, Newtonian forces and stresses.

## 1. Introduction

Our knowledge of inertia and the forces generated by it has not changed much since the time of I. Newton, who formulated his 1st law (of inertia) as a statement that “everybody continues to be held in its state of rest or uniform and rectilinear motion, as long as and since it is not compelled by applied forces to change this state” [1]. This formulation raises several questions at once: why did Newton limit himself to rectilinear motion, if there is also a uniform rotation of bodies in the absence of any “applied” forces? What is the difference between “applied force” and “reaction force”, “action” from “reaction”, and what is force in general? And how to distinguish force as the cause of the process from force as its consequence? How to distinguish the nature of forces? And how to distinguish motion in the absence of forces from motion when their resultant is equal to zero? What is uniform motion if the concept of speed has not yet been defined?

Etc.

Obviously, for a consistent answer to these questions, the law of inertia would have to be preceded by Newton's 2nd law (the law of force), according to which "an increase in the amount of motion is proportional to the driving force and occurs in the direction of the straight line along which this force acts", as well as his 3rd law, which defines the concept of "opposing forces" (reactions) and their difference from the "driving force". It is also obvious that both should have been preceded by a definition of the concept of the speed of movement, its "quantity" and the duration of the "applied force".

As for the concept of “force of inertia”, which appears in the 1st law, it is also a consequence of the 2nd and 3rd laws, since it refers to reaction forces and is opposite to “applied force”. This inconsistency, along with the absence of algebra (and even more so vector algebra) at the time of I. Newton, is the reason why discussions about what inertia forces are, whether they exist in nature or are fictional, whether they depend on speed whether they belong to the functions of a state or a process, whether they are an “innate” or “emergent” (acquired) property of bodies, etc. understanding”, but, as it were, “from scratch” (in retrospect), guided only by strictly substantiated provisions of a general scientific nature.

## 2. The need to consider the momentum of the oscillatory form of motion

Without exception, all fundamental disciplines describe the state of the object of study (system) with the help of extensive and intensive parameters, which are, respectively, quantitative or qualitative measures of one or another of its properties. The extensive parameters include the mass $M$, the number of moles of $k$-th substances $N_k$, entropy $S$, charge $Q_e$, impulse $\boldsymbol{P}$, its moment $\boldsymbol{L}$, etc.; to intensive ones - gravitational $\psi_g$, chemical $\mu_k$, electric potentials $\varphi$, speed $\boldsymbol{\upsilon}$, etc. In the general case of spatially inhomogeneous systems, most of these extensive parameters change both due to the transfer of the energy carrier corresponding to them through the boundaries of the system, and spontaneously due to internal mutual transformations. Thus, the volume occupied by a certain mass M can change both as a result of the expansion work performed by the system, and when it expands into a void without performing work. The number of moles of $k$-th substances $N_k$, can change both due to their diffusion through the boundaries of the system, and as a result of internal chemical reactions in the system. The amount of disordered motion can change both due to the conductive and convective transfer of momentum through the boundaries of the system, called heat transfer and heat and mass transfer, and due to its chaotization (transition of part of the ordered motion into disordered). The momentum of the system can change both due to the application of external forces, and under the action of internal friction forces.

In spatially inhomogeneous media, this duality is a consequence of the dependence of the density $\rho_k = d\Theta_k/dV$ of any $k$-th independent component of the system $\Theta_k \equiv M_k, N_k, S_k, 3_k, \boldsymbol{P}_k, \boldsymbol{L}_k$, etc. from the radius vector of the field point $\boldsymbol{r}$. As a result, the total change in this density $\rho_k = \rho_k(t, \boldsymbol{r})$ in time includes the “convective” $(\partial\rho_k/\partial\boldsymbol{r})(d\boldsymbol{r}/dt) = (\boldsymbol{\upsilon}\cdot\nabla)\rho_k$ and the “local” $(\partial\rho_k/\partial t)_{\boldsymbol{r}}$ components:

$$d\rho k/dt = (\mathbf{\upsilon} \cdot \nabla)\rho k + (\partial\rho k/\partial t)r \qquad (1)$$

The first term on the right side of this expression expresses the change in the energy carrier $\Theta_k$ due to its transfer through the system boundaries, the second one reflects the presence of internal sources or sinks of this value. Such duality makes it extremely difficult to find the coordinates of the process of energy exchange between the system and the environment, i.e., a parameter that necessarily changes during its course and still is unchanged in its absence. To get around this difficulty, classical thermodynamics is limited to the consideration of the so-called "equilibrium" (quasi-static) processes, which are so slow that the internal "sources" or "sinks" of coordinates become negligible, and the state of the system remains practically homogeneous (internal equilibrium), despite the flow process. However, in this case, the power of the processes under consideration, as well as their driving forces and speeds, turn out to be negligible, which forces us to look for the causes of the occurrence and the direction of processes outside the framework of these usual concepts, in particular, in the system's aspiration to a more probable state. Other fundamental disciplines, where neglecting the speed and power of processes is unacceptable, generally exclude internal (irreversible) processes from consideration, considering the object of application of forces to be structureless and limiting themselves to the study of "conservative" systems. Such are classical and quantum mechanics.

However, another way is possible, which does not exclude from consideration the reversible or irreversible part of real processes. This is achieved by rejecting the thermodynamic postulate on the compatibility of the concepts of "equilibrium" and "process", and recognizing that any (including quasi-static) processes occur only in spatially inhomogeneous systems. The latter is easy to prove by expressing the value of $\Theta_k$ both as an integral of its density $\Theta_k = \int\rho_k \, dV$ and through its mean value $\bar{\rho}_k = \Theta_k / V$. In this case, the flow of any $k$-th process $d\Theta_k/dt$ is subject to the identity:

$$\int [d(\rho_k - \bar{\rho}_k)/dt] dV \equiv 0 \qquad (2)$$

It directly follows from here that in spatially homogeneous media, where $\rho_k - \bar{\rho}_k$ everywhere, no processes ($d(\rho_k - \bar{\rho}_k) / dt \neq 0$) are possible. Therefore, the description of real processes requires the introduction of additional parameters of spatial inhomogeneity. However, before introducing these parameters, let us pay attention to the fact that expression (1) is a "kinematic" equation of the wave in its so-called "single-wave" approximation, in which $d\rho_k/dt$ plays the role of the "damping function" of the wave [2]. The process of such wave formation is illustrated in Figure 1. It follows from it that the standing wave of density ρ of any medium is due to the transfer of a certain amount of it with mass $M$ from a position with a radius vector $\mathbf{r}'$ to a position $\mathbf{r}''$ by a half-wave length $\lambda_k/2$. This process is associated with a change in its impulse $\mathbf{P} = M\boldsymbol{\upsilon}$ and with the performance of some work $dW = \boldsymbol{\upsilon}\cdot d\mathbf{P}$ against the forces of the Newtonian forces of inertia of the medium. This work, in accordance with the modern expression of the force of inertia $\mathbf{F}_i = - d\mathbf{P}/dt$ ass $M$ turns out to be equal to the "live force" of G. Leibniz:

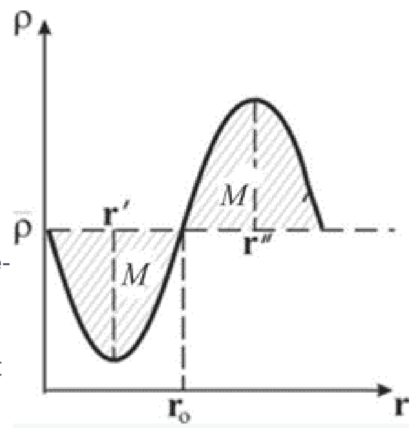

**Fig.1.** Wave formation

$$E^{v} = \int \boldsymbol{\upsilon} \cdot d\mathbf{P} = M \upsilon^{2} \qquad (3)$$

The value υ has the meaning of the speed of propagation of a perturbation in a given medium, which was put in the "pre-Einstein" era as the basis for determining the energy of the ether, for which υ is equal to the speed of light in vacuum c and $E^v = Mc^2$ (H. Schramm (1871); N. Umov (1873), J. Thomson (1881), O. Heaviside (1890), A. Poincaré (1898), Hazenorl (1904) [3].

Thus, the energy E, which, according to the proposal of T. Jung (1807), replaced the concept of "living force" by G. Leibniz, originally had the meaning of a quantitative measure of disordered (non-directional) oscillatory motion $E^v = M\upsilon^2$. For any $k$-th substance with mass $M_k$ and refractive index $n_k = \upsilon_k /c >1$, this energy is less than the energy of aether. When the motion in the system under the action of external forces acquires an orderly character, a part of this energy passes into the so-called "kinetic" energy $E^\upsilon = M\boldsymbol{\upsilon}^2/2$. On the contrary, when the oscillatory motion in the system decays ($\upsilon \rightarrow 0$), this energy partially transforms into the “potential” $E^r = \int \boldsymbol{F} \cdot d\boldsymbol{r}$, which depends only on the mutual position of the bodies (the radius vector $\boldsymbol{r}$ and has the meaning of the energy of the “inhibited” (“frozen") of motion. This corresponds to the energy balance equation:

$$dE^v = 2\boldsymbol{\upsilon} \cdot d\mathbf{P} = dE^\upsilon + dE^r \qquad (4)$$

which is a somewhat unusual form of the law of conservation of energy. This form makes it possible to preserve the simple and clear original meaning of energy as a general measure of motion (actual and retarded) and as a measure of the system's performance, without resorting to the indefinite concept of "interaction". Unfortunately, the “post-Newtonian” generations of researchers preferred to call the disordered energy of oscillatory motion $E^v$ “internal” $U$, thereby replacing expression (4) with the sum of external (kinetic $E^\upsilon$ and potential $E^r$) and internal energy $U$ and calling it “the law of conservation of the total energy of an isolated system $E_{iz}$):

$$\mathrm{E}_{из} = (E^\upsilon + \mathrm{E}^r + U) = const \qquad (5)$$

In this expression, the internal energy U acquired the meaning of the disordered (non-workable) part of the energy of the system (“anergy”), which was the result of the irreversible transformation of the ordered (kinetic and potential) energy into it. Thus, the idea of a spontaneous unilateral (irreversible) termination of all processes occurring in it as a result of the dissipation of ordered forms of energy was imposed on the Universe as a whole. This concept is reflected in the “general (basic) principle of thermodynamics”: “An isolated system always comes to a state of thermodynamic equilibrium over time and can never spontaneously leave it” [3]. The internal inconsistency of this postulate lies in the fact that for isolated systems the concept of external (kinetic and potential) energy is meaningless. Its external inconsistency is also evident, arising from the fact that the balance in the Universe has not come already within the 13.7 billion years allotted to it by the "Standard Cosmological Model". The actual absence of isolated subsystems (metagagalaxies) in the Universe due to the lack of isolation from gravitational forces does not correspond to it either. Moreover, this postulate contradicts the very concept of science as a methodology for cognizing Nature, which studies its laws, and does not prescribe a line of behavior for it.

The above-proved impossibility of the occurrence of any processes in a homogeneous (“internally equilibrium”) system puts an end to attempts to expel the concept of force not only from thermodynamics (due to its “uselessness” for quasi-static processes), but also from statistical and quantum mechanics (where the concept of force was replaced by "exchange interaction"), as well as special and general relativity (where the gravitational force was replaced by "curvature of space") [4].

Moreover, the interpretation of the law of conservation of energy in the form (5) is in fact unacceptable for isolated systems, since for them the concept of external energy is meaningless. Along with the generally accepted calibration of Newton's law of gravitation, in which the potential energy acquired negative values, this led to the fact that "modern physics does not know what energy is" [5]. Only the recognition of the "indestructibility" of motion and the understanding of energy as a quantitative measure of all its forms opens up the possibility of uniting all fundamental disciplines based on the concept of energy $E$ and force $\boldsymbol{F}$ as its displacement derivative d$\boldsymbol{r}$. Such a discipline, distinguished by the unity of the conceptual system of the mathematical apparatus, was developed by us in our doctoral dissertation [6] and called "energodynamics" [7].

## 3. The need to distinguish between amount of movement and impulse

Modern physics does not recognize the fundamental difference between the amount of motion Ᵽ$M\upsilon$, introduced by Descartes, and the impulse $\boldsymbol{P} = M\boldsymbol{\upsilon}$, considering the speed as a pure vector quantity, and $P$ and $\boldsymbol{P}$ as synonyms. Meanwhile, the concept of speed and momentum is applicable to both ordered and disordered forms of motion. Such, in particular, is the speed of light c, which is a scalar quantity. The difference between the oscillatory form of motion and the amount of motion as its measure is the absence of displacement of the medium as a whole, while the momentum is always associated with displacement.

The path proposed by energodynamics, based on considering the oscillatory form of energy $E^v = M\upsilon^2$, makes it possible to study processes in isolated systems, for which all conservation laws were actually formulated. In such systems, all processes become internal, which excludes the possibility of changing the parameters $\Theta_k$ due to external energy exchange and eliminates the above-mentioned duality of the process coordinate concept. It becomes obvious that the states of rest and motion are characterized by different coordinates. For the first coordinate is the amount of energy carrier $M_k$, for the second - the amount of its movement $P_k = M_k\upsilon_k$ (oscillatory, translational $P_k^{\,w}$ and rotational $P_k$ ). At the same time, due to the additivity of the energy

$$E^{\,v} = \Sigma_k E_k^{\,v} = \Sigma_k P_k \upsilon_k \qquad (6)$$

In this case, the researcher's attention switches to studying the processes of mutual transformation of "partial" (from Latin "partialis") energies $E_k$ of all its $k$-the components (including ether-like media such as hidden mass, physical vacuum, non-baryonic, dark matter, etc., from which all known types of matter in the Universe were formed). At the same time, the energy $E_K$ includes kinetic $E_K^{\,\upsilon}$ and potential $E_k^{\,r}$ components, the first of which is a single measure of all forms of actual (observed) motion, and the second is a single measure of "inhibited" (hidden) motion, attributable to rest energy.

Thanks to such a classification of energy forms, all material carriers of rest energy $M_k$ and motion $P_k = M_k\upsilon_k$ buy a single physical meaning and a single dimension, which radically simplifies the system of physical quantities and simplifies the transition from one of its types of energy to another. In particular, since all real components of the system take part in thermal motion, its energy carrier $P_q = \Sigma_k M_k \upsilon_k = M\upsilon_q$ is singled out in energodynamics and is called a thermal impulse, i.e., an impulse that has lost its vector nature due to the chaotic nature of thermal motion [8]. Consideration of a thermal impulse as a carrier of thermal motion frees one from the need to introduce the concept of entropy $S$, which gave rise to many misunderstandings and paralogisms such as the Gibbs paradox, the theory of "thermal death of the Universe" [9] and led to "a blatant contradiction of thermodynamics with the theory of evolution" (I. Prigogine)[10].

## 4. Inadmissibility of considering mass as a measure of inertia

At the time of I. Newton, when algebra (and even more so vector algebra) did not yet exist, all laws were formulated verbally. Only with the advent of vector algebra, Newton's 2nd law began to be written in the form:

$$\mathbf{F} = d\mathbf{P}/dt \qquad (7)$$

in which the speed $\boldsymbol{\upsilon}$ was perceived only as a vector. As a result, the difference between momentum and momentum disappeared. Meanwhile, speed is not always a vector. In particular, the speed of light in vacuum can in no way be attributed to vector quantities. Similarly, the speed of disordered oscillatory motion, which appears in the expression "living force" by G. Leibniz, is not a vector. Here we are dealing with a case where the followers of the great thinkers of the past, who did not reach their heights, in an attempt to "correct" them essentially reduced their knowledge. Meanwhile, from the definition of force given by I. Newton, it followed that the “state of rest” and the “state of motion” violated by the applied force $\boldsymbol{F}$ are different states. Consequently, their coordinates must also be distinguishable. In energodynamics, as in mechanics, the state of rest is characterized by the mass $M$, and the state of motion is characterized by the amount of movement $P = M\upsilon$, which in the case of ordered motion has a vector character and is called the impulse $\boldsymbol{P = M\upsilon}$. In accordance with the formulation of Newton's 1st law, this meant that the measure of ordered motion considered by his mechanics is exclusively the amount of movement $P = M\upsilon$, and not the mass $M$, which was completely absent in his expression (6). In this regard, a natural question arises: at what stage in the development of mechanics did the mass $M$ turn from a measure of the amount of matter, as understood by I. Newton and his predecessors, into a measure of inertia? After all, the force of inertia $\boldsymbol{F}$ and in those days did not differ in any way from the applied force F and, therefore, could not distort the understanding of the momentum. Newton also lacked the concept of acceleration $\boldsymbol{a} = d\boldsymbol{\upsilon}/dt$, and, consequently, the division of the right side of (6) into mass and acceleration. Such an understanding of mass could not appear in thermodynamics either, where the mass $M$ was the coordinate of the process of mass transfer of the system with the environment and, as any coordinate, should not have changed during any other process, including the process of acceleration.

There should have been no non-distinguishing between momentum and momentum in the special theory of relativity (SRT), which asserted the existence of a limiting perturbation propagation velocity equal to the speed of light in a vacuum c. In this case and then it should have become obvious that relation (6) is non-linear, since when the speed $u = c =$ const is reached, no, even an infinitely large applied force $\boldsymbol{F}$ can cause further acceleration of the body $\boldsymbol{a} = d\boldsymbol{\upsilon}/dt$. This would mean that between the left and right parts of (6) there should be a variable “inertia” coefficient $k_и(u)$, which changes along with the speed $u$ and vanishes at $u = c$:

$$\mathbf{F} = k_{и}(u)d\mathbf{P}/dt \qquad (8)$$

The meaning of this coefficient as a value inverse to the efficiency factor (COP) of the acceleration process $\eta_u = |\mathbf{F}_{in}| / |\mathbf{F}|$, is revealed only in energy dynamics, which generalizes Newton's 3rd law to the case when the applied force F is counteracted not only by the inertial force Fi, but also by others reaction forces $F_r$ available in the system, including the friction force Ft. In this case, only the force of inertia $\boldsymbol{F}_{in} = -d\boldsymbol{P}/dt$, which, in contrast to the external (applied) force $\boldsymbol{F}$, should be attributed to the "useful action", is a function of the acceleration process of the system under study. The relationship between u and the process rate is given in energodynamics by the theory of similarity of energy conversion processes [11], according to which this efficiency for any installation vanishes twice: at "idle" and in the "short circuit" mode.

Expression (8) is directly related to the operation of charged particle accelerators, indicating the existence in them of a regime similar to the "short circuit" of the secondary winding of the transformer, when all the power supplied to it is dissipated. This fully applies to Kaufman's experiments on electron acceleration [11], explaining the increase in the ratio of the electron mass me to its charge e observed in them by a decrease in the efficiency of the acceleration process with increasing speed, and not by relativistic effects. Thus, taking into account irreversibility in acceleration processes reveals the inconsistency of A. Einstein's postulate about the dependence of mass on velocity. This becomes especially obvious if we consider an isolated system in which an explosion of matter is initiated. In this case, the flying fragments acquire tremendous speed. If the mass of these fragments increased with speed, then their total mass would also increase, which is incompatible with the law of conservation of the mass of an isolated system.

It follows from this that any experiments on accelerators to find the dependence of mass on velocity, which do not take into account the efficiency of the acceleration process, give obviously distorted results even in the case when the dependence on velocity is attributed not to mass, but to momentum. Thus, there was and is no reason to consider the mass as a measure of inertia, and not the momentum or the force of inertia.

## 5. Reality and universality of inertial forces

The inadmissibility of interpreting mass as a measure of inertia forces us to rethink the very concept of inertia and inertial forces. First, the inertial forces F and are a kind of reaction forces $\boldsymbol{F}_r$, like centrifugal and Carioles forces. Secondly, inertial forces are functions of the process, not of the state. This means that they disappear with the termination of the acceleration process, while the functions of the process remain unchanged. Therefore, there are no fields of inertial forces as functions of the state of the medium that fills space.

Further, according to the energy balance equation (4), the inertial forces F and, like any other forces $\boldsymbol{F}$, can be found as derivatives of the energy of the system E according to one of the independent displacements of the object of their application $d\boldsymbol{r}$, and therefore belong to the emergent parameters of the material system that arise due to its heterogeneity. This means that in themselves these forces, like their fields, are not substantial.

Finally, if we take its impulse $\boldsymbol{P}_k$ as the coordinate of any $k$-th process, then the inertia forces will appear as a universal measure of its acceleration. This is especially obvious if we express the acceleration process in terms of the specific (unit) applied force:

$$\mathbf{f}_t = \mathbf{F}/M_k = -\eta_{\text{U}}\mathbf{a}_k \qquad (9)$$

This allows us to introduce, by integrating the expression $\boldsymbol{a}_k = d\boldsymbol{\upsilon}_k/dt$, the concept of the inertia of any process as a value reciprocal to its acceleration $\boldsymbol{a}_k$ and equal to the time τ=Δ$t$, during which the speed of the process $\boldsymbol{\upsilon}_k$ will also change by unity under the action of a unit force $\boldsymbol{f}_k$. The inertia of the system is expressed in a certain delay $\tau = \Delta t$ of the speed of any real process $\boldsymbol{\upsilon}$ with respect to the moment of application of the driving force $\boldsymbol{F}$. This delay is especially noticeable at the initial stage of the process, where it is due only to the finite propagation velocity of the perturbation introduced by the applied force $\boldsymbol{F}$. In this case, the acceleration process is expressed by the cotangent of the angle α of the slope of the curve τ = τ ($\boldsymbol{\upsilon}_k$). This means that ideally (when $\eta_{\text{U}}$ = 1) the inertia τ decreases as the speed of any process $\upsilon$ increases, while its acceleration, on the contrary, should increase.

The intervention of the irreversibility of the acceleration process, however, changes the essence of the matter beyond recognition. If the speed of movement of the energy carrier becomes equal to the speed of propagation of the perturbation in the given medium $c/n_k$, then the acceleration process, of course, stops. This corresponds to the vanishing of $\eta_{\text{U}}$. Thus, it becomes obvious that irreversibility should be considered not only in thermodynamics, but also in any other fundamental discipline. This is all the more important since irreversibility manifests itself not only in friction losses (energy dissipation), but also in the dependence of the inertia of a process on the perturbation propagation velocity $c/n_k$. It depends on it which of the reaction forces available in the system will be activated before the others, and, consequently, which trajectory will follow the process of converting energy from one form to another. Hence the irreversibility associated with the “branching” of the process trajectory, which is absent in their quasi-static nature [12]. Here we have an example of how the ideas of the great thinkers of the past are distorted if we follow the philosophical trend of reductionism and simplify the world for its better understanding by a wide audience of the "scientific community".

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